STATUS OF FAMILY LOPHOZIACEAE (HEPATICAE) IN INDIA

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ABSTRACT

Status of family Lophoziaceae in India has been discussed in the light of recent investigations and our own observations on Indian taxa. A total of 19 taxa have been recognised under eight genera including Isopaches Buch., Lophozia (Dumort.) Dumort., Schistochilopsis (N. Kitag.) Konstant., Anastrepta (Lindb.) Schiffn., Anastrophyllum (Spruce) Schiffn., Tritomaria Schiffn. ex Loeske, Tetralophozia (R.M. Schust.) Schljakov and Plicanthus R.M. Schust. Four taxa viz., Anastrophyllum minutum var. himalayanum var. nov., Lophozia udarii sp. nov., Lophozia indica sp. nov. and Schistochilopsis incisa var. himalayana var. nov., have been described as new to science. Sphenolobus longkyrdumii A.P. Singh & V. Nath is proposed as synonym under Metahygrobiella albula (Mitt.) Grolle (family Cephaloziaceae Mig.), hence excluded.

Keywords: Morpho-taxonomy, Liverworts, Lophoziaceae

INTRODUCTION

Family Lophoziaceae (Dumort.) Dumort. is a large family of about 280 globally distributed species (De Roo & al., 2007). A number of recent studies particularly based on genetic analysis and phylogenetics not only suggest exclusion of various elements earlier placed under family Lophoziaceae but also provide some interesting findings (Schill & al., 2004; Yatsentyuk & al., 2004; De Roo & al., 2007; Konstantinova & Vilnet, 2009; Vilnet & al. 2009; Söderström & al., 2010).

In India, the family has been treated very casually resulting in a complete lack of knowledge of the same. Whatever work has been done so far, remains restricted to sporadic taxonomic description, or listing of some taxa in floras. Hence, in the light of the above mentioned recent findings as well as due to lack of adequate information on several Indian taxa of Lophoziaceae, it was felt desirable to provide an updated complete account of various taxa of the family known from this country. The family was earlier treated in India as subfam. Lophozioideae Cavers under family Jungermanniaceae with genera: Anastrepta (Lindb.) Schiffn., Anastrophyllum (Spruce) Steph., Chandananthus Mitt., Lophozia (Dumont.) Dumort., Sphenolobopsis (N. Kitag.) Konstant. (as Lophozia), Tritomaria Schiffn. ex Loeske (Parihar & al., 1994), Andrewsianthus R.M. Schust. (Bapna & Kachroo, 2000) and Sphenolobus (Lindb.) Berggr. (Singh & Nath, 2007). However, In the light of recent molecular studies, a number of shifts have been suggested regarding the status of various taxa (see Schill & al., 2004; Yatsentyuk & al., 2004; Heinrichs & al., 2005; Forrest & al., 2006; He-Nygren & al., 2006; De Roo & al., 2007; Vilnet & al., 2008; Cradall-Stotler & al., 2009; Konstantinova & Vilnet, 2009; Vilnet & al., 2009; Söderström & al., 2010) which created a need for a comprehensive revision of the group to fulfill the lacuna in Indian bryology.

elements of the latter, which are closely related to Scapaniaceae. Following Yatsentyuk & al., (2004), Heinrichs & al., (2005) included Lophoziaceae into Scapaniaceae followed by Forrest & al., (2006), He-Nygren & al., (2006), De Roo & al., (2007) and Heinrichs & al., (2007). However, on the other hand Grolle and Long (2000), Crandal-Stotler and Stotler (2000) and Dumsholt (2002) treated it under Jungermanniaceae. Söderström & al., (2010) separated Anastrophyllaceae Söderstr., De Roo and Vilnet from Lophoziaceae on the basis of molecular studies and kept Anastrophyllum (Spruce) Steph., Anastrepta Lindb., Barbilophozia Loeske, Chandonanthus Mitt., Crossocalyx Meylan, Gymnocolea Dumort., Hamatostrepta Váòa and Long, Isopaches Buch, Neorothocaulis Söderstr., De Roo & Vilnet, Orthocaulis H. Buch., Plicanthus Schust., Schlajakovia Konstant. & Vilnet, Schljakovianthus Konstant. & Vilnet, Sphenolobopsis R.M. Schust. & N. Kitaag., Sphenolobus (Lindb.) Berggr. and Tetraloaphozia Schust under this family. Though final status of the family continues to be disputed, the family Lophoziaceae has now been accepted as polyphyletic in origin (Yatsentyuk & al., 2004; De Roo & al., 2007; Schill & al., 2004; Vilnet & al., 2008, 2009; Cradall-Stotler & al., 2009; Söderström & al., 2010). As the final status of family Lophoziaceae including its allied families like Anastrophyllaceae is still under scrutiny, we therefore, hesitate to segregate the members of Anastrophyllaceae for now. Hence, a total of eight genera with 19 taxa have been discussed under family Lophoziaceae to ascertain the present status in India.

MATERIAL AND METHODS

The present study is based on fresh as well dried herbarium specimens, deposited in Lucknow University Hepatic Herbarium (LWU) as well as obtained from overseas Herbaria (FH, NICH, NY). Types of new taxa have been deposited in the Lucknow University Heptaic Herbarium (LWU).

Key to the genera of Lophoziaceae in India

1. Leaves strictly 2-lobed ................................................................. 2
1a. Leaves lobe number variable, 2-4(-5)-lobed .................................................. 4
2. Plants appressed ........................................................................ Isopaches
2a. Plants suberect to erect ........................................................................... 3
3. Leaves spreading, dorsal lobe never folded over ventral; lobes 1/8-1/10 of the leaf length; leaves obliquely inserted at dorsal surface; dorsal half of leaf base decurrent; ventral half of leaf base transverse with reflexed margin; lobe apex always obtuse .......................... Anastrophyllum
3a. Leaves antically secund, dorsal lobe folded over ventral; lobes 1/4-1/3(-1/2) of the leaf length; leaves transversely inserted at dorsal surface, dorsal half of leaf base transverse; ventral half of leaf base slightly decurrent without reflexed margin; lobe apex acute, subacute to obtuse ........................ Anastrophyllum
4. Leaf margin entire .......................................................................... 6
4a. Leaf margin denatate .............................................................................. 7
5. Leaves 2-4(-5)-lobed, dorsal half rarely folded over the ventral; stem dorsiventrally differentiated internally ........................................... Lophozia
5a. Leaves (2-) 3-4 lobed, dorsal half folded over ventral, stem not dorsiventrally differentiated internally .................................................. Tritomaria
6. Leaves irregularly lobed ...................................................................... Schistochilopsis
6a. Leaves 3-4 lobed .................................................................................. 8
7. Leaves symmetrically 4-lobed, transversely inserted; leaf cells with indistinct trigones .............................................. Tetralophozia
7a. Leaves asymmetrically 3-lobed, obliquely inserted; leaf cells with bulging trigones ................................................. Plicanthus

Isopaches Buch., Mem. Soc. Pro F. Fl. Fenn. 8: 287. 1932

Plants appressed to substratum; with gemmiparous, ascending to erect slender stems. Cortical layer with uniformly thickened cells; medullary cells thin-walled. Leaves succuous, canaliculate, broadest above middle, obliquely inserted, bifid about 1/3 of their length with pointed lobes. Leaf cells uniformly thickened, in moist conditions thin-walled with small trigones. Underleaves lacking.
Dioicous. Perianth cylindrical below but 3-5 plicate above, gradually contracted to lobulate mouth.

Type: *I. bicrenatus* (Schimdt.) Buch.

The genus is represented in India with single species, *I. decolorans* (Limpr.) Buch. (Long, 2005 as *Laphozia decolorans*; Rawat & Verma, 2013)


Plants small, 2.0 - 4.5mm in size, pale green to bright green when fresh, whitish to yellowish brown when dr, succulent, growing in dense patch, creeping, closely appressed to substratum; shoots occasionally branched, branching 'Frullania-type'. Stem elliptical in cross-section, fleshy, 147-212µm across, up to 10 cells wide; cells
undifferentiated, 16 - 23 × 13-26µm in size, thin walled, atrigonic. Rhizoids numerous, scattered along the ventral surface except the shoot apices. Leaves succubous, obliquely inserted, closely imbricate producing julaceous habit, concave, broader than long, 0.68 - 1.1 × 0.49 - 0.85mm in size, unistratose; ventral insertion oblique; dorsal insertion transverse; margins hyaline, decolourate, entire, occasionally with few one-celled projections appearing as small tooth near subapical margin, rarely with a large 4-6 cells high and 3-4 cells broad tooth or lobe at the dorsal base of leaf; apex bilobed, rarely with a third small to large lobe, lobes unequal, acute, terminating in a single elongated apical cell, 19 - 22 × 13 - 16µm in size; subapical cells 13 - 26 × (9.7) 13-16µm; median cells (13) 19 - 23 × (13)16 - 23µm in size; basal cells 16 - 29 × 13 - 16µm in size; cells slightly thick-walled; trigones indistinct except at apices; cuticle smooth. Underleaves variable in shape and size, rounded lobed to elongate. Rhizoids numerous. Gemmae not seen.

Dioecious Male and female plants are same in size. Male plants very rare in population. Androecia terminal; bracts similar to leaves, with one antheridium per bract; antheridia spherical to elliptical; stalk biseriate, short. Gynoecia terminal; bracts larger than leaves, 2-3lobed; bracteoles smaller, 2-3-lobed. Perianth green, elongate, 5-paniculate, mouth lobulate, lobes denticate, teeth 1-2-celled. Mature sporophytes not observed.

Habitat: Growing on partially shady road side slopes with Solenostoma sp. and Diplophyllum nanum. The locality receives heavy snowfall during the winters.

Type: Austria, 1879, Breider J. s.n. (G!)


Distribution: Sikkim, Arunachal Pradesh (Tawang) (Long, 2005; Rawat and Verma, 2013)

Specimens examined: India : Arunachal Pradesh, Tawang town, c. 2950mts., 27 April 2002, K.K. Rawat and M.S. Azeem 15598/02, 15607/02 (LWU).

Long (2005) reported this species from Sikkim Himalaya as Laphozia decolorans. Though Buch (1933) suggested the synonymy of Lophozia decolorans into Isopaches decolorans quite long time back, however, got established recently by De Roo & al., (2007) on the basis of phylogenetical studies. Rawat and Verma (2013) recently reported this species from Arunachal Pradesh also.


Plants medium to large, pale green to brownish green or reddish brown, scattered or in caespitose patches, on soil covered rocks or humus; branching simple, sparse, always postical intercalary. Stem prostrate to suberect, ascending, subrounded to elliptical in transverse section, differentiated into small, thick-walled cortical and large, thin-walled medullary cells. Leaves succubous, alternate, imbricate to contiguous, obliquely inserted on the antical half with long decurrence and transversely inserted on the ventral half of the stem, subvertically erect to subhorizontally spreading, secund dorsally, antical margin convex at the base and postical leaf margin strongly decurved or reflexed, leaf abaxially concave, cordate, ovate to broadly ovate, unequally bilobed; lobes much smaller in comparison to leaf length, apex obtuse to blunt with shallow to crescent sinus; cells moderate-sized, thin-walled, with minute to large trigones. Underleaves absent or vestigial. Cuticle smooth or faintly verrucose. Gemmae (1-) -2 celled, angular.

Dioecious. Male bracts intercalary, in 2-5 pairs, saccate, similar to the leaves but smaller in size. Perianth cylindrical-obovoid, deeply plicate above middle, gradually contracted to narrow mouth.
In India, the genus is represented by a single species, *Anastrepta orchadensis* (Hook.) Schiffn. According to Schuster (1951a) *Anastrepta* is a specialized derivative from its close relative *Lophozia*. This specialization seems to be in its growth habit (strongly ascending and suberect) but the mode of leaf insertion is transverse on the ventral half in *Anastrepta* in contrast to other species of *Lophozioideae* which are transversely inserted on dorsal half and the difference in the stem anatomy make *Anastrepta* absolutely distinct from *Lophozia* (see Kitagawa, 1966).

Further, Schuster (1981) described a number of criteria which delimit *Anastrepta* and suggest affinity of this genus to include it in subfamily *Lophozioideae* as suberect growth, curved at apex, stem with distinct and firm
cortex, branching lateral intercalary, capsule wall 5 - stratose, female bract connate with bracteole, presence of gemmae, abundant rhizoids, pluriplicate perianth with rounded plicae and male bract 1-2 androus with distinct paraphyses.


Plants medium to large, 8 - 30mm long, 0.9 - 1.5 (-1.95)mm wide (with leaves), pale green, brownish to reddish-brown, scattered or in caespitose patches on soil covered rocks or humus; shoots simple to sparingly branched; branches sparse, always postical intercalary. Stem rigid, subterete, upcurved at apices, subrounded, elliptical to more or less flattened in transverse section, 0.30 - 0.34mm and 14-16 cells wide laterally, 0.18 -0.20mm and 15-18 cells wide vertically; differentiated into cortical and medullary cells; cortical cells in 2-3 layers, smaller, thick-walled, pigmented, subrounded, polygonal to sub-quadrature, 3.8 - 11.4 × 7.6-15.2µm in size; medullary cells larger, thin-walled, non-pigmented, flattened, oblong, polygonal to octagonal, 15.2 - 26.6 × 7.6 - 11.4µm in size. Rhizoids numerous, scattered on ventral surface of the stem.
Leaves imbricate to contiguous, alternate, succuous, subvertically erect to sub-horizontally spreading, leaf insertion different on both sides of stem, obliquely inserted on the antical half with decurrence and transversely inserted on postical half, leaf abaxially concave, antical leaf margin strongly decurved and reflexed, cordate, ovate to broadly ovate, 0.54 - 0.78 (-1.29)mm long, 0.60 - 0.66 (-1.32)mm wide, almost as long as wide, widest above the base, shortly bilobed; lobes broadly triangular, 1/10 - 1/8 of the total leaf length, antical lobe slightly smaller than postical, 3-7 cells high, 7-10 cells wide, postical lobe 4-7 cells high, 9-16 cells wide, lobe apex subacute, sometimes obtuse to blunt, sinus shallowly rounded to lunate, (0.09-) 0.12 - 0.18 (-0.24)mm deep, 0.21 - 0.27 (-0.45)mm wide; cells minute to medium sized, thin-walled; apical cells small, rounded to subrounded with minute trigones, 9 - 18 × 12 - 18µm in size; median cells rounded, subrounded to polygonal with distinct trigones, 12 - 24 × 9 - 18µm in size; marginal cells small, polygonal, more or less isodiametric, 12 - 18 × 9 - 15µm in size; basal cells large, subrounded, polygonal, slightly elongated with large trigones, 18 - 33 × 15 - 21µm in size. Cuticle smooth to faintly verrucose. Gemmae not seen.

Dioicous. Male plants up to 28mm long, 0.72 - 0.90mm wide (at male bract portion); male inflorescence both terminal as well as intercalary; bracts in 2-5 pairs, almost leaf-like but smaller in size, saccate, ovate to subquadrate, 0.54 - 0.75mm long, 0.60 - 0.72mm wide; cells thin-walled, trigones minute to absent; apical cells rounded to subrounded, 9 - 18 × 12 - 18µm in size; median cells subrounded, 9 - 27 × 12 - 27µm in size; basal cells large, subquadrate, elongated, polygonal, 30 - 45 × 15 - 21µm in size. Female plants not seen.

**Habitat:** On soil covered rocks, humus or rotten logs in the subalpine coniferous forest, rarely ascending to the alpine zone (Kitagawa 1966).

**Type:** *Jungermannia orcadensis* Hook., Scotland, ex Hb. Hooker (PC!)

**Range:** Bhutan, China, Czech Republic, France, Germany, India, Java, Japan, Nepal, Taiwan, United States of America. (Mitten, 1861; Grolle, 1966; Hattori, 1966; Kitagawa, 1966; Frahm, 1987; Pippo & al., 1997; Aicardi & al., 1998; Kučera and Váňa, 2003; Staples and Imada, 2006; Singh & al., 2010).

**Distribution:** Manipur (Ukhrul), Sikkim (Dzongri, Tsomgo Lake), West Bengal (Darjeeling, Sandakphu, Phalut) (Hattori, 1966; Singh & al., 2010).

**Specimens examined:** India: Patria Darjeeling (Phalut-Sandakphu), c. 3200 - 3550m.; June 6, 1960; Hara & al., 201016 (NICH). Nepal: East Nepal, above Topke Gola; c. 3650m.; June 18, 1972; Z. Iwatsuki 312159 (NICH).

*Anastrepta orcadensis* was reported from India (Sikkim Himalaya) as *Jungermannia orcadensis* on the basis of collections of J.D. Hooker (Mitten, 1861). Chopra (1938, 1943) listed two species of *Anastrepta, A. orcadensis* and *A. sikkimensis* from Darjeeling. Later, Kitagawa (1966) synonymized *A. Sikkimensis* under *A. orcadensis*. Herzog (1939) listed *A. orcadensis* from Tsongo lake in Sikkim Himalaya. Later on Parihar (1961-62), Hattori (1966, 1971) and Kitagawa (1975) also listed it from Eastern Himalaya. Grolle (1966), Mizutani (1979) and Parihar & al., (1994) listed this species both from Eastern Himalaya and Nepal.

This plant can be easily differentiated with other Lophoziaceae taxa due to specialized and peculiar type of leaf insertion, which makes leaves markedly reflexed along the postical margin. The leaf insertion is antically oblique with decurrence and transversely inserted on postical half.

The study is based on the authentic specimens obtained from NICH, Japan. Of the two specimens investigated, one was from Darjeeling (India) and the other was from East Nepal. Striking differences in the plants of both the locations were observed, which seem to be interesting environmental effect on the same species in both the regions. The plants of Darjeeling are small, 8 - 12mm long, 0.9 - 1.5mm wide, reddish brown in colour with stiff texture, leaves smaller 0.54 - 0.78mm long, 0.60 - 0.66mm broad and stem having similar structure and anatomy but cell size is slightly smaller than those of the plants from Nepal which were much larger, up to 50mm long, 1.09 - 1.95mm wide (with leaves), pale green to light brown in colour, smooth textured,
much larger leaf up to 1.29mm long, 1.32mm broad and the stem is also larger in diameter with large cells than those of the Darjeeling plants.

**Anastrophyllum** (Spruce.) Steph., Hedwigia 32: 140.1893.

Plants medium, small to very large, reddish brown to blackish brown; branching lateral intercalary, also from the axil of leaf. Stem rigid, ascending to erect, terete, orbicular to suborbicular in cross section, differentiated into 1-3-layered, deeply pigmented, collenchymatous, thick-walled cortical cells and large, slightly pigmented medullary cells. Leaves succubous, distant to loosely imbricate forming cluster at the apex, alternate, loosely caespitose, strongly secund dorsally, concave to canalicate, subtransversely inserted on the dorsal half and obliquely inserted on the ventral half up to stem midline, oblong-ovate, quadrate, sub-quadrate to rectangular, shallowly to deeply 2-lobed to (1/16-) 1/10 - 1/2 (-2/3) of its length, lobes equal or subequal, blunt and divergent, broadly to narrowly triangular, subparallel, asymmetric, acute to obtuse, sinus deep to shallow; dorsal margin usually smaller than ventral, both margins incurved; cells small to moderate, collenchymatous, unevenly thick-walled with simple, nodular and confluent trigones; apical cells small, polygonal, subisodiametric; median cells larger than apical cells with nearly confluent trigones; basal cells distinctly elongated with longitudinally confluent trigones (cell lumen small and irregular in shape). Cuticle nearly smooth, faintly to distinctly verrucose.

Asexual reproduction by means of 1-3-celled elliptical or ovoid, angulate gemmae formed at the apices of the leaf at plant apex. Perianth large, highly emergent, deeply pluriplicate above the middle.

*Type*: *Anastrophyllum donianum* (Hook.) Steph. (*Jungermannia doniana* Hook.)

The discovery of the genus in India was made by Mitten (1861), who reported *Jungermannia piligera* Nees, *J. doniana* Hook. and *J. assimile* Mitt. from Sikkim, on the basis of specimens collected by J.D. Hooker in 1848. A fourth species, *Anastrophyllum alpinum* Steph., was probably also collected by Hooker and described by Stephani (1917) (see Schill & Long, 2003). Grolle (1964) reported *A. joergensenii* Schiffn. from Sikkim and reduced *A. alpinum* Steph. under *A. joergensenii*. Schill & Long (2003) however, doubted *J. piligera* as *A. bidens* (Reinw., Blume et Nees) Steph. Hattori (1966) reported *A. minutum* (Schreb. ex Cranz) R.M.Schust. as *Sphenolobus minutus* from Sikkim. Recently Daniels & al. (2012) reported *A. aristatum* (Herzog ex N. Kitag.) A.E.D. Daniels & al. from India and China.

Another species of the genus viz. *A. subacuta* Herzog (= *Cuspidatula subacuta* Herzog) is now treated as *Horikawayella subacutum* (Herzog.) S. Hatt. & Amak. under Solenostomataceae.

Buch (1933) divided *Lophozia-Sphenolobus* complex into eight genera including *Anastrophyllum* and *Sphenolobus*, differentiated mainly on the basis of leaf size and insertion pattern. Schuster (1951a) considered these characters insufficient for differentiation and synonymized *Sphenolobus* under *Anastrophyllum*. However, Müller (1954) resurrected *Sphenolobus* and differentiated it from *Anastrophyllum* in the presence of large size of plant, mode of leaf insertion, form of leaves, strongly thickened cell walls and elongated cells of stem, which was later accepted followed by Kitagawa (1966). In a recent revision of *Anastrophyllum*, Schill & Long (2003) treated *Sphenolobus* as synonym of *Anastrophyllum*. However, recent molecular studies (De Roo & al., 2007) have shown *Sphenolobus* as distinct from *Anastrophyllum* gene pool, as discussed earlier, but no morphological characters could be assigned to differentiate the two taxa. Molecular techniques are always helpful, provided they are supported by the morphological expression otherwise identification would never be possible. *Sphenolobus* is thus treated here under *Anastrophyllum*.

**Key to the species of Anastrophyllum in India**

1. Leaves deeply bilobed, up to or more than half of the leaf length ................................................................. 2
1a. Leaves shallowly bilobed, less than half of the leaf length .............................................................................. 3
2. Leaf lobe apex with single row of 2-3 cells; female bract 1-4 lobed, margin irregularly serrate, sinuate and denticulate; perianth mouth ciliate and sparsely denticulate ........................................... *A. bidens*
2a. Leaf lobe apex with single row of 5 or more cells; female bract 1-3-lobed, margin entire or wavy; perianth mouth ciliate but not denticulate ................................................................. *A. aristatum*
3. Leaves triangulate ovate, elongated, radiating at shoot apex ................................................................. A. donianum
3a. Leaves ovate to orbicular-ovate, not radiating at apex ................................................................. 4
4. Leaf cells at the apex in irregular arrangement .................................................................................. 5
4a. Leaf cells at the apex in regular concentric rows .............................................................................. 6
5. Leaves are rounded boat shaped, lobes equal .................................................................................... A. alpinum
5a. Leaves ovate to subquadrate, with unequal to subequal lobes ........................................................ A. assimile
6. Gemmae 1-3 celled, triangular and angulate ...................................................................................... A. minutum
6a. Gemmae strictly 2-celled, elliptical to spindle shaped with tapering ends ................................ A. minutum var. himalayanum


Plants small to medium, slender, upto 16mm long, 0.45 - 1.1mm wide (with leaves), blackish brown, reddish brown at apex, forming loosely caespitose mat on rock; branching lateral or postical intercalary reducing the ventral half of normal leaf; the leaf near branch emergence ovate to lanceolate. Stem brownish black, rigid,
terete, rounded to subrounded, 0.10 - 0.13mm wide, 8 - 10 cells wide across diameter; cells differentiated into 2-layered, small, thick-walled, rounded, deeply pigmented cortical cells, 3.8 - 7.6µm wide, moderately thick-walled; medullary cells rounded to subrounded, slightly pigmented, 7.6 - 15.2 × 11.4 - 15.2µm. Rhizoids frequently scattered on the ventral surface of the stem. Leaves contiguous to distant, alternate, succuous, secund, erect to vertically oriented towards axis, insertion transverse, concave, canaliculated, subovate, quadrate, subquadrate, to rectangular, 0.30 - 0.42mm long, 0.27 - 0.33mm wide, slightly longer than wide, widest just above the base, bilobed for 2/3 - 3/5 of its total length, lobes unequal, narrowly triangular, divergent; lobes with apiculate, acute to subacute apex, acute lobe ending into triangulate or setiform cell; dorsal lobe smaller, 0.09 - 0.18mm long, 0.06 - 0.15mm wide, 13-17 cells high, 9-11 cells wide, ventral lobe larger, 0.15-0.24mm long, 0.09 - 0.12mm wide, 15-20 cells high, 11-14 cells wide; leaf lamina symmetric to asymmetric with dorsal margin nearly of same length, sinus widely to narrowly acute, 0.15 - 0.21mm deep, 0.06 - 0.18mm wide; cells brownish, thick-walled with large, bulging trigones; apical cells subrounded, quadrate to subquadrate, 9 - 15 × 9 - 18µm; median cells quadrate, subquadrate to rectangulate, 5 - 21 × 9 - 15µm; basal cells elongated-rectangulate, 15 - 30 × 12 - 18µm. Cuticle verrucose. Gemmae and fertile plants not seen.

Habitat: On moist rocks and humus in montaneous areas, at higher altitude (Kitagawa, 1966), also grows along river margins, in disturbed or logged areas on mossy boulders, decaying stumps and logs (Schill & Long, 2003).

Type: Indonesia, Java “habitat in Java insula frequens inter muscos ad terram. Leg. Blume.” (Iso : E).


Distribution: Sikkim.

Anastrophyllum bidens was first listed by Hattori (1971) and subsequently by Kitagawa (1975) and Parihar & al., (1994) from Eastern Himalaya. However, its first authentic report with a certain locality in India is credited to Schill & Long (2003), who described this species in great detail. In fact, they found the two samples from Sikkim, described as Anastrophyllum piligerum, proved as A. bidens and hence confirmed the presence of A. bidens in Indian territory. Another specimen from Sikkim, again described as A. piligerum by Mitten (1861) was also doubted as A. bidens.

Anastrophyllum bidens is rather different from all other Indian species of Anastrophyllum due to slender, rigid plants with deeply bilobed leaves (2/3 - 3/5 of their length), lobes narrowly triangular, much longer than broad (dorsal lobe 13-17 cells high, 9-11 cells wide, ventral lobe 10-20 cells high, 11-14 cells wide) with apiculate or acute apex ending into single triangulate cell.

Mitten (1861) described Anastrophyllum piligerum (Nees) Spruce as Jungermannia piligera Nees. from Sikkim on the basis of collections made by J. D. Hooker and accordingly the species was listed from Himalaya by later workers (Chopra, 1943; Parihar, 1961-62, Parihar & al., 1994). Abeywickrama (1959) reported this species as new to Himalayas. However, Schill and Long (2003) in their revisionary study of Anastrophyllum in Himalayan region doubted the specimen described by Mitten as A. bidens, although they could not see that specimen. However, the specimens from Sikkim, described by Hattori (1966) as A. piligerum, were available to Schill and Long and they treated them as A. bidens. As no authentic specimen from Indian territory was available to confirm the status of A. piligerum in India, hence treating here it as a doubtful record.


Type: Indonesia, Borneo, Sarawak, Dulit Ridge, 1300m, on tree trunk, P.W. Richards 1908 (Holo : JE).

Range: Australia, China, India, Indonesia, Papua New Guinea. (Daniels & al., 2012).

Distribution: Tamil Nadu.
The species has recently been reported from India and China by Daniels & al., (2012).


*Type*: Scotland, Angus-shire, Clova. 1795, G. Donn. s.n. (BM) (Schill & Long, 2003).

*Range*: Bhutan, Canada, China, Czech Republic, Greece, India, Norway, Poland, Scotland, Tibet, United States of America (Schill & Long, 2003).

*Distribution in India*: Sikkim (Dzongri, Tsomgo lake) (Mitten, 1861; Schill & Long, 2003).

*A. donianum* was among the first three species of the genus described from India as *Jungermannia doniana* Hook. by Mitten (1861) from Sikkim on the basis of Hooker's collection in 1848. The plants are well represented in Sikkim as has been collected repeatedly since its original discovery. However, except Sikkim it has not been reported from anywhere else in the country. It is a quite distinct species due to its boat-shaped, elongated triangulate-ovate leaves. (for detail description, see Schill & Long, 2003).

**Anastrophyllum alpinum** Steph., Sp. Hepat. 6: 103. 1917.

*Type*: Syn : China (Delavay), Himalaya (Hooker). Lecto : India, Sikkim (J.D. Hooker) 3657 (G, lectotype selected by Grolle, 1964). (Schill & Long, 2003).

*Range*: India, Bhutan, China, Nepal, Scotland (Schill & Long, 2003 as *A. joergensenii*; Long & al., 2006).

*Distribution*: Sikkim, Uttarakhand (Chakrata) (Nath & al., 2002).

The species is well represented in India as confirmed through type and report by Nath & al., (2002, misidentified as *A. joergensenii*) from western Himalaya based on a collection made in 1976. The specimens were not available and report is based after Nath & al., (2002) and Long & al., (2006).

Grolle (1964) reported *A. joergensenii* from Sikkim and synonymized *Anastrophyllum alpinum* Steph. (from China and Sikkim) under *A. joergensenii*. It has been once again reported from Western Himalayas by Nath & al. (2002, misspelled as *A. jorgensenii*). Schill and Long (2003) also reported *A. joergensenii* from Sikkim on the basis of type of *A. alpinum*. However, Long & al., (2006) distinguished *A. joergensenii* from *A. alpinum* not only on the basis of molecular analysis but also supported the same by the differentiation in morphological characters. We agree with the findings of Long & al., (2006) and excluding *A. joergensenii* from Indian territory.


(Fig. 5)

Plants small to medium, upto 19mm long, 0.63 - 1.1mm wide (with leaves), reddish to blackish brown, rigid, in scattered patches, loosely caespitose on rock; branching postical or lateral intercalary. Stem brownish-black, rigid, subterete, slightly arched at the apex, rounded to subrounded (in cross-section), 14-16 cells wide across the diameter; cells differentiated into 2-3 layers of brownish small cortical cells, 7.6 - 15.2 × 7.6 - 11.4µm, oblong, rounded to sub-rounded thick-walled, and pigmented; medullary cells large 11.4 - 26.6 × 7.6 - 19.0µm, subrounded, isodiametric, moderately thick-walled, non-pigmented. Rhizoids frequently scattered on the ventral surface of stem. Leaves contiguous to more or less imbricate, alternate, succubous, second, spreading horizontally to the stem, insertion transverse, dorsal half sub-transverse, ventral half slightly decurrent upto the stem midline, concave, canalicate, subovate, quadrate to rectangular, 1.1 - 1.9mm long and 0.51 - 1.6mm wide, longer than wide, widest just above the base, strictly bilobed to 1/3-1/2 of leaf length, lobes unequal, dorsal lobe smaller, 0.18 - 0.22mm long, 0.52 - 0.55mm wide, 18-20 cells high and 25-30 cells wide, folded over ventral one, broadly triangulate, divergent, apex subacute to obtuse; ventral lobe larger, apex obtuse to blunt, 0.15 - 0.20mm long, 0.63 - 0.97mm wide, 25-27 cells high 34-36 cells wide, sinus acute to descending subacute, 0.20 - 0.30mm deep, 0.45 - 0.52mm wide; leaf lamina asymmetric, dorsal margin smaller than ventral, entire, slightly arched inwards; cells minute, unevenly thick-walled, brownish with large, distinct confluent trigones; apical cells rounded-subrounded, quadrate to subquadratc, 12 - 18 × 9 - 15µm; median cells subquadratc to rectangular, 12 - 21 × 12 - 15µm; basal cells elongated- rectangular, 15 - 33 × 12 - 18µm (mid basal mainly vitta-like), lumen quadrate to subrounded. Cuticle smooth to slightly verrucose. Gemmae and fertile plants not
Habitat: On rocks at higher altitude.

Type: India, Sikkim, Lachen, alt. 10-11,000ft., J.D. Hooker 1321. (NY).

Range: Australia, Bhutan, Canada, China, Greenland, India, Indonesia, Italy, Japan, Korea, Nepal, Norway, Papua New Guinea, Switzerland (Kitagawa, 1966; Schill & Long, 2003)

Distribution: Sikkim (Lachen), West Bengal (Darjeeling, Sandakphu, Phalut).

Specimen examined: India, Sikkim, 7/1882, J.D. Hooker; 2 (FH) (Type of *J. assimile* Mitt!).

Anastrophyllum assimile, a very widely distributed species was first reported from India (Sikkim Himalaya) by Mitten (1861) as *Jungermannia assimile* on the basis of collections made by J.D. Hooker and Thompson. Further Chopra (1943), Parihar (1961-62) and Hattori (1966) listed this species from Sikkim Kitagawa (1975)
from West Bengal (Darjeeling) in the Eastern Himalaya.

This species is distinct from others in colouration and absence of gemmae. According to Schuster (1969) it differs from all other species in its glossy texture when dry and it is more or less greyish or blackish brown. Müller (1954) considered *A. minutum* similar to *A. assimile* in appearance and asymmetric leaves with smaller antical lobe, 1/3 - 1/2 of the leaf length, but it differs from the latter in having non-elongated basal leaf cells, equally thickened cell wall, acute to uniseriate (1-3-celled) lobe apex and reddish brown plants (see also Schuster, 1969).

This species is also confused with *A. michauxii* (F. Weber) H. Buch ex A. Evans in overall appearance, cell structure, lobes 1/3-1/2 of the leaf length and obtuse lobe apex but reddish to pale brown plants, symmetric as well as squarrose leaf and frequent occurrence of gemmae in *A. michauxii* undoubtfully separate it from *A. assimile*.


Plant small to large or medium, 10 - 25mm long, 0.60 - 0.81mm wide (with leaves), reddish brown to pale brown, branching ventral intercalary as well as axillary from the axil of normal leaf. Stem brown, rigid, terete, erect, procumbent, orbicular to elliptical, 0.16 - 0.18mm, 11-13 cells wide vertically, 0.30 - 0.22mm, 12-15 cells wide laterally across diameter, cells slightly differentiated into cortical and medullary cells; cortical cells rounded, subrounded, quadrate, 1-(-2)-layered, slightly thick walled, nearly subequal, 11.4 - 19.0 × 11.4 - 15.2µm; medullary cells thin walled, polygonal to subquadrat, slightly larger than cortical, 15.2 - 30.4 × 11.4 - 22.8µm. Rhizoids few and scattered on the ventral surface of the stem. Leaves distant to imbricate, alternate,
succubous, dorsally secund, horizontally oriented, insertion transverse on dorsal half and slightly decurrent on the ventral half up to stem midline, concave, canaliculate, quadrate-subquadrate to rectangulate, 0.42 - 0.66mm long, 0.39 - 0.66mm wide, as long as wide, widest above the base, bilobed; lobes unequal, divergent, 1/3-1/2 of the leaf length, broadly triangulate with acute to acuminate lobe apex (1-3-celled); dorsal lobe smaller, 0.12 - 0.18mm long, 0.12 - 0.24mm wide, 22-29 cells high, 24-32 cells wide; ventral lobe larger, (0.24) 0.30 - 0.33mm long, 0.21 - 0.33mm wide, 26-31 cells high, 32-40 cells wide, sinus descending acute, 0.15 - 0.24mm deep, 0.18 - 0.54mm wide, leaf disc asymmetrical with dorsal margin, smaller than ventral; cells minute, pale brown evenly thick walled, with confluent indistinct trigones; apical cells quadrate, subquadrate to polygonal, 12 - 24 µm × 12 - 24µm; median cells quadrate to subquadrate, 12 - 24 × 9 - 21µm; basal cells elongated, thick walled, 15 - 36 × 12 - 21µm, lumen of the cell quadratic to subrounded, cuticle with verrucose ornamentation. Gemmae present at the apices of apical leaf, formed from the leaf margin, 1-3-celled, ovoid and angulate, 18 - 33 × 12 - 24µm.

**Habitat**: Terrestrial, forming caespitose mats on soil enriched with humus and crevices of rocks.

**Type**: Greenland [Voucher for Dillenius, Hist. Musc.: 481. Lichenastrum no. 2 tab. 69, fig. 2. 1741] (Holo : OXF) (Schill & Long, 2003).

**Range**: Central, East and South Africa, Austria, Belgium, Bhutan, Britain, Bulgaria, China, Czech Republic, Denmark, Finland, France, Germany, Greenland, Hungary, Iceland, Indonesia, Ireland, Italy, Japan, Mexico, Netherlands, Nepal, Norway, India, Papua New Guinea, Poland, Portugal, Russia, Romania, Spain, Sweden, Switzerland, Ukraine, Venezuela, Yugoslavia (Schill and Long, 2003).

**Distribution**: Uttarakhand (Ghangharia), Sikkim (Dzongri).

**Specimens examined**: India, Uttarakhand, Ghangharia, c. 3400-3500m, on way to Hemkund, Sept. 26, 1999; Deepak Sharma 11976/99, 11977/99, 11980/99, 11990/99, 11991/99, 12000/99 (LWU).

**Anastrophyllum minutum** (Schreb. ex Cranz) R.M. Schust. was first reported from Sikkim in India by Hattori (1966). Schill & Long (2003) confirmed the presence of the species in Indian region.

**Anastrophyllum minutum** approaches *A. michauxii* in overall appearance and identical gemmiparous shoots. Both are also similar in slightly undifferentiated stem and 1-3-celled angulate gemmae, but *A. minutum* differs from *A. michauxii* in quadrate, subquadrate to rectangular and transversely inserted dorsal half of the leaf (squarrose, ovate and slightly decurrent in *A. michauxii*), leaf lobe 1/3 - 1/2 of the leaf length (1/2 in the latter), lobe apex acute to acuminate (1-3-celled), (broadly acute to obtuse in the latter), cell wall with indistinct trigones (distinct trigones in the latter).

*A. minutum* is more or less similar to *A. assimile* also in appearance, asymmetric leaf lobe, 1/3 of the leaf length with dorsal lobe smaller than ventral, but can be easily distinguished in pale to reddish brown (blackish to reddish brown in the latter), only slightly differentiated stem (much differentiated in the latter), leaf apex 1-3-celled, acute to acuminate (subacute to obtuse in the latter) and angulate gemmae (absent in the latter).

Kitagawa (1966) pointed out that the Japanese and Himalayan plants of *A. minutum* diverge from the European - North American plants phenotypically in having often divergent and abruptly acute to acuminate leaf lobe; the more strongly thick walled marginal leaf cells and irregularly lobed and spinose dentate female bracts. Indian plants of *A. minutum* agree with the Japanese plants. According to Schuster (1969) however, The Japanese and Himalayan populations may represent new subspecies for the differences attributed by Kitagawa (1966).

**Anastrophyllum minutum** var. **himalayanum** S. Srivast., S.C. Srivast. & K.K. Rawat var. nov.  (Figs. 8, 9)

*Plantae dissimilis Anastrophyllum minutum strictus bicellulatis, ellipticus, fusiformis gemmae.*


Plants small to medium, 4 - 8mm long, 0.6 - 1.1mm wide (with leaves), reddish brown to pale brown, rigid in loosely caespitose scattered patches; branching frequent, terminal or lateral intercalary, the ventral half of the
normal leaf at branch emergence (near branch) reduced to half becoming lanceolate to ovate in shape, subfloral innovation much frequent. Stem brown, rigid, terete, orbicular to elliptical in outline in cross section, 0.09 - 0.1mm wide vertically, 0.15 - 0.17mm wide laterally, 6-8 cells wide vertically, 10-12 cells wide laterally, differentiated; cortical cells smaller, rounded to subrounded, oblong thick walled, pigmented, in 1-(-2) layers, 11.4 - 22.8 × 11.4 - 19.0µm; medullary cells relatively larger, subrounded, polygonal, oblong, moderately thick-walled, non pigmented, 11.4 - 26.6 × 11.4 - 19.0µm. Rhizoides frequent, scattered on the ventral surface of stem. Leaves distant inbricate to contiguous, alternate, succubous, secund, subhorizontally to vertically oriented, insertion transverse, slightly decurrent on the ventral half up to the stem midline, concave, canalicate, broadly ovate, subquadrate to rectangular, 0.51 - 0.66mm long, 0.48 - 0.60mm wide, nearly as long as wide and more so (leaf near the branch emergence unlobed, ovate to lanceolate), bilobed, lobes divergent 1/3 - 1/2 of the leaf length; dorsal lobe slightly smaller and folded over ventral, 0.24 - 0.30mm long, 0.21 - 0.24mm wide, 21-30 cells high, 22-33 cells wide; ventral lobe 0.24 - 0.30mm long, 0.18 - 0.27mm wide, 26-38 cells high, 27-44 cells wide; leaf margins symmteric with dorsal and ventral margins nearly of the same length, spreading; cells minute, brownish, thick walled, with distinct and confluent trigones; apical cells rounded, subrounded, polygonal, quadrate to subquadrate, 12 - 21 × 9 - 18µm; median cells rounded to subrounded or quadrate to subquadrate, 12-21 × 22 - 18µm; basal cells elongated, quadrate to rectangular, 18 - 30 × 12 - 21µm; lumen of cells rounded to squarrose. Gemmae present at the margins of apical leaf lobe, strictly 2-celled, elliptical to spindle-shaped with tapering ends, 18 - 30 × 9 - 15µm. Cuticle prominently verrucose under SEM.

Dioicous? Male plants not seen. Female plants up to 8mm long, 1.1mm wide; gynoecia on main axis or branches, female bracts in one pair, closely imbricate, clustered at apex, broadly rectangulate, broader than long,
0.60 - 0.72 mm long, 0.72 - 0.87 mm wide, bilobed; lobes 1/3-1/2 of the bract length, lobe apex acute to subacute, sinus acute to subacute, broadly divergent, 0.30 - 0.39 mm deep, 0.30 - 0.63 mm wide, cells similar to the leaf cells, thick-walled with confluent trigones; apical cells rounded to subrounded, 15 - 21 x 12 - 18 µm; median cells rounded, subrounded or quadrate, 15 - 31 x 15 - 21 µm; basal cells elongated, subquadrate to rectangular, 24 - 33 x 15 - 24 µm. Perianth ciliated while young, enclosed within the surrounding female bracts. Sporophyte not seen.

**Habitat**: Terrestrial, on soil covered rocks, either in pure patches or commonly associated with *Blepharostoma trichophyllum*, *Solenostoma confirtissima*, *Tritomaria exsecta* and *Schistochilopsis incisa*.

**Range**: India (Endemic to Western Himalaya).

**Distribution**: Uttarakhand- Chamoli (Ghangharia, on way to Hemkund).

*Anastrophyllum minutum* var. *himalayanum* can be differentiated from typical *A. minutum* in having strictly 2-celled, always spindle-shaped gemmae, however, as compared to up to 4-celled, subspherical-cubical, irregularly angular, stellate or ± ovoid gemmae in the latter.

*A. minutum* var. *himalayanum* is also related to *A. hellerianum* in minute plants, bilobed leaves with descending sinus, leaf lobes 1/3-1/2 of the leaf length, leaves not strictly secund dorsally, obtuse to subacute leaf lobe apex, and indistinct confluent trigones. However, *A. hellerianum* can be easily separated in having radially symmetrical undifferentiated stem up to 7 cells across diameter, strictly 1-celled gemmae and faintly verrucose cuticle.

**Lophozia** (Dumort.) Dumort., Rec. d’Obs. 17. 1835.

Plants small to medium, slender to robust, yellowish to whitish or olive green, or even brownish to reddish brown; branching lateral-terminal, or intercalary with furcate terminal lateral branching. Stem prostrate to erect ascending, orbicular, elliptical to flattened in cross-section, with or without dorsiventral differentiation. Leaves alternate, succuous, obliquely inserted, imbricate to contiguous, vertically to subhorizontally oriented, rarely canalicate, usually bilobed, sometime polymorphic, 2-3-lobed to (1/10) 1/8-1/2 of its total length, margin entire; leaf lobe broadly triangulate with acute, subacute to obtuse apex, sinus descending, rounded to lunate, obtuse, subacute to acute or V-shaped; cells with distinct to indistinct trigones. Underleaves absent to vestigial. Gemmae pale green to reddish brown, 1-4-celled, ovoid, elliptical to angulate.

Diocious. Male inflorescence terminal or intercalary on main shoot; bracts in 2-12 pairs, similar to but smaller than leaves, imbricate, concave, saccate. Female inflorescence terminal, with subfloral innovations; bracts usually larger than leaves. Perianth well developed, free from bracts, cylindrical, terete, faintly plicate at apex, mouth entire or with small projecting cells.

**Type**: *Lophozia ventricosa* (Dicks.) Dumort.

Mitten (1861) for the first time recognized 3 species of *Lophozia* as *Jungermannia pluridentata* Mitt., *J. setosa* Mitt. and *J. ventricosa* Dicks from Sikkim. Later Chopra (1938) listed *L. turbinate* and *L. bidens* from Darjeeling and *L. bidentata* and *L. guttulata* from Kurseong. At the same time, Herzog (1939) listed *L. setosa* from Tsomgo lake in Sikkim. Chopra (1943) and later Parihar (1961-62) listed a total of 5 species viz. *L. alpestris*, *L. incisa* and *L. piacenzai* from Western Himalaya and *L. pluridentata* and *L. setosa* from Eastern Himalaya.

Hattori (1966) listed 4 species, *L. incisa* (Schrad.) Dumort., *L. longidens* Lindb., *L. setosa* (Mitt.) Steph., and *L. wenzelii* (Nees) Steph. from Eastern Himalaya with *L. longidens* and *L. wenzelii* for the first time from India. Most recently, Parihar & al., (1994) listed 9 species of *Lophozia* viz. *L. alpestris*, *L. incisa* and *L. piacenzai* from Western Himalaya and *L. pluridentata* and *L. setosa* from Eastern Himalaya.

Hattori (1966) listed 4 species, *L. incisa* (Schrad.) Dumort., *L. longidens* Lindb., *L. setosa* (Mitt.) Steph., and *L. wenzelii* (Nees) Steph. from Eastern Himalaya with *L. longidens* and *L. wenzelii* for the first time from India. Most recently, Parihar & al., (1994) listed 9 species of *Lophozia* viz. *L. alpestris* (Scheich.) Evans, *L. handelli* Herz., *L. hatcheri* (Evans) Loeske, *L. incisa*, *L. longidens*, *L. piacenzai* Gola, *L. pluridentata*, *L. setosa* and *L. wenzelii* from India. However, recent studies have resulted in the change in taxonomic concept of the genus *Lophozia*. As such *L. alpestris* is now treated under *Leiocolea collaris* (Nees) Schljakov; *L. maybaeae* (S. Hatt.) Kitag. is now *Leiocolea maybaeae* (S. Hatt.) Furuki & Mizut., while *Lophozia hatcheri* is treated under *Barbilophozia hatcheri* (Evans) Loeske (see Excludenda). Thus, in present state of our knowledge only three species of *Lophozia* viz., *L. longidens*, *L. piacenzai* and *L. wenzelii* are known to occur in India. The present study
revealed hitherto two undescribed species from the country, viz. *L. udarii* sp. nov and *L. indica* sp. nov., which are described and illustrated alongwith *L. wenzelii*.

**Key to the species of genus Lophozia in India**

1. Leaves 2-lobed, with wide, shallow, rounded to lunate sinus. ..........................*L. wenzelii*

1a. Leaves polymorphic, 2-3-lobed, with narrow to wide, acute, subacute to obtuse sinus ............................................2

2. Leaves generally 2 (-3)-lobed, rectangulate; lobes 1/4 - 1/3 of the leaf length; cells with minute trigones; perianth mouth without dentition, apical marginal cells of the perianth, rectangulate, base thick or fleshy, 3-4 stratose .....................................*L. udarii*

2a. Leaves generally (2-) 4-lobed, obtrapezoidal; lobes 1/4 - 1/3 (1/2) of the leaf length; cells with distinct nodulose trigones; perianth mouth with few 1-2-celled dentitions, apical marginal cells of perianth quadrate to subquadrate, base not fleshy or massive, unistratose.........................*L. indica*

(Fig. 10)

Plants medium, upto 20mm long, (0.66-) 0.75 - 1.05 (-1.2mm) wide with leaves, pale green to light brown, in dense patches or in tufts; branching sparse, furcate and terminal. Stem subterete, soft, pale green on dorsal surface, reddish brown on ventral side of stem, tinged with reddish brown at the apex, suborbicular to elliptical in cross section, 0.20 - 0.29mm, 14-16 cells wide laterally, 10-12 cells wide vertically across diameter, slightly dorsiventrally differentiated; dorsal cells larger, subrounded, polygonal, 22.8 - 34.2 × 15.2 - 26.6µm; ventral cells small, subrounded to subquadrate, 15.2 - 22.8 × 11.4 - 15.2µm. Rhizoids absent at the apex of the plant.

Leaves contiguous to imbricate, alternate, succubous, obliquely inserted with no decurrence, subvertically to erect spreading, generally laterally compressed to one side, strongly concave, saucer-shaped, dorsally second, mainly towards the stem apex, broadly obovate to orbicular, quadrate to rectangulate, 0.90 - 0.96mm long, 0.72 - 0.90mm wide (widest near the base), shortly bilobed to 1/8-1/6(-1/3) of its length; lobes unequal to subequal, broadly triangular. incurved; dorsal lobe 6-15 cells high, 15-28 cells wide, ventral lobe 7-12 cells high, 19-29 cells wide, apex obtuse to weakly acute, sinus wide, some what rounded, shallow to lunate,(0.6-) 0.12 - 0.18µm deep, 0.33 - 0.48mm wide; cells medium sized, thin-walled, trigonous; apical cells rounded, subrounded, polygonal, (15.2-) 19.0 - 30.4 × 11.4 - 22.8µm; median cells rounded to subrounded, 22.8 - 41.8 × 22.8 - 30.4µm; marginal cells distinct with single layer of small, quadrate to subquadrate cells, 15.2 - 30.4 × 19.0 - 30.4µm; basal cells large, polygonal to subquadratately elongated with distinct large trigones, (19.0-) 45.6 - 57.0 × 22.8 - 38.0µm; cuticle smooth. Gemmae and fertile plants not seen.

**Habitat**: On moist, sandy, muddy soil, rarely on humus.

**Type**: Germany: Riesengebirge Koppenplan, ca 1400m, V. Flotow 1824 (FH).


**Distribution**: Sikkim (Dzongri).

**Specimens examined**: Japan, Mont. Hakkoda, Faurie 1488 (FH).

Schlajakov (1980) and Bakalin (2005b) proposed inclusion of *L. wenzelii* into sect. Sudeticae however, Vilnet & al., (2007) rejected the same, though imphasized that “*L. ventricosa-L. wenzelii* complex represented the most complicated and intricate complex”.

*Lophozia wenzelii* was first reported from India by Hattori (1966) from Eastern Himalaya, (Sikkim). Unfortunately specimens of this species were not available for study and therefore, the details provided in the description are based on the specimens obtained from Farlow Herbarium. The plants of *Lophozia wenzelii* are characteristically dense leaved with incurved leaf lobes having rather deeper and angular sinuses, stiff textured leaves, dorsal lobe vertically oriented (more or less ladder like), regular arrangement of strongly concave to saucer-like strongly incurved and very broad lobes, sinus very wide and never angulate in mature plants.

This species closely resembles *L. alpestris*, but differs in having leaves rather distantly arranged and tinged red at the apex and are flaccid, erectopatent, antically secund, concave and saucer-shaped as opposed to imbricate, concave to canaliculate leaves which are rotund to oblong rotund in *L. alpestris*. Further, the shortly incurved leaf-lobes which are broadest in middle, larger leaf cells with small but distinct trigones in *L. wenzelii* are distinctly different from those of *L. alpestris* which has leaf lobes not incurved and broadest below with relatively smaller, minutely trigonous leaf cells (see Macvicar,1912).

*L. wenzelii* is often confused with *L. ventricosa*, but 4-9 oil-bodies per cells, concave leaves (often strongly saucer-like), small leaf-lobe, 1/8-1/6 of the leaf length with broad and shallow sinus separate the former from the latter, which has numerous oil-bodies per cell, plane and flat leaves, and leaf lobes 1/2 - 2/3 of the leaf length with deeper sinus (see Schuster, 1969).
Lophozia udarii S. Srivast., S.C. Srivast. & K.K. Rawat sp. nov.

Plants medium, pale green to dull brown in caespitose patches; branching axillary, terminally furcate. Stem elliptical in cross section, 17-19 cellulae lata lateralis, 11-13 cellulae lata verticalis, folia subimbricatus vel contiguus, oblaurus inserta, quadrangularis vel rectangularis, ad ¼-1/3 inciso, 2(-3) lobis. Cuticula grosse verrucosa. Perianthia longe exserta, cylindrica vel ovata, ore sine dentatus brevissime plicata, cellulae apicales hyaline & rectangularis, basales 3-4 stratosa.


Plants medium, pale green to dull brown in caespitose patches; branching axillary, terminally furcate. Stem elliptical in cross section, 17-19 cellulae lata lateralis, 11-13 cellulae lata verticalis, folia subimbricatus vel contiguus, oblaurus inserta, quadrangularis vel rectangularis, ad ¼-1/3 inciso, 2(-3) lobis. Cuticula grosse verrucosa. Perianthia longe exserta, cylindrica vel ovata, ore sine dentatus brevissime plicata, cellulae apicales hyaline & rectangularis, basales 3-4 stratosa.
apical cells rounded, subrounded to polygonal, 15.2 - 30.4 × 15.2 - 34.2µm; median cells suborbicular, polygonal to rectangular, 19.0 - 38 × 15.2 - 38µm; basal cells suborbicular, polygonal to rectangular, 19.0 - 38 × 15.2 - 30.4µm; cuticle faintly verrucose. Gemmae not seen.

Dioicus. Male plants not seen. Female plants upto 11.00mm long (0.75-) 0.9 - 1.35mm wide with leaves. Perianth fully exserted, covered with 1 pair of bracts at base. Bracts 2-4-lobed to 1/4-1/3 of their length, similar but larger than leaves, 1.2 - 1.4mm long, 1.05 - 1.4mm wide, concave, imbricate as long as wide; lobes broadly triangular with acute (1-3-celled uniseriate) to subacute apex, sinus wide, obtuse at the base; cells thin walled with minute trigones; apical cells rounded, subrounded to subquadrate, 15.4 - 30.4 × 15.4 - 26.6µm; median cells irregularly subrounded to polygonal, 15.2 - 45.6 × 15.2 - 34.2µm; basal cells subquadrate to rectangular, 19.0 - 41.8 × 19.0 - 34.2µm. Sporophyte upto 1.17mm long, 0.36mm wide, with unfertilized archegonia on calyptra. Mature sporophyte not seen.

Habitat: Terrestrial, on soil and humus.

Range: India, probably endemic to western Himalaya.
L. udarii is characteristically different from the rest of the species of the genus in having polymorphic leaves (quadrate-ovate to oblong-ovate), variable leaf lobes apex (acute, subacute to obtuse) and sinus (narrowly to broadly acute or rounded to lunate), mouth of the perianth without dentitions and base of perianth 3-4 stratose.

This species also resembles Leiocolea mayebarae (Hatt.) Furuki and Mizut. in polymorphic leaves, acute to acuminate leaf lobes and faintly verrucose cuticle. However, it differs in relatively minute size of the plants, subterete to rounded stem, distantly arranged leaves and perianth mouth with projecting cells in L. mayebarae.

**Lophozia indica** S. Srivast, S.C. Srivast. & K.K. Rawat sp. nov. (Figs. 13, 14)

Plante mediocris, 6-8mm longa, (0.9) 1.44 - 2.07mm lata. Caulis late ellipticus, 14-16 cellulae lata lateralis & 8-10 cellulae lata verticalis, dorsiventralis differens. Folia caulina subimbricata ad distans, aggregates ad apice subquadriatis vel obtrapazialis asymmetricis, 2-4 lobis, lobis lateralis generallis angustis terminus in triangulates dentatis. Cuticula grosse verrucosa. Gemmae 1-2 cellulae, flavovirens, globosa vel angulata. Perianthia longi exserta, cilindrica, ore breviter plicata cum 1-2 cellula minutus, dentatis.


Plants medium, blackish brown in dense patches, sparsely branched. Stem flattened, elliptical in cross section, 14-16 cells wide laterally, 8-10 cells wide vertically across diameter, dorsiventrally differentiated with flattened, irregularly rectangular to triangulate larger dorsal cells, 19.0 - 53.2 (-60.0) × 15.2 - 34.2µm; ventral cells small, subrounded, quadrate to subquadrate, 15.2 - 26.6 × 11.4 - 19.0µm. Rhizoids dense on ventral surface of stem. Leaves subimbricate to distant (clustered at apex), succuous, alternate, subtransversely inserted, subvertically to horizontally oriented, quadrate, subquadrate to obtrapezoidal, (0.48-) 0.54 - 0.75 (-0.90)mm long, (0.45-) 0.60 - 0.78 (-0.87)mm broad, asymmetric, dorsal margin larger, 2-4 lobed to 1/4 - 1/3 (-1/2) of its length, lobes broadly triangulate, 0.12 - 0.36mm long, 0.15 - 0.60mm wide, lobe apex obtuse to subacute, lateral lobe generally reduced into narrow apex gradually ending into triangulate dentitions, sinus wide, obtusely rounded in 2-lobed leaves, narrow, acute to subacute in 3-4-lobed leaves, 0.06 - 0.36mm deep, 0.15 - 0.60mm wide; leaf cells thin-walled with distinct trigones; apical cells large, elongated, subrounded, polygonal, 22.8 - 45.6 (-57.0) × 15.2 - 41.8µm, apical lobe ending into single triangulate dentition, 34.2 - 152.0µm long, 15.2 - 22.8µm wide; median cells rounded, subrounded to polygonal, 15.2 - 38.0 × 15.2 - 26.6µm; basal cells polygonal to rectangularly elongated, 26.6 - 41.8 × 15.2 - 30.4µm, cuticle verrucose. Gemmae pale green, 1-2-celled, rounded, triangular to polygonal, 15.2 - 26.6 × 11.4 - 19.0µm.

**Habitat**: Terrestrial, on soil and humus.

**Range**: India, probably endemic.

**Distribution**: Uttarakhand, on way to Hemkund from Ghangharia.

L. indica is highly distinctive from the rest of the species of Lophozia in subtransverse to slightly oblique leaf insertion; polymorphic, 2-4-lobed leaves; apical part of perianth with quadrate to subquadrate cells and perianth mouth with 1-2-celled minute dentitions.

This species resembles Schistochilopsis incisa (Schrad.) Konstatn. in overall appearance, colour of the plant, more than 2-lobed leaves and elliptical stem (in a cross-section), however, the latter can be easily differentiated from L. indica in having spinate dentitions on leaf lobes, ciliate perianth apex with elongated and dentate apical cells as opposed to absence of spines and dentitions on leaf lobes, perianth apex with quadrate to subquadrate apical cells and few minute, 1-2-celled dentitions in L. indica.

Lophozia indica is close to Lophozia udarrii, but it differs from the latter on the basis of number of leaf lobes (generally (2-) 4-lobed in L. indica, while 2 (-3) -lobed in L. udarrii), leaf shape (obtrapezoidal in L. indica, while rectangulate in L. udarrii), trigones (distinct nodulose trigones in L. indica, while minute in L. udarrii) and perianth base (uniformly unistratose in L. indica, while thick or fleshy, 3-4 stratose towards base in L. udarrii).


Plants pale to dark green or slightly brownish tinged, firm, rigid but flaccid when dry, largely caespitose, prostrate with ascending apices or suberect to erect in growth; branching less frequent, irregular, lateral intercalary or ventral intercalary replacing the ventral half of the lateral leaves. Stem slightly differentiated into usually smaller cortical cells and comparatively larger medullary cells. Leaves succulent, distant to closely imbricate towards apex, alternate, spreading to subvertically oriented, strongly incurved, falcate secund, transversely inserted up to the stem midline, typically asymmetrically lobed, margin entire, sinus open; cells small, thick-walled with small trigones. Underleaves completely absent. Gemmae reddish-brown, formed at the apices of plant, 1-2-celled, ovoid or elliptical in shape with tapering ends.

Androecia secondary-intercalary; bracts ventricose, antheridia with uni-or biseriate stalks. Perianth cylindrical-obovoid, deeply plicate above the middle, gradually contracted to ciliate mouth; female bract 3-4 lobed, as large as leaves, lobes entire or dentate; bracteole wanting or present. Capsule wall 3-5 stratose, the outermost cell-layers with nodular thickenings, the innermost with semi-annular bands.

Type: Jungermannia exsecta Schmid. ( ♂ Tritomaria exsecta (Schmid.) Schifferm.)

Loeske (1909) proposed the genus on the basis of Jungermannia exsecta Schmid. Kitagawa (1966), considering Tritomaria as a heterogenous taxon, proposed the division of the genus into two subgenera, subgen. Tritomaria Kitag. and subgen. Trilophozia R.M.Schust. According to him, Tritomaria was closely related to Lophozia and might have been derived from a Lophozia like ancestor. However, the most reliable feature to separate Tritomaria from Lophozia is the the asymmertrically 3-lobed leaves and its more transverse insertion. Schuster (1969) divided the genus Tritomaria into two subgenera, viz. subg. Tritomaria and Tritomaria subg. Saccobasis on account of tranversely inserted sharply lobed leaves, strongly dentate perianth mouth in the former, and arched dorsal half insertion towards apex, blunt to rounded leaf lobe, truncate perianth with entire mouth in the latter. He (Schuster, 1969) further divided... further divided the subg. Tritomaria in 2 sections, sect. Tritomaria and sect. Trilophozia on the basis of the presence of abundant red brown gemmae, as wide as long leaves, single seriate antheridal stalk, 14-16 cells high stem, 3-4 stratose capsule wall in the former and occasional yellowish brown to yellowish, usually 3-5mm wide gemmae, 2-seriate antheridal stalk, 5-stratose capsule wall, 20-22 cells wide stem in the latter. Accordingly T. exsecta was placed under sect. Tritomaria. Crandall-Stotler & al., (2009) treated Tritomaria under family Scapaniaceae. Vána & al., (2013) however treated the genus Tritomaria under Lophoziaeceae, which has been followed here.

In India, the genus is represented by two species, T. exsecta (Schmidt.) Schifferm. and T. ferruginea (Grolle) Vána. However only T. exsecta was available for study and the report of T. ferruginea is based after Long (2005). According to Vána & al., (2013) the only distinguishing character in A. ferruginea is the presence of Anomocladata-type branching which is not found in other species of the genus, including T. exsecta. Tritomaria ferrugineus (Grolle) Vána, Phytotaxa 81(1): 24. 2013 Andrewsianthus ferrugineus Grolle, Ergeb. Forsch.
Fig. 15. Tritomaria exsecta (Schrad.) Loeske 1. Plant, dorsal view. 2. Plant portion showing ventral half leaf insertion. 3. Plant portion showing branching. 4-11. Folded leaves. 12-18. Inflated leaves (All figures drawn from LWU 11980/99)


_Type_: Nepal, Vorhimalaya, westlich unter Rauje gegen Ringmo, 4000m, 1962, Poelt, Nr. H 200 (Holo : M!, Iso : JE!, F!, NICH) (Váňa & al., 2013).

*Range*: India, Nepal, Bhutan (Grolle, 1966; Pradhan & Joshi 2009, Long, 2005)

*Distribution*: Sikkim

The species was reported by Long (2005) from Sikkim as Andrewsianthus ferrugineus. Váňa & al., (2013)
transferred A. ferrugineus under the genus Tritomaria.


(Figs. 15, 16)

Plant medium to robust, 4 to 14mm long, 3 to 5mm wide with leaves, pale to dark green, tinged with red at the
apex, firm and rigid but flaccid when dry, densely caespitose, decumbent, erect or ascending from a prostrate base, strongly acroscopically arched; branching irregular and less frequent, arising from the axil of normal leaves, ventral intercalary replacing the ventral half of the normal leaf. Stem rigid, green above, brown to nearly dark on ventral surface, robust, terete, elliptical to rarely subrounded in cross-section, 0.24 - 0.29 mm × 0.13 - 0.17mm, 15-17 cells wide laterally, 12-14 cells wide vertically across diameter, cells differentiated, thin-walled, trigones; cortical cells in single layer, slightly pigmented, small, quadrate to subquadrate, 14.4 - 19.0 × 7.6 - 14.4µm; medullary cells large, quadrate, subquadrate, irregularly rounded to angulate, 14.4 - 26.6 × 14.4 - 19.0µm, trigones small, triangular. Rhizoids scattered on the ventral surface of stem. Leaves contiguous to loosely imbricate, alternate, distant in younger plants, succubous, secund to spreading, horizontally attached to the stem, dorsal and ventral half transversely inserted up to stem midline, conspicuously concave canaliculate, ovate, subovate to subquadrate, (0.63-) 0.87 - 1.2mm long, (0.57-) 0.72 - 0.90mm wide, longer than wide, (2-) - 3(-4) -lobed to (1/10-) 1/5 -2/5 of the length; dorsal lobe short, arcuate, 12-34 cells long and 5-22 cells wide, 3 to 4-celled uniseriate at apex; the ventral larger lobe may further divide in 2(-3) unequal to subequal, acute to acuminate lobes, 10 to 28 cells long and 8-30 cells wide, lobes divergent; dorsal lobe with deep sinus; ventral lobes with shallow sinus; margins entire, arched and incurved, ventral margin much longer than dorsal; leaf cells minute, generally with small trigones, thick-walled with middle lamella visible mainly at apical portion; apical cells quadrate to subquadrate, rounded-slightly rectangular, 7.6 - 19.0 × 7.6 - 15.2µm; median cells small, similar to apical cells, 11.4 - 19.0 × 7.6 - 11.4µm; basal marginal cells generally quadrate to rectangular, 11.4-19.0 × 11.4 - 15.2µm; basal median cells elongated, rectangular to subrectangular with minute trigones, 22.8-45.6 × 14.4 - 19.0µm; oil-bodies (2-)3-6(-8) per cell, spherical to subspherical or elliptical, 1.9 - 5.7 × 1.9 - 3.8µm; cuticle verrucose under SEM. Underleaves absent.

Gemmae present generally on the tips of the upper most leaves, generally 2-lobed, red-rust in colour, ovoid or elliptical with tapering end, (1-)2-celled, 15 - 21 × 12 - 15µm. Gemmae producing apical cells of the leaves generally get elongated 2-3 times the normal cells, light in colour, rectangular to subrectangular, 19.0 - 57 × 14.4 - 19.0µm. After detachment gemmae accumulate on the leaf surface.

**Habitat:** Terrestrial and epiphytic, growing on soil covered rocks or, in soil filled crevices in rocks, compactly attached with the substratum and epiphytically on the bark of Fir and Betula at 1-1.5m height above ground at the altitude between 3050 - 3700m.

**Type:** Germany, Schrader s.n. (Iso : G!)

**Range:** East Africa, Austria, China, England, Finland, France, Germany, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Madeira Isl. (Portugal), Mexico, Norway, Philippines, Russia, Sri Lanka, Sweden, Switzerland, Taiwan (Hattori, 1966; Schuster, 1969; Vana, 1982; Gradstein and Vana, 1987; Piippo, 1990; Piippo & al., 1997; Srivastava, 2002).

**Distribution:** Uttarakhand (Valley of flower, Hemkund), Arunachal Pradesh (Tawang-Bomdir), Sikkim (Dzongri), West Bengal (Phalut).
Tritomaria exsecta was first reported from India by Mitten (1861) as Jungermannia exsecta from Sikkim. Chopra (1943) and Parihar (1961-62) listed this species from Himalaya under Sphenolobus exsectus, a later synonym of Tritomaria exsecta. Grolle (1966) and Hattori (1966) listed this species as Tritomaria exsecta from Nepal and Sikkim Himalaya, respectively. The Indian population of the species are generally sterile.

The present investigation is based on the study of plants from various bryologically rich areas of Eastern as well as Western Himalaya. The plants show a wide range of vegetative characters and the Indian population is generally sterile.

The important characters by which the species can be recognized include the obliquely trilobed, concave, canaliculate and extremely asymmetrical form of leaves, with ventral leaf margins usually much longer than the dorsal margin and dorsal lobe thus appears as a tooth (2-4-celled uniseriate at the apex), the ventral lobes unequal to subequal and divergent with shallow sinus. The arrangement of leaves is also variable as some plants show contiguous to loosely imbricate arrangement while others generally have distant and alternate leaves at base and contiguous to loosely imbricate at apex. The leaf cells are small, rectangular to polygonal in shape and thick-walled. Basal cells are also much elongated in the middle giving vitta like appearance. The stem is elliptical to suborbicular in cross section with slight difference in the cortical and medullary cells. The gemmae are usually 2-celled, elliptical to ovoid in shape, generally present at the leaf lobe apices. The gemmiparous shoots appear red-rust in colour due to gemmae. The cells of the leaf lobe producing gemmae become enlarged, much elongated up to 2-3 times the normal leaf cells after the formation of gemmae. As such, the gemmae producing cells are distinctly different from rest of the cells.

Tritomaria exsecta approaches Tritomaria exsectiformis (Breide) Schiffn. due to extraordinarily similar appearance having 3-lobed, transversely inserted concave-canaliculate leaves, reddish brown mass of gemmae at the shoot apices and quite similar size of plants. However, the larger leaf cells and angular or pyramidal form of the large bulging trigones in T. exsectiformis (evenly thick-walled in T. exsecta) clearly distinguish T. exsecta from it (see also Schuster, 1969).

Another species, Tritomaria scitula is also allied to T. exsecta in trilobed leaves, reddish brown mass of gemmae at the leaf apices, but uniform lobes of the leaf in the former separate it from T. exsectata which has assymetrical leaves (see also Schuster, 1969).

This species is also allied to T. quinquedentata in appearance, 3-lobed, spreading and slightly concave leaves of relatively larger size with short dorsal lobe and transverse insertion but broader than long and nearly constant absence of gemmae in T. quinquedentata remarkably distinguished it from T. exsecta (see also Schuster, 1953).


Plants prostrate to ascending, pale green to bright green and slightly brownish. Stem oval, soft, sparsely branching, undifferentiated internally; rhizoids sparse to common. Leaves succubous, inserted at various angles, distant to imbricate, spreading to appressed, flat to concave, divided by variously shaped sinus into 2-3(-4) lobes, lobes entire, cells collenchymatous or not, walls usually thin, sometime thickened; oil bodies 2-50 per cell; underleaves usually absent. Asexual reproduction by gemmae in masses at apices of shoot or on tips of specialized, attenuate branches. Sexual reproduction dioicous. Androecia intercalary, 2-5 androus, antheridial stalk (1-)2-seriate. Gynoecia terminal, female bracts in 1 pair. Perianth exserted 1/2-3/4 of its length, mainly cylindric, complicated at mouth, mouth dentate to ciliate and lobulated; perigynium entirely absent. Capsule oval, walls (3-)5-stratose, exterior walls with nodular thickenings, interior walls with annular thickenings, reddish brown. Elaters 2-spiral, reddish brown. Spores 10 - 16µm. Elaters 2-spiral, reddish brown. Spores 10 - 16µm. (based on Bakalin, 2011).

Type: Schistochilopsis cornuta (Kitag.) Konstant.

Konstantinova and Vasiljev (1994) proposed generic status for subgen. Schistochilopsis Kitag., alongwith other species, included Lophozia incisa (Schrad.) Dumort. and L. setosa (Mitt.) Steph. as Schistochilopsis incisa (Kitag.) Konstant. and S. setosa (Mitt.) Konstant. Söderström & al., (2010) supported the treatment and retained
genus *Schistochilopsis* under paraphyletic family (incl. Lophoziaceae). The treatment of Konstantinova and Vasiljev (1994) is accepted here and hence, the presence of genus *Schistochilopsis* in India is confirmed with two species, *S. setosa* and *S. incisa*. In addition, another new variety of the latter is reported here from western Himalayan region as *S. incisa* var. *himalayana* var. nov.

**Key to the species of the genus *Schistochilopsis* in India.**

1. Plant very large, robust, upto 45mm long; stem upto 22 cells wide laterally, dorsiventrally differentiated; leaf margin with spinose dentitions with the dentitions setose to 2-5-celled uniseriate.......................... *S. setosa*

1a. Plants small to medium, upto 13mm long; stem 16-18 cells wide laterally, not differentiated; leaf margin with 1-celled, triangulate dentitions........................................................................................................... 2

2. Leaf generally (2-)3-5-lobed, never antically connate, cells with distinct trigones; cuticle smooth; gemmae spindle-shaped ........................................................................................................... *S. incisa*

2a. Leaf generally 2-3-lobed, seldom antically connate, cells with minute trigones; cuticle faintly verrucose; gemmae not seen ........................................................................................................... *S. incisa* var. *himalayana* var. nov.

Plants very large, robust up to 45 mm long, 1.92 (2.0) - 3.2 (3.6) mm wide with leaves, pale-green to brownish, sparsely branched. Stem subterete, rigid, pale green, flattened, more or less elliptical in outline in cross section, 19-27 cells wide laterally, 12-17 cells wide vertically, dorsiventrally differentiated with dorsal cells larger, quadrate, subquadrate, polygonal, 30.4 - 53.2 × 22.8 - 41.8 µm; ventral cells small, subquadrate, rounded to polygonal, 15.2 - 30.4 × 11.2 - 22.8 µm. Rhizoids dense on the ventral surface of stem. Leaves imbricate to contiguous, alternate, succous, obliquely inserted with no decurrence, subvertically to horizontally oriented, very large, much broader than long, 1.32 - 2.0 mm long, 2.4 - 2.8 mm broad, with spines or dentitions along the entire margin, (3) 4-5-lobed; lobes unequal to subequal, ovate to broadly triangulate, dentitions 0.18 - 0.40 mm long and 0.01 - 0.04 mm wide, 11-29 in number, 1-celled setose to 2-5-celled uniseriate, sinus narrowly acute to subacute, 0.6 - 1.0 mm deep; cells thin walled with large, distinct trigones; apical cells rounded, sub-rounded, polygonal, mostly elongated at the base of dentition, 31.5 - 67.5 × 22.5 - 31.5 µm; median cells rounded, polygonal, 38.0 - 60.8 × 22.8 - 41.8 µm; basal cells elongated, polygonal, 30.4 - 76.0 × 19.0 - 39.2 µm, marginal dentitions much elongated; cells of marginal dentitions subquadrate to rectangulate, 83.0 - 133.0 × 15.2 - 22.8 µm; cuticle smooth under SEM. Gemmae pale green, 2-4-celled, angulate, present at apices.

Dioicous. Male plants up to 45 mm long, 3.2 mm broad (0.19 - 0.20 mm broad in the region of bracts), androecia both terminal and intercalary; bracts in 6-12 pairs, concave, closely imbricate, 3-5-lobed to 1/4 - 1/3 of the bract length, similar to leaves but smaller and with less dentitions, 1.2 - 1.5 mm long, 1.44 - 2.4 mm wide; cells thin-walled, trigonous; apical marginal cells without dentitions, sub-rounded, sub-quadrate to polygonal, 24.0 - 54.0 × 12.0 - 42.0 µm with minute trigones; median cells sub-rounded to polygonal, 24.0 - 60.0 × 30.0 - 45.0 µm with distinct trigones; basal cells elongated, rectangulate with prominent trigones, 36.0 - 72.0 (87.0) × 24.0 - 42.0 µm; antheridia 4-6 per bract; body sub-rounded to sub-globose up to 0.20 mm long and 0.18 mm wide; stalk biseriate, up to 1.1 mm long, 0.02 mm wide.

Habitat: On rocks.
Type: India, Sikkim, Yumthong, c. 12,000 ped., September 9, 1949, J. D. Hooker 1317 (Holotype & Isotype: NY). Range: Bhutan, China, India, Nepal (Srivastava, 2002).

Schistochilopsis setosa was first reported from India by Mitten (1861) as Jungermannia setosa from Sikkim Himalaya and subsequently listed by others (Herzog, 1939; Chopra, 1943; Parihar, 1961-62; Hattori, 1966; Grolle, 1966; Kitagawa, 1975). Later, Mizutani (1979) and Parihar & al., (1994) again listed this species from Eastern Himalaya and Nepal. However, this species has not been observed in recent collections available to us, suggesting the rare occurrence of the species in the area.


Plants medium to large, up to 13 mm long, 1.5 - 1.9 (-2.5) mm wide with leaves, blackish-brown, forming compact, often extensive, pure patches; branching furcate or often terminal. Stem prostrate or ascending, broad, fleshy, flattened, oblong-elliptical in cross-section, 16-18 cells wide across diameter laterally, 5-7 cells wide.
vertically, with no dorsiventral differentiation; cortical cells smaller, rounded to sub-rounded, or elliptical, 19.0 - 30.4 × 11.4 - 19.0µm; medullary cells larger, flattened, oblong, elliptical, 30.4 - 49.4 × 22.8 - 34.2µm. Rhizoids abundant, crowded on the ventral surface of stem. Leaves contiguous to imbricate at apex, generally distant in lower portion, alternate, succubous, obliquely inserted with slight decurrence dorsally, horizontally to subhorizontally spreading, some leaves concave with dorsal half secund over ventral, generally spreading, polymorphous, quadrate, subquadrate, rounded ovate, obtrapezoidal to obrhomboidal, 0.60 - 0.75 × 0.66 - 0.81mm, 2-5-lobed to 1/4 - 1/3 (-1/2) of its length; lobes unequal, narrowly to broadly triangulate, 0.15 - 0.30mm long, 0.15 - 0.48mm wide, with spinous marginal teeth; antical lobe generally ends into 1-celled spinous tooth; sinus narrowly acute to subacute, 0.15 - 0.30mm deep, 0.18 - 0.36 (-0.45)mm wide; cells medium, thin-walled, trigonous; apical cells rounded to sub-rounded or polygonal, 15.2 - 38.0 × 15.2 - 26.6µm; apical lobe ending cell triangulate and spinous, 76.0 - 95.0 × 11.4 - 26.6µm; median cells rounded to sub-rounded or polygonal with distinct trigones, 19.0 - 34.2 × 22.8 - 38.0µm, with triangulate, rather short marginal dentitions, 60.0 - 83.6 × 11.4 - 15.2µm; basal cells rounded to sub-rounded or slightly elongated, 22.8 - 41.8 × 22.8 - 34.2µm; cuticle smooth. Gemmae present on the apices of the leaf, pale green, 1-2-celled, elliptical to triangulate.

Dioicous. Male plants not seen. Female plants 10 - 12mm long, 1.5 - 1.9 (2.5)mm wide, perianth 1/2 - 2/3 exserted; involucral bracts in one pair, similar to but larger than leaves, concave, erect, closely imbricate, 3-5-lobed to 1/4-1/3 (-1/2) of bract length, broadly obtrapezoidal to obrhomboidal, 0.63 - 0.81mm long, 0.90 - 1.2mm wide; lobes with many, long dentitions; cells medium, thin-walled; apical cells rounded to subrounded or polygonal, with trigones, 15.2 - 38.0 × 15.2 - 26.6µm; median cells rounded to subrounded or polygonal with distinct trigones, 26.6 -
41.8 × 15.2 - 30.4µm, with long and triangulate marginal dentitions, 45.6 - 133.0 × 11.4-26.6µm; basal cell elongated-rectangulate without trigones, 34.2 - 53.2 × 15.2 - 22.8µm. Perianth cylindrical, obovoid, pluriplicate, mouth ciliate-dentate with 1-3-celled teeth; cell of dentation triangulate to quadrate, 76.0 -144.0 × 11.4 - 19.0µm; sub-apical cells elongated-rectangulate with minute acute trigones, (22.8-) 30.4 - 53.2 × 11.4 - 15.2µm; median cells sub-quadrate to rectangulate with or without minute trigones, 15.2 - 30.4 × 15.2 - 22.8µm; basal cells irregularly polygonal with distinct trigones, 22.8 - 30.4 × 19.0 - 30.4µm. Sporophytes not seen.

Habitat: Terrestrial, on soil covered rocks or humus, in crevices.

Type: Germany, Goettingen, Anon. - s.n. (Iso : G!).

Range: Central America, Bulgaria, Canada, Caucasus, China, Czech-republic, Denmark, England, Finland, France, Germany, India, Ireland, Japan, Korea, Mexico, Nepal, Norway, Poland, Russia, Slovakia, Sweden, Switzerland, Taiwan, (Gradstien and Vaña, 1987; Piipoo, 1990; Piipoo & al., 1997; Srivastava, 2002).

Distribution: Jammu and Kashmir (Zanskar), Uttarakhand (Ghangharia, on way to Hemkund, and Valley of Flowers), Sikkim, West Bengal (Darjeeling, Phalut, Sandakphu).


Schistochilopsis incisa was first described as Lophozia incisa from India by Kashyap (1932) from Western Himalaya (see also Chopra, 1943; Parihar, 1961-62; Parihar & al., 1994) and subsequently from Sikkim and West Bengal in the eastern Himalaya and Nepal (Grolle, 1966; Hattori, 1966; Kitagawa, 1975).

Schistochilopsis incisa has been variously treated by different workers earlier, e.g. under subgenus Dilophozia (Macvicar, 1912) and under subgenus Massula (Müller, 1954; Kitagawa, 1966) on the basis of deep green colour, flaccid texture of the plant, fleshy, flattened stem dorsiventrally not differentiated and by the large, thin-walled leaf cells with numerous oil-bodies. Later, Schuster (1969) treated it under section Incisae of the subgenus Massula on the basis of plants with bluish green colour, 2-5-lobed, asymmetric leaves, lobes usually sharply pointed (often apiculate) at apex, absence of underleaves and presence of greenish, angulate, 1-2-celled gemmae.

Schistochilopsis incisa seems to resemble S. setosa in having 3-4-lobed leaves with spinous dentitions but differs in relatively larger plants, high number of dentitions, which are 1-4 celled and are rectangularly elongated in L. setosa.

Schistochilopsis incisa var. himalayana Srivast., S.C. Srivast. & K.K. Rawat var. nov. (Fig. 21)

Planta media vel robusta, 6-12mm longa & 0.76 - 0.96 (1.35)mm lata, Caulis phaeobrunea late ellipticus, 5 - 7 cellule latis verticalis & 16 - 18 cellule latis lateralis. Folia dimorphe, anticus conatus & simplex, imbricatus vel contigus ad apice, gradatim distans ad basi, mutto lata quain longa, 2 - 3 lobis. Cuticula grosse verrucose.


Plants medium to large, 6 - 12mm long, 0.75 - 0.96 (-1.35)mm wide with leaves, blackish brown, forming dense caespitose patches; branching regular furcate and terminal. Stem prostrate to ascending, blackish-brown, thick, flattened to oblong-elliptical in outline in cross-section, 16-18 cells wide laterally, 5-7 cells wide

vertically, with no differentiation, cortical cells slightly smaller, sub-quadrate to rectangular, 26.6-41.8 × 15.2-22.8µm; medullary cells large, rectangularly elongated, polygonal, 26.6 - 45.6 (-57.0) × 19.0 - 30.4µm. Rhizoids dense on ventral surface of the stem. Leaves, imbricate to contiguous in apical portion to generally distant below, alternate, subtransversely inserted upto stem mid-line, in some part dorsally connate, (mainly near branching in robust plants), 2-3-lobed to 1/4-1/3 of its length, large, subquadrate to obrhomboidal, 0.60 - 0.81mm long, (0.90) 1.35 - 1.95mm broad, the part of leaf connation (0.06-) 0.21 - 0.36mm wide; lobes broadly triangular with 4-9 dentitions along the margins, 0.06 - 0.30mm long, 0.30 - 0.45mm wide, apex obtuse to subacute (with 1 triangular cell at apex), sinus acute to obtusely wide, 0.15 - 0.24mm deep, 0.33 - 0.48mm wide; cells thin walled with minute trigones, apical cells sub-rounded, quadrate to sub-quadrate, 19.0 - 38.0 × 19.0 - 30.4µm; median
cells sub-rounded, quadrate to sub-quadrate, 19.0 - 26.6 \times 15.2 - 22.8 \mu m with the marginal dentitions on the lobe triangulate, up to 91.2 \mu m long and 11.4 - 19.0 \mu m wide; basal cells sub-quadrate to rectangularly elongated, 30.4-53.2 \times 15.2 - 22.8 \mu m; cuticle faintly verrucose. Gemmae and fertile plants not seen.

Habitat: Terrestrial, on soil covered rock, on humus or on organic substrate.

Range: India (probably endemic).

Distribution: Uttarakhand (Ghangharia, Valley of Flowers).


The new variety shows a very peculiar characteristic of dorsally connated leaf which is not exhibited by any other species of the genus. The variety can be differentiated from typical *S. incisa* in dorsally connated leaf near branching in robust plants (totally absent in *S. incisa*), leaf margin with few dentitions (dentitions frequent in *S. incisa*), and leaf cells without trigones (leaf cells with trigones in *S. incisa*).

The connation of the leaf is observed in majority of robust plants near branching but not in regular manner. The plant with connated leaves also show simple free leaves. Significantly the jointed leaves are not opposite but are alternate and the connation takes place in the alternately opposite leaves.


Plants yellowish to reddish brown; branches rare, lateral intercalary and axillary. Stem erect to suberect with straight apex, rigid, firm, differentiated into 2(-3) rows of thick-walled cortical and collenchymatous medullary cells. Leaves subimbricate to contiguous, alternate, succubous, vertically to subvertically oriented with transverse insertion, symmetrically 4-lobed; lobes erect, ovate-triangulate to lanceolate, margin reflexed, lobes thus convex adaxially with 2-6, 1-celled dentitions, cilia up to 6-celled. Underleaves large, bifid; lobes much longer with deep sinus, base of the underleaves with few cilia or teeth; cells quadrate, subquadrate to polygonal, thick-walled, with indistinct confluent trigones. Gemmae not seen.

Dioicous. Male plants not seen. Female inflorescence terminal often with subfloral innovation. Bracts similar to but larger than leaves, the lobes gradually narrowed toward apex, with relatively less dentitions. Perianth 1/3-1/2 exerted, short, ovoid, mouth contracted, ciliate and dentate.

Type: *Jungermannia setiformis* Ehrh.

The species referable to the genus *Tetralophozia* in India were earlier reported as part of *Chandonanthus* Mitt. Herzog (1939) for the first time reported *C. setiformis* from Sikkim. Parihar (1961-62) also listed *C. setiformis* from Eastern Himalaya. Hattori (1966) listed another species, *C. filiformis* in place of *C. setiformis*. Hara (1971) listed only *C. filiformis* from Eastern Himalaya. Grolle (1966) and Mizutani (1979) reported *C. filiformis* from Nepal. Hattori (1966) remarked that *C. filiformis* does not occur in Eastern Himalaya, but *C. setiformis*, a closely allied European species occurs in this area. Both the species now belong to genus *Tetralophozia* (Urmi, 1983; Schuster, 2002) as *Tetralophozia filiformis* and *T. setiformis*. Konstantinova (2002) also did not mentioned distribution of *T. setiformis* in India. The available specimens confirmed the presence of *T. filiformis* in India which is described and illustrated here.


Plants medium to large, up to 18mm long, 0.36 - 0.90mm broad, yellowish to reddish brown, filiform; branching rare, lateral intercalary and axillary. Stem not arched, straight, erect to suberect, rigid, orbicular to suborbicular in cross-section, 0.17 - 0.22mm long, 0.13 - 0.15mm wide, 10-12 cells across diameter, differentiated, cortical cells in 2(-3) rows, small, 7.6 - 11.4 \times 3.8 - 7.6\mu m, thick-walled; medullary cells large, collenchymatous irregularly, suborbicular, polygonal, 11.4 - 19 \times 7.6 - 15.2\mu m. Rhizoids few, scattered over the ventral surface of the stem. Leaves subimbricate to contiguous, alternate, succubous, vertically to subvertically
oriented with transverse insertion, palmate, digitatus (fingered), (0.13-) 0.18 - 0.21mm long, 0.09 - 1.35mm wide, symmetrically 4-lobed; lobes equal to subequal, triangulate, ovate to lanceolate with incurved margin and acute to subacute apices, adaxially convex; leaf base with short, 1-celled dentitions to 2-6 celled uniseriate cilia; sinus 0.13 - 0.18mm deep, 0.9 - 0.15mm wide. Underleaf large, bifid with deep sinus, sinus 0.30 - 0.52mm deep, 0.15 - 0.34mm wide; lobes ovate-triangulate to lanceolate, with few cilia or teeth at the base, 0.31 - 0.6mm long, 0.27 - 0.30mm wide; leaf cells thick-walled with indistinct trigones; apical cells of the leaf quadrate to subquadrate, 11.4 - 19.0 × 11.4 - 15.2µm; median cells irregularly subquadrate to polygonal, 11.4 - 19.0 × 11.4 - 19.0µm; basal cells large, irregularly rectangulate with confluent trigones, (19.0-) 30.4 - 38 (-45.6) × 11.4 -
19.0µm; underleaf cells similar to but smaller than leaf cells; apical cells rounded to subquadrate, 7.6 - 11.4×7.6 - 11.4µm; median cells quadrate to subquadrate, 11.4 - 19.0×11.4 - 15.2µm; basal cells elongated-rectangulate, 19.0 - 38.0×11.4 - 19.0µm. Gemmae not seen.

Dioicous. Male plants not seen. Female inflorescence terminal with subfloral innovation; bracts similar to but larger than leaves with less dentitions, 0.60 - 0.75mm long, upto 0.66mm wide; perianth 1/3 - 1/2 exserted, ovoid, mouth contracted, ciliate and dentate, cilia long, 1-4 celled; apical cells of the perianth narrowly elongated, 19.0 - 38.0×11.4 - 15.2µm; median cells rectangular, 11.4 - 30.4×11.4 - 15.2µm; basal cells elongated-rectangulate, 19.0 - 30.4(-38.0)×11.4 - 15.2µm. Sporophyte not seen.

Habitat: Terrestrial

Type: China, Delavay (G!)

Range: China, India, Finland, Japan, Norway, Sweden (Hattori, 1966; Srivastava, 2002).

Distribution: Sikkim (Dzongri, Tsomgo lake), West Bengal (Darjeeling, Phalut).


*Tetralophozia filiformis* was first reported from India as *Chandonanthus filiformis* from Tsomgo lake, Sikkim by Herzog (1939). Parihar (1961-62); Kachroo (1966) and Kitagawa (1975) also listed this taxon as *Chandonanthus filiformis* from Eastern Himalaya, while Grolle (1966) and Mizutani (1979) reported this species from Nepal.

*Tetralophozia* can be differentiated from *Chandonanthus* in having symmetrically 4-lobed leaves (2, 3-4 lobed, asymmetric leaves in *Chandonanthus*), transverse insertion of leaves (oblique insertion in *Chandonanthus*), perianth mouth contracted (rather wide open in *Chandonanthus*), and lateral intercalary branching (postical intercalary in *Chandonanthus*). The main difference in both the genera is in the structure of cells. The cells are thick walled and rounded with nearly guttulate lumen in the former while the cells are thin-walled with coarse and obvious, often confluent trigones in the latter (see Schuster, 1960).


Plants in loose patches, yellowish to golden brown, medium to large. Stem rigid to stiff, procumbent to erect, simple to sparsely branched lateral intercalary; cortical cells in 2-4 layers. Leaves obliquely inserted, asymmetrically 3(-4)-lobed, margin dentate to ciliate, apices acuminate; cells thin walled with large, nodulose to confluent trigones; cuticle smooth to striate. Underleaves small. Paraphyllia may be present.

Dioicous. Gynoecia terminal; perianth long emergent, 5-6 plicate, mouth ciliate to spinose.

Type: *Chandonanthus squarrosus* (Hook.) Mitt.

The genus *Plicanthus* was also reported earlier from India as *Chandonanthus* Mitt., as Herzog (1939) for the first time reported its 2 species, *C. setiformis* (from Sikkim) and *C. birmensis* (from Darjeeling-Kalimpong). Parihar (1961-62) enumerated 3 species (*C. birmensis*, *C. hirtellus* and *C. setiformis*) of this genus from Eastern Himalaya. Hattori (1966, 1971, 1975) listed 3 species of this genus. Grolle (1966) reported one species, *C. filiformis* and Mizutani (1979) listed 3 species (*C. birmensis*, *C. filiformis* and *C. hirtellus*) from Nepal. Hattori (1966) remarked that *C. filiformis* does not occur in Eastern Himalaya, but *C. setiformis* a closely allied European species occurs in this area. Manju & al., (2008) listed *Chandonanthus birmensis* as *Plicanthus birmensis* in south India (Kerala). Out of the all, *C. birmensis* and *C. hirtellus* are now *Plicanthus birmensis* and *P. hirtellus* respectively (Schuster, 2002) and discussed here.

Schuster (1960) divided *Chandonanthus* into two subgenera, *Chandonanthus* subg. *Chandonanthus* and *Chandonanthus* subg. *Tetralophozia*, the former being tropical antipodal in distribution while the latter occurs in arctic and alpine region (see Schuster, 1969). These subgenera were later on elevated as distinct and independent...
genera (Urmis, 1983). Currently Chandonanthus is represented in India by 2 validly recognized species, C. hirtellus and C. birmensis. The detailed description of both the species have been given by Udar and Kumar (1982) from Eastern Himalaya and Tiwari and Airi (1988) from Western Himalaya. Schuster (2002) while revising Chandonanthoideae segregated Chandonanthus into three elements. Genus Tetraloephiza (Schust.) Schljakov, Chandonanthus s. str. (on basis of C. squarrosus) and Plicanthus Schust. According to him genus Chandonanthus s. str. is represented by single species C. squarrosus (Hook.) Mitt. and is purely Australasian element. He synonymized including others, C. birmensis and C. hirtellus (species reported in India) under genus Plicanthus.

**Key to the species of Plicanthus in India**

1. Plant reddish to greenish brown, leaf margin entire with few occasional teeth along the margin, underleaf with 1-2 marginal teeth at the base ....................................................... P. birmensis
2. Plant yellowish brown, leaf margin with many sharp marginal teeth and cilia, underleaf with numerous marginal teeth at the base .............................................................. P. hirtellus


For detail taxonomic description and illustration see Udar & Kumar (1982 as Chandonanthus birmensis).

**Habitat:** On rocks, humus or grows epiphytically.

**Range:** China, India, Indonesia, Japan, Madagascar, Myanmar, Russia, Taiwan, Thailand (Hattori, 1966; Lai & al., 2008; Konstantinova & al., 2009; Bakalin, 2010).

**Distribution:** Kerala, Uttarakhand (Almora, Binsar, Pindari, Ranikhet), West Bengal (Darjeeling, Victoria falls, Phalut, Sandakphu, Kurseong). (Udar and Kumar, 1982; Manju & al., 2008)

The plants of *P. birmensis* can be differentiated from those of *P. hirtellus* in the presence of few weakly developed teeth at the margins of leaf base and faintly developed verrucose cuticle in the former and several well developed teeth at leaf margin in the latter. The cuticle in *P. hirtellus* is reported to be papillately-striatedly verrucose (see Kitagawa, 1965 as Chandonanthus hirtellus). As the plants are already worked out in detail by Udar and Kumar (1982) and Tewari and Airi (1988), hence details are not being provided here.


**Habitat:** Grows either in pure population or in association with other liverworts in shady places.

**Range:** Africa, Australia, Canada, China, India, Indonesia, Japan, Polynesia, Sri Lanka, Taiwan, Thailand (Udar and Kumar, 1982; Piipoo & al., 1997; Lai & al., 2008)

**Distribution:** Meghalaya (Shillong), Sikkim (Nathula Pass, Dhongri), Uttaranchal (Almora, Chauhattia, Dhakuri, Loharkhet, Pithoragarh, Pindari, Ranikhet), West Bengal (Darjeeling, Yoksam, Sandakphu, Tonglu, Kurseong). (Hattori, 1966; Udar and Kumar, 1982)

**Excluded Taxa**

*Sphenolobus longkyrdumi* A.P. Singh and V. Nath = *Metahygrobiella albula* (Mitt.) Grolle syn. nov. (Cephaloziaceae)

**Type:** India, Meghalaya, east Khasi hills, Longkyrdum-Dawki road, 07.11.1998, V Nath & al. 206083B (Holo : LWG) (Singh & Nath, 2007)

Lophozia hatcheri (Evans) Steph., = *Barbilophozia hatcheri* (Evans) Loeske

*Barbilophozia hatcheri* (Evans) Steph. is reported from Himalaya by Stephani (1901) as Lophozia hatcheri but the exact locality of this species in India was not clearly mentioned. Unfortunately it has not been possible to collect this species from India.
Tetralophozia setiformis (Ehrh.) Schljakov.

Presence of this taxon in India is doubtful (see Konstantinova, 2002).

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भारत में लोफोजिओसी (हेपेटिसी) कुल की स्थिति

स्पष्टा श्रीवास्तव, एस. सी. श्रीवास्तव एवं के. के. रावत

सारांश

सामान्यतः अनुसंधान एवं भारतीय टेक्सस पर हमारे अपने अबलोल के आलोक में भारत में लोफोजिओसी कुल की स्थिति का विवेचन किया गया है। आइसोपिकल बूक, लोफोजिओसी (ड्रूडर्ट) ड्रूडर्ट, सिस्टोक्लीमासिस (एन डिटाग) कोटेंट, एनेस्ट्रास्टा (लिंडब) जिफिन, एनेस्ट्रोफाइल्म स्कुट जिफिन, ट्रिटोमेरिया जिफिन, ट्रिटोलोफोजिओसी (आर एम शूट) एवं शिक्झस आर एम शूट वन्य आंतो ओं के अंतर्गत कुल 95 टेक्सस की उंगान की गई है। एनेस्ट्रोफाइल्म माइनस एक्सेर्चर हिमालय, लोफोजिओसी उद्योग, लोफोजिओसी इंडिका एवं सिस्टोक्लीमासिस इंसाइड्रस प्रभेद हिमालय अनुप्रयोग नई वे चार टेक्सस विज्ञान के लिए मध्य रूप में वर्णित हैं। स्पष्टोलोक्स लोफोजिओसी ए. पी. सिंह एवं श. नाथ को मेटाफोजिओसी एल्पा (मिट) ग्राल (कुल सफेलोजिओसी मिग) के अंतर्गत पत्रिकावाचक प्रस्तावित होने के कारण शामिल नहीं किया गया है।