Taxonomy and distribution of *Cheilolejeunea larsenii* Mizut. (Marchantiophyta, Lejeuneaceae), with special reference to three new synonyms

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*Cheilolejeunea exinnovata* E.W.Jones, a rare and poorly known liverwort from Africa and Brazil, *C. ghatensis* G.Asthana, S.C.Srivast. & A.K.Asthana, previously endemic to India, and *C. adnata* (Kunze ex Lehm.) Grolle var. *autoica* Gradst. & Ilk.-Borg. reported only from French Guiana are proposed as new synonyms of the Asian *Cheilolejeunea larsenii* Mizut., so far known only from China and Thailand. *Cheilolejeunea larsenii* is characterized by its rounded leaf apex, a small and strongly inflated leaf lobule that possesses a distinctively long and unicellular lobule tooth, and an absence of gynoecial innovations. A detailed description, taxonomic notes, new localities, distribution map, and illustrations of *C. larsenii* are provided.

**Keywords:** *Cheilolejeunea adnata* var. *autoica*, *Cheilolejeunea exinnovata*, *Cheilolejeunea ghatensis*, Hepaticae, India, Malaysia

**Introduction**

*Cheilolejeunea* (Spruce) Steph. (including *Aureolejeunea* R.M.Schust., *Evansiolejeunea* Vanden Berghen and *Omphalanthus* Lindenb. & Nees) is the third largest genus of Lejeuneaceae (Marchantiophyta) with about 180 currently accepted species (Ye *et al.*, 2011). Owing to the lack of a worldwide taxonomic revision, the number of species in the genus is an approximation. *Cheilolejeunea larsenii* Mizut. was originally described based on a collection from Thailand by K. Larsen *et al.* in 1966 (Hattori & Mizutani, 1969). Possibly owing to the lack of illustrations in the protologue, *C. larsenii* was not well understood and known only from the type collection for a long time (Lai *et al.*, 2008). The second report for this species was published recently, based on collections from Hainan, China (He & Zhu, 2011). According to the protologue, *C. larsenii* was characterized by autoecious sexuality, rounded leaf apex, small and strongly inflated leaf lobule with a long unicellular tooth, and an absence of gynoecial innovations. In 1982, a new species, *C. exinnovata* E.W.Jones, very similar to *C. larsenii*, was described based on an epiphyllous collection made in Sierra Leone (Jones, 1982). Outside Sierra Leone, *C. exinnovata* is also known from Ghana, Zimbabwe and Brazil but has never been commonly collected (Jones, 1982; Wigginton, 2009). Fourteen years later, Asthana *et al.* (1996) described a new species, *Cheilolejeunea ghatensis*, very similar to *C. exinnovata*, that was considered to be an Indian endemic taxon. Recently, Gradstein & Ilkin-Borges (2009) proposed a new variety from French Guiana, *Cheilolejeunea adnata* (Kunze ex Lehm.) Grolle var. *autoica* Gradst. & Ilk.-Borg. A critical comparative morphological study with fertile samples from Brazil, China, French Guiana, India, Malaysia, Sierra Leone, and Thailand revealed that the African *C. exinnovata*, the Indian *C. ghatensis* and the American *C. adnata* var. *autoica* are conspecific with the little known *C. larsenii* Mizut.

**Materials and Methods**

Observations were made on recent and older collections from various herbaria as indicated below. Samples were examined under a light microscope (Zeiss Imager A1 or Olympus BX 43). The photomicrographs were made with a Spot Flex digital camera and Olympus DP 71 digital camera. Line drawings were made with the aid of an Olympus drawing tube.

**Description and Taxonomic Notes**

*Cheilolejeunea larsenii* Mizut., Dansk Bot. Ark. 27 (1): 95. 1969. (Figures 1–4)
Type: Thailand. Northern, Phitsanulok, Tung Salaeng Luang, epiphytic on tree-trunk, evergreen east of the forest station, 700 m, 25 July 1966, K. Larsen, T. Smitinand & E. Warncke 911 (holotype: AAU!; isotype: NICH-287706!).

*Cheilolejeunea exinnovata* E.W.Jones, J. Bryol. 12(1): 37. 1982; syn. nov. Type: Sierra Leone. Kenema District, Gola North Forest Reserve, in unexploited 'primary' forest, on leaf of undershrub, E.W. Jones 1568 (holotype: BM, not located; isotypes: E (E00007508)!, JE!).


Illustrations: Jones (1982, p. 38, Figures 1 and 2 as *Cheilolejeunea exinnovata*), Asthana et al. (1996, p. 133, Figure 4 as C. ghatensis), Gradstein & Ilkiu-Borges (2009, p. 65, Figure 35 as C. adnata var. autoica).

Plants green, up to 12 mm long. Shoots 0.5–1.2(–1.5) mm wide, irregularly branched, branching of *Lejeunea*-type, leaf sequence of lateral branches lejeuneoid. Stem 70–90 μm in diameter, transverse section consisting of 7 cortical cells (18–38 × 15–24 μm) and 9–11 smaller medullary ones (9–20 × 7–17 μm), ventral merophyte 2 cells wide. Rhizoids few, fasciculate, brown, at base of underleaf, rhizoid disc absent. Leaves imbricate or contiguous, spreading from stem at an angle of (45–)60–85(–90)°. Lobes asymmetrically ovate or ovate-oblong, weakly convex, 0.32–0.60(–0.70) mm long, 0.28–0.50 mm wide, usually somewhat falcate, apex rounded, plane, margin entire,
ventral margin plane, usually sinuate near base, dorsal margin strongly arched and nearly plane. Lobe cells thin-walled or slightly thick-walled, trigones small, intermediate thickenings usually absent or weakly developed, marginal cells subquadrate to oblong, 10–16 × 8–13 μm, median cells mostly isodiametric, 13–25 × 11–22 μm, basal cells slightly longer than median ones in shape, 25–40 × 18–30 μm. Cuticle smooth. Ocelli and vitta absent. Oil bodies (1–)2–3 per median cell of leaf lobe, 9.9–19.2 × 4.4–8.2 μm.

Figure 2 Cheilolejeunea larsenii Mizut. (A) Leaf, ventral view. (B – C) Spores. (D) Elater. (E) Portion of shoot, ventral view. (F) Marginal cells of leaf lobe showing oil bodies. (G) Median cells of leaf lobe showing oil bodies. (H) Leaf lobule showing the long and unicellular lobule tooth. All from Y. Yu & T. Peng 20100715-15 (HSNU).
composed of minute granules 2.5–6.0 μm in diameter. Lobules triangular-ovate or ovate, (1/6–)1/5–1/4 as long as lobes, strongly inflated, lateral free margin strongly incurved and usually not visible in situ, bordered by 4(–6) rectangular cells, apex connate to leaf lobe across 1 cell, apex with 2 teeth, first tooth indistinct, second tooth (lobular tooth) usually unicellular, elongate, 18–40 × 8–14 μm, (2–)3–4 times longer than wide, hyaline papilla at the distal side of the second tooth, keel arched, smooth. Underleaf bilobed to 1/3–1/2 its length, distant, transversely inserted, oblong to suborbicular, 0.20–0.28 mm long, 0.20–0.26 mm wide, usually slightly longer than wide, 1.5–2.5 times as wide as the stem, margin plane and entire.

Figure 3 Cheilolejeunea larsenii Mizut. (A – F) Leaves. (G) Portion of shoot with a gynoecium and androecium, ventral view. (H – J) Leaf lobules. (K) Median cells of leaf lobe. (A) and (B) from Chuah & Yong 009/002/39 (HSNU), (C), and (I–K) from J.M. Bekker 2233-1 (holotype of C. adnata var. autoica, GOET), (D, G) from E.W. Jones 1568 (isotype of C. exinnovata, E), (E, F and H) from A.E.D. Daniels & J.L. Mabel 378 (HSNU).

Figure 4 Plants of Cheilolejeunea larsenii Mizut. on tree trunks.
**Autoecious. Androecia** usually terminal on short or long lateral branches, bracts in 2–6 pairs, imbricate, hypostatic, obliquely or erectly spreading, shallowly bilobed, bract lobule slightly shorter than bract lobe or almost as long as bract lobe, keel arched, bracteole 1–2, similar to underleaf in shape, borne only on basal portion of androecium. *Gynoecea* terminal on very short or long branches, without gynoecial innovations, bracts in 1 pair, bract lobe oblong or obovate, 0.40–0.70 mm long, 0.28–0.50 mm wide, obliquely or horizontally spreading, apex rounded, margin entire, bract lobule narrowly ligulate, ca 1/2–3/4 as long as bract lobe, apex obtuse to acute, margin entire, keel nearly straight or slightly sinuated, bracteole mostly oblong-obovate, 0.40–0.54 mm long, 0.20–0.32 mm wide, margin entire and plane, apex bilobed 1/3–1/2 its length, lateral base connate with bract lobule. *Perianth* emergent, oblong or oblong-obovate, inflated, 0.50–0.84 mm long, 0.38–0.60 mm wide, with 4(–5) keels, keels and surface smooth, beak 2–3 cells long. *Capsule* ca 0.19–0.28 mm in diameter, valves ca 0.32 mm long, ca 0.18 mm wide at middle, seta 7 cells long, articulate after elongation, 12 outer cells surrounding 4 inner ones, foot with 3 transversal cell rings. *Ellaters* linear, attached to margins of the valves, 260–275 μm long, 14–16 μm wide, with a weak single spiral band of thickenings. *Spores* irregularly oblong in shape, 570–670 per capsule (He & Zhu, 2011), green, 72–105 × 26–41 μm, surface minutely papillose, usually with several weak rosettes. *Asexual* reproductive organs not seen.

*Cheilolejeunea larsenii* is a little known species, which was originally described based only on the type collected in Thailand (Hattori & Mizutani, 1969). Besides the type locality, the other known locality is thus far in Hainan, China (He & Zhu, 2011). Additional fertile samples from China, India, Malaysia and Thailand allowed us to make a more critical comparison of *C. larsenii* with the African *C. exinnovata* and the American *C. adnata* var. *autoica*. As a result of our morphological study, we found that the three species are conspecific. Hence, *Cheilolejeunea exinnovata* and *C. adnata* var. *autoica* are proposed to be synonymized with *C. larsenii*. *Cheilolejeunea ghaternis* is a rare species known only from south India (Asthana *et al.*, 1996). Although its type specimen was not available for our study, a recent collection from the same region in south India is identical with the original description given by Asthana *et al.* (1996). Our examinations of the Indian plant and the type of *C. larsenii* revealed that there is no significant difference between the species and its synonymy is proposed here.

As shown in Figures 1–3, *Cheilolejeunea larsenii* is well characterized and easily recognized by the small size of the plants (mostly 0.7–1.1 mm wide), small and strongly inflated leaf lobules, long unicellular lobule tooth, autoecious condition, and absence of gynoecial innovations. The elongate unicellular tooth of the leaf lobule occurs also in several *Cheilolejeunea* species, especially in members of the *Cyrtolejeunea* clade (Ye *et al.*, 2013). *Cheilolejeunea larsenii*, however, can immediately be distinguished from the other members of the *Cyrtolejeunea* clade by its *Calypogeia*-type oil bodes (Figure 2G–H), small leaf lobules only 1/6–1/4 as long as leaf lobes, and the absence of gynoecial innovations. Most of the members in the *Cyrtolejeunea* clade bear *Jungermannia*-type oil bodies, except *C. uhagurica* whose oil bodies are hitherto unknown. *Cheilolejeunea larsenii* is most closely related to *C. adnata* (Kunze ex Lehm.) Grose from tropical America. The two species share many similarities, e.g. the long unicellular lobular tooth, the underleaf shape, small and strongly inflated leaf lobules, indistinct trigones, and the lack of gynoecial innovations. *Cheilolejeunea adnata*, however, differs in being dioicous and possessing strongly caducous leaves with rhizoids on the margin (Schuster, 1980, p. 908, Figure 679).

The other species that highly resembles *Cheilolejeunea larsenii*, is *C. sandvicensis* (Steph.) Steph., an older name but based on sterile and poorly known plants collected in Hawaii (holotype: G-18802!) (Stephani, 1890 as *Lejeunea sandvicensis* Steph., Stephani, 1897; Evans, 1891 as *L. sandvicensis*, Evans, 1900). It is difficult for us to make a decision regarding the synonymy of these names, until fertile plants and/or molecular evidence based on material collected in Hawaii are available.

*Cheilolejeunea larsenii* also bears remote similarities with the pantropical *C. decursiva* (Sande Lac.) R.M. Schust. and the tropical Asian *C. verrucosa* Steph. *Cheilolejeunea larsenii* is similar to *C. decursiva* in the presence of elongated unicellular tooth of the leaf lobule, but the latter differs in the presence of gynoecial innovations, and spathulate leaves with large leaf lobules about 1/2 as long as the leaf lobes (Zhu & Lai, 2005). Although *C. decursiva* is a pantropical species (Shu *et al.*, 2014), no fresh samples of *C. decursiva* were available for observation, hence, the difference of oil bodies between the two remains unknown. *Cheilolejeunea verrucosa* Steph. is known from China, Indonesia, Malaysia, and Papua New Guinea (Zhu *et al.*, 2002). It shares some similarities with *C. larsenii* in the small leaf lobules, unicellular lobule tooth, small and remote underleaves, and lack of gynoeccial innovations. *Cheilolejeunea verrucosa*, however, is easily separated from *C. larsenii* by the dioicous sexuality, oblong leaf lobes with a nearly straight ventral margin, and usually papillose leaf cells. In addition, the lobular tooth of *C. verrucosa* is shorter, and not elongated.
In the taxonomic treatment of *Cheilolejeunea* in India, Asthana *et al.* (1996) showed that *C. ghatensis* (in the present paper as a synonym of *C. larsenii*) is similar to *C. imbricata* (=*C. trapezia* (Nees) R.M.Schust. & Kachroo, cf. Zhu & Grolle, 2004). However, *C. trapezia* differs from *C. larsenii* in having rectangular leaf lobules. The molecular evidence (unpublished data) also indicated that the two species are not closely related. *Cheilolejeunea trapezia* belongs to subgen. *Xenolejeunea* Kachroo & R.M.Schust., whereas *C. larsenii* is a member of subg. *Cheilolejeunea*.

*Cheilolejeunea larsenii* exhibits variation in its leaf shape. In most specimens from Africa and Tropical America, the leaf lobe is usually somewhat falcate with a distinctive sinuate, basal ventral margin (Figures 2A and 3A, C and D). In the Asian collections, however, the both straight and sinuate basal ventral margins of leaf lobes are present, even on different leaves from the same stem (Figure 3B, E and F). The leaf lobules are usually strongly inflated, but sometimes strongly reduced (Figure 2E) in specimens from China and Peninsular Malaysia. The leaf lobes are rounded at apex, but plants from Thailand and China tend to be rounded-obtuse especially on the shoot apex (Figure 2E). The lobular apex is not usually visible, except for the elongated tooth, owing to the strongly incurved free margin of the leaf lobe. The lobular tooth is usually unicellular and elongated (Figure 3H–J). Jones (1982) doubted the consistency of the numbers of free marginal cells on the leaf lobule. In the Asian and American collections cited in the present paper, the free margin is bordered mostly by four cells, but sometimes up to six cells, as in the type of *C. exinnovata* from Sierra Leone. Although a distinct dorsal keel of the perianth is shown in Asthana *et al.* (1996) for *C. ghatensis*, the present study revealed that the dorsal keel of the perianth is absent or only ill-defined in most collections (Figure 1C). In most taxa of *Cheilolejeunea*, spores bear well developed rosettes, but in *C. larsenii* the rosettes on spores are usually ill-defined (Figure 2B and C). In the type of *C. exinnovata*, the gynoecia usually occur on an abbreviated lateral branch, only bearing 1–2 pairs of reduced obliquely or almost erect-spreading vegetative leaves (Figure 3G). In most Asian and American samples, however, the gynoecia are usually terminal on a relatively long branch with over three pairs of well-developed vegetative leaves, which are widely spreading (Figure 1B).


**Habitat:** Usually on tree trunks (Figure 4) or on living leaves, and sometimes growing on rocks, at relatively low (200–880 m) altitudes.

**Distribution:** SE Asia (China, India, Malaysia, Thailand), Africa (Ghana, Sierra Leone, Zimbabwe) (cf. Jones, 1982), and the Neotropics (Northern Brazil, French Guiana). It is surprising that only

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**Figure 5**  Distribution map of *Cheilolejeunea larsenii* Mizut. (•)
few records of this species have been reported worldwide (Figure 5). More detailed investigations on *Cheilolejeunea* in the Neotropics, Africa and tropical Asia may reveal further localities of this species in both the New World and the Old world.

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**Taxonomic Additions and Changes:** *Cheilolejeunea larsenii* Mizut. (*Cheilolejeunea exinnovata* E.W. Jones syn. nov., *Cheilolejeunea ghatensis* G. Asthana, S.C. Srivast. & A.K. Asthana syn. nov. and *Cheilolejeunea adnata* var. autoica Gradst. & Ilk-Borg. syn. nov.)

**References**


