

GENUS *DIPLASIOLEJEUNEA* (LEJEUNEACEAE, PORELLALES) NEW TO INDIA, WITH RECORDS OF TWO SPECIES FROM THE WESTERN GHATS

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The genus *Diplasiolejeunea* is added to the liverwort flora of India from the Kerala part of the Western Ghats reporting two species: *Diplasiolejeunea cavifolia* Steph. and *D. cobrensis* Gottsche ex Steph. The genus is known from tropical Asia with eight species. Among them *Diplasiolejeunea cavifolia* is widespread, but still the genus was not yet recorded from India.

Key words: *Diplasiolejeunea*, genus record, India, Kerala, Lejeuneaceae, Western Ghats

INTRODUCTION

Diplasiolejeunea (Spruce) Schiffn. is a pantropical genus of the liverwort family Lejeuneaceae represented by approximately 75 valid species (Prudêncio *et al.* 2018, Söderström *et al.* 2016) around the world. Most of the species are epiphytes and occur in a good number in the American and African continents, but from Asia this genus is represented only by eight species including the pantropical *Diplasiolejeunea cavifolia* Steph., *D. cobrensis* Gottsche ex Steph. and *D. rudolphiana* Steph. while *D. ingekarolae* Schäf.-Verw., *D. jovet-astiae* Grolle, *D. longilobula* Herzog, *D. onraedtii* Grolle, and *D. patelligera* Herzog are restricted to Asia (Grolle 1995, He 1997, Lai *et al.* 2008, Piippo 1990, 1994, Schäfer-Verwimp 2004, 2006, Zhu and So 2001).

The genus *Diplasiolejeunea* is characterised by the development of underleaves along every lateral leaf (similar condition is found only in the genus of *Colura* (Dumort.) Dumort.). Leaf lobes are large, usually loosely imbricate, apices are broad and rounded, leaf cells of lobes plane or with distinct trigones and intermediate thickenings and often with ocelli, hyaline papilla is situated at the base of the tooth on the inner surface of the lobule, underleaves deeply bifid with sharp or blunt apices and the perianth is sharply five keeled. The species of the genus are epiphytes (epiphyllous or ramicolous, growing on living leaves or on twigs) in the wet tropics.

During our recent investigation of the family Lejeuneaceae of Kerala, some interesting specimens were observed, among these two species belonging to the genus *Diplasiolejeunea*, viz. *D. cavifolia* and *D. cobrensis*. The majority of *Diplasiolejeunea* species are recorded from a narrow range of distribution, except for *D. cavifolia*, *D. cobrensis* and *D. rudolphiana*, which are pantropical (Dong *et al.* 2012). However, the present study recorded for the first time the genus along with these two species from India. A detailed description of both species with photo plates, illustration and the distribution map of *D. cobrensis* are provided.

DESCRIPTION OF SPECIES

Diplasiolejeunea cavifolia Steph. (Figs 1–2)

Diplasiolejeunea cavifolia Steph., Bot. Jahrb. Syst. 20: 318 (1895); Piippo, Trop. Bryol. 9: 55 (1994); Schäfer-Verwimp, Cryptogamie, Bryol. 25(1): 13 (2004). – Bas.: *Lejeunea cavifolia* Steph., Bot. Jahrb. Syst. 8: 89 (1886). = *Diplasiolejeunea brachyclada* A. Evans, Bull. Torr. Bot. Club, 39: 216 (1912). = *D. javanica* Steph. Sp. Hepat. (Stephani) 5: 928 (1916). = *D. ocellata* Steph., Sp. Hepat. (Stephani) 5: 920 (1916). = *D. vandenberghenii* Grolle, Rev. Bryol. Lichénol. 29: 208 (1960), *nom. illeg.*

Diplasiolejeunea cavifolia was described by Stepani under different names as *D. javanica* Steph., *D. ocellata* Steph. and *Lejeunea cavifolia* Steph. (Blocked synonym *Lejeunea cavifolia* (Ehrh.) Lindb.; later homonym), many other workers also reported this species under different names. Unknowingly, Evans (1912) also reported this species as *D. brachyclada* Evans from Puerto Rico with detailed description and illustrations. Later, all these names were synonymised under *Diplasiolejeunea cavifolia* (Grolle 1978, Jones and Harrington 1983).

Plants pale green to yellowish, scattered, 4–8 mm long, 1.25–1.56 mm wide including leaves, stem widely branching; rhizoids hyaline, clustered at the base of underleaves. Leaves loosely imbricated, lobes widely spreading, not firmly appressed to the substratum, broadly ovate, plane, 0.75–1.0 × 0.5–0.6 mm, dorsal margin rounded and extending across the stem, slightly curved or with wavy margin, margin plane, apex rounded or slightly obtuse in some leaves. Cells plane, without trigones and intermediate thickenings, thick walled, marginal cells rectangular to polygonal, 9.2–15.3 × 10.2–16.6 µm, median cells polygonal, 8.4–23.6 µm, basal cells elongated, polygonal, 15.8–35.5 × 11.2–21.1 µm, ocelli scattered in the lobe; lobule ovate, 0.4–0.5 × 0.2–0.28 mm, inflated, 1/2 as long as the leaf lobe, keel arched, free margin involute up to near the base, first tooth acute (median), truncate or T-shaped, three to four cells long, one or two cells wide at base, proximal tooth inflexed, shorter than first tooth, lies along the ventral margin of leaf lobe, acute, hyaline papilla

seen on the base of the first tooth, indistinct. Underleaves distant, rounded to subcordate at base, deeply bifid, $0.22\text{--}0.30 \times 0.18\text{--}0.20$ mm, three times wider than the stem, sinus wide, lobes 6–10 cells wide at base, acute, margin en-

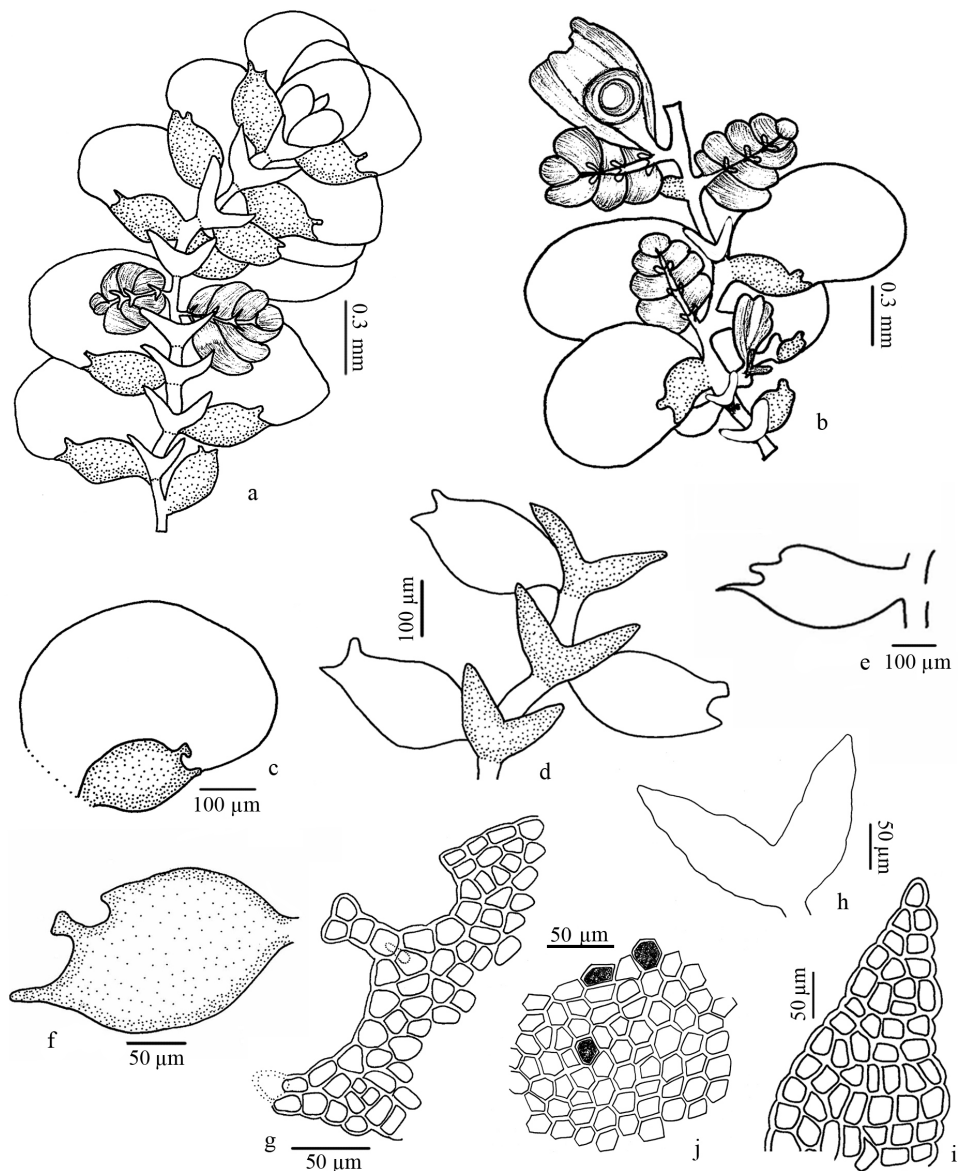


Fig. 1. *Diplasiolejeunea cavifolia* Steph. a = portion of plant with male branch; b = portion of plant with androecial and gynoecial branches; c = single leaf with lobule; d = plant ventral view with lobule and underleaf; e, f = lobules; g = t-shaped lobule with basal hyaline papilla; h = underleaf; i = underleaf lobe cells; j = leaf lobe cells (after Chandini 10515b)

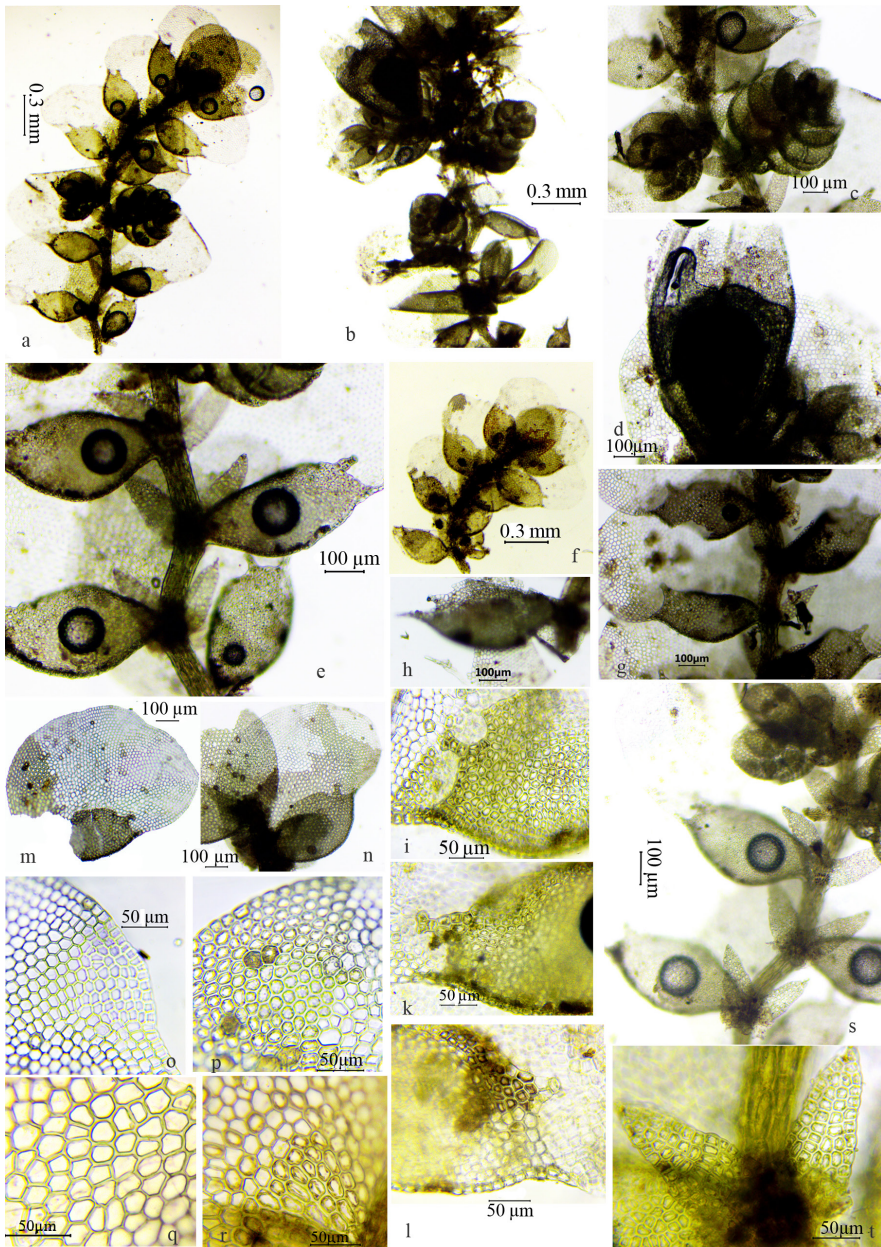


Fig. 2. *Diplasiolejeunea cavifolia* Steph. a = plant with male branch; b = portion of plant with male and female branch; c = male branch; d = perianth; e and g = plant ventral view with lobe and underleaf; f = portion of plant; h, i, j, k, l = different leaf lobules; m, n = leaf lobe; o, p = leaf lobe marginal cells; q = leaf lobe median cells; r = leaf lobe basal cells; s = portion of stem with underleaves; t = single underleaf lobule (after Chandini 10515b)

ture. Monoecious, observed as autoicous, female inflorescence present on very short branch, perianth oblong or oblong ovate, rounded to truncate at apex, very short beak present, $0.76\text{--}0.12 \times 0.46\text{--}0.85$ mm, bracts obliquely spreading, rounded at apex, as long as leaf lobe; male gametocia on very short branches, bracts imbricate, in 3–4 pairs, mature sporophyte is not seen by us (Figs 1 and 3). Spori, as observed by Weis (2001), are $45\text{--}55 \times 20\text{--}30$ μm in size, with rosettes of $5\text{--}7$ μm diameter decorated by obtuse spines.

Specimen examined: India, Kerala, Palakkad district, Silent Valley National Park, Parathode, way to Poochippara (1,000 m +), coll.: Chandini (10515b), 11.01.2018 (ZGC).

Habitat: Epiphyllous, associated with *Lejeunea cocoes* Mitt., *Leptolejeunea elliptica* (Lehm. et Lindenb.) Schiffn. in evergreen forest above 1,000 m.

Distribution: Cambodia, China (Hainan), Java, Sumatra, Luzon, Malaysia, Sri Lanka, Taiwan, New Caledonia (Schäfer-Verwimp 2006), Vietnam, Laos and Thailand, Philippines (Lai *et al.* 2008, Miller *et al.* 1983, Söderström *et al.* 2020), Australia (McCarthy 2003), Melanesia (Piippo 1990), West Indies (Evans 1912, Reyes 1982, incl. distribution map), Central America, Mexico, South America (Schäfer-Verwimp 2004), all over tropical Africa (Wigginton 2018), Madagascar and the Mascarene islands (Marline *et al.* 2012, Wigginton 2018).

Diplasiolejeunea cobrensis Gottsche ex Steph.
(Figs 3–5)

Diplasiolejeunea cobrensis Gottsche ex Steph., Spec. Hepat. 5: 923 (1916) subsp. *cobrensis* = *D. harpaphylla* Steph., Sp. Hepat. 5: 919 (1916). = *D. incurvata* Jovet-Ast et Tixier, Rev. Bryol. Lichénol. 31: 29 (1962).

Plant small, light green, loosely attached to the substratum, 2–4 mm long, 0.85–1.1 mm wide including leaves, irregularly branched, branches up to 1 mm long, stem c.s. with 3 medullary and 7 cortical cells, 82.9 μm in diameter; rhizoids hyaline, fasciculate. Leaves imbricate, obliquely spreading, lobe convex in dorsal margin, asymmetric, semi-circular, broadly ovate, $0.6\text{--}0.67 \times 0.48\text{--}0.60$ mm, ventral margin curved to nearly straight, entire, cells with prominent trigones and intermediate nodular thickenings, usually one per cell wall, marginal cells rectangular to pentagonal, $6.9\text{--}11.6 \times 8.2\text{--}15.4$ μm , median cells polygonal, $13.2\text{--}25.6 \times 10\text{--}25.9$ μm , basal cells more irregular, $20.8\text{--}35.6$ μm in size; ocelli scattered, 8–15, basal ocellus larger than companion cells, usually one, rarely two, $53.2\text{--}60.4 \times 30.2\text{--}37.5$ μm ; oil bodies 2–5 per cells, rounded, granular, scattered in lobes, lobules and underleaves; lobules inflated, tubulate, $1/3\text{--}1/2$ as long as the leaf lobe, $0.17\text{--}0.19 \times 0.07\text{--}0.09$ mm, first tooth normally well developed, consisting of 1–2 cells, single cell observed

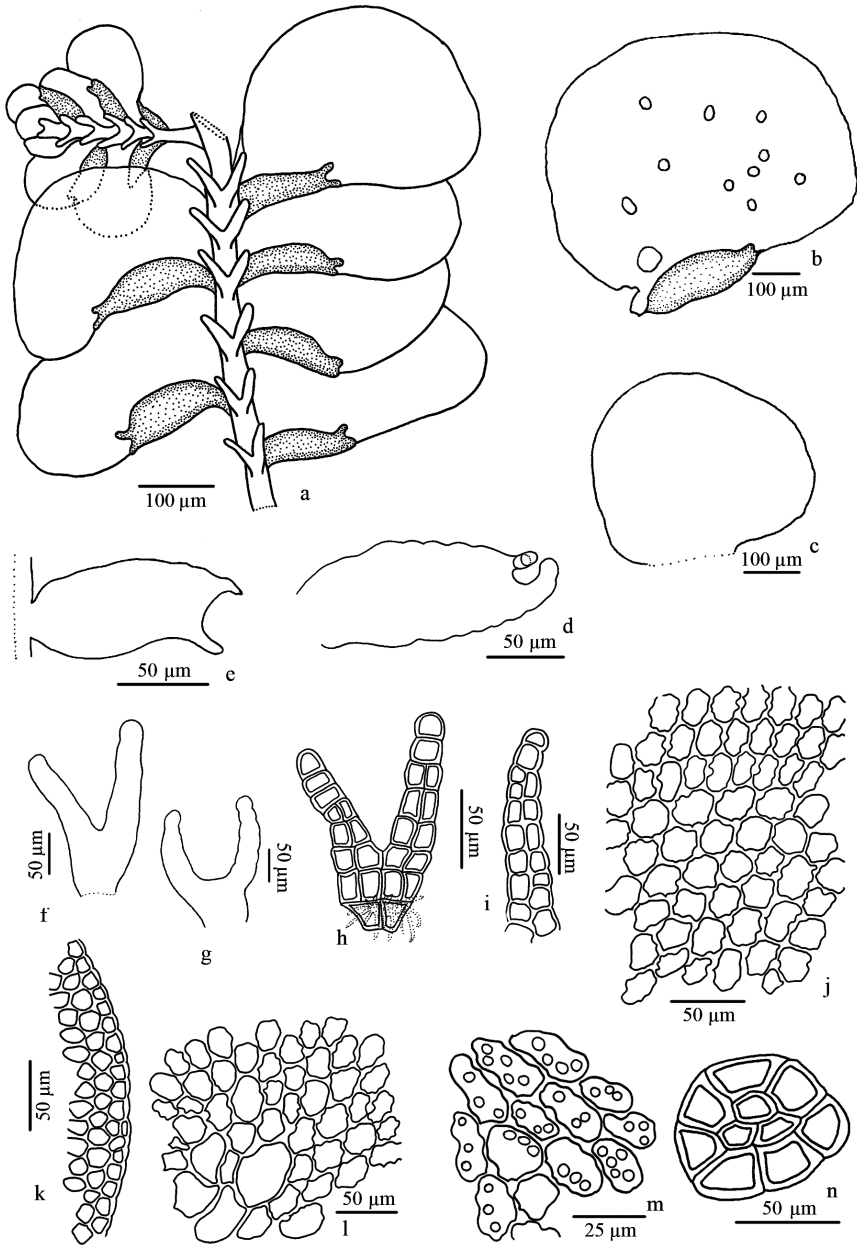


Fig. 3. *Diplasiolejeunea cobrensis* Gottsche ex Steph. a = portion of plant ventral view; b = single leaf (ventral); c = single leaf (dorsal); d, e = leaf lobules; f, g, h = underleaves; i = underleaf lobe cells; j = leaf lobe median cells with trigones and intermediate thickenings; k = marginal cells; l = leaf lobe basal cells with ocelli; m = leaf cells with oil bodies; n = stem cell. s. (after Vinjusha 13182b)

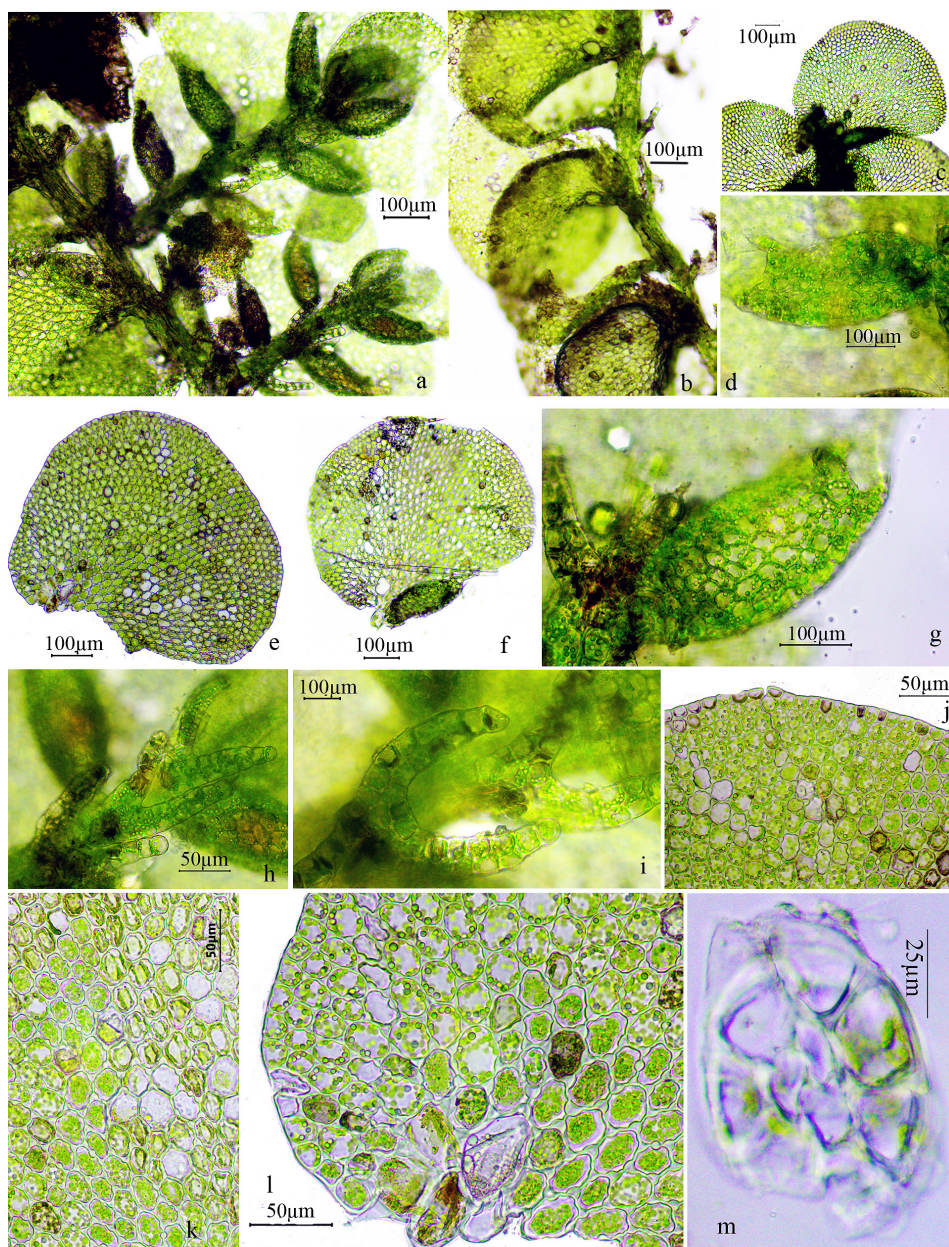


Fig. 4. *Diplasiolejeunea cobrensis* Gottsche ex Steph. a = portion of plant with branches; b = portion of plant, ventral view; c = leaf arrangement on stem; d, g = leaf lobule; e = leaf lobe; f = leaf with lobule; h, i = underleaves; j = leaf lobe maginal cells; k = leaf lobe median cells; l = leaf lobe basal cells with ocelli; m = stem c. s. (after Vinjusha 13182b)

as superimposed in some lobules, proximal tooth one celled, indistinct, lies along the ventral margin, hyaline papilla indistinct at base of lobule teeth. Underleaves small, not much wider than the stem, deeply bilobed nearly to the base, sinus U- or V-shaped, $0.12\text{--}0.22 \times 0.05\text{--}0.09$ mm, lobes 2–3 cells wide at base; biseriate, 5–6 cells long, ending with 1–3 uniserial cells at tip, sexual and asexual reproductive structures not seen (Figs 2 and 4).

Habitat: Epiphyllous, associated with *Leptolejeunea balansae* Steph. in semi-evergreen forests.

Specimen examined: India, Kerala, Wayanad district, Kuruva dweep (750 m), approx. $11^\circ 49' \text{ N}$, $76^\circ 06' \text{ E}$, coll.: Vinjusha (13182b), 07.12.2018 (ZGC).

Distribution: Cuba (type from El Cobre, coll.: Wright 1173) (Reyes 1982); Guyana (Gradstein and Hekking 1989); Brasil (Germano and Pôrto 2004, Prudêncio *et al.* 2018, Schäfer-Verwimp 1992); West Africa (Ghana – Jones 1973; Sierra Leone – Jones and Harrington 1983, East African islands (Mafia – Pócs and Váňa 2015; Mayotte – Pócs 2010; Madagascar – Grolle 1966, Tixier 1986 (several localities under *D. harpaphylla*); Pócs 2001 (also the ssp. nov. *andringitrae*); Dong *et al.* 2012, Marline *et al.* 2012), China (Hainan – Zhu and So 2001), Vietnam (Jovet-Ast and Tixier 1962 (as *D. incurvata* sp. nov.)); Thailand (Tixier 1973, 1986 (as *D. incurvata*), Schäfer-Verwimp 2006, Lai *et al.* 2008); Malaysia (Sabah, Mt Kinabalu – Mizutani 1966 (mistaken as *D. brachyclada*, corrected in 1970 and a Sabah east coast record added). There is an unpublished record new to the Andes: Peru, Dept. Pasco, prov. Oxapampa, Parque Nacional Yanachaga-Chemillén, epiphyllous in cloud forest at 2,415 m elevation. Coll. J. Larraín & C. Rothfels (40272/AB), 22 May 2016, det. Pócs (EGR!).

DISCUSSION

Even though, *Diplasiolejeunea cavifolia* is described as widely distributed one, not yet reported any species of *Diplasiolejeunea* from India. This may be due to the inadequate survey of the family Lejeuneaceae in our area. Compared to other genera of Lejeuneaceae of Kerala *Diplasiolejeunea* are represented only with these collections. Both taxa are epiphyllous along with the other members of the same family and prefer montane evergreen forest patches. They are easily identifiable by its double number of underleaves and not firmly appressed nature of the thallus to the substratum. *D. cavifolia* is distinguished by its leaf lobules with mostly three to four cells long linear or T-shaped first tooth. Lobe cells plane and mostly hexagonal in shape, distant underleaves with triangular, acute lobes. *D. cobrensis* can be distinguished by half circle shaped lobes, its cells with trigones and intermediate nodular thick-

enings, with 2–5 oil bodies, scattered ocelli with large basal ones. The lobule is tubular with usually two celled first tooth and with an obsolete second tooth. Underleaves small and deeply bilobed nearly to the base with 2–3 basal cells, biseriate lobes ending at 2–3 celled uniseriate apex. *D. cobrensis* has similarities by its tubular lobule and small underleaves with 1–2 cells wide segment to *Diplasiolejeunea cornuta* Steph., widespread in Africa. But differs from it by its entire lobe margin and by its scattered ocelli (*D. cornuta* has acuminate lobes with dentate margin and only basal ocelli). It is remarkable, how different the two Indian species are in their way of dispersal. While *D. cavifolia* is very widespread and common in all wet tropics, *D. cobrensis*, although also pantropical, in general is very rare and has a scattered distribution (see map on Fig. 5). The explanation of this difference is not easy, as both are monocious, have no organs of vegetative reproduction and rarely produce sporophytes. The spori of *D. cavifolia* are too large for long range air dispersal and the spori of *D. cobrensis* are not yet known. Either historical factors cause the difference or they are able to reproduce themselves at different level of fragmentation and so aerial dispersal can be counted to different extent. Dong *et al.* (2012) claimed on the base of their phylogram of maximum likelihood analysis, that *D. cavifolia* evolved in the Neotropis and from there dispersed to the Paleotropis and *D. cobrensis*, vice versa, evolved in Africa and migrated from there to the other continents.

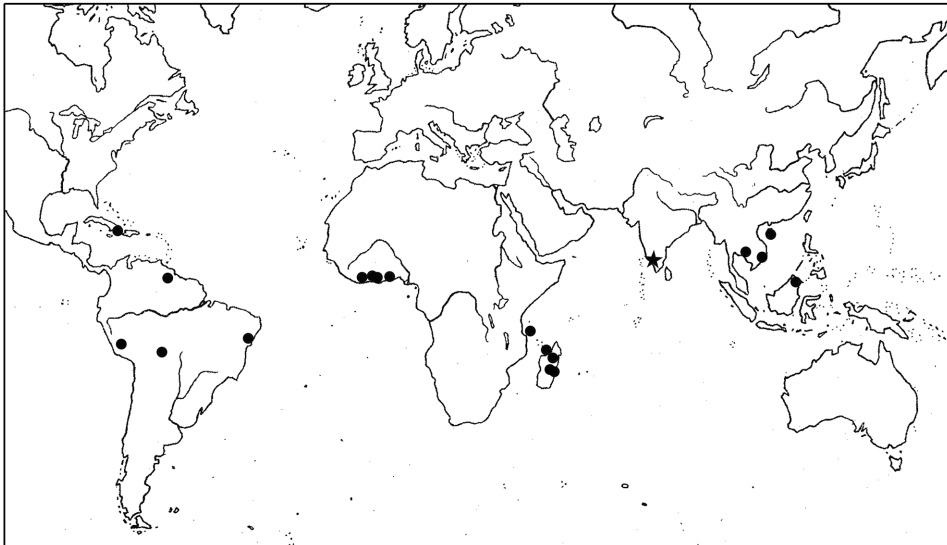


Fig. 5. Worldwide distribution of *Diplasiolejeunea cobrensis* Gottsche ex Steph. Dots = known distribution; asterisk = the new locality in India

The present discovery is a new generic record for the Indian flora. Over the years several partial treatment and floristical approaches appeared, but a comprehensive world treatment of this genus was not yet published.

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