

Two new species of Lejeuneaceae tribe Lejeuneae (Marchantiophyta) from Colombia

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Two new species of Lejeuneaceae tribe Lejeuneae (Marchantiophyta) from Colombia. – Acta Mus. Siles. Sci. Natur., 68: 29-36, 2019.

Abstract: We describe the new liverwort species *Lejeunea ryszardii* from montane rainforest in the Central Cordillera of Colombia (Dept. Quindío) and *Rectolejeunea halinae* from submontane rainforest in the Western Cordillera (Dept. Risaralda). Both species stand out by copious vegetative reproduction via caducous leaves. *Lejeunea ryszardii* resembles the Caribbean *L. paucidentata* in the leaf lobes with toothed margins and a narrow base but strikingly differs from the latter species in: 1) leaf margins with mamilliose cells, which are sometimes crowned by a small papilla, and with scattered rhizoids with or without a tooth-like base; 2) lobules with narrowly elongate, curved, sharp tooth; 3) stem epidermis brownish and somewhat thick-walled; 4) copious production of caducous leaf lobes. Moreover, *L. ryszardii* is dark green to brown in color and probably dioicous while *L. paucidentata* is light green and autoicous. *Rectolejeunea halinae* resembles the neotropical *R. flagelliformis* in having ciliate caducous leaves but clearly differs from the latter in the pointed leaf tips, the presence of ocelli in underleaves, and the flagelliform shoots with flat, entire-margined underleaves. The discovery of these new species adds two further endemic taxa to the rich bryophyte flora of the Colombian Andes.

Key words: Colombia, *Lejeunea paucidentata*, *Lejeunea ryszardii*, *Rectolejeunea flagelliformis*, *Rectolejeunea halinae*, liverworts, morphology, taxonomy.

Introduction

Colombia is one of the biologically most diverse countries of this planet. About the size of France and the Iberian Peninsula combined, Colombia harbors more species of plants than any other neotropical country except Brazil (Ulloa Ulloa *et al.* 2017). The recent plant catalogue of Colombia (Bernal *et al.* 2016) lists about 24,500 species of vascular plants and 1,650 of bryophytes (932 mosses, 703 liverworts, 15 hornworts), with about 25% of vascular plant species and 5% of bryophytes being endemic. This high diversity is undoubtedly due to the enormous variety of climate, soils and topography in Colombia resulting in a great diversity of vegetation formations such as the wet lowland rainforests of Amazonia and the Chocó region, the semi-deserts along the Caribbean Coast and the lush montane forests and harsh páramos of the Andes, which is split in three huge cordilleras and reaches its highest elevation in the Sierra Nevada de Santa Marta (5775 m), the world's highest coastal mountain.

Based on the ongoing studies of the first author on the liverwort flora of Colombia (e.g., Gradstein 2016; Gradstein & Reeb 2018; Gradstein *et al.* 2018a, 2018b), several species new to science were recently described (Gradstein & Reiner-Drehwald, 2017a, 2017b; Reiner-Drehwald & Gradstein 2018). Here we describe two further new liverwort species, both in the tribe Lejeuneae, the most speciose group of the family Lejeuneaceae with well over one thousand species in about 45 genera, including large groups such as *Cheilolejeunea*, *Cololejeunea*, *Colura*, *Diplasiolejeunea*, *Drepanolejeunea* and *Lejeunea*. Characteristic features of the Lejeuneae are the thin stems with ventral merophytes usually only 1-2 epidermal cells wide, the predominance of bifid underleaves, the sporophyte foot made up of only 3 transverse cell rings, the seta made up of 16 rows of cells (12 outer rows, 4 inner rows) and the butterfly- or broadly quadrate-shaped hinge of the capsule wall (Gradstein 2013).

The generic classification of Lejeuneae has long been considered notoriously difficult due to the common occurrence of parallel evolution in the group and the lack of stable generic characters (e.g., Schuster 1963; Gradstein *et al.* 2003). Recent taxonomic studies based on integrated molecular and morphological analyses, however, have considerably improved our understanding of systematic relationships within the tribe (e.g., Dong *et al.* 2013; Heinrichs *et al.* 2013, 2014; Wei *et al.* 2014; Schäfer-Verwimp *et al.* 2014; Ye *et al.* 2015; Bechteler *et al.* 2016; Zhu & Shu 2017; Zhu *et al.* 2017).

The two new species of Lejeuneae described in this paper were discovered during fieldwork by the first author in Colombia. Their discovery adds two further endemic species to the rich bryophyte flora of the country. It is a pleasure to dedicate the new species to Halina Bednarek-Ochyra and Ryszard Ochyra at the occasion of their 60th and 70th birthdays, respectively, and in recognition of their major contributions to bryology.

Descriptions of the new species

Lejeunea ryszardii Gradst. & Ilkiu-Borges sp. nov.

Fig. 1

DIAGNOSIS: *Stems and branches partly denuded by abundant production of caducous leaf lobes. Stems brownish, epidermal cell walls slightly thickened. Leaf lobes with a very narrow base, apex acuminate, margins irregularly crenate and with scattered rhizoids and teeth terminating in a rhizoid. Lobules flask-shaped, ca. 1/3 × leaf length, with a narrowly elongate, curved tooth.*

TYPE: Colombia, Department Quindío, Municipio Filandia, Vereda Cruces, Granga Experimental "Bengala", 1900-2000 m, old secondary montane forest on steep slope, on base of tree trunk, 30 April 2018, S. R. Gradstein & C. Agudelo-H. 12726a (holotype: HUUQ!; isotypes: MG!, PC!).

EPONYMY: dedicated to Ryszard Ochyra at the occasion of his 70th birthday.

Plants dull dark green to brownish green when dry, to 1.5 cm long, main stem with leaves ca. 1 mm wide, sparsely to densely pinnately branched, all branches of the *Lejeunea*-type, slightly smaller than the main shoot. Stems and branches partly denuded by abundant production of caducous leaf lobes, denuded shoots bearing lobules and underleaves only. **Stems** brown, 70-90 µm wide, made up of 7 rows of epidermal cells surrounding 10-13 rows of narrower medullary cells, epidermal cells subrectangular in ventral view, 35-50 × 25-35 µm, slightly less elongate in dorsal view, epidermal cell walls slightly thickened, pale brown; ventral merophyte 2 epidermal cells wide. **Leaves** contiguous to subimbricate, widely spreading. Leaf lobes asymmetrically ovate-falcate, slightly convex, ca. 0.5 × 0.35-0.45 mm, apex acuminate, acumen 2-6 cells long, 2-3 cells wide in the lower half, tip of 1-2 subquadrate cells, frequently terminating in a short rhizoid, the rhizoid to 0.1 mm long; leaf margins irregularly crenate due to mamillate cells, the cells thin-walled or, when large, crowned by a small papilla, margins furthermore with scattered rhizoids (especially on leaves near denuded shoots) and 2-5 irregular blunt teeth especially on the dorsal margin, less commonly on the ventral margin, the teeth 1-2 cells long, usually terminating in a short rhizoid; leaf lobes conspicuously narrowed to the base, insertion line 0.1-0.14 mm long, ca. 1/3 the width of the base, basal margin of lobe ± parallel to stem, lobe conspicuously recessed along the line of detachment opposite the free margin of the lobule. Median leaf cells hexagonal, isodiametrical to elongate, 25-35 × 20-27 µm, marginal leaf cells smaller, quadrate to subrectangular 15-20 × 10-15 µm, basal cells similar to median cells or more elongate; cell walls with small, simple or slightly radiate trigones and ± without intermediate thickenings; cuticle smooth; oil bodies not observed. Lobules well-developed, not reduced, strongly inflated, diverging at an oblique angle with the stem, curved and shortly flask-shaped with a narrow, rounded orifice, 150-180 × 100-120 µm, 1.5 × longer than wide, ca. 1/3 × lobe length, free margin appressed to the surface of the lobe, bordered in the upper half (proximal to the apex) by 3 transversely narrowed cells which are oriented obliquely towards the free margin and 3-4 × wider than long, apical tooth long, 30-38 × 12-13 µm, 2.5-3 × longer than wide, curved outwards, apical free margin (between the tooth and the junction of the free margin and the ventral lobe margin) bordered by 4 rectangular, long than wide cells which are sometimes protruding outwards, free margin not continuing along the ventral margin of the leaf lobe; keel strongly arched, smooth, sinus strongly indented, angle between keel and ventral margin of the lobe sharp, ca. 90°. **Underleaves** distant, flat, ± appressed to the stem, broadly ovate, 0.15-0.18 × 0.18-0.21 mm, slightly wider than long 2.5-3 × stem width, slightly smaller on branches, bifid to 1/2, sinus V-shaped, lobes straight, triangular, 5-6 cells wide at base, apex subacute, former by 1 cell, margins curved, entire, base rounded, cordate, insertion line curved, at outer angles with a prominent, large cell (belonging to the lobule); rhizoid disc small, rhizoids short, colorless, often absent. Dioicous (?); gynoecia not observed. **Androecia** terminal or intercalary on elongate or short-specialized branched, male bracts strongly swollen, suberect, subimbricate, in 2-5 pairs, lobes smaller than vegetative leaf lobes, margins crenate, lobules hypostatic, almost as large as lobe;

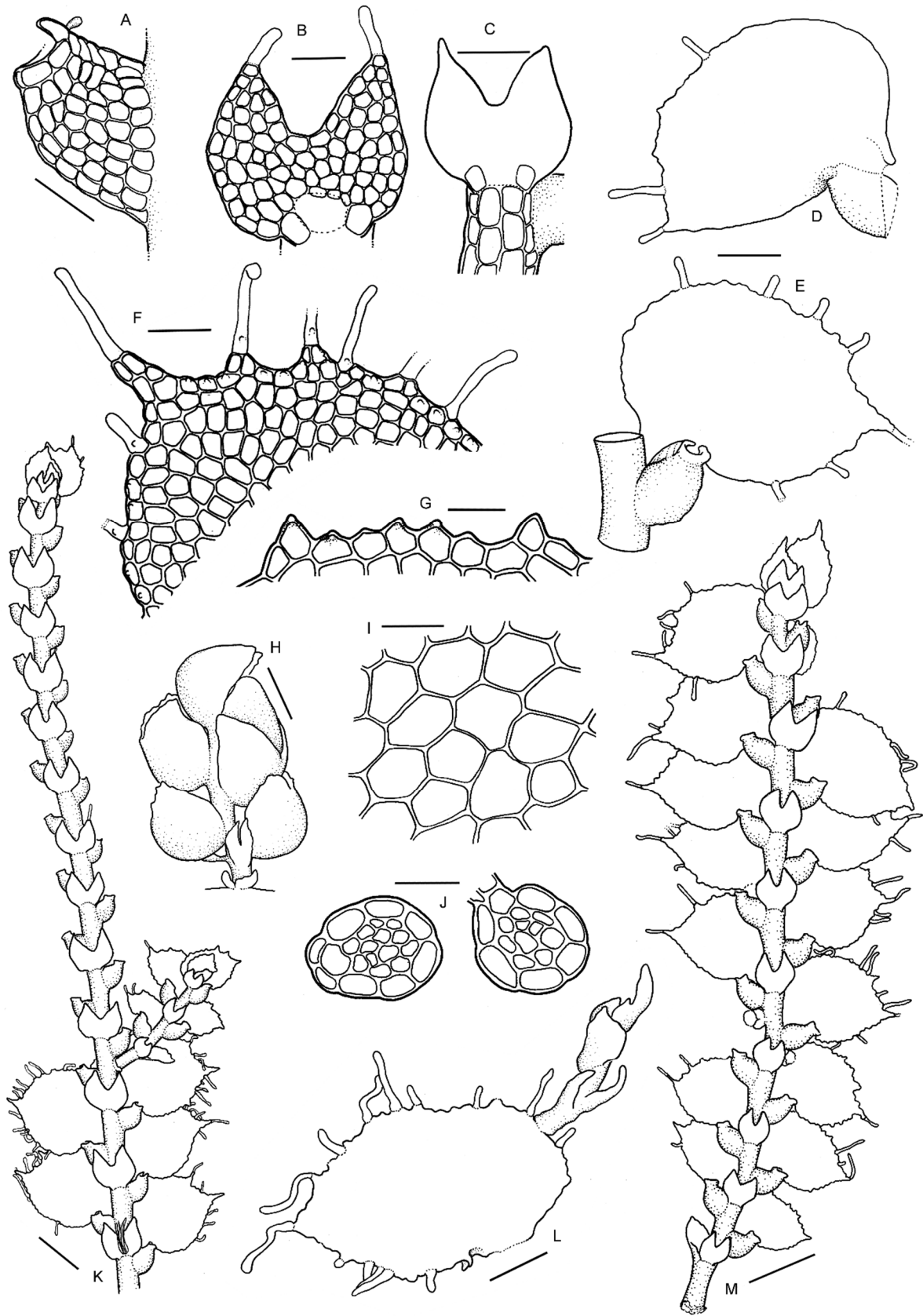


Fig 1: A-M – *Lejeunea ryszardii*. A – Lobule. B – Underleaf with apices terminating in a short rhizoid. C – Underleaf and portion of stem. D – Leaf, dorsal view. E – Leaf, ventral view. F-G – Leaf margins. H – Androecia. I – Median cells of the leaf lobe. J – Cross sections of stem. K – Habit with shoot portion producing caducous leaf lobes, ventral view. L – Caducous leaf with rhizoids and juvenile plantlet. M – Habit, ventral view. (A, B, F, J= 50 μ m; D, E, H, L= 100 μ m; G, I= 25 μ m; K, M= 250 μ m).

keel arched, smooth in the lower half, crenate in the upper half; antheridia two (?) per bract; one male bract retracted to the base of spike. **Vegetative reproduction** abundantly by caducous leaf lobes, the lobes ovate to ovate-oblong, plane, $0.3-0.45 \times 0.25-0.3$ mm, otherwise as in stem leaves.

DISTRIBUTION AND HABITAT: *Lejeunea ryszardii* is known from one locality on the western slope of the Colombian Central Cordillera, in the department of Quindío. The new species was growing on the base of a large tree in an old secondary montane forest at about 2000 m, on rather smooth bark and in a dense mat of various species of Lejeuneae. Accompanying species included *Lejeunea aphanes* Spruce, *L. concinnula* Spruce & Steph., *L. debilis* (Lehm. & Lindenb.) Mont. & Nees, *Microlejeunea epiphylla* Bischl. and *Otigoniolejeunea huctumalcensis* (Lindenb. & Gottsche) Y.M. Wei *et al.*

DISCUSSION: *Lejeunea ryszardii* is readily recognized by: 1) stems and branches partly denuded by caducous leaf lobes; 2) leaf lobes asymmetrically ovate-falcate, conspicuously narrowed to the base, apex acuminate and usually terminating in a rhizoid, margins irregularly crenate by mamillate cells which are occasionally crowned by a small papilla, and with short teeth and scattered rhizoids with or without a tooth-like base; 3) lobules swollen, flask-shaped, never reduced, with a narrowly elongate, curved tooth; 4) stems with a slightly thick-walled, brownish-colored epidermis. The new species seems to be most closely related to *L. paucidentata* (Steph.) Grolle, a species widespread in the Caribbean region where it is known from Cuba, Jamaica, the Dominican Republic, Puerto Rico, Guadeloupe and Dominica (Reiner-Drehwald & Goda 2000; Schäfer-Verwimp & van Melick 2016). The two species share toothed leaf lobes with a narrow base, small inflated lobules and small bifid underleaves (maximally $3 \times$ stem width) with entire margins and a cuneate to rounded base. *Lejeunea paucidentata* differs sharply from *L. ryszardii*, however, in the absence of caducous leaf lobes, the leaf margins with sharp teeth which are not terminating in a rhizoid, the absence of marginal rhizoids and papillate mamillae, the short, straight lobule tooth ($15-25 \mu\text{m}$ long), and the colorless, thin-walled stem epidermis (see Reiner-Drehwald & Goda 2000). Moreover, *L. paucidentata* is lighter green in color and autoicous, and usually copiously fertile; *L. ryszardii*, on the other hand, is only known from male plants and is probably dioicous. In its putative dioicy, *L. ryszardii* is similar to other asexually reproducing *Lejeunea* species of tropical America, all of which are dioicous (*L. cancellata* Nees & Mont., *L. concinnula*, *L. deplanata* Nees, *L. galeata* Spruce, *L. laetevirens* Nees & Mont., *L. oligoclada* Spruce, *L. phyllobola* Nees & Mont., *L. ptosimophylla* C. Massal., *L. rionegrensis* Spruce, *L. tapajosensis* Spruce) with exception of the autoicous *L. angusta* (Lehm. & Lindenb.) Mont.

Lejeunea ryszardii and *L. paucidentata* also differ in geographical distribution, *L. ryszardii* occurring in the Andes and *L. paucidentata* in the West Indies. The distribution of most neotropical *Lejeunea* species remains incompletely known (Reiner-Drehwald *et al.* 2013), however, and *L. ryszardii* and *L. paucidentata* may thus well be more widely distributed than is currently known and have overlapping ranges. Indeed, several Caribbean species extend to the Andes of Colombia, for example *Alobiellopsis dominicensis* (Spruce) Fulford, *Bazzania eggersiana* Steph. Pagán, *Ceratolejeunea rubiginosa* Steph., *Cheilolejeunea lineata*, *Cololejeunea antillana* Pócs, *Drepanolejeunea evansii* Bischl., *Fuscocephaloziopsis biloba* (Herzog) Fulford, *Harpalejeunea tridens* (Besch. & Spruce) Steph., *Lejeunea bermudiana* (A. Evans) R.M. Schust., *Lepidozia patens* Lindenb., *Marchantia inflexa* Nees & Mont., *Nowellia evansii* Grolle, *Plagiochila arcuata* Lindenb., *P. eggersii* Inoue, *P. husnotii* Steph., *Prionolejeunea ampliretis* Herzog, *P. arguta* (Nees) Steph., *P. trachyodes* (Spruce) Steph. and *Radula fendleri* Steph. (Gradstein & Uribe 2016; Gradstein unpubl.). The occurrence of *L. paucidentata* in Colombia, or *L. ryszardii* in the West Indies, may therefore be possible.

***Rectolejeunea halinae* Gradst. & Ilkiu-Borges sp. nov.**

Fig. 2

DIAGNOSIS: *Leaf apex predominantly acute to apiculate to shortly acuminate. Ocelli present in leaves and underleaves. Caducous leaves with cilia. Underleaves on flagella flat, with entire margins.*

TYPE: Colombia, Cordillera Occidental, Department Risaralda, Mistrato, along trail from Jeguadas to Puerto de Oro, ca. 1200 m, submontane rainforest, on branches in the forest canopy, 27 July 1992, *Gradstein 8538* (holotype COL, isotypes GOET!, MG!, PC!).

EPONYMY: dedicated to Halina Bednarek-Ochyra at the occasion of her 60th birthday.

DESCRIPTION: **Plants** pale green, very small, to 6 mm long, ca. 1 mm wide, growing appressed flat to ascending, branched at the base of the stem, branching *Lejeunea*-type, shoot apex frequently terminating in a leafless flagellum with underleaves. **Stems** rather rigid, 80-90 μm in diameter, rounded in cross section, of 7-8 epidermal cells surrounding the same number of medullary cells, all stem cells thick-walled, walls colorless. **Leaves** imbricate, obliquely to widely spreading, insertion shortly J-shaped (Fig. 2E). Leaf lobes convex, asymmetrically obvate-oblong, 0.55-0.6 x 0.35-0.4 mm, becoming progressively smaller towards the base of the stem, length of insertion ca. 2/5 of leaf width, margins slightly crenulate, with or without a few blunt, rudimentary teeth, becoming ciliate in leaves at the base of the flagella, apex flat or recurved, acute to apiculate to shortly acuminate on well-developed leaves, rounded on small basal leaves. **Cells** subsodiametrical-hexagonal, small, 14-20 μm in midleaf, becoming slightly larger towards the base, walls uniformly thickened; oil bodies not seen; ocelli present in all leaves except in the small leaves at the stem base, 2-3(-4) large dark-brown ocelli present at the leaf base (2-3 \times larger than normal cells) and forming a short row, (1-)3-10 much smaller, pale-colored ocelli present scattered high up in the lamina, as large as normal cells or slightly smaller. Lobules ovate to ovate-oblong, 1.5-2 \times longer than wide, ca. 1/3 \times leaf length (ca. 1/2 \times leaf length in small leaves at the shoot base), inflated, becoming flattened towards apex, free margin inflexed in the lower half, flattened towards apex, cells of the free margin rectangular in the lower half, quadrate towards apex, the apex with a long, falcate tooth, 35-50 μm long, 3-4 \times longer than wide, thick-walled; lobule cells similar to lobe cells but smaller, ocelli lacking in the lobule; keel curved, making a wide angle with the ventral margin of the leaf lobe. **Underleaves** distant to subimbricate, flat and appressed to stem, orbicular to slightly longer than wide, ca. 0.25 mm long and 0.2-0.25 mm wide, 2-2.5 \times stem width, bifid to 2/5-1/2, apex of underleaf lobes acute, of 1-2 cells in a row, outer margins entire or bluntly angled, bases cuneate and shortly decurrent, insertion almost straight; cells similar to lobe cells but smaller; ocelli present, 2-5 per underleaf, similar to those in the leaf lamina (ocelli absent in small underleaves at the shoot base). **Vegetative reproduction** by caducous leaves produced on terminal flagelliform shoots; flagellar stems with 7-8 swollen epidermal cells surrounding the same number of medullary cells, all stem cells thin-walled; caducous leaves flat, without or with a highly reduced lobule, margin with 3-10 cilia consisting of a row of 1-5 quadrate to subrectangular cells tipped by a short rhizoid (rhizoid 1-4 \times longer than the cells of the cilia), base of the cilia 2 cells wide; cells of caducous leaves similar to those of leaf lobes but with slightly more pronounced trigones, ocelli in caducous leaves light brownish, 4-15 per leaf, scattered (sometimes 2 adjacent), large dark brown basal ocelli lacking; underleaves of flagella mostly appressed to the stem and with entire margins. **Gametocidia** not observed.

DISTRIBUTION AND HABITAT: *Rectolejeunea halinae* is only known from the type locality on the western slope of the Colombian Western Cordillera, in the department of Risaralda. The new species was growing in loose mats on canopy branches in submontane rainforest at about 1200 m, in a ramicolous bryophyte community rich in members of Lejeuneaceae including *Bryopteris filicina* (Sw.) Nees, *Ceratolejeunea cornuta* (Lindenb.) Steph., *Cyclolejeunea peruviana* (Lehm. & Lindenb.) A.Evans, *Drepanolejeunea biocellata* A.Evans, *Lejeunea flava* (Sw.) Nees, *Lepidolejeunea cordifissa* (Taylor) M.E.Reiner, *L. involuta* (Gottsche) Grolle, *Microlejeunea acutifolia* Steph., *Stictolejeunea squamata* (Willd.) Schiffn. and the newly described *Cheilolejeunea schiavoneana* M.E.Reiner & Gradst. (Gradstein & Reiner-Drehwald 2017b).

DISCUSSION: *Rectolejeunea* was recently reviewed by Reiner-Drehwald & Grolle (2012) who accepted five species in the genus: *R. berteriana* (Steph.) A.Evans (correct name: *R. versifolia* [Schiffn.] L.Soderstr. & A.Hagborg; see Söderström *et al.* 2015), *R. emarginuliflora* (Schiffn.) A.Evans, *R. flagelliformis* A.Evans and *R. truncatilobula* C.J.Bastos in tropical America, and *R. queenslandica* (B.M.Thiers) X.L.He in tropical Australia. However, *R. truncatiloba* was recently transferred to the new, monospecific genus *Yanoella* R.L.Zhu *et al.*, whereas *R. queenslandica* probably belongs to *Thiersianthus* R.L.Zhu *et al.*, a genus recently described from Borneo (Zhu *et al.* 2018). Reiner-Drehwald & Grolle (2012) listed two further species

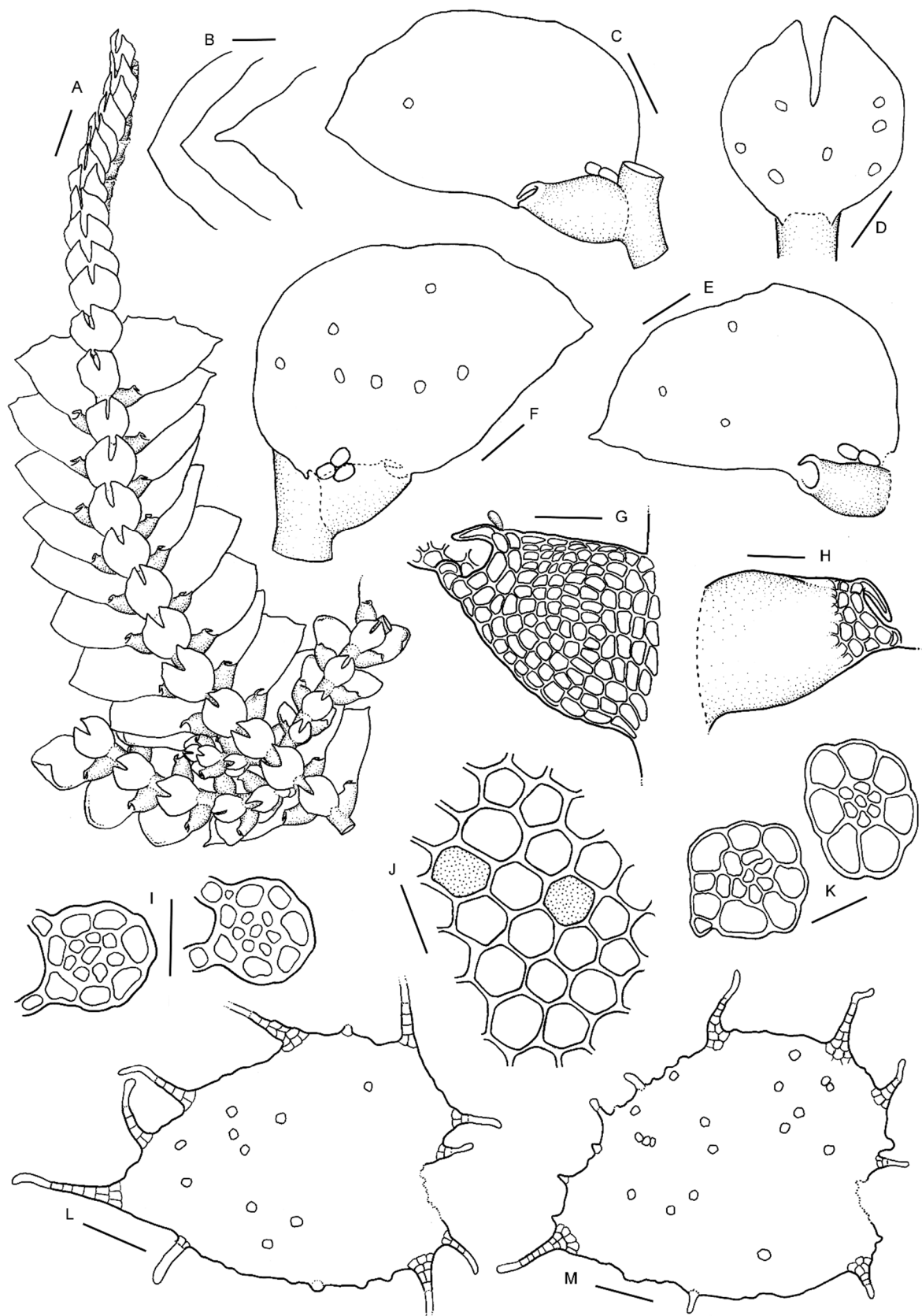


Fig 2: A-M – *Rectolejeunea halinae*. **A** – Habit with terminal flagelliform shoot producing caducous leaves. **B** – Leaf apices. **C** – Leaf, ventral view. **D** – Underleaf showing ocelli. **E** – Leaf, ventral view. **F** – Leaf, ventral view. **G-H** – Lobules. **I** – Cross section of a stem. **J** – Median cells of leaf lobe showing two ocelli. **K** – Cross section of stem from flagelliform shoots. **L-M** – Caducous leaves with cilia and rhizoids. (A= 250 μ m, B, G, H, I, K= 50 μ m; C, D, F, L, M= 100 μ m; J= 25 μ m).

as doubtful members of *Rectolejeunea*, *R. colombiana* R.M.Schust. and *R. intermedia* R.M.Schust. (both from Colombia), but according to Zhu *et al.* (2018) both species must be excluded from *Rectolejeunea*. *Rectolejeunea colombiana* has *Lejeunea*-type innovations and belongs in the genus *Lejeunea* (Zhu *et al.* 2018); probably it is a synonym of *L. phyllobola* Nees & Mont. (Gradstein, unpubl.). *Rectolejeunea intermedia*, on the other hand, has ocelli and is probably conspecific with *Otionirolejeunea huctumalcensis* (Gradstein, unpubl.).

As a result, only four species remain in *Rectolejeunea*, *R. emarginuliflora*, *R. flagelliformis*, *R. versifolia* and the here described *R. halinae*; all four are restricted to the Neotropics. The main features of the genus are: 1) plants very small, often less than 1 mm wide; 2) lobules ca. 1/4 of leaf length, strongly inflated, with a truncate apex and a long, falcate tooth (tooth occasionally short in *R. emarginuliflora* and *R. versifolia*); 3) leaf cells very small, less than 20 µm long in midleaf, with thin or uniformly thickened walls, trigones absent, cuticle smooth, oil bodies in normal leaf cells usually absent; 4) ocelli present at leaf base and scattered through the leaf lobe, sometimes also present in underleaves (*R. emarginuliflora*, *R. halinae*); 5) vegetative reproduction by small caducous leaves produced on specialized flagelliform shoots. Species with caducous leaves produced on unspecialized shoots, many of which were assigned to *Rectolejeunea* in the past (see Schuster [2000] and Reiner-Drehwald & Grolle [2012]), are excluded from the genus.

The new species *R. halinae* is readily recognized by the pointed leaf apex (acute to apiculate to shortly acuminate). In all other *Rectolejeunea* species the leaf apex is rounded; exceptionally, leaves just below the flagelliform shoot in *R. flagelliformis* have pointed tips. The latter species shares the presence of ciliate caducous leaves with *R. halinae* and shows greatest similarity to the new species. Indeed, *R. halinae* was tentatively identified as *R. flagelliformis* by Reiner-Drehwald & Grolle (2012, p. 458). *Rectolejeunea flagelliformis* clearly differs from *R. halinae*, however, by the absence of ocelli in underleaves, the flagelliform branches with squarrose underleaves with toothed margins, and the mostly rounded leaf tips. The two species possibly differ also in sexuality as *R. flagelliformis* is autoicous, and is usually copiously fertile, whereas *R. halinae* lacks gametocidia and may be dioicous.

Acknowledgments: The first author is indebted to Alfons Schäfer-Verwimp for information on *Lejeunea paucidentata* and for making specimens available for study, to Carlos Agudelo-H. (Universidad del Quindío, Colombia) for organizing fieldwork of the first author in the Central Cordillera of Colombia in 2018, and to the National Geographic Society (grant # 46 91-91 to the late J.-P. Frahm) for supporting fieldwork in the Western Cordillera of Colombia in 1992.

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