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## *Frullania hohenesteri* (Marchantiophyta: Frullaniaceae) – a new species from Santa Catarina, South Brazil

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**Abstract:** Schäfer-Verwimp, A. & Winter, G. (2023): *Frullania hohenesteri* (Marchantiophyta: Frullaniaceae) - a new species from Santa Catarina, South Brazil. *Frahmia* **39**:1-14\*.

*Frullania hohenesteri* is described and illustrated from Santa Catarina, South Brazil. It belongs to the subgenus *Trachycolea* sect. *Irregulares* because of its peculiar flattened and smooth perianth with two lateral keels. This unique feature makes it unmistakable among Neotropical or New World *Frullania* species, and it represents the first record of sect. *Irregulares* for the New World. The new species is compared with members of sect. *Irregulares*, previously known only from Australasia and New Guinea. *Frullania patula* is excluded from sect. *Irregulares*, and *F. morobensis* is considered doubtful to belong here.

**Key words:** *Trachycolea*, section *Irregulares*, new species, new record, sporophyte, stem cross section



Fig. 1. Habitus of *Frullania hohenesteri*

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## 1. Introduction

The genus *Frullania* is one of the most species rich genera of liverworts with worldwide 675 currently accepted taxa, 87 of these belong to variety or subspecies level, and 115 are categorized with one star, the lowest taxon confidence level ("serious doubts about the value of the taxon") (Söderström et al. 2016). The *Frullania* flora of Brazil is comparatively well known. Lima (2019) treated 34 species in seven subgenera (*Chonantheria*, *Diastaloba*, *Trachycolea* [as *Frullania*], *Homotropantha*, *Frullania* [as *Thyopsiella*], *Meteoriopsis* and *Saccophora*) including one new species which was later on published as *F. amazonica* E.Lima, Ilk.-Borg. et Gradst. (Lima et al. 2020). *Frullania curvilobula* Schäf.-Verw., D.F.Peralta et S.M.Siqueira is another species from Brazil described in recent times (Schäfer-Verwimp et al. 2012). Now, another new species of *Frullania* came to light, collected during the 6-years-stay of the first author with his wife in Brazil, which still was hidden more than 30 years among unidentified specimens. We describe and illustrate it as *Frullania hohenesteri* sp. nov.

## 2. Description of the new species

*Frullania hohenesteri* Schäf.-Verw. et Gerh.Winter, sp. nov.

*Frullania*, subgen. *Trachycolea* sect. *Irregulares* E.A.Hodgs. ex S.Hatt. 1983

Figs. 1-18 (all figures from isotype in FR)

**Diagnosis:** The new species is characterized by the following combination of characters: (1) small to medium sized plants, 2-3 cm long, 1.5-1.8 mm wide with leaves (when flattened), (2) stem clearly corticated in cross section, (3) leaf lobes with semirobund dorsal appendage and a small group of enlarged and coloured basal cells, (4) leaf lobules of *Trachycolea*-type with usually strongly flaring mouth, (5) medium leaf cells elongate and sinuate due to large knot-like trigones and intermediate thickenings, the walls dark brown, and (6) flattened and ventrally concave perianth with two lateral keels.

**Etymology:** The new species is named in honour of Prof. Dr. Adalbert Hohenester (1919-1999), Professor of Geobotany at the University of Erlangen-Nürnberg and the second author's revered teacher, who introduced him to the wonderful world of bryophytes, especially to *Frullania*.

**Type:** BRAZIL. Santa Catarina: Serra do Rio do Rastro, Urubici, Waldweide an der Straße zum Morro da Igreja, epiphytisch bei 1650 m [above sea level]; ca. 28°03' S, 49°24' W, 31. Dezember 1990, leg. Schäfer-Verwimp & Verwimp 13564/A [Holotype: JE; isotypes: FR, SP, CAS].

**Plants** light to dark brown to blackish in herbarium (Fig. 1); shoots 1.5 - 1.8 mm wide (when flattened), irregularly pinnately to bipinnately branched, branches obliquely to nearly horizontally spreading, 1.5-10 mm long, longer branches branched again.

**Stems** 2-3 cm long, in cross section 180-220 µm wide, 150-210 µm high, ventrally ±flattened, sometimes ±pentagonal with rounded edges, 9-11 cells high, 10-13 cells wide, with prominent cortex of 1(-2) rows of strongly thickened cells with dark brown walls, ca 15-18 x 15-18 µm, rounded-quadrate to elongate, ± sharply separated from irregularly ±polygonal hyaline medullary cells with strongly thickened ±pellucid to light brown walls, 10-20 x 10-27 µm (Fig. 2).

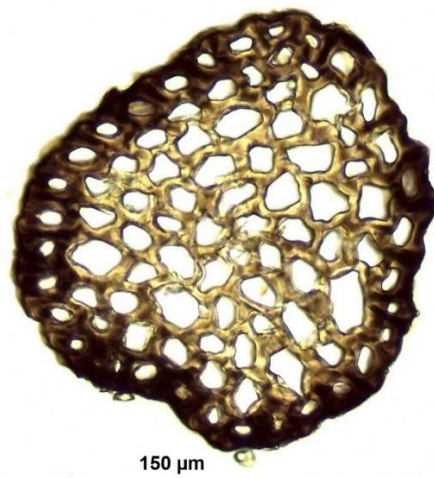


Fig. 2. Cross-section of stem

**Lobes** of stem leaves imbricate, widely spreading, dorsally extending 1-1.5(-2) x stem width beyond the farther edge of stem, slightly to strongly concave (if seen from ventral side when moist), shortly oblong-ovate with widely rounded and usually narrowly incurved apex and  $\pm$ semicircular appendage at dorsal base (Figs. 3 & 6), 1.0-1.2 mm long and 0.8-0.95 mm wide.

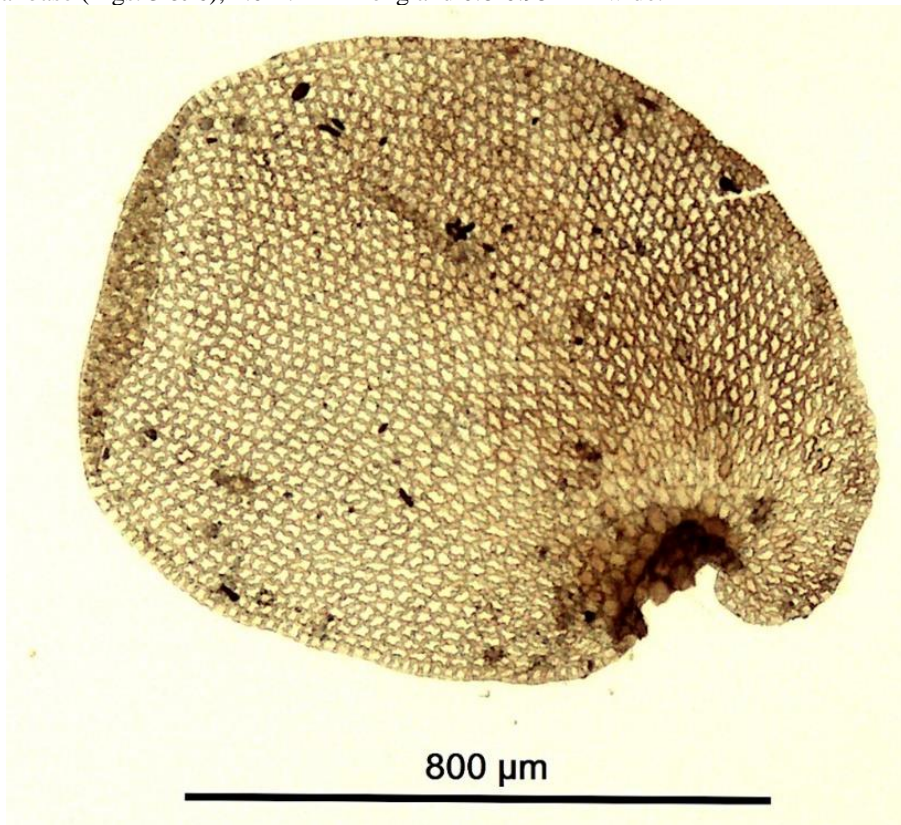


Fig. 3. Stem leaf lobe

Marginal **cells of leaf lobe** (sub-)quadrate to short rectangular, 15-18 x 15-20  $\mu\text{m}$ , trigones small; median cells irregular in shape, subquadrate to mostly elongate, 17-30 x 15-20  $\mu\text{m}$ , the walls dark brown and sinuate due to large knot-like trigones and intermediate thickenings (Fig. 4); a small group of (ca 20-30) basal cells enlarged, up to 33 x 60  $\mu\text{m}$ , conspicuously coloured, with thickenings similar to central leaf cells (Fig. 5).

Oil bodies not seen

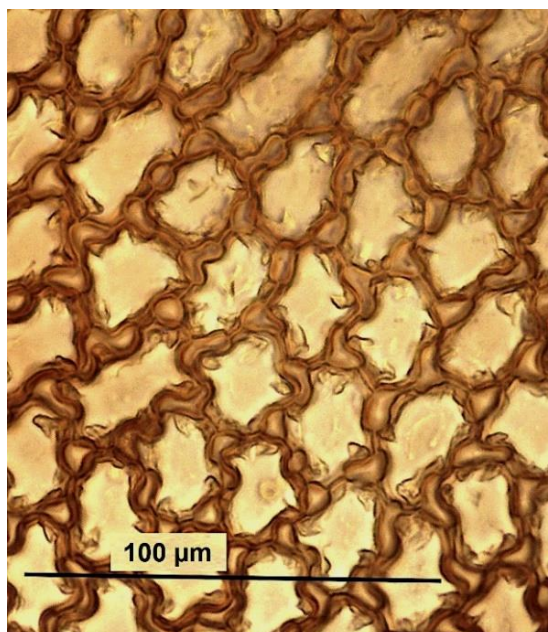


Fig. 4. Median cells of leaf lobe

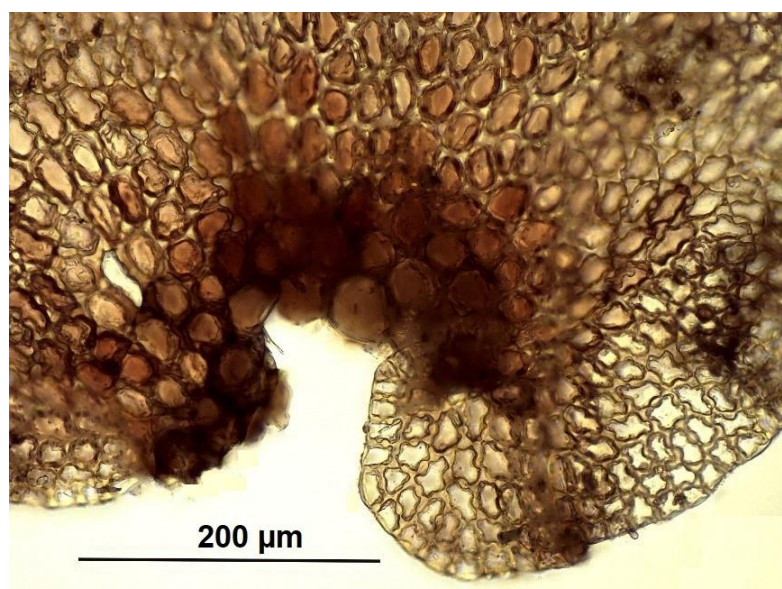


Fig. 5. Basal cells of leaf lobe

**Leaf lobules** of stem leaves 1.2-1.5 x longer than wide, campanulate, often strongly flaring at the mouth (Fig. 6 & 7), mouth directed to the base to slightly spreading from the stem, upper part often overlapping the stem, 270-280  $\mu\text{m}$  wide at junction with the flaring part, 350-360  $\mu\text{m}$  wide at mouth, 360-400  $\mu\text{m}$  long, the marginal cell row(s) of the mouth sometimes appearing  $\pm$ hyaline; cells irregular in outline, usually longer than wide, walls sinuose due to strongly thickened knotlike trigones and intermediate thickenings, cell walls and thickenings dark brown, 14-16 x 18-22  $\mu\text{m}$ . Leaf lobules of branch leaves somewhat smaller than those of stem leaves and becoming even smaller towards branch apex, more often contiguous to imbricate than distant, the mouth oriented to the base or more often spreading up to 45° from the stem, upper part partly or wholly overlapping the stem, often contiguous or even imbricate with the lobule of the opposite leaf, often  $\pm$ flattened to the mouth, more strongly so than in stem leaf lobules, sometimes appearing  $\pm$ helmet-shaped because of unequally flattened lower part.

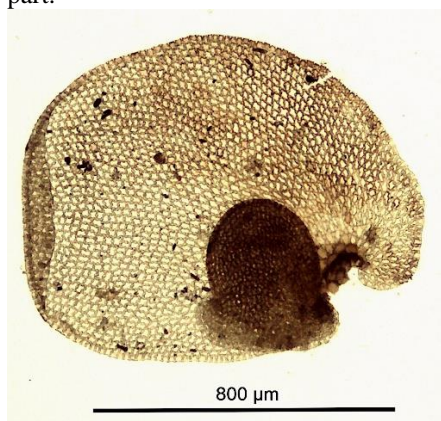


Fig. 6. Stem leaf with lobule

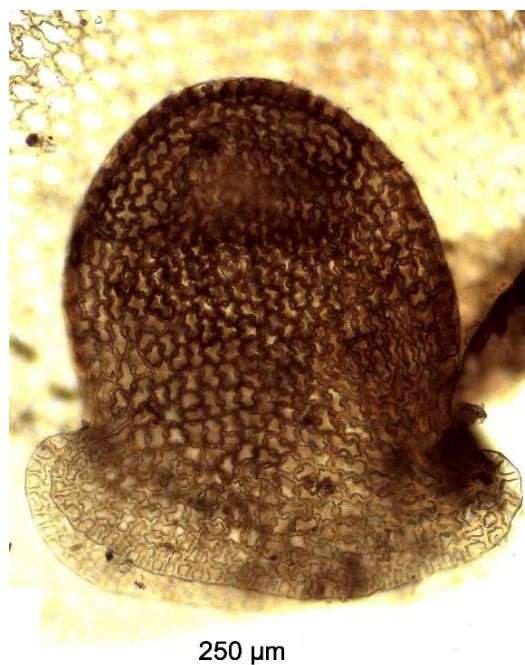


Fig. 7. Lobule of stem leaf

**Stylus** small, triangular, 3(-4) cells [38-64  $\mu\text{m}$ ] wide at base and 3(-4) cells [41-51  $\mu\text{m}$ ] high (Fig. 8).



Fig. 8. Stylus

**Hemiphyll** deeply divided, one lobe smaller [209  $\mu\text{m}$  wide, 425  $\mu\text{m}$  long], broadly ovate-lanceolate, the other lobe  $\pm$  rectangular [213  $\mu\text{m}$  wide, 536  $\mu\text{m}$  long], apically slightly incised and inner “lobe” with a horn-like prolongation (Fig. 9); first branch leaf ovate-lanceolate, small with a normal lobule.

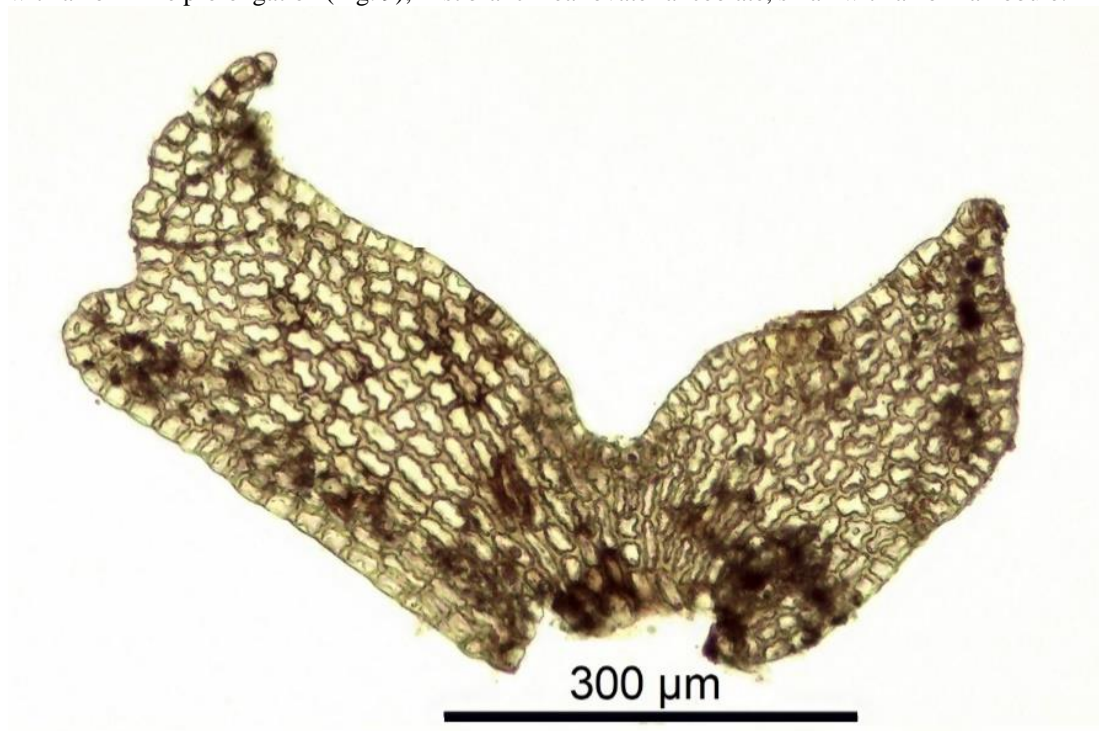


Fig. 9. Hemiphyll

**Stem underleaves** slightly remote to contiguous to slightly imbricate, obovate-obcuneate, strongly narrowed to the cuneate base thus appearing stipitate (Fig. 10), 740-850  $\mu\text{m}$  long, 600-650  $\mu\text{m}$  wide at widest part above middle, at base 150-170  $\mu\text{m}$ , sinus V-shaped to more rarely U-shaped, the lobes  $\pm$ triangular, acute to narrowly obtuse, ending in one cell or two cells side by side, occasionally with 1-2 lateral teeth or  $\pm$ obtuse lobes, rhizoids occasionally strongly developed, up to 15  $\mu\text{m}$  wide, very finely papillose, originating in bundles from central part; branch underleaves similar but generally smaller.

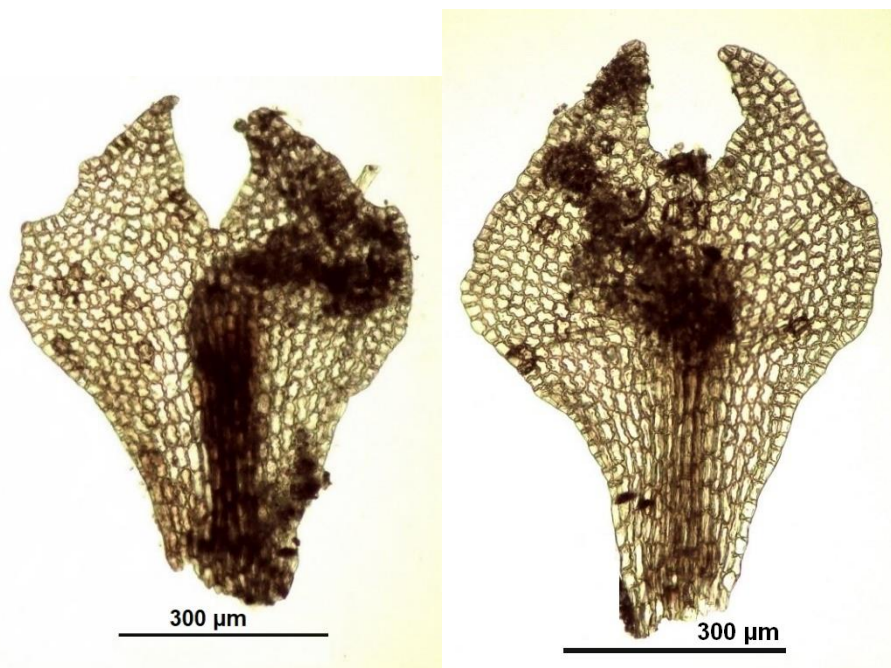


Fig 10. Stem underleaves

**Dioicous or autoicous** (only two plants with androecia seen, one dioicous and one autoicous). **Androecia** lateral on stem and branches, very short, usually overtopping stem leaves, (600-)900-1500  $\mu\text{m}$  long, 480-850  $\mu\text{m}$  wide, (3-)4-6 pairs of bracts (Fig. 11), lobes and lobules broadly rounded, the lobe laterally with one obtuse tooth, the cells with triangular trigones and occasional intermediate thickenings; one basal bracteole, obovate, shallowly bilobed.



Fig. 11. Androecia

**Gynoecea** terminal on primary and secondary branches, usually innovating below, bracts in 3 pairs; **innermost bract** lobe widely ovate, apex rounded to subacute, margin smooth, 1.3-1.5 mm long, 1 mm wide, lobule highly connate with the lobe ( $\pm 0.4-0.6$  lobe length), lanceolate,  $\pm$ as long as lobe, 350-400  $\mu\text{m}$  wide at junction with the lobe, apex acute-acuminate, sometimes apiculate, the margin sparingly toothed, lobed or with one lacinia up to 30 cells long and 2-3 cells wide at base, cells elongate with dark brown walls and strongly nodulose trigones; **innermost bracteole** connate with bract lobules for several cells (difficult to see; the second-innermost bracteole only slightly so) with an  $\pm$ ovate base and long ciliate-like lobes, up to 1 mm long (from connate base to apex), 200-250  $\mu\text{m}$  wide at junction with bract lobules, the lobes 2-4(-5) cells wide at base, 20 cells long, ending in an uniseriate tip of 5-12 cells, crowned by a hyaline papilla (Fig. 12).

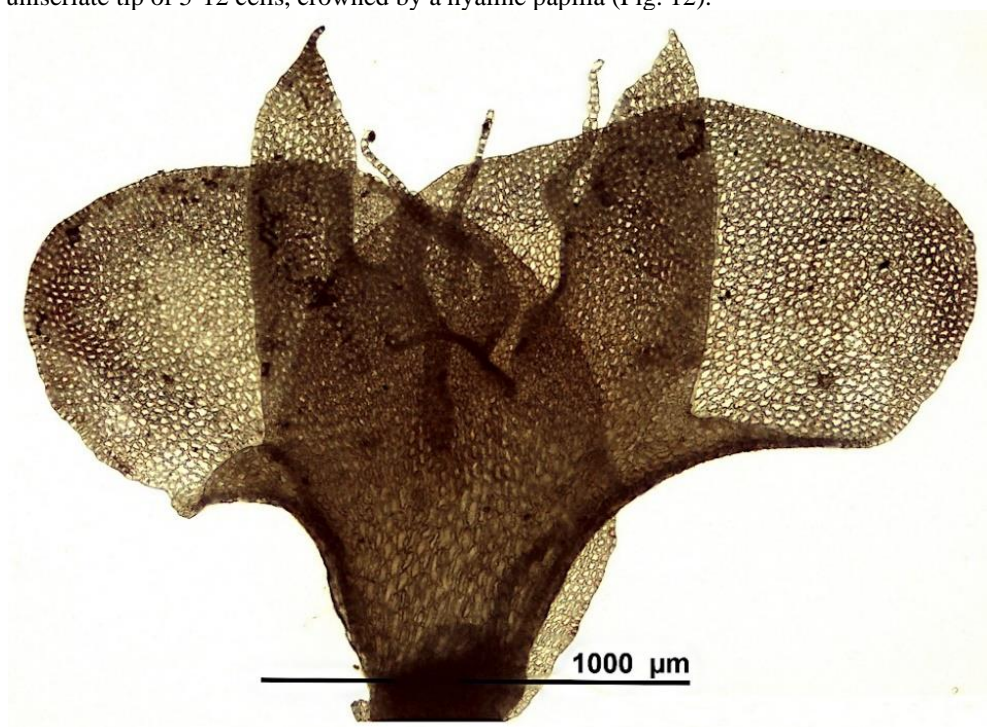


Fig. 12. Innermost bract and bracteole

**Perianth** obovate-oblong, up to half exserted, dorsiventrally flattened and ventrally concave, in cross section nearly semi-circular (Fig. 13), with two lateral blunt keels (no trace of any further keel), keels and surface smooth, 2.0-2.5 mm long, 0.9-1.2 mm wide in situ (1.4-1.6 mm wide when flattened), slightly retuse at apex, beak conspicuous, 170-180  $\mu\text{m}$  long, 100  $\mu\text{m}$  wide (Fig. 14).



Fig 13. Perianth cross section



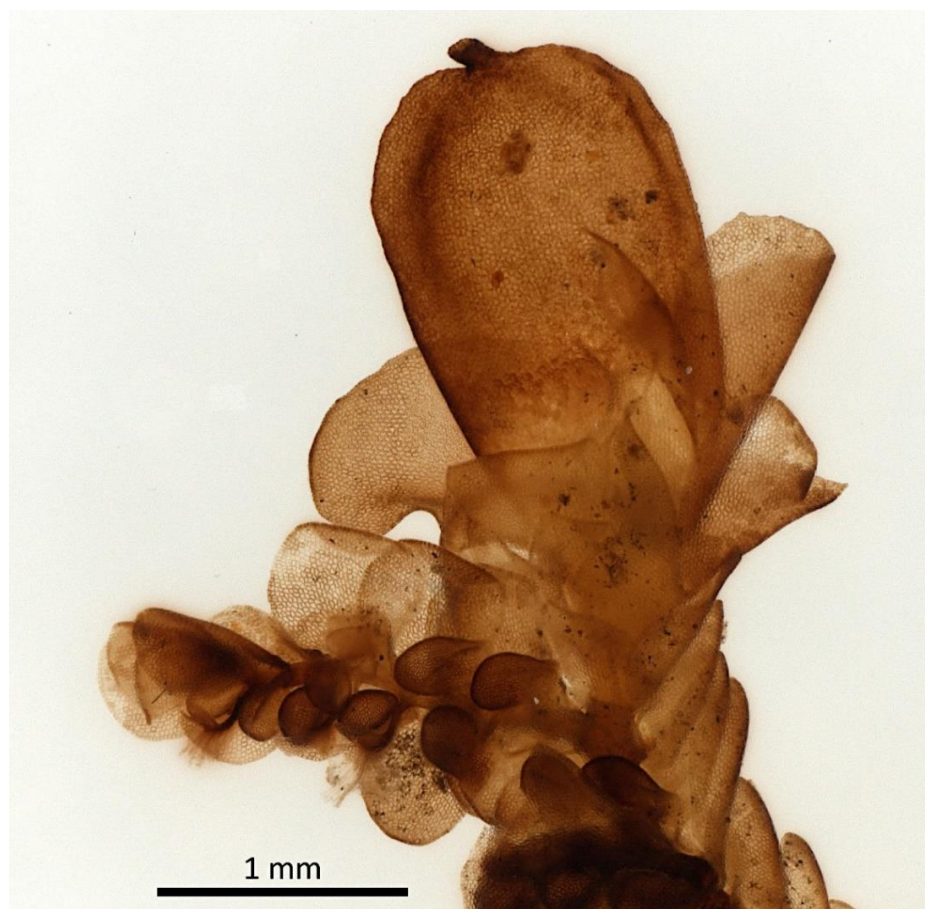


Fig 14. Perianth, ventral view

**Sporophyte** globular, 1mm wide, 0,9-1,0 mm high, seta 250  $\mu\text{m}$  wide (at middle), in cross section of upper part 340 x 300  $\mu\text{m}$ , with 32 marginal and 32 medullary cells, inner cells  $\pm$  polygonal, 34-38 x 40-45  $\mu\text{m}$ , cell walls thin with small trigones, marginal cells more rounded-(sub-)quadrate and slightly smaller, partially collapsed.

**Elaters** unispiral, 350-500  $\mu\text{m}$  long, 20-23  $\mu\text{m}$  wide, finely and densely papillose, the spiral 5  $\mu\text{m}$  in diameter (Fig. 15); 90 elaters per capsule, in one valve 22 elaters (2+4+6+6+4) (Fig. 16), in the alternating valve 23 elaters (1+3+5+6+6+2) could be observed (the numbers of the lower rows of the alternating valve with some uncertainty) (Fig. 17).

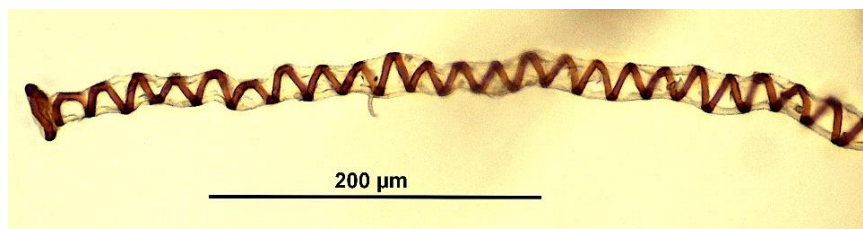


Fig 15. Elater

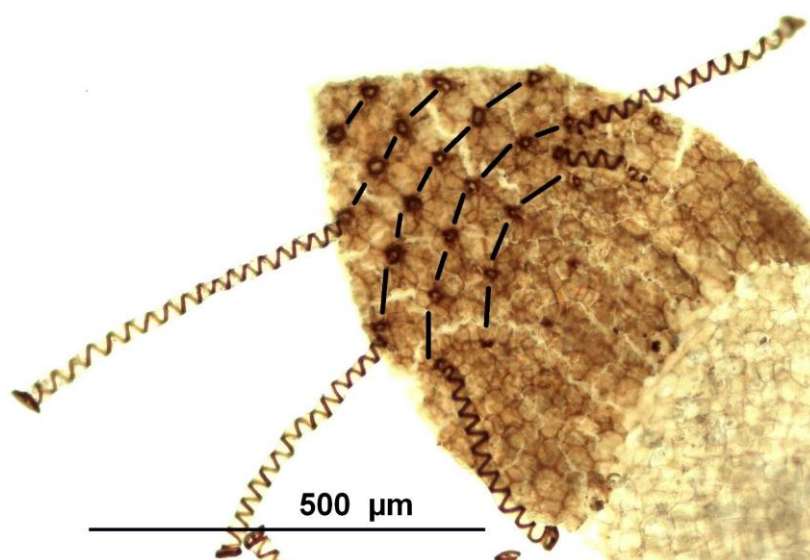


Fig 16. Capsule valve showing the pattern of elater insertion of 22 elaters

Weis (2001) mentioned shorter elaters of *Frullania* being (110-)150-250(-340) μm long and 15-20 μm in diameter; Schuster (1992: 19) reported on the numbers of elaters per valve being nearly constant within the species, in some species of subgen. *Trachycolea* large numbers (24 per valve in *F. dilatata* (L.) Dumort., 31-32 in *F. ericoides* (Nees) Mont.), in other members of *Trachycolea* small numbers (*F. sabaliana* R.M.Schust. with 15-17 elaters per valve, *F. oakesiana* Austin 8-10 per valve).

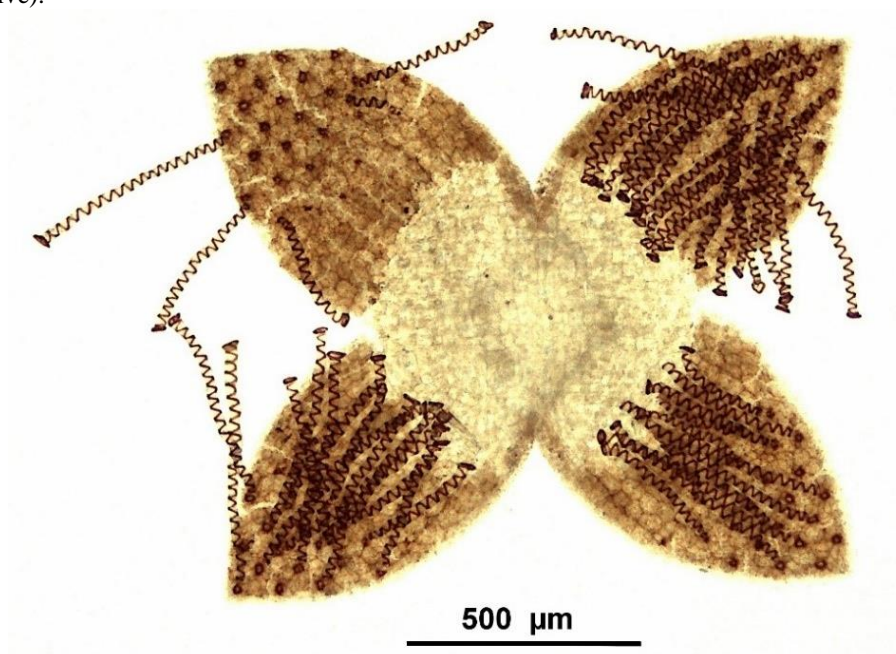


Fig 17. Capsule valves, flattened out with elaters

Outer cells of capsule valve with strong,  $\pm$ cylindrical or cone-shaped yellowish thickenings (Fig. 18) and two small groups of deep brown thick walled cells around the sinus of two opposed valves.

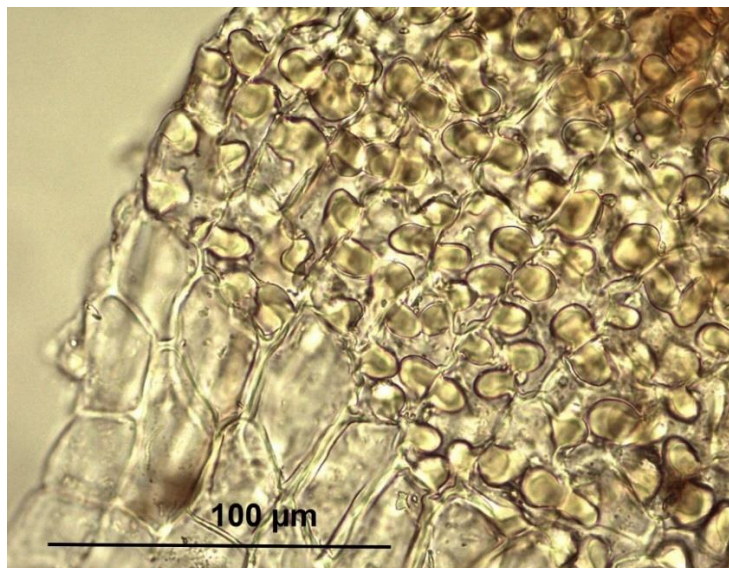


Fig. 18. Outer cells of capsule valve

No spores seen.

Vegetative reproduction not seen.

### 3. Distribution, habitat and associated species

*Frullania hohenesteri* is so far known only from its type from the Serra do Rio do Rastro in Santa Catarina, South Brazil. It represents the first species of *F.* subgen. *Trachycolea* sect. *Irregulares* for the New World, further members of this section are known only from Australasia and New Guinea.

It was growing appressed to bark of hardwood tree in humid but rather open secondary forest used as pasture for cattle, along the road to Morro da Igreja at an altitude of 1650 m above sea level. Frequent occurrence of fog and trees of only a few meters of height favoured a forest rich in liverworts, mosses and lichens.

Several liverworts, among these *Frullania beyrichiana* (Lehm. et Lindenb.) Lehm. et Lindenb., *Harpalejeunea subacuta* A.Evans, *Cheilolejeunea xanthocarpa* (Lehm. et Lindenb.) Malombe, *Diplasiolejeunea replicata* (Spruce) Steph., *Microlejeunea bullata* (Taylor) Steph. and *M. cystifera* Herzog were growing mixed with *Frullania hohenesteri*.

Furtheron, *Schlotheimia tecta* Hook. et Wils., *Frullania setigera* Steph., *Cololejeunea verwimpfi* P.Tixier, *Drepanolejeunea araucariae* Steph., *Brachiolejeunea laxifolia* (Taylor) Schiffn., *Lepidozia brasiliensis* Steph. with admixed *Clasmatocolea vermicularis* (Lehm.) Grolle, *Orthostichella pachygastrella* (Müll. Hal.) B.H.Allen et W.R.Buck, *Fissidens crispus* Mont., *Porotrichodendron superbum* (Taylor) Broth., *Sematophyllum swartzii* (Schwägr.) W.H.Welch et H.A.Crum with some shoots of *Phyllogonium viride* Brid., *Syzygiella concreta* (Gottsche) Spruce, *Trichocolea brevifissa* Steph., *Herbertus juniperoides* subsp. *acanthelium* (Spruce) Feldberg et

Heinrichs, *Leptoscyphus porphyrius* (Nees) Grolle, *Microlejeunea squarrosa* (Steph.) Heinrichs, Schäf.-Verw., Pócs et S.Dong, *Isopterygium subbrevisetum* (Hampe) Broth., and *Orthotrichum araucarieti* Broth. are growing in the vicinity of a few meters and have been collected at the same place.

**4. Comparison with species of *Frullania* subgen. *Trachycolea* sect. *Irregulares* E.A.Hodgs. ex S.Hatt., J. Hattori Bot. Lab. 54: 143, 1983 (Hattori 1983).**

Söderström et al. (2016) listed the following five species belonging to sect. *Irregulares* (their geographical range and some remarks are added in brackets):

*Frullania astrolabea* Steph., Sp. Hepat. (Stephani) 4: 460, 1910. [In footnote 209: "possibly conspecific with *Frullania scandens*"] ["Hawai (Expeditio "Astrolabe")"; Astrolabe did not visit Hawai, but Tavai in South New Zealand].

*Frullania deplanata* Mitt., Bot. antarct. voy. II (Fl. Nov.-Zel. 2): 161, 1855. [Australia (VIC, NSW), Tasmania, New Zealand incl. Auckland Isl. and Campbell Isl.].

*Frullania morobensis* S.Hatt. et Streimann, J. Hattori Bot. Lab. 59: 109, 1985. [New Guinea - known only in sterile condition].

†*Frullania patula* Mitt., Bot. antarct. voy. II (Fl. Nov.-Zel. 2): 159, 1854. [Campbell and Snares Isl, New Zealand].

*Frullania scandens* Mont., Ann. Sci. Nat. Bot. (sér. 2) 19: 258, 1843. [Australia (VIC), Tasmania, New Zealand (North Isl, South Isl), Campbell Isl., Antipodes Isl. and Auckland Isl. (New Zealand), Stewart Isl.]

As *F. astrolabea* possibly is conspecific with *F. scandens* und *F. patula* with its terete perianth may be disregarded for comparison, we compare our new species only with *F. deplanata*, *F. scandens* and *F. morobensis*.

The latter one is known only in sterile condition and it seems questionable to us that *F. morobensis* in fact belongs to this section before the perianth is found. Apart from this it is unmistakable by its reniform, only 1/5 bifid underleaves as well as by its large, inflated, highly galeate lobules with elongate beak (Hattori & Streimann 1985). The authors of *F. morobensis* placed it correctly in subgen. *Trachycolea*, however, not in sect. *Irregulares*.

*Frullania deplanata*, the type species of sect. *Irregulares*, seems to be similar to *F. hohenesteri* in its overall aspect, especially its size, leaf lobes and perianth; however, it is a dioicous species and readily distinguished by the widely obovate underleaves and the falcate-galeate lobules only 150-

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† As sect. *Irregulares* with its type species *Frullania deplanata* is defined by its smooth, dorsiventral flattened perianth with two lateral keels (compare Hattori 1983: 143, "A aliis sectionibus subgen. *Trachycolea* differt perianthiis dorsiventrals valde deplanata, cum carinis lateralibus, laevibus"), we consider *Frullania patula* with its terete and completely keel-less perianth as a member of subgen. *Trachycolea*, however, not belonging to sect. *Irregulares*, despite it forms a moderately supported monophyletic lineage together with *F. deplanata* and *F. scandens* (Hentschel et al. 2009).

250 µm long (Hattori 1983, with figs. 53-54). In *F. hohenesteri* underleaves are stipitate and the lobules campanulate, 360-400 µm long.

*Frullania scandens* is also dioicous and a somewhat larger species; it is further on readily separated from our new species by widely orbicular, only 1/5 bifid underleaves and very large, asymmetric, galeate and strongly inflated leaf lobules (Hattori 1983, with fig. 65); it is different also by the leaf lobe with non-appendiculate bases (dorsal base with semirobund appendage in *F. hohenesteri*).

None of these three species seems to have the coloured group of enlarged basal cells, campanulate leaf lobules, and the stipitate underleaves of *F. hohenesteri*. Remarkable, too, seems to be the stem cross section with rather sharply delimited cortex, unusual (or even unknown) in the genus *Frullania* (Schuster 1992). However, stem cross sections in sect. *Irregulares* are still not known.

Own observations in stem cross sections of *Frullania deplanata* (specimen Schäfer-Verwimp & Verwimp 13813 from New Zealand, North Island, Mount Egmont, 18. Jan. 1991) also showed clear cortication by one row of smaller, strongly thick-walled (especially outer cell walls) and dark brown cells, though less sharply delimited against the larger medullary cells which are usually thick-walled, only rarely thin-walled on one side with a neighbouring cell; the medullary cells are hyaline with light-brown walls in contrast to the dark brown cell lumens and walls of the cortical cell row. Also, *Frullania scandens* (specimen Schäfer-Verwimp & Verwimp 14302, New Zealand, South Island, Arthur's Pass, 5. Febr. 1991) revealed a clearly corticated stem in cross section with one row of smaller, dark brown and strongly thick-walled cells similar as in *F. deplanata*.

## 5. Conclusion

Though it seems surprising to find a member of *Frullania* sect. *Irregulares* in South Brazil, the bryogeographical connection between Australasia, (South Africa), and southern South America is not a rare pattern and is evidenced on genus level, for example by genera like *Balantiopsis*, *Isotachis*, *Lepicolea*, *Lethocolea*, *Triandrophyllum*, *Leptostomum*, *Lepyrodon*, *Notoligotrichum* and *Ptychomnion*, but also by species like *Clasmatocolea humilis* (Hook.f. et Taylor) Grolle, *C. vermicularis* (Lehm.) Grolle, *Blindia magellanica* Schimp. ex Müll.Hal., *Chrysoblastella chilensis* (Mont.) Reimers, and others. Such Gondwana species often have isolated disjunct occurrences in the mountains of Southeast and South Brazil and/or at higher altitudes of the tropical Andes (Schuster 1984; Vanderpoorten et al. 2010). However, so far no single member of *Frullania* sect. *Irregulares* is known from southern South America or even the New World, and our new species represents an extraordinary extension of its range.

## 6. Acknowledgements

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