

Flora of Singapore precursors, 41: Taxonomic updates on the moss genus *Ectropothecium* and allied genera (Hypnaceae)

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ABSTRACT. Eight species of *Ectropothecium* Mitt. previously reported and misapplied in Singapore have been critically investigated, which resulted in different reinterpretations and taxonomic reshufflings of several taxa, and discovery of new records for Singapore. Two native species, *Ectropothecium monumentorum* (Duby) A.Jaeger and *E. tutuilum* (Sull.) Mitt. (with *E. ichnotocladum* (Müll.Hal.) A.Jaeger and *E. moritzii* A.Jaeger as newly proposed synonyms) remain recognised in the genus. *Ectropothecium stigmophyllum* Broth. is a non-native species newly recorded in Singapore. *Ectropothecium singaporense* Dixon is transferred to *Calohypnum* Sakurai as *C. singaporense* (Dixon) S.He & B.C.Ho, and continues to be treated as a species endemic to Singapore. *Ectropothecium buitenzorgi* auct. non (Bél.) Mitt. and *E. incubans* auct. non (Reinw. & Hornsch.) A.Jaeger were misapplied names for the native *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho. *Crepidophyllum modestum* Herzog (reported for the first time with sporophytes for the genus) is a non-native record new to the country. *Calohypnum*, *Crepidophyllum* Herzog and *Neoptychophyllum* S.He represent new generic names for Singapore. *Ectropothecium intorquatum* (Dozy & Molk.) A.Jaeger and *E. zollingeri* (Müll.Hal.) A.Jaeger are excluded from Singapore. Additionally, *Ectropothecium sodale* (Sull.) Mitt. was found only in cultivation; thus, it is not treated in the flora. Lectotypes are designated for *Ectropothecium moritzii* A.Jaeger, *E. moritzii* var. *stereodontoides* Dixon, *Hypnum ichnotocladum* Müll.Hal., and *Hypnum monumentorum* Duby. New combinations are proposed in *Calohypnum* and *Neoptychophyllum*.

Keywords. Bryophytes, *Calohypnum*, *Crepidophyllum*, *Hypnum*, *Neoptychophyllum*, pleurocarpous moss

Introduction

Ectropothecium Mitt. is a genus of pleurocarpous mosses mainly found in tropical and subtropical forests, with a strong tendency for insular distribution. The genus currently comprises approximately 210 accepted species (Brinda & Atwood, 2023) and presents one of the most challenging taxonomies among hypnalean mosses (Whittier, 1976; Iwatsuki, 1992; Higuchi & Iwatsuki, 1994). As initially established and described by Mitten (1868), *Ectropothecium* was mainly characterised by regularly and closely

pinnately prostrate stems, falcate-secund leaves with double costae, linear, often prorate laminal cells, inconspicuously developed alar regions, elongate setae, tiny capsules, and a perfect “hypnoid” peristome. With this circumscription, *Ectropothecium* morphologically resembles some species of *Calohypnum* Sakurai, *Crepidophyllum* Herzog, *Hypnum* Hedw. s.l., *Isopterygium* Mitt., *Taxiphyllum* M.Fleisch., and *Vesicularia* (Müll.Hal.) Müll.Hal.

So far, *Ectropothecium* has not been found in North America, Europe, Russia, and Central, West, and northern North Asia. Apart from a few recent regional floristic treatments that included a limited number of species from China, India, Japan, Mexico, Central America, New Caledonia, and Uganda (Gangulee, 1980; Higuchi & Iwatsuki, 1994; Nishimura & Ando, 1994; Noguchi et al., 1994; Hedenäs, 2005; Zhang & He, 2005; Allen, 2018), no worldwide monograph on *Ectropothecium* has been published. Despite the large number of published *Ectropothecium* species, few studies have attempted to revise them taxonomically. The systematics of *Ectropothecium* is far from resolved, and further studies are sorely needed. For example, out of the 18 reported *Ectropothecium* species in New Caledonia, Higuchi & Iwatsuki (1994) recognised only three species after their revision; 11 names were reduced to synonymy, and four were excluded from this French territory.

A comprehensive taxonomic review of *Ectropothecium* was presented by He (2019), with an emphasis on defining its generic limits. In doing so, he reinstated *Neoptychophyllum* S.He, a new name replacing the later homonym *Ptychophyllum* Broth., which was formerly considered a generic synonym of *Ectropothecium* (Nishimura, 1984). A recent revised plant checklist of Singapore (Lindsay et al., 2022) listed seven names under *Ectropothecium*: *E. buitenzorgi* (Bél.) Mitt., *E. ichnotocladum* (Müll.Hal.) A.Jaeger, *E. incubans* (Reinw. & Hornsch.) A.Jaeger, *E. monumentorum* (Duby) A.Jaeger, *E. moritzii* A.Jaeger var. *moritzii*, *E. singaporense* Dixon, and *E. zollingeri* (Müll.Hal.) A.Jaeger, while excluding *E. intorquatum* (Dozy & Molk.) A.Jaeger from the moss flora of Singapore. As a precursor to the upcoming treatment for the *Flora of Singapore* (Bryophytes), we revised all taxa reported in the above-mentioned checklist.

This study resulted in significant reinterpretations and recognition of *Ectropothecium* in Singapore. Among the reported species, only *E. monumentorum* remains recognised as a native species in the genus. *Ectropothecium ichnotocladum* and *E. moritzii* are newly proposed synonyms for *E. tutuillum* (Sull.) Mitt., a name newly introduced for Singapore. *Ectropothecium stigmophyllum* Broth. represents a new non-native record for the country. *Ectropothecium singaporense* has been transferred out of the genus, resulting in a new combination, *Calohypnum singaporense* (Dixon) S.He & B.C.Ho. *Ectropothecium buitenzorgi* and *E. incubans* were previously misapplied to *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho, which is a newly recorded species in Singapore. *Crepidophyllum modestum* Herzog is a non-native species newly recorded in the country. *Calohypnum*, *Crepidophyllum* and *Neoptychophyllum* represent three new moss genera in Singapore. The report of *Ectropothecium zollingeri* in Singapore has been misapplied to *Taxiphyllum barbieri* (Cardot & Copp.) Z.Iwats., a species known only from cultivation in Singapore and is thus excluded from the

flora. Similarly, *Ectropothecium sodale* (Sull.) Mitt. is identified by this study as a species found only in cultivation in Singapore.

Materials and methods

We examined all available specimens of *Ectropothecium* and related taxa from Singapore, which are deposited in the herbaria BM, FH, KLU, and SING. Herbarium acronyms follow Thiers (continuously updated). Accepted names were determined by comparing them with the type specimens of the relevant species.

In this paper, we provide a description and illustrations for each recognised species in the Singapore flora based solely on specimens collected within Singapore. For each native taxon, we conducted a provisional IUCN conservation assessment for Singapore, using the criteria outlined in Davison (2008) and followed in Lindsay et al. (2022).

Taxonomic treatment

Key to genera associated with *Ectropothecium* in Singapore

(only genera in bold are treated here)

- 1a. Leaf alar cells distinctly differentiated with 1(–2) or a group of conspicuously inflated, thin-walled cells and numerous smaller, nearly quadrate supra-alar cells 2
- 1b. Leaf alar cells weakly to relatively differentiated, not inflated, with a few or a group of smaller, quadrate or shortly rectangular cells 5
- 2a. Stem leaves distinctly and strongly plicate, alar cells strongly inflated, hyaline, consisting of 4–6 cells and a few, much smaller supra-alar cells **4. Neoptychophyllum**
- 2b. Stem leaves not or hardly plicate; alar cells moderately inflated, consisting of 1(–2) to 3–4 cells and numerous, quadrate supra-alar cells 3
- 3a. Capsules cylindrical, usually more than 3 mm long; exothecial cells not collenchymatous; alar cells of stem leaves clearly developed in a small group, consisting of 3–4 moderately inflated, hyaline cells and numerous quadrate supra-alar cells **1. Calohypnum**
- 3b. Capsules ovoid, usually less than 1.2(–1.5) mm long; exothecial cells collenchymatous; alar cells of stem leaves consisting of 1(–2) inflated, thin-walled cells and several smaller, quadrate supra-alar cells 4
- 4a. Laminal cells thin-wall, lax, not prorate; leaf margins subentire to serrulate; surfaces of exothecial cells and operculum distinctly mammillose; operculum conic **2. Crepidophyllum**

- 4b. Laminal cells moderately thick-walled, often prorate, rarely smooth; leaf margins usually serrulate to serrate, occasionally subentire; surfaces of exothelial cells and operculum smooth; operculum usually rostrate **3. *Ectropothecium***
- 5a. Laminal cells usually lax, rhomboid-hexagonal, occasionally linear, always smooth; alar cells not or hardly differentiated; pseudoparaphyllia complex consisting of both filamentous and foliose ones in the same species; exothelial cells collenchymatous *Vesicularia*
- 5b. Laminal cells narrow, elongate linear, smooth or prorate; alar cells weakly to relatively developed; pseudoparaphyllia uniform either filamentous or foliose; exothelial cells not collenchymatous 6
- 6a. Pseudoparaphyllia filamentous; leaf margins entire or only serrulated near the tips *Isopterygium*
- 6b. Pseudoparaphyllia foliose; leaf margins often serrulate or serrate, sometimes to the base *Taxiphyllum*

1. *Calohypnum* Sakurai, J. Jap. Bot. 25: 219 (1950); Kučera et al., Taxon 68: 651 (2019). – TYPE: *Calohypnum sakuraii* Sakurai, lectotype designated by Kučera et al. (2019: 651).

Insomniella Hedenäs et al., Bryoph. Diversity & Evol. 40: 47 (2018). – TYPE: *Insomniella plumiformis* (Wilson) Hedenäs et al. [= *Calohypnum plumiforme* (Wilson) Jan Kučera & Ignatov].

Hypnum sect. *Oldhamii* Ando, J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 14: 171 (1973). – TYPE: *Hypnum oldhamii* (Mitt.) A. Jaeger [= *Calohypnum oldhamii* (Mitt.) Jan Kučera & Ignatov].

Plants usually medium-sized to rather large, seldom small, yellowish green to brownish, moderately to distinctly glossy, often forming flattened mats. **Stems** prostrate to somewhat erect, pinnately to subpinnately branched; in cross-section, hyalodermis absent, central strand often developed; pseudoparaphyllia subfoliose to foliose, occasionally mixed with filamentous ones. **Stem and branch leaves** more or less similar or differentiated, usually secund to distinctly falcate-secund, narrowly to broadly ovate-lanceolate, smooth to hardly plicate; leaf base sometimes decurrent; margins plane or sometimes recurved near the base, often serrulate above, entire below; costa double, short, usually to 1/4 leaf length; upper and median laminal cells linear, smooth to prorate; alar cells often differentiated in a well-defined group, with a few thin-walled, inflated cells at basal angles and some quadrate, subquadrate supra-alar cells. **Brood bodies** absent. **Dioicous**. **Perichaetia** lateral; perichaetial leaves ovate-lanceolate or subulate, outer leaves reflexed, inner ones erect. **Seta** elongated, usually yellowish. **Capsule** erect to inclined, or horizontal, often cylindric to long-

cylindric, usually curved; annulus weakly to distinctly differentiated; operculum conic; peristome double; exostome teeth with external surface with distinct zig-zag line, finely to distinctly cross-striolate basally, hyaline and papillose distally; endostome basal membrane high, segments nearly as high as teeth; cilia 1–3 or sometimes rudimentary. *Calyptra* cucullate, naked. *Spores* spherical, smooth or finely papillose.

Distribution. The genus tentatively comprises six species and a variety with temperate to tropical distribution (Kučera et al., 2019; Akiyama, 2021). A single species occurs in Singapore.

Ecology. On trees and rocks in the forest.

Etymology. Greek, *calo-* = beautiful, *-hypnum* = pertaining to *Hypnum* Hedw.; referring to the beautiful, creeping growing habit.

Taxonomy. Until recently, the generic delimitation and subdivisions of *Hypnum* s.l. largely followed that of Ando (1972, 1973), which included *Calohypnum*. However, several phylogenetic studies have indicated that *Hypnum* sensu Ando is clearly non-monophyletic (Huttunen et al., 2012; Terracciano et al., 2012; Schlesak et al., 2018). In a recent phylogenetic revision of the genus *Hypnum*, Kučera et al. (2019) proposed various taxonomic and nomenclatural rearrangements. Their analyses, based on molecular sequence data from three gene loci, revealed that several taxa previously placed in *Hypnum* sect. *Oldhamii* Ando and *Hypnum* sect. *Curvifolia* Ando form a clade distant from the *Hypnum* s.s. lineage typified by *Hypnum cupressiforme* Hedw. This group of species, including *Hypnum plumiforme* (= *Calohypnum plumiforme*), is currently assigned to *Calohypnum*, a resurrected genus. However, no significant and meaningful morphological traits have been found to separate *Calohypnum* from *Hypnum* (Akiyama, 2021).

1.1. *Calohypnum singaporense* (Dixon) S.He & B.C.Ho, **comb. nov. – *Ectropothecium singaporense* Dixon, Bull. Torrey Bot. Club 51: 239 (1924); Dixon, Gard. Bull. Straits Settlement. 4(1): 30 (1926); Holttum, Gard. Bull. Straits Settlement. 4(2 & 3): 91 (1927); Wee, Gard. Bull. Singapore 32: 63 (1979); Johnson, Mosses Singapore Malaysia 98 (1980); Mohamed & Tan, Bryologist 91: 37 (1988); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Tan & Ho, Guide Mosses Singapore 126 (2008); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 40 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 46 (2022). – TYPE: [Singapore], Singapore Botanic Gardens, in grass in open place, 20 March 1913, *Binstead s.n.* [Dixon Herb. No. 78] (holotype BM [BM013841031] n.v.; isotypes G [G000265173], PC [PC0101395]). (Fig. 1)**

Plants rather large, sometimes elongate, yellowish green to brown, moderately glossy. *Stems* prostrate, to c. 7 cm long, regularly to somewhat irregularly pinnately

branched; in cross-section, hyalodermis absent, central strand weakly developed; pseudoparaphyllia complex, with subfoliose and foliose ones around branch primordia and multiple subfilamentous ones near the primordia. **Stem leaves** moderately falcate-secund, ovate-lanceolate, $2\text{--}2.5\text{--}(2.8) \times 0.8\text{--}0.9\text{--}(1)$ mm, slightly plicate; leaf base more or less decurrent; margins plane, serrulate above, entire below; costa short, double, sometimes weak; median laminal cells linear, $65\text{--}70\text{--}(75) \times 3\text{--}4$ μm , smooth or sometimes faintly prorate; alar cells differentiated, in a group of quadrate to subquadrate cells, associated with a few somewhat inflated cells at basal angles. **Branch leaves** smaller and narrower, narrowly ovate-lanceolate, $1.5\text{--}1.9 \times 0.5\text{--}0.6$ mm; alar cells much less developed. **Brood bodies** absent. **Dioicous**. **Perichaetial** leaves ovate-lanceolate, slightly plicate. **Seta** and **capsule** not seen.

Distribution. Mohamed (1987) reported the species as *Ectropothecium singaporense* from two limestone hills in Selangor and in either Kelantan or Terengganu states of Peninsular Malaysia. While it is not surprising for the species to occur in areas neighbouring Singapore naturally, its occurrence in a limestone area should be noteworthy (see Ecology). However, a search in KLU (K.T. Yong, pers. comm.) did not yield any verified specimens under this name for species confirmation. In the absence of verified vouchers supporting the occurrence of this species outside Singapore, *Calohypnum singaporense* will be regarded as endemic to Singapore.

Ecology. On tree base and exposed roots and the root mass of dead Bird's nest fern.

Etymology. Of Singapore.

Provisional IUCN conservation assessment. Globally not assessed. Assessed here as Endangered (EN/D) in Singapore.

Additional specimens examined. SINGAPORE: **Bukit Batok:** 16 Aug 2020, *Ho* 20-399 (SING [SING0296405]). **Central Catchment:** MacRitchie Reservoir Park, 28 Jan 1998, *Tan* 98-345 (SING [SING0235250]); ibidem, 16 Nov 1998, *Tan* 98-381 (SING [SING0234857]); ibidem, 9 Dec 2013, *Ho* 13-504 (SING [SING0233930]); ibidem, 5 May 2018, *Ho et al.* 18-015 (SING [SING0244138]); ibidem, 14 Jul 2020, *Ho* 20-318 (SING [SING0296363]). **Tanglin:** National University of Singapore, Bukit Timah Campus, 4 Jun 2013, *Ho* 13-220 (SING [SING0233957]); Singapore Botanic Gardens, 1898, *Ridley* 762 (SING [SING0086110]); ibidem, 1 Aug 2020, *Ho* 20-379 (SING [SING0296387]); ibidem, 20 Aug 2020, *Ho* EV 20-27 (SING [SING0298447]); ibidem, 3 Dec 2020, *Ho* 20-543 (SING [SING0303846]); ibidem, 30 Jun 2021, *Ho* PV 21-49 (SING [SING0346086]); ibidem, 4 Mar 2012, *Linis* 4817-12 (SING [SING0173947]).

Notes. The alar cells of stem leaves exhibit distinct and well-developed inflated cells in a group, along with numerous more or less quadrate supra-alar cells. However, the development of alar cells in branch leaves is less pronounced, with occasional presence of 1–2 moderately inflated alar cells. Further examination of the type specimen of *Ectropothecium singaporense* has revealed that it does not belong to the genus *Ectropothecium*, but rather to *Calohypnum*. As a result, it is treated in the latter genus with a new combination.

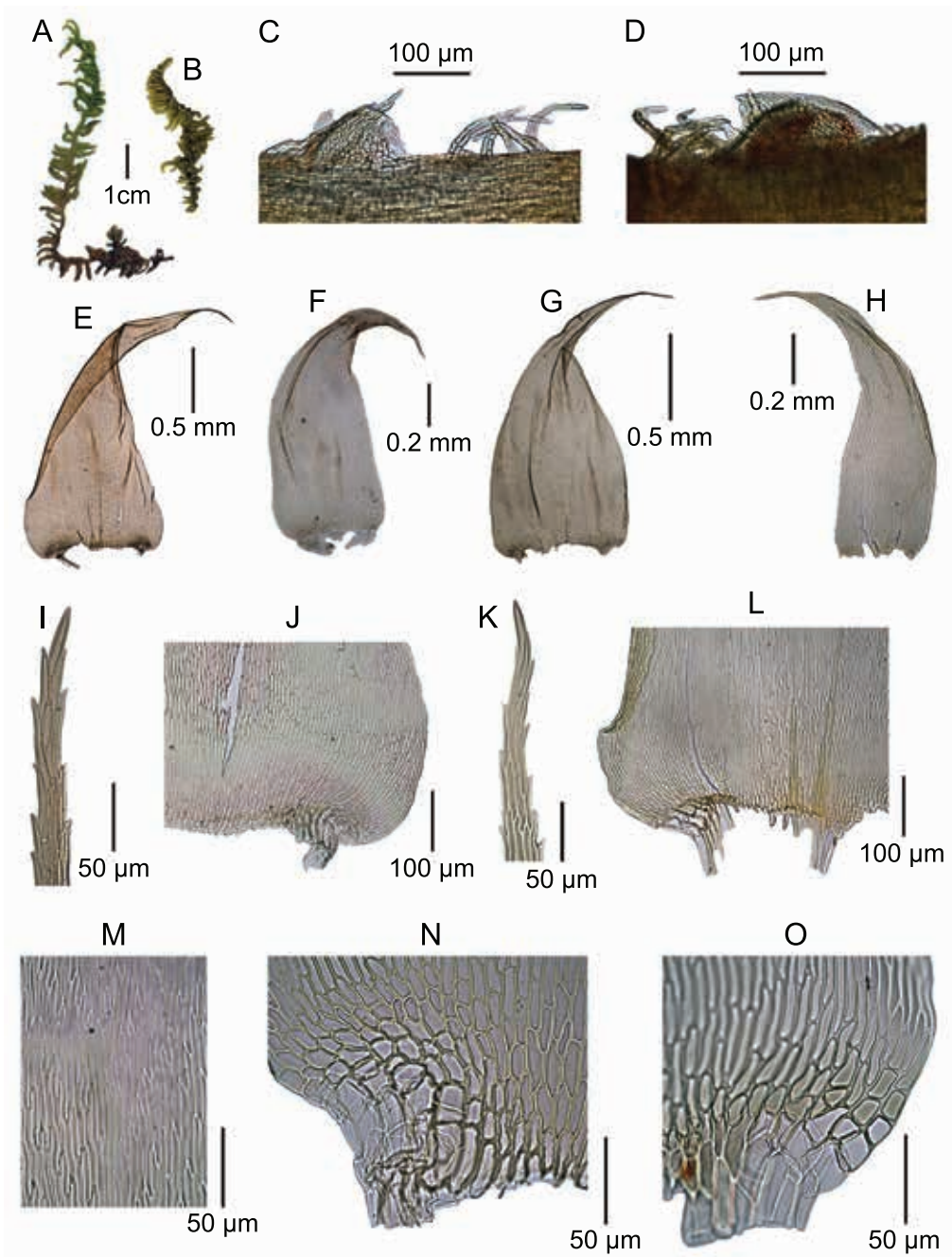


Fig. 1. *Calohypnum singaporense* (Dixon) S. He & B. C. Ho. **A, B.** Habit. **C, D.** Pseudoparaphyllia. **E, G.** Stem leaves. **F, H.** Branch leaves. **I, K.** Leaf apices. **J, L.** Leaf bases. **M.** Median laminal cells. **N, O.** Alar cells. B, E, F, I, J, prepared from *Binstead s.n.* (PC), the isotype of *Ectropothecium singaporense* Dixon; A, C, D, G, H, K–O from *B.-C. Ho 20-379* (SING). (Photos: S. He)

Calohypnum singaporense resembles *C. plumiforme* ($\equiv$ *Hypnum plumiforme* Wilson), but it differs from the latter in several aspects. These differences include the presence of atypical pseudoparaphyllia that are foliose around branch primordia and subfilamentous near the branch primordia, often prorate upper laminal cells (especially on the branch leaves), and longer and narrower laminal cells (measuring $65\text{--}75 \times 3\text{--}4 \mu\text{m}$ in *C. singaporense*, as opposed to $40\text{--}60 \times 4\text{--}5 \mu\text{m}$ in *C. plumiforme*).

2. *Crepidophyllum* Herzog, Hedwigia 66: 356 (1926), non C.F.Reed (1948), nom. illeg. [Hymenophyllaceae]. – TYPE: *Crepidophyllum modestum* Herzog.

Since *Crepidophyllum* is a monospecific genus, the generic features are the same as *C. modestum* (see below).

Distribution. Endemic to Papua New Guinea (former German New Guinea) prior to this study. It is here reported new to Singapore.

Ecology. See under species.

Etymology. Greek, *crepido-* = sandal or sole, *-phyllum* = leaf; alluding to the sole-like shape of the leaves.

Taxonomy. In the field, plants of *Crepidophyllum* resemble those of *Ectropothecium* and *Vesicularia* because of their tiny capsules and transparently thin leaves. Microscopically, *Crepidophyllum* exhibits a similar formation of a single inflated alar cell as observed in *Ectropothecium*. Both genera also share numerous similarities in their gametophytic and sporophytic characteristics. However, the monospecific *Crepidophyllum* differs from *Ectropothecium* species in several ways. These include the presence of thin-walled, lax laminal cells, mammillose exothecial and operculum cells, and a conic operculum. While these differences are relatively noticeable, *Crepidophyllum* still maintains a close relationship with *Ectropothecium*. In the instance where sporophytes are absent, some *Ectropothecium* species with relatively thin-walled laminal cells may be mistaken for *Crepidophyllum*. Additionally, *Crepidophyllum* shares similarities with *Vesicularia*, but the latter never possesses a single inflated alar cell, and the surface of exothecial cells of the capsule and operculum is smooth. Both Herzog (1926) and Nishimura (1999) also suggested a close relationship between *Crepidophyllum* and *Vesicularia*.

2.1. *Crepidophyllum modestum* Herzog, Hedwigia 66: 356, t. 3: f. 54–61 (1926). – TYPE: [Papua New Guinea], Deutsch Neuguinea, Finisterregebirge, 800–1000 m, 1925, G. Eiffert s.n. (holotype JE [JE04006075]; isotype JE [JE04006074]). (Fig. 2)

Plants small, elongated, yellowish green, moderately glossy, forming thin, flattened mats. **Stems** creeping, to c. 5.5 cm long, pinnately branched; in cross-section

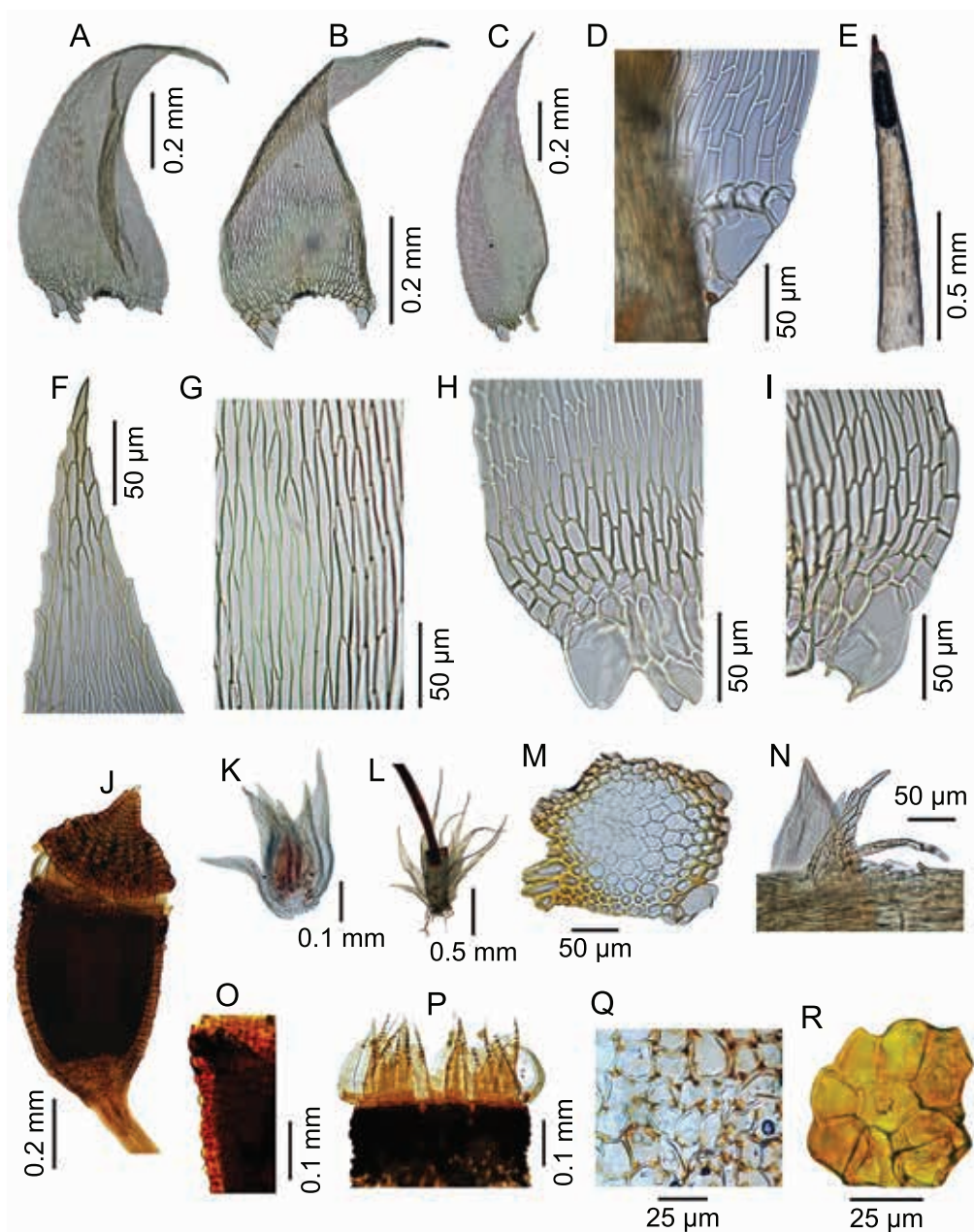


Fig. 2. *Crepidophyllum modestum* Herzog. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Leaf base attached to stem, showing an inflated alar cell. **E.** Calyptra. **F.** Branch leaf apex. **G.** Median laminal cells. **H, I.** Basal parts of leaves, showing a single inflated alar cell. **J.** Capsule. **K.** Perigonium. **L.** Perichaetium. **M.** Cross section of stem. **N.** Pseudoparaphyllia. **O.** A profile view of capsule walls, showing mammillose exothelial cells. **P.** Peristome teeth. **Q.** Exothelial cells, showing collenchymatous wall thickening. **R.** Stoma (immersed). All images prepared from Lua et al. BCH 21-047 (SING). (Photos: S. He)

epidermal and outer cortex 2–3 rows of small, thick-walled cells; inner cortical cells larger, thin-walled, firm; a central strand weakly differentiated; paraphyllia absent, pseudoparaphyllia subfilamentous to subfoliose and foliose. **Stem leaves** more or less similar, $0.9\text{--}1 \times 0.4\text{--}0.6$ mm, from a triangular-ovate base, gradually narrowed to a long acuminate apex. **Branch leaves** somewhat dimorphic, $0.7\text{--}0.8 \times 0.25\text{--}0.3$ mm, dorsal ones wider, ovate-lanceolate, shortly acuminate; ventral ones narrowly ovate-lanceolate; margins subentire to serrulate; costae indistinct, short, double; laminal cells thin-walled, lax, rhomboidal to elongate-hexagonal, $70\text{--}90 \times 6\text{--}7$ μm ; alar cells at each corner with an inflated cell. **Autoicous**. **Perichaetia** lateral; perichaetial leaves differentiated from sterile leaves, oblong-lanceolate, gradually narrowed to long acuminate. **Perigonia** near perichaetia on the same branches; perigonial leaves small, ovate, abruptly narrowed to a short acumen. **Seta** elongated, to c. 1.5 cm long, smooth. **Capsule** horizontal to pendulous, notably small, less than 1.1 mm long, urn ovoid, often constricted below mouth when dry; exothecial cells mammillose, subquadrate to hexagonal, collenchymatous; stomata a few at urn base, immersed; annuli differentiated; operculum conic, cells mammillose; peristome double, exostome teeth 16, narrowly lanceolate, slightly bordered; cross-striate on the outer surface, trabeculate on the inner surface; median line zig-zag; endostome basal membrane high, segments 16, linear-lanceolate, papillose, cilia 2–3. **Calyptra** cucullate, naked. **Spores** spherical, 8–10 μm diam., finely papillose.

Distribution. Originally endemic to Papua New Guinea. New to Singapore. *Crepidophyllum modestum* is likely an escaped species from cultivation in Singapore, and we expect it to be distributed in other regions of Malesia, particularly on lowland limestone areas.

Ecology. On discarded concrete slab, or coral/limestone rocks introduced for horticultural landscaping.

Etymology. Latin, *modestum* = modest and unassuming; presumably referring to the small plant size of the species.

Additional specimens examined. SINGAPORE: **Southern Islands:** St. John's Island, Mangrove & campsite, 2 Feb 2021, *Lua et al.* BCH 21-047 (SING [SING0310121]). **Tanglin:** Singapore Botanic Gardens, 1 Oct 2020, *Ho RF 20-05* (SING [SING0298405]); ibidem, 5 Oct 2020, *Ho RF 20-21* (SING [SING0298421]); ibidem, 5 Oct 2020, *Ho RF 20-25* (SING [SING0298425]); ibidem, 5 Oct 2020, *Ho RF 20-30* (SING [SING0298430]).

Notes. According to Herzog (1926), *Crepidophyllum modestum* exhibits thin-walled and lax laminal cells similar to those found in *Vesicularia*. Additionally, it possesses a single inflated alar cell at each corner of the leaf base attached to stems. Herzog (1926) described the species as dioicous, based on the presence of perigonia at the time of study. It is possible that the perigonia and perichaetia of this moss mature at different times. Therefore, the determination of sexuality based on limited material could be inaccurate, as it is highly likely that the New Guinean plants, when collected, only

bore perigonia and the perichaetia had not yet emerged.

Crepidophyllum modestum has only been known from the type collection mentioned in the literature. This report represents the first record of the species outside Papua New Guinea. In Singapore, we categorise it as a non-native “naturalised” species following the definition provided in Lindsay et al. (2022). This study also presents the first discovery of sporophytes for the genus and species. Given its abundance but with restriction to (introduced) calcareous substrates in Singapore, we anticipate its natural distribution in other parts of Malesia, particularly in lowland limestone areas.

3. *Ectropothecium* Mitt., J. Linn. Soc., Bot. 10: 180 (1868); Fleischer, Musc. Buitenzorg 4: 1383 (1923 [‘1915–1922’]); Brotherus in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 11: 455 (1925); Bartram, Philipp. J. Sci. 68: 354 (1939); Gangulee, Mosses E. India 3, fasc. 8: 1982 (1980); Manuel, Fed. Mus. J. 26: 117 (1981); Noguchi et al., Ill. Moss Fl. Japan 5: 1166 (1994); Zhang & He, Moss Fl. China 8: 103 (2005); Frey & Stech in Frey (ed.), Syllabus, ed. 13, Pt. 3: 234 (2009); He, Bryoph. Diversity & Evol. 41: 24 (2019); Norhazrina et al., Malayan Nat. J. 72: 389 (2020). – TYPE: *Ectropothecium buitenzorgi* (Bél.) Mitt., lectotype designated by Chen (1978: 266).

Hypnum auct. non Hedw.: Van den Bosch & Van der Lacoste in Dozy & Molkenboer, Bryol. Jav. 2, fasc. 50: 140 (1866 [‘1861–1870’]), p.p.

Plants small to medium-sized, thin, slender to somewhat sturdy, moderately glossy, light green, yellowish to brownish green, forming more or less complanate mats. **Stems** prostrate, irregularly to regularly pinnately branched, usually complanate; in cross-section epidermal and outer cortex 2–3 rows of small, thick-walled cells; inner cortical cells larger, ± thin-walled, firm; a central strand weakly differentiated; paraphyllia absent, pseudoparaphyllia complex, consisting of filamentous, subfilamentous, and subfoliose to foliose types. **Stem leaves** weakly to strongly falcate-secund, sometimes not falcate, narrowly to broadly ovate-lanceolate, apex short to long acuminate; usually dorsal, ventral, and lateral leaves somewhat differentiated; margins plane to reflexed, distally serrulate to serrate; costae short, double, sometimes absent; median and upper laminal cells smooth or often distinctly prorate; basal cells shorter and broader, narrowly oblong; alar cells few, often consisting of 1(–2) inflated cells and 2–4 quadrate or shortly rectangular supra-alar cells. **Branch leaves** smaller, slightly heteromorphic, more or less similar to stem leaves, ovate- to oblong-lanceolate or lanceolate-subulate, weakly to strongly falcate-secund or non-falcate. **Autoicous** or **dioicous**. **Perichaetia** lateral; perichaetial leaves differentiated from sterile leaves, oblong-ovate to broadly lanceolate, gradually or abruptly long acuminate. **Seta** elongated, smooth. **Capsule** inclined or pendulous, notably small, urn ovoid, often constricted below mouth when dry; exothecial cells quadrate to shortly oblong, thin- to moderately thick-walled, weakly to strongly collenchymatous; stomata a few at urn base, superficial; annuli differentiated; operculum conic at base, apiculate to shortly rostrate; peristome double, exostome teeth 16, narrowly lanceolate, slightly bordered;

cross-striate on the outer surface, trabeculate on the inner surface; median line zig-zag; endostome basal membrane high, segments 16, linear-lanceolate, papillose, cilia (1–)2–3(–4). *Calyptra* cucullate, naked. *Spores* spherical, smooth to lightly papillose.

Distribution. With approximately 210 currently accepted species, *Ectropothecium* is primarily a pantropical and subtropical genus. The genus is well-represented in the moss floras of insular Southeast Asia and the Pacific Islands. In Singapore, three species of *Ectropothecium* are recognised in this study.

Ecology. The species of *Ectropothecium* are predominantly found in lowland forests, where they commonly occur as epiphytes on tree trunks, rotting wood stumps or logs. They can also be found as lithophytes on rocks or boulders and occasionally on soil as secondary habitats. Outside Singapore, the genus has been reported at elevations up to 2840 m.

Etymology. Greek, *ektropion*- = turning aside, *-thekion* = little vase or vessel; alluding to the capsules that are turning abnormally in an inclined position.

Taxonomy. The taxonomy of *Ectropothecium* is one of the most complex among hypnlean mosses in tropical regions. Delimiting the boundaries of *Ectropothecium* has been challenging because of structural similarities and convergence with other morphologically similar genera traditionally classified within the Hypnaceae s.l., including *Hypnum* s.l., *Isopterygium*, *Taxiphyllum*, and *Vesicularia*. The current understanding of its taxonomy aligns with the circumscription of He (2019).

Key to species of *Ectropothecium*

- 1a. Leaf shape lanceolate, gradually narrowed toward apex; apical margins subentire to remotely serrulate; median laminal cells smooth, long-linear, (65–)70–90(–100) µm long 3.1. *E. monumentorum*
- 1b. Leaf shape oblong- to ovate-lanceolate, abruptly narrowed, shortly acuminate to slenderly acuminate; apical margins serrulate to serrate; median laminal cells slightly to distinctly prorate, moderately linear, 35–50(–55) µm long 2
- 2a. Stem leaves not falcate, apices shortly acuminate; branch leaf apices narrowly acute; costae distinct, double, to c. 1/4 the leaf length; median laminal cells distinctly prorate 3.2. *E. stigmophyllum*
- 2b. Stem leaves falcate, apices slenderly long-acuminate; branch leaf apices acuminate; costae indistinct, double, shorter than 1/6 the leaf length; median laminal cells slightly prorate 3
- 3a. Stems irregularly branched; stem leaf apices slenderly acuminate, margins subentire to only minutely serrulate; branch leaf somewhat serrulate *E. sodale* [cultivated only, treated as an excluded species]

- 3b. Stems more or less regularly and pinnately branched; stem leaf apices somewhat piliform, both stem and branch leaf margins distinctly serrate 3.3. *E. tutuilum*

3.1. *Ectropothecium monumentorum* (Duby) A.Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–1878: 259 (1880); Fleischer, Musc. Buitenzorg 4: 1413 (1923 [‘1915–1922’]); Dixon, Gard. Bull. Straits Settlem. 4(1): 32 (1926), p.p.; Holttum, Gard. Bull. Straits Settlem. 4(2 & 3): 91 (1927); Bartram, Philipp. J. Sci. 68: 361, pl. 27: f. 467 (1939); Wee, Gard. Bull. Singapore 32: 63 (1979); Johnson, Mosses Singapore Malaysia 101, f. 86 (1980); Gangulee, Mosses E. India 3, fasc. 8: 1986, f. 1028 (1980); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Wee & Mohamed, Gard. Bull. Singapore, Suppl. 3: 74 (1995); Tan & Ho, Guide Mosses Singapore 126 (2008); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 40 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 46 (2022). – *Hypnum monumentorum* Duby in Moritzi, Syst. Verz. 132 (1846 [‘1845–1846’]); Van der Lacoste in Dozy & Molkenboer, Bryol. Jav. 2, fasc. 60: 196, t. 295 (1868 [‘1861–1870’]). – TYPE: [Indonesia], Java, Buitenzorg, *Zollinger 1537* (lectotype G [G00265125], designated here; isolectotypes BM [BM000749743], L [L0623829]). (Fig. 3)

Plants relatively small, to c. 2 cm long, forming more or less complanate mats, somewhat glossy, yellowish brown. **Stems** prostrate, more or less complanately and subpinnately branched; pseudoparaphyllia complex, consisting of filamentous, subfilamentous and subfoliose forms. **Stem leaves** hardly falcate, oblong-lanceolate, 1.3–1.4 × c. 0.3 mm; margins plane, almost entire; costae short, double; median and upper laminal cells smooth, (65–)70–90(–100) × 5–6 µm, thin-walled; basal cells shorter and broader, narrowly oblong; alar region consisting of 1 inflated cell and 2–4 quadrate or shortly rectangular supra-alar cells. **Branch leaves** similar to stem leaves in size, oblong-lanceolate or lanceolate-subulate, not falcate. **Autoicous. Perichaetial leaves** differentiated from sterile leaves, abruptly narrowed from a round leaf base to a long acuminate apex. **Seta** elongate, smooth, c. 1 cm long. **Capsule** slightly inclined, significantly small, ovoid, constricted below the mouth when dry; exothecial cells quadrate to shortly oblong, moderately thick-walled, clearly collenchymatous; annuli differentiated; opercula not seen; peristome double; exostome teeth 16, narrowly lanceolate, slightly bordered; cross-striate on the outer surface, trabeculate on the inner surface; median line zig-zag; endostome basal membrane high, segments 16, linear-lanceolate, papillose, cilia 1–2 or rudimentary. **Calyptra** not seen. **Spores** spherical, 8–10 µm diam., minutely papillose.

Distribution. China (Hong Kong, Taiwan), Myanmar, Thailand, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, and the Philippines.

Ecology. On calcareous substrate, on walls, bricks, chalky soil, and rocks, rarely on bark, in the plains and hills throughout the distribution range.

Etymology. Latin, *monumentis* = tomb, burial place; from the tombs of two zoologists, Heinrich Kuhl and Johan Conrad van Hasselt, in the cemetery within the Botanical Gardens at Buitenzorg, now Bogor.

Provisional IUCN conservation assessment. Globally not assessed. Assessed here as Endangered (EN/D) in Singapore. Although only three specimens from Singapore have been identified, the species is expected to be more common and may have been previously misidentified and filed under *Isopterygium*.

Additional specimens examined. SINGAPORE: **Central Catchment:** Thomson Nature Park, 16 Jul 2020, *Ho 20-360* (SING [SING0296371]). **Tanglin:** Singapore Botanic Gardens, 1894, *Ridley 329* (SING [SING0086107]); *ibidem*, Sep 1957, *Johnson 84* (KLU [acc. no. B998]).

Notes. The presence of oblong-lanceolate leaves, subentire to nearly entire margins, and thin-walled median laminal cells are characteristic features of *Ectropothecium monumentorum*. The first report of *Ectropothecium monumentorum* in Singapore was made by Dixon (1926: 32) based on four collections by Ridley. However, apart from *Ridley 329*, the other three Ridley collections do not belong to *Ectropothecium*. *Ridley 307* and *Ridley 319* are specimens of *Isopterygium albescens* (Hook.) A.Jaeger, while *Ridley 613* belongs to *Vesicularia reticulata* (Dozy & Molk.) Broth.

3.2. *Ectropothecium stigmophyllum* Broth., Denkschr. Kaiserl. Akad. Wiss. Wien, Math.-Naturwiss. Kl. 84: 398 (1908). – TYPE: [Samoa], Upolu, Berg Lanutoo, Auf Baumrinde (on tree bark), August 1905, *Rechinger 2984* (holotype H [H1467007]). (Fig. 4)

Ectropothecium perminuatum Broth. ex E.B.Bartram, Philipp. J. Sci. 68: 356, pl. 27: f. 459 (1939), **syn. nov.** – TYPE: [Philippines], Luzon, Laguna Province, Mount Maquiling, 9–12 December 1912, *Robinson 17032* (holotype FH [FH00060594]; isotypes BM [BM000749728], NY [NY01238859]).

Ectropothecium perscabrum Tixier, Rev. Bryol. Lichénol. 34: 171, f. 28 (1966), **syn. nov.** – TYPE: [Vietnam], Tonkin, Environs de Chapa, July 1927, *Pételot 8* (holotype PC n.v.; isotypes G [G00265167], S [B72181]).

Plants small to medium-sized, to c. 2.5 cm long, moderately glossy, green to yellowish green. **Stems** prostrate, subpinnately branched; pseudoparaphyllia complex, consisting of mostly filamentous ones, and some foliose, lanceolate ones. **Stem leaves** not falcate, oblong-lanceolate to ovate-lanceolate, 0.65–0.7 × c. 0.2 mm, shortly acuminate at apex; margins weakly serrulate; costae short, double; median and upper laminal cells moderately to distinctly prorate, 35–50 × 3–4.5 µm; basal cells shorter and broader, narrowly oblong; alar region consisting of 1 inflated cell and 2–4 small, quadrate or shortly rectangular supra-alar cells. **Branch leaves** more or less heteromorphic, slightly

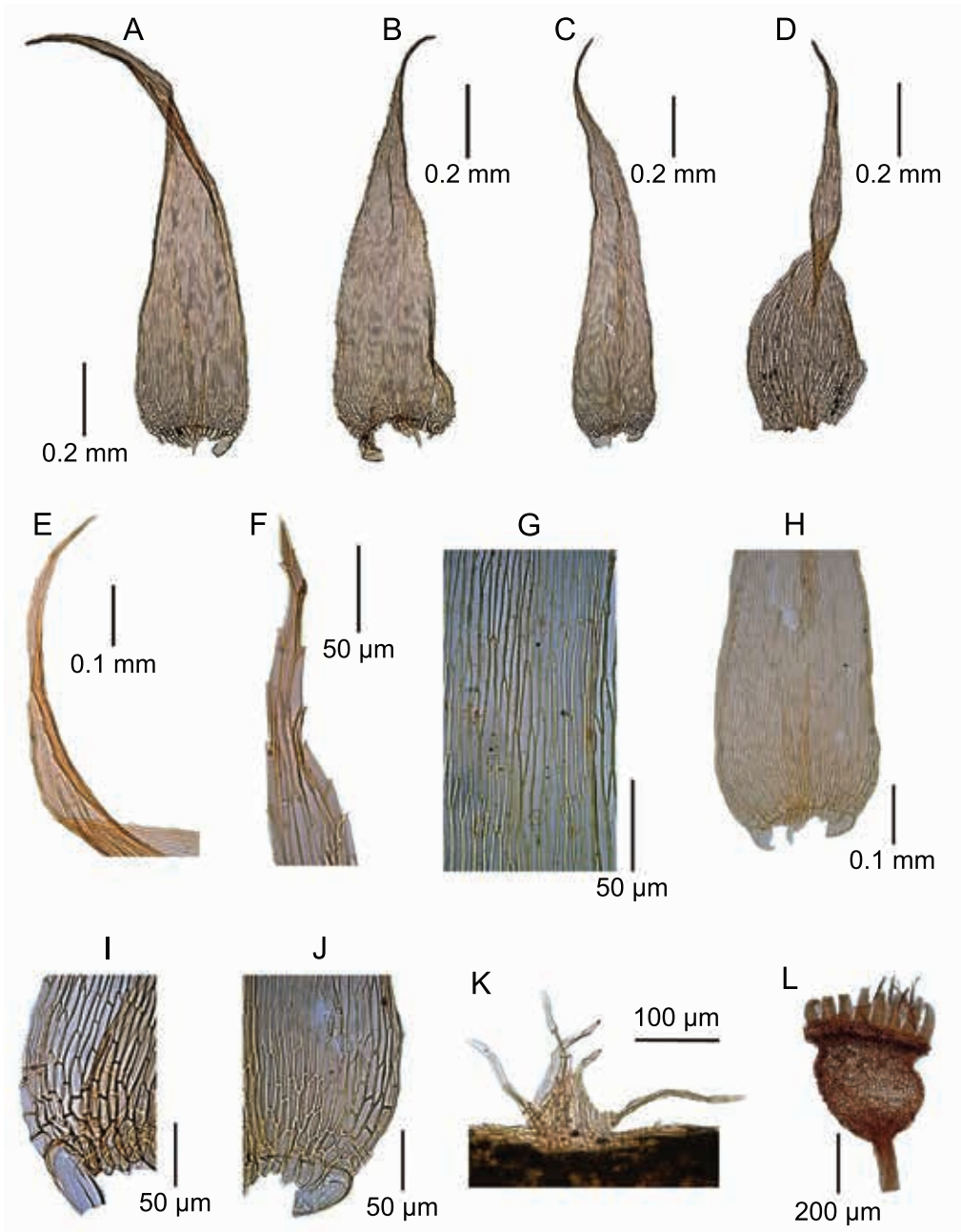


Fig. 3. *Ectropothecium monumentorum* (Duby) A.Jaeger. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Perichaetial leaf. **E.** Stem leaf apex. **F.** Branch leaf apex. **G.** Median laminal cells. **H.** Basal part of leaf. **I, J.** Alar region, showing an inflated alar cell. **K.** Pseudoparaphyllia. **L.** Capsule with peristome teeth. All images prepared from *Ridley 329* (SING). (Photos: S. He)

larger, ovate-lanceolate, not falcate, $0.7\text{--}0.8 \times c. 0.3$ mm; leaf upper margins distinctly serrulate to serrate; median laminal cells noticeably prorate. **Dioicous.** **Perichaetial leaves** differentiated from sterile leaves, rather abruptly narrowed from a round base to a long-acuminate apex. **Sporophyte** not seen.

Distribution. Vietnam, the Philippines, and Samoa. New to Singapore as a non-native species.

Ecology. In its native range, on surface of old limestone under shade. Also on bark, less often on soil.

Etymology. Greek, *stigma*- = a mark, dot pricked in; *-phyllum* = leaf; probably referring to the distinctly prorate laminal cells that appear as dots on the leaf surface.

Additional specimen examined. SINGAPORE: **Tanglin:** Singapore Botanic Gardens, 14 Mar 2012, *Linis* 4834-12 (SING [SING0173964]).

Taxonomy. *Ectropothecium stigmophyllum* is characterised by the presence of distinctly prorate laminal cells and non-falcate leaves. The pseudoparaphyllia in this species are complex and may consist of filamentous structure mixed with several 2-rowed subfilamentous or a few subfoliose ones. While *Ectropothecium stigmophyllum* may bear some resemblance to certain species of *Isopterygium*, the presence of complex pseudoparaphyllia and distinctly prorate laminal cells should serve as distinguishing features. Species of *Isopterygium*, on the other hand, typically possess exclusively filamentous pseudoparaphyllia.

Notes. The species is currently only known in Singapore from a single collection found at the Singapore Botanic Gardens, likely through introduction of horticultural plants. Based on the definition provided in Lindsay et al. (2022), we classify this species as a non-native “casual” moss in Singapore.

3.3. *Ectropothecium tutuilum* (Sull.) Mitt., J. Linn. Soc., Bot. 10: 180 (1868); Iwatsuki, Hikobia 11(2): 125, 130, f. 1 & 5: 1–2 (1992). – *Hypnum tutuilum* Sull., Proc. Amer. Acad. Arts 3: 75 (1854). – TYPE: [Island of Tutuila], American Samoa, U.S. Explor. Exped. under Captain Wilkes, 1838–1842, *Anonymous collector s.n.* (lectotype FH [herb. Sullivant no. 136, FH00290385], designated by Iwatsuki (1992: 125 [as ‘no. 126’])); remaining syntypes G [G00265132], JE [JE04005155, JE04005156], M [M0178189]). (Fig. 5)

Hypnum ichnotocladum Müll.Hal., Syn. Musc. Frond. 2: 301 (1851), **syn. nov.**; Van der Lacoste in Dozy & Molkenboer, Bryol. Jav. 2, fasc. 60: 197, t. 296 (1868 [‘1861–1870’]). – *Stereodon ichnotocladus* (Müll.Hal.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1(2): 99 (1859). – *Ectropothecium ichnotocladum* (Müll.Hal.) A.Jaeger, Ber. Thätigk.

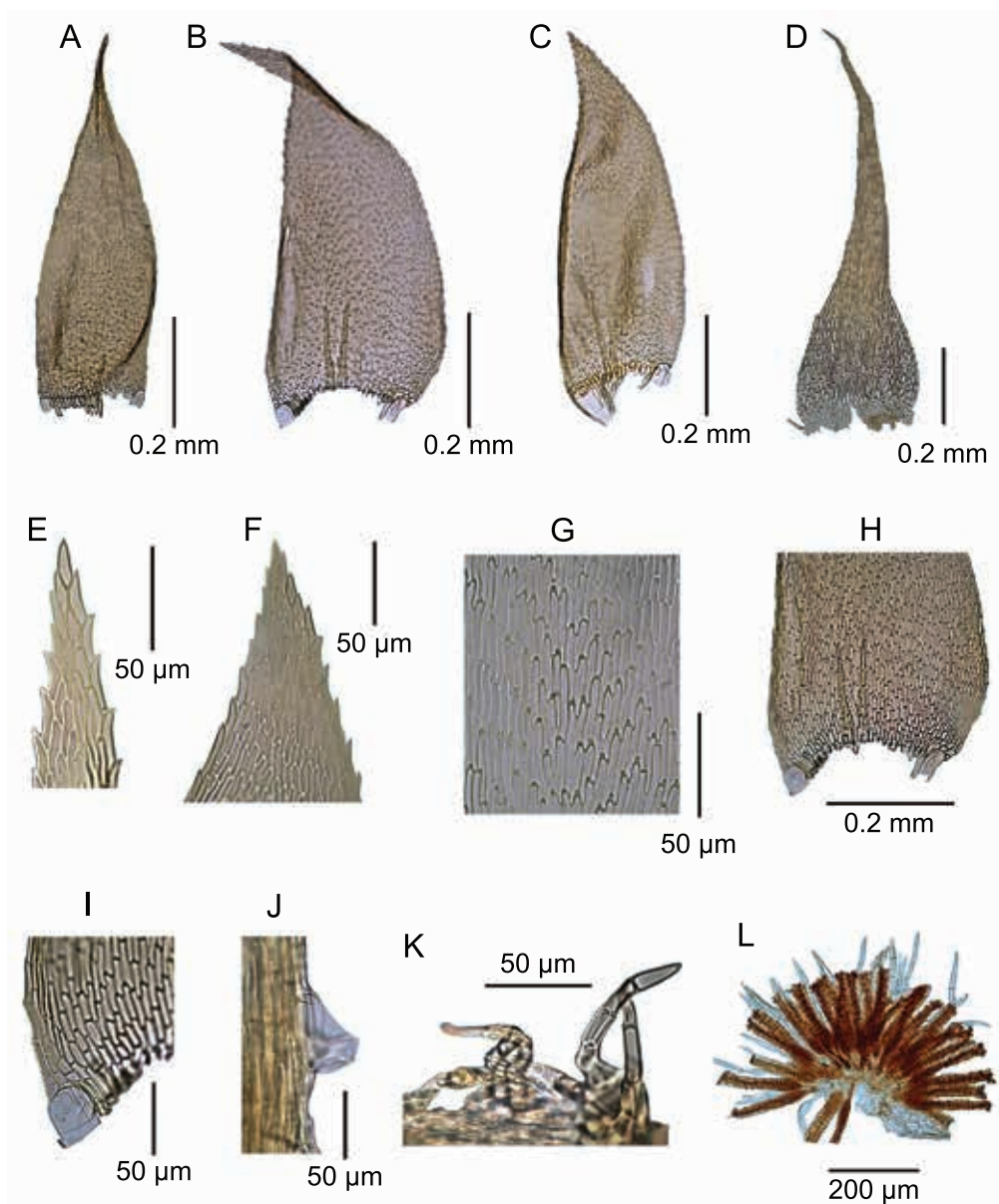


Fig. 4. *Ectropothecium stigmophyllum* Broth. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Perichaetial leaf. **E, F.** Leaf apices. **G.** Median laminal cells. **H.** Basal part of leaf. **I.** Alar region. **J.** An inflated alar cell remaining on the stem. **K.** Pseudoparaphyllia. **L.** Archegonia. All images prepared from *Linis 4834-12* (SING). (Photos: S. He)

St. Gallischen Naturwiss. Ges. 1877–1878: 259 (1880); Fleischer, *Musc. Buitenzorg* 4: 1394 (1923 [‘1915–1922’]); Bartram, Philipp. J. Sci. 68: 355, pl. 27: f. 458 (1939), p.p.; Tan & Ho, *Guide Mosses Singapore* 126 (2008); Yong et al., *Rev. Moss Checkl. Penins. Malaysia & Singapore* (FRIM Res. Pam. 133) 39 (2013), p.p.; Lindsay et

al., Gard. Bull. Singapore 74(Suppl. 1): 45 (2022). – TYPE: [Indonesia], Java, Prov. Buitenzorg [= Bogor], *Miquel s.n.* (holotype B n.v. (possibly destroyed); lectotype L [L0623858], designated here; isoelectotype FH [sheet no. 3232]).

Ectropothecium moritzii A.Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877–1878: 262 (1880), **syn. nov.**; Fleischer, Musc. Buitenzorg 4: 1404 (1923 [‘1915–1922’]); Dixon, Bull. Torrey Bot. Club 51: 241 (1924); Holttum, Gard. Bull. Straits Settle. 4(2 & 3): 91 (1927); Wee, Gard. Bull. Singapore 32: 63 (1979); Johnson, Mosses Singapore Malaysia 98 (1980); Mohamed & Tan, Bryologist 91: 37 (1988); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Higuchi & Nishimura, Bull. Natl. Sci. Mus. Tokyo, B 32: 176 (2006); Tan & Ho, Guide Mosses Singapore 126 (2008); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 40 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 46 (2022). – *Hypnum moritzii* Müll.Hal., Syn. Musc. Frond. 2: 303 (1851), nom. illeg. non Duby (1846); Van der Lacoste in Dozy & Molkenboer, Bryol. Jav. 2, fasc. 60: 200, t. 299 (1868 [‘1861–1870’]). – TYPE: [Indonesia], Java, Prope Tjibodas, *Zollinger 1528* (holotype B n.v. (possibly destroyed); lectotype G [G00265128], designated here; isoelectotype JE [JE04005181]).

Ectropothecium moritzii var. *stereodontoides* Dixon, Bull. Torrey Bot. Club 51: 241 (1924), **syn. nov.** – TYPE: [Malaysia], Pahang, Fraser Hill, on log in jungle, 4000 ft, 15 September 1923, *Holttum SFN 11375* (lectotype BM [BM000850196], designated here; isoelectotype SING [SING0165876]); also the same locality, 4000–4370 ft, 18 September 1922, *Burkill & Holttum SFN 8715d* (remaining syntype BM [BM000850197]).

Chaetomitrium ridleyi Broth., Bull. Torrey Bot. Club 51: 241 (1924), nom. illeg. pro syn.

Trichosteleum leptocarpon auct. non (Schwägr.) M.Fleisch.: Dixon, Gard. Bull. Straits Settle. 4(1): 40 (1926).

Warburgiella leptocarpos auct. non (Schwägr.) M.Fleisch.: Wee, Gard. Bull. Singapore 32: 62 (1979), as ‘*leptocarpa*’; Johnson, Mosses Singapore & Malaysia 111 (1980), as ‘*leptocarpa*’; Mohamed & Tan, Bryologist 91: 36 (1988), p.p., as ‘*leptocarpa*’; Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 108 (1994), as ‘*leptocarpa*’; Tan & Ho, Guide Mosses Singapore 137 (2008), as ‘*leptocarpa*’; Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 111 (2013), p.p., as ‘*leptocarpa*’.

Plants medium-sized, to c. 4 cm long, forming more or less complanate mats, moderately glossy, yellowish green to yellowish brown. **Stems** prostrate, somewhat complanately and pinnately branched with short branches; pseudoparaphyllia complex, consisting of filamentous, subfilamentous to subfoliose ones. **Stem leaves** slightly falcate-second,

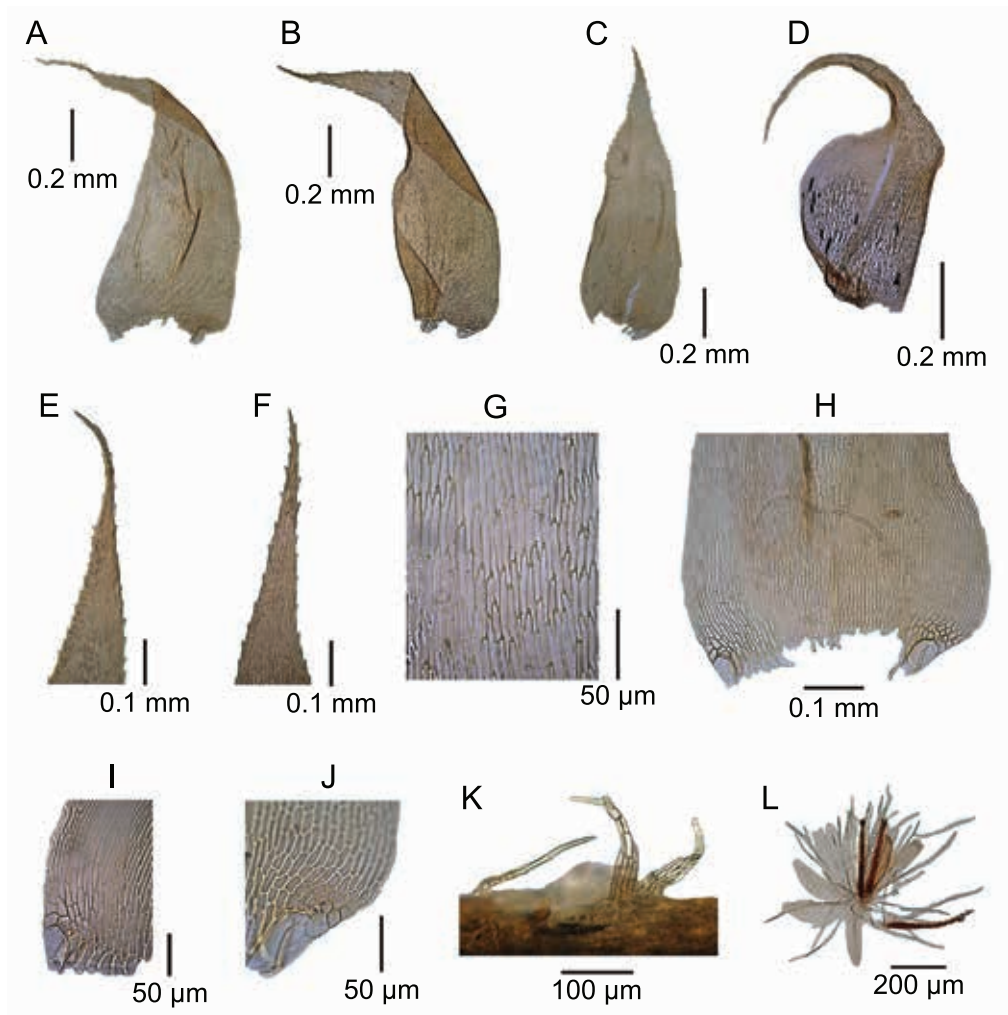


Fig. 5. *Ectropothecium tutuilum* (Sull.) Mitt. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Perichaetial leaf. **E.** Stem leaf apex. **F.** Branch leaf apex. **G.** Median laminal cells. **H.** Basal part of leaf. **I, J.** Alar region, showing an inflated alar cell. **K.** Pseudoparaphyllia. **L.** Archegonia and antheridia on the same gametangium. All images prepared from *Tan 98-346* (SING). (Photos: S. He)

broadly ovate-lanceolate, $1.4\text{--}1.6 \times 0.5\text{--}0.6$ mm, abruptly narrowed to almost filiform apices; margins plane, distally serrate; costae short, double; median and upper laminal cells slightly prorate, $45\text{--}52 \times 4\text{--}5$ µm; basal cells shorter; alar region consisting of 1 inflated cell and 2–4 quadrate or shortly rectangular supra-alar cells. **Branch leaves** smaller, not falcate, slightly heteromorphic, narrowly ovate-lanceolate, $1.2\text{--}1.3 \times c. 0.4$ mm, with a shortly acuminate apex. **Synicous.** **Perichaetial leaves** differentiated from sterile leaves, abruptly narrowed from broadly ovate base to lanceolate apex. **Sporophyte** not seen.

Distribution. China (Taiwan), Laos, Vietnam, Thailand, Peninsular Malaysia, Singapore, Borneo, Sumatra, Java, the Philippines, and Vanuatu.

Ecology. On rotten wood or on forest floor.

Etymology. Of Tutuila, the third largest island in Samoa.

Provisional IUCN conservation assessment. Globally not assessed. Assessed here as Critically Endangered (CR/D) in Singapore.

Additional specimens examined. SINGAPORE: **Bukit Timah:** 12 Feb 1890, *Goodenough 203* (BM [BM000989412], SING [SING0086112]); ibidem, 12 Feb 1890, *Ridley 203* (BM [BM001007634]); ibidem, 1891, *Ridley s.n.* (BM [BM001007633]); ibidem, 1898, *Ridley 353* (BM [BM001244715], SING [SING0092415]); ibidem, 1908, *Ridley 39* (BM [BM001007635]). **Central Catchment:** MacRitchie Reservoir, Conduit, outhouse, 28 Jan 1998, *Tan 98-346* (SING [SING0234892]). **Jurong:** Jurong Road, 17th Mile, Nov 1917, *Baker 6347* (BM [BM001007706]).

Notes. *Ectropothecium tutuulum* is distinguished by its stem and branch leaves, which have subpiliform leaf apices and strongly serrate leaf margins. Previously, this species was misidentified and treated as *E. ichnotocladum* or *E. moritzii* in various reports in Singapore, as cited in the aforementioned sections on nomenclature and synonyms. The species name, *Ectropothecium tutuulum*, is now being introduced for the first time in Singapore. It was also incorrectly referred to as *Trichosteleum leptocarpon* based on *Ridley 353* (SING [SING0092415]) from Bukit Timah. This erroneous record was later propagated in checklist compilations as '*Warburgiella leptocarpos*'.

Iwatsuki (1992) selected a specimen in FH "herb. Sullivant no. 136 [mistyped as 126]" as the lectotype of *Hypnum tutuulum* Sull. Several specimens identified as types of this name from various herbaria bearing the same information were also found except that they have no number. The 136 on the lectotype is probably a Herb. Sullivant's number issued much later and the gathering itself has neither collector's name nor collection number. Since it is uncertain whether the other type specimens are duplicates of the lectotype, and that specimens of a gathering are considered syntypes (Art. 40 Note 1 of the ICN), these are listed as syntypes.

4. *Neoptychophyllum* S.He, Bryoph. Diversity & Evol. 41: 24 (2019). – *Ptychophyllum* Broth., Mitt. Inst. Allg. Bot. Hamburg 7: 139 (1928), nom. illeg. non C.Presl (1843), nec Dixon & Herzog (1928). – TYPE: *Neoptychophyllum borneense* (Broth.) S.He (= *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho).

Ptychophyllum Dixon & Herzog, Rev. Bryol., n.s. 1: 105 (1928), nom. illeg. non C.Presl (1843). – TYPE: *Ptychophyllum aureum* Dixon & Herzog (= *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho).

Plants medium-sized to rather robust, to more than 6 cm long, yellowish green to yellowish brown, somewhat glossy. **Stems** creeping, pinnately branched; in cross section a central strand slightly differentiated; paraphyllia absent, pseudoparaphyllia foliose, occasionally mixed with subfoliose to filamentous ones. **Stem leaves** moderately falcate, oblong-lanceolate to broadly triangularly lanceolate, moderately to strongly plicate, rather abruptly narrowed to a flexuose, long acumen, decurrent at base with hyaline, enlarged cells; margins plane or slightly recurved as a result of plication, distinctly serrate at upper half, subentire to entire below; costa weak, short and double; laminal cells linear, smooth or sometimes projecting at upper ends; alar cells strongly inflated, hyaline, numerous; supra-alar cells much smaller, numerous, quadrate. **Branch leaves** smaller, narrowly ovate-lanceolate, less falcate, other features similar to stem leaves, except for having fewer inflated alar cells. **Phyllodioicous** or **monoicous**. **Perichaetial leaves** abruptly narrowed from a rounded base. **Seta** elongated, up to 4 cm long. **Capsule** notably small, short-ovoid; peristome double, hypnoid. **Calyptra** not seen. **Spores** spherical, minutely papillose.

Distribution. This monotypic genus was previously only known from Borneo but appears to have a wider distribution in the neighbouring regions. In other parts of Southeast Asia, the genus may have been classified under the name *Ectropothecium*. The presence of this genus in Singapore is a new discovery.

Ecology. Usually at higher elevations on shrubs, tree-trunks, roots, or rotten logs in mossy forest.

Etymology. Greek, *neo-* = new; *ptycho-* = having folds, pleated; *-phyllum* = leaf; referring to the plicate leaves.

Taxonomy. The name *Neoptychophyllum* was recently created to replace the later homonym *Ptychophyllum* Broth., which was previously considered as a synonym of *Ectropothecium* by Nishimura (1984: 154). As discussed by He (2019), *Neoptychophyllum* can be clearly distinguished from *Ectropothecium* by the presence of several well-developed and inflated alar cells grouped together, as well as strongly plicate leaves. In contrast, *Ectropothecium* has been defined as having only a single inflated alar cell in the alar region. The inclusion of the species within *Ectropothecium* in the past was likely because of an unclear delimitation of the genus concept, specifically regarding the alar region (Nishimura, 1984).

4.1. *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho, **comb. nov.** – *Ectropothecium dixonii* M.Fleisch. in Dixon, J. Linn. Soc., Bot. 43: 318, pl. 27: f. 15 (1916 [‘1915–1917’]), as ‘*dixonii*’. – TYPE: [Malaysia, Sabah], Sekong, 23 April 1913, *Binstead 108* (holotype FH; isotypes BM [BM000850188], G [G00265122], P [PC0101314] n.v.). (Fig. 6)

Ptychophyllum borneense Broth., Mitt. Inst. Allg. Bot. Hamburg 7: 139 (1928), **syn. nov.** – *Ectropothecium ptychofolium* N.Nishim., Bull. Natl. Sci. Mus. Tokyo, B, 10: 154, f. 1–2 (1984). – *Neoptychophyllum borneense* (Broth.) S.He, Bryoph. Diversity & Evol. 41: 24, f. 3 (2019). – TYPE: [Malaysia], Borneo, Sarawak, Mt Poeh, 4800 ft, August 1892, *Everett s.n.* (lectotype H [H-BR3502004], designated by Nishimura (1984: 154); isolectotypes BM [BM000749726], JE [JE04005163, JE04005164]).

Ptychophyllum aureum Dixon & Herzog, Rev. Bryol., n.s. 1: 106, f. 5 (1928). – TYPE: [Indonesia], Borneo [East Kalimantan], *Balneti s.n.* (holotype BM [BM000749727]).

Ectropothecium malaccense Broth., Gard. Bull. Straits Settlm. 4(1): 31 (1926), nom. inval. pro syn.

Ectropothecium incubans auct. non (Reinw. & Hornsch.) A.Jaeger: Dixon, Gard. Bull. Straits Settlm. 4(1): 31 (1926); Wee, Gard. Bull. Singapore 32: 63 (1979); Johnson, Mosses Singapore Malaysia 98 (1980); Mohamed & Tan, Bryologist 91: 36 (1988); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Tan & Ho, Guide Mosses Singapore 126 (2008); Wong et al., Checkl. Pl. Nee Soon Swamp Forest 95, 267 (2013); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 39 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 46 (2022).

Ectropothecium buitenzorgii auct. non (Bél.) Mitt.: Holttum, Gard. Bull. Straits Settlm. 4(2 & 3): 91 (1927), as ‘*buitenzorgii*’; Wee, Gard. Bull. Singapore 32: 63 (1979), as ‘*buitenzorgii*’; Johnson, Mosses Singapore Malaysia 97 (1980), as ‘*buitenzorgii*’; Tixier, Nova Hedwigia 36: 86 (1982), as ‘*buitenzorgii*’; Mohamed & Tan, Bryologist 91: 36 (1988), as ‘*buitenzorgii*’; Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994), as ‘*buitenzorgii*’; Tan & Ho, Guide Mosses Singapore 126 (2008), as ‘*buitenzorgii*’; Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam 133) 38 (2013), as ‘*buitenzorgii*’; Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 45 (2022).

Plants medium-sized to somewhat robust, to c. 5 cm long, yellowish green to yellowish brown, slightly glossy. **Stems** creeping, pinnately branched; in cross section a central strand weakly differentiated; pseudoparaphyllia foliose, subfoliose, and occasionally mixed with filamentous ones. **Stem leaves** moderately falcate, ovate-lanceolate, 1.6–2.1 × 0.6–0.9 mm, modestly plicate, rather abruptly narrowed to a flexuose, long acumen, decurrent at base as a result of enlarged alar cells; margins plane or slightly recurved as a result of plication, distinctly serrate at upper half, subentire to entire below; costa weak, short, double; laminal cells linear, 60–70 × 5–6 µm, upper and lower cells moderately thick-walled, median cells nearly smooth or sometimes projecting at upper ends; alar cells strongly inflated, hyaline, numerous; supra-alar cells much smaller, numerous, quadrate. **Branch leaves** narrowly ovate-lanceolate,

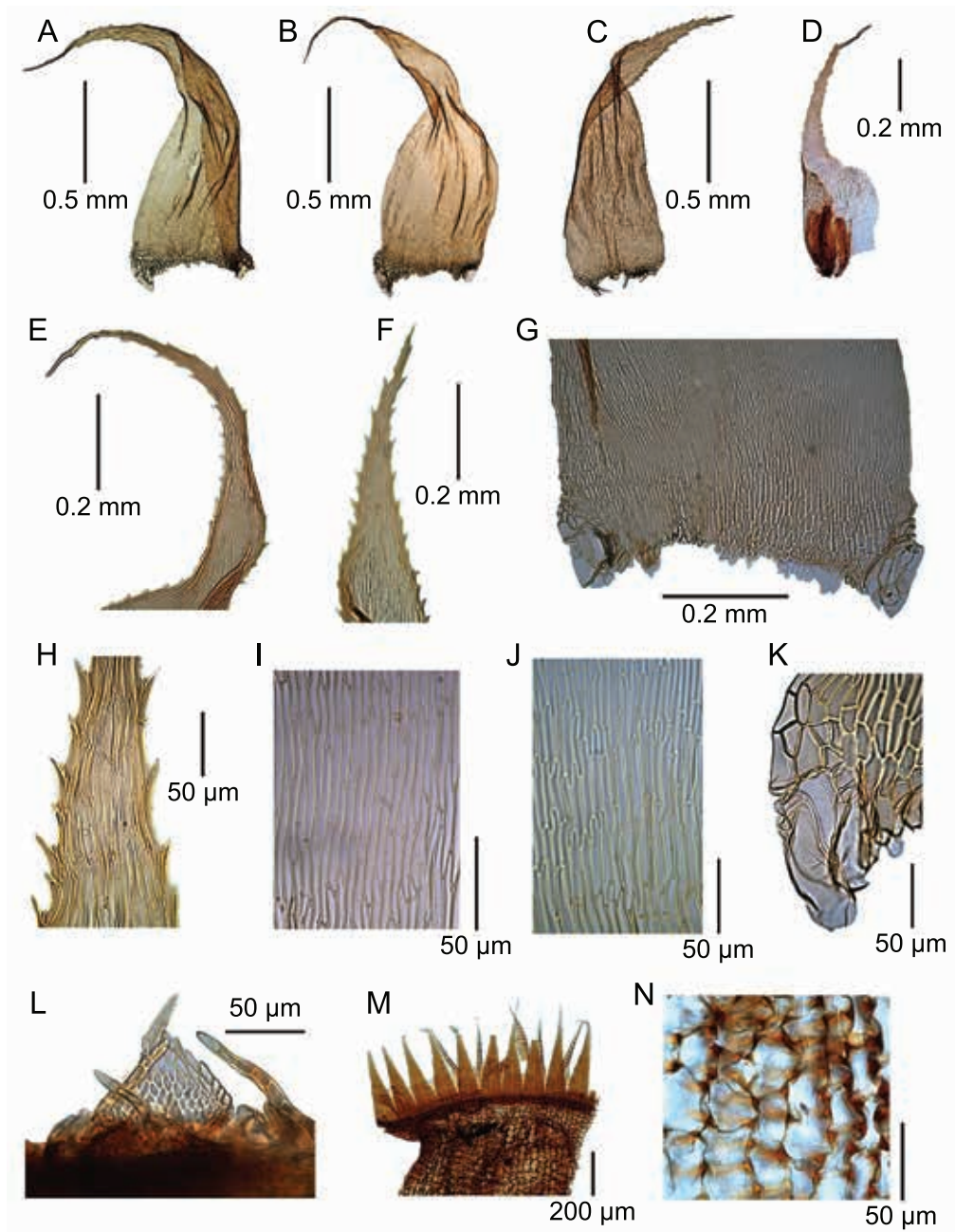


Fig. 6. *Neoptychophyllum dixonii* (M.Fleisch.) S.He & B.C.Ho. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Perichaetial leaf. **E.** Stem leaf apex. **F.** Branch leaf apex. **G.** Basal part of leaf. **H.** Upper part of leaf. **I.** Median laminal cells. **J.** Lower laminal cells. **K.** Alar region, showing several inflated alar cells. **L.** Pseudoparaphyllia. **M.** Peristome teeth. **N.** Exothecial cells, showing collenchymatous wall thickening. All images prepared from *Ridley 24* (SING). (Photos: S. He)

less falcate, $1.4\text{--}1.9 \times 0.5\text{--}0.6$ mm, other features similar to stem leaves, except for having fewer inflated alar cells. **Monoicous** with perigonia and perichaetia on the same plant. **Perichaetial leaves** abruptly narrowed from a rounded base. **Seta** elongated, up to 4 cm long. **Capsule** notably small, short-ovoid, constricted below mouth; exothecial cells short-rectangular, collenchymatous; stomata on neck, immersed; annulus well-developed, revolute; peristome double, exostome teeth 16, yellowish brown, cross-striolate in lower 2/3, densely papillose above, distinctly bordered; endostome light yellow, basal membrane high, segments well-developed, upper parts keeled, as high as the teeth, perforate; cilia rudimentary. **Calyptra** not seen. **Spores** small, spherical, $8\text{--}10$ μm diam., minutely papillose.

Distribution. Thailand, Singapore, and Borneo, but probably more widespread in the neighbouring areas of the region.

Ecology. Unknown in Singapore. Reported elsewhere at higher elevations on shrubs, tree-trunks, roots, rotten logs, and litter in shady mossy forest.

Etymology. Hugh Neville Dixon, 1861–1944, British bryologist and authority on mosses before World War II.

Provisional IUCN conservation assessment. Globally not assessed. Assessed here as Critically Endangered (CR/D) in Singapore.

Additional specimens examined. SINGAPORE: without locality, *Ridley s.n.* (FH [FH00965167]).

Central Catchment: Chan Chu Kang, 1890, *Ridley 271* (BM [BM000989350, BM001007632], SING [SING0086104]); MacRitchie Reservoir, Feb 2001, *Tan 01-51* (SING [SING0234893]).

Lim Chu Kang: Sungai Buloh, 1890, *Ridley 24* (SING [SING0086111]; ibidem, 1892, *Ridley 243* (FH [FH00965168]); ibidem, *Ridley s.n.* (FH [FH00965169]). **Tanglin:** Singapore Botanic Gardens, 1895, *Ridley 605* (BM [BM001007714], SING [SING0086103]).

Notes. The original material of *Ectropothecium dixonii* included perichaetia but lacked sporophytes. Fleischer in Dixon (1916: 318) described the species as dioicous. Both type specimens of *Ptychophyllum borneense* and *Ptychophyllum aureum* are also sterile, but Brotherus (1928: 139) and Dixon & Herzog (in Herzog, 1928: 106) respectively described both species as dioicous. Nishimura (1984: 154) described the species as phylloidioicous based on non-type fruiting material, where dwarf male plants were found. However, the Singapore plants display normal perigonia and perichaetia on the same stem, indicating that species is clearly autoicous. In case where one of the gametangial organs is absent in a specimen, it may lead to an assumption of a dioicous sexual condition in the plant.

The Singapore specimens of this species were labelled and reported under various names, including unpublished herbarium names such as *Ectropothecium malaccense* Broth., nom. inval. (*Ridley 271*) and *Ectropothecium ridleyi* Broth., nom.

inval. (Ridley 243). The Singapore record of *Ectropothecium incubans* was also based on Ridley 271, which was subsequently propagated in later checklist compilations. All of these collections match the type of *Ectropothecium dixonii* M.Fleisch. The plants in the Singapore specimens have less plicate leaves and somewhat weaker development of the inflated alar cells.

Ectropothecium ptychophyllum was a new name proposed by Nishimura (1984) to replace *Ptychophyllum borneense* when the species was regarded as a species of *Ectropothecium*. It was given a new name because the combination *Ectropothecium borneense* Broth. & Geh. had already been taken up.

The first report of *Ectropothecium buitenzorgi* in Singapore was made by Holttum (1927), who gave the specimen locality from the Singapore Botanic Gardens. However, no specific voucher specimen was indicated. Subsequent literature citing this species from Singapore likely relied on Holttum's report. Interestingly, none of the collections of *Ectropothecium* in Singapore corresponds to this species. A collection from the Singapore Botanic Gardens labelled as *Ectropothecium buitenzorgi* (Ridley 605) belongs to a putative form of *Neoptychophyllum dixonii* with weak development of alar cells on the stem leaves. Therefore, the Singapore report of *Ectropothecium buitenzorgi* is considered here as a misapplied name.

Excluded taxa and species found only in cultivation

Among the eight species of *Ectropothecium* previously reported in Singapore, six of them have been dealt with under various names in this treatment. The following species are excluded from the Singapore flora based on the findings and analyses conducted in this study.

1. *Ectropothecium intorquatum* (Dozy & Molk.) A.Jaeger – Wee, Gard. Bull. Singapore 32: 63 (1979); Mohamed & Tan, Bryologist 91: 36 (1988); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Tan & Ho, Guide Mosses Singapore 126 (2008); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 39 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 753 (2022).

Notes. The species in question was initially reported for Singapore by Wee (1979), but no voucher specimen was provided for verification. Since then, this report has been repeatedly cited in the subsequent checklists until Tan & Ho (2008) considered it a dubious record for Singapore. In the most recent checklist by Lindsay et al. (2022), the species was explicitly excluded. Without the discovery of any additional voucher specimens supporting the occurrence of this species in Singapore, we concur with its exclusion.

2. *Ectropothecium sodale* (Sull.) Mitt., J. Linn. Soc., Bot. 10: 180 (1868). – *Hypnum sodale* Sull., Proc. Amer. Acad. Arts 3: 78 (1854). – TYPE: [Society Islands], Mo'orea (Eimeo), Tahiti, U.S. Explor. Exped. under Captain Wilkes, 1838–1842, in herb. Sullivant, *Unknown collector 135* (lectotype FH [FH00290393], designated by Iwatsuki (1992: 125); isolectotypes G [G00265133], JE [JE04005160]). (Fig. 7)

Notes. A specimen (*Ho 18-063*, 23 May 2018, SING [SING0244798]) was collected inside a cool glasshouse, which was subsequently demolished. The specimen has been determined as *Ectropothecium sodale*. This species has been known from the Philippines, New Guinea, and the Pacific islands. However, no other specimens of this species have been found in open environment in Singapore. It is assumed that the species can only survive in an enclosed, man-made environment with a constant cool temperature of 18–24°C and high humidity. Therefore, it is considered a non-native species in Singapore, and it once occurred only in cultivation. As a result, it is here excluded from the local flora. For future reference, the species is still included in the key, and illustrations are provided.

3. *Ectropothecium zollingeri* auct. non (Müll.Hal.) A.Jaeger: Dixon, Gard. Bull. Straits Settle. 4(1): 32 (1926); Holttum, Gard. Bull. Straits Settle. 4(2 & 3): 91 (1927); Mohamed & Tan, Bryologist 91: 37 (1988); Turner & Tan in Wee & Ng (eds), First Look Biodivers. Singapore 107 (1994); Tan & Ho, Guide Mosses Singapore 126 (2008); Yong et al., Rev. Moss Checkl. Penins. Malaysia & Singapore (FRIM Res. Pam. 133) 40 (2013); Lindsay et al., Gard. Bull. Singapore 74(Suppl. 1): 46 (2022). – *Glossadelphus zollingeri* auct. non (Müll.Hal.) M.Fleisch.: Wee, Gard. Bull. Singapore 32: 61 (1979).

Notes. The initial report of *Ectropothecium zollingeri* in Singapore was derived from the report of *Glossadelphus zollingeri* in Dixon (1926), which was based on a collection made in the water tank of the Plant House at the Singapore Botanic Gardens (13 Jun 1918, *Burkill 3258*, BM [BM001007705], SING [SING0087304]). However, it has been determined by our study that this voucher material is a misidentification of *Taxiphyllum barbieri* (Cardot & Copp.) Z.Iwats., commonly known as the Java moss. This moss is widely cultivated in aquaria for tropical fish (Iwatsuki, 1982). *Burkill 3258*, along with its two duplicates, is the only known collection that was used to validate *Glossadelphus zollingeri* ($\equiv$ *Ectropothecium zollingeri*) in Singapore. Since *Taxiphyllum barbieri* is considered a cultivated moss species in Singapore, it is excluded from the treatment in the *Flora of Singapore*.

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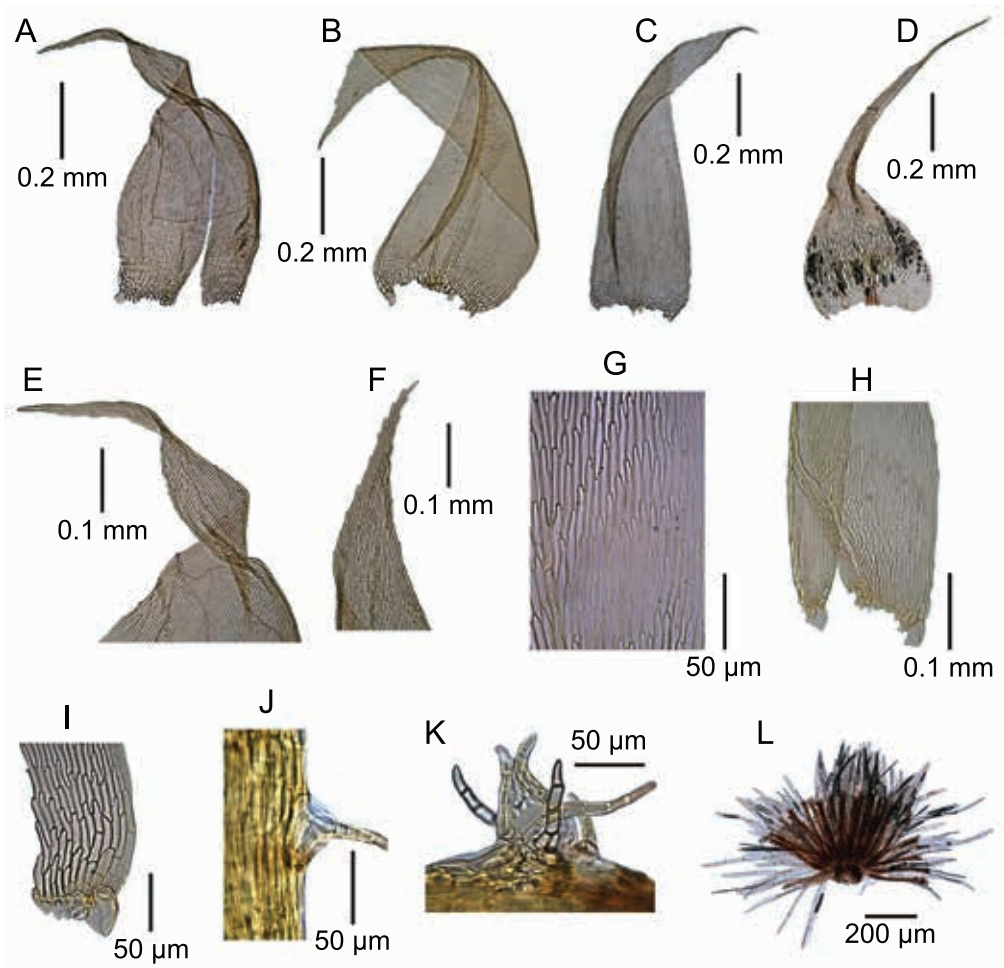


Fig. 7. *Ectropothecium sodale* (Sull.) Mitt. **A, B.** Stem leaves. **C.** Branch leaf. **D.** Perichaetial leaf. **E.** Stem leaf apex. **F.** Branch leaf apex. **G.** Median laminal cells. **H.** Basal part of leaf. **I.** Alar region. **J.** An inflated alar cell remaining on the stem. **K.** Pseudoparaphyllia. **L.** Archegonia. All images prepared from *Ho 18-063* (SING). (Photos: S. He)

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