



Additions to the mosses of Palawan Island, with notes on the phytogeography of the Palawan moss flora

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(Manuscript received 25 November 2022; Accepted 3 April 2023; Online published 13 April 2023)

ABSTRACT: Thirty-one species in 22 families of mosses are reported as new records for the island of Palawan, the Philippines. Two of these, *Acroporium downii* (Dixon) Broth. and *Trichosteleum pseudomamosum* M. Fleisch., are also reported here as new to the Philippine moss flora. A re-examination of the floristic affinity of the moss flora of Palawan revealed that: 1) it has high similarity and close floristic affinity with Mindoro rather than Luzon; 2) the islands of Mindoro, Palawan, and Mindanao have close floristic affinities with Sulawesi and the Nusa Tenggara Islands, roughly corresponding to the area of Wallacea; 3) Luzon Island, as a whole, has a closer floristic affinity with Peninsular Malaysia and Borneo; and 4) inferences on the distribution of *Clastobryum caudatum* (Sande Lac.) M. Fleisch. and *Meteorium crispifolium* Herzog provide additional information on the role of Palawan as a refugium for a past, xeric flora in the Philippines.

KEY WORDS: *Acroporium downii*, new records, Philippines, phytogeography, range extensions, *Trichosteleum pseudomamosum*.

INTRODUCTION

Tan (1996) published a biogeographic account of Palawan mosses after visiting the island between 1987 and 1993. His sizable moss collections were mainly from Palawan's lowland evergreen rainforests, semi-deciduous forests, and karst forests from sea level up to 1200 m asl of mountain ridges that run along the island's long central axis. This enabled him to increase the number of mosses known from Palawan to ca. 192 moss species in 88 genera. It is currently the only representation of Palawan's moss flora to date. Before its publication, there were only a few moss collections from Palawan Island, mainly by H.H. Bartlett, J. Bermejós, H.M. Curran, G.E. Edaña, F.W. Foxworthy, E.D. Merrill, and C.M. Weber. Their collections were later organized by Bartram (1939) when he published his Philippine moss flora.

According to Tan (1996), the moss flora of Palawan is known primarily as an extension of the Philippine flora and, in its entirety, an integral component of the West Malesian flora with little influence from Borneo, its closest neighboring island. Floristic affinities of the island's moss flora are strongest with the moss floras of the Philippine archipelago, Java, and the Lesser Sunda Islands, but not with the Bornean moss flora. Furthermore, Tan (1996) stated that the island's moss flora is also known to harbor a handful of moss species with disjunct distributions either between Indochina and Palawan or between Palawan and South Malesia-Australasia. The latter include species absent in Borneo, Sumatra, and other wetter parts of the Philippines and New Guinea.

So far as we are aware, no paper on the mosses of Palawan has been published after the moss checklist

presented by Tan (1996). Fortunately, there are a significant number of readily available Palawan moss collections from several collectors deposited in the National Herbarium at the National Museum of the Philippines (PNH) and the Botanical Herbarium of the University of the Philippines Los Baños Museum of Natural History (CAHUP) that can add considerably to our growing knowledge of mosses in the island. In addition, we also included recent moss collections in other places on the island, including those from mossy forests and ultramafic sites on the island's mountain peaks, well over 1200 m asl that are either rarely or have never been visited by earlier botanists representing the unreported taxa hitherto. We organized these collections to be treated as all Palawan mosses known by the time after Tan's Palawan moss checklist was published up to late December 2022.

In this paper, we report 31 new moss records for Palawan, serving as the first part of our report series of new species records for the island. Two of these are new records for the Philippine moss flora. In addition, we also present new findings on the phytogeographic affinity of the Palawan moss flora in light of recent information on the mosses of Palawan and other major Philippine islands.

MATERIALS AND METHODS

Earlier collections studied are from the Philippine National Herbarium, National Museum of the Philippines, Manila (PNH). These mainly include materials collected by J.R. Cabalquinto and B.O. van Zanten in 1989 but were not reported by Tan (1996). On the other hand, collections from recent field works are deposited at the



UPLB Museum of Natural History Botanical Herbarium (CAHUP) and the Palawan State University Herbarium (PPC) —with duplicates at the Herbarium of the Botanical Garden-Institute, Far East Branch of the Russian Academy of Sciences, Vladivostok (VBGI).

In re-examining the floristic affinity of the Palawan moss flora, information on the distribution of the reported species —as well as the moss floras of major Philippine islands which have been studied in detail (*i.e.* Luzon, Mindoro, Palawan, and Mindanao) —were updated by reviewing all relevant journal articles published after Tan and Iwatsuki (1991) up until 2022. Likewise, the most recent checklists and pertinent publications after these were consulted for information on the moss floras of Vietnam (*e.g.* He and Khang, 2012; Ho *et al.*, 2015; Koponen *et al.*, 2019), Peninsular Malaysia (*e.g.* Yong *et al.*, 2013; Norhazrina *et al.*, 2020), Borneo (*e.g.* Suleiman *et al.*, 2006, 2017), Sulawesi (*e.g.* Gradstein *et al.*, 2005; Ariyanti *et al.*, 2009), and the Nusa Tenggara Islands (*e.g.* Touw, 1992a). Species noted as doubtful records were excluded.

To compare and analyze the floristic affinity of the Palawan mosses, the Kroeber's Similarity Index [%K = $(C \times (A+B) / 2AB) \times 100$, where A = number of taxa in first floristic area, B = number of taxa in second floristic area, and C = number of shared taxa between the two floristic areas being compared] was computed both at the generic and species levels following Linis (2009). Also, hierarchical clustering was performed, and a dendrogram was constructed based on Ward's Method and Euclidean Distances —implemented in PAST 4.11 (Hammer *et al.*, 2001).

RESULTS AND DISCUSSION

Thirty-one species in 22 families of mosses are here reported as new records for the island of Palawan —of which, *Acroporium downii* (Dixon) Broth. and *Trichosteleum pseudomamosum* M. Fleisch. are reported as new to the Philippine moss flora. The list of species is presented alphabetically for ease of reference. Classification and nomenclature follow Brinda and Atwood (2022—continuously updated); otherwise, stated. Comments, distribution, and specimens examined are provided for each entry.

New Philippine Moss Records

Sematophyllaceae Broth.

1. *Acroporium downii* (Dixon) Broth., Nat. Pflanzenfam. (ed. 2) 11: 436. 1925. **Fig. 1**

Description. Robust, yellowish green plants in tufts. Stems elongate, creeping eventually ascending to becoming erect, irregularly branched; branches up to 2.50 cm long, ascending to erect, densely foliate with cuspidate tips. Leaves narrowly triangular-lanceolate, 1.50–3.00 mm long and 0.50–0.70 mm wide, eventually narrowing into subtubulose apex, falcate-secund,

recurved or slightly concave; margins incurved, entire; ecostate. Upper and median leaf cells elongate to linear, 80–175 μ m long and 6–8 μ m wide, papilla not well-developed; basal cells shorter, pitted below; alar cells oblong, usually 3–5 cells in one row, inflated, thin-walled, yellowish brown to reddish brown; supra-alar cells absent. Perichaetial leaves ovate-lanceolate, up to 3.0 mm long and up to 0.80 mm wide, gradually tapering into long flexuose and strongly toothed filiform points; alar cells not strongly developed. Setae up to 3.0 cm long, smooth. Capsules ovoid, 0.90–1.00 mm long and 0.50–0.60 mm wide, erect; exothecial cells collenchymatous.

Comments. Tan (1994) noted that *Acroporium downii* is similar to *A. convolutum* (Sande Lac.) M. Fleisch. — both sharing similarities in their perichaetial leaf morphology. Although, *A. downii* is distinguished from the latter species by its 1) broad leaf base, 2) leaf margins incurved throughout, 3) setaceous leaf apices, 4) single leaf cell papilla which is not as well-developed, and 5) perichaetial leaves which gradually taper into long flexuose and strongly toothed filiform points which are usually as long as or considerably longer than the rest of the leaf. *Acroporium downii* (Fig. 1) also looks like a papillose version of *A. johannis-winkleri* Broth., as stated by Tan (1994). However, *Acroporium johannis-winkleri* has incrassate alar cells. In addition, supra-alar cells are absent in *A. downii* but are present in *A. johannis-winkleri* with 1 to 2 rows of small and irregular hyaline cells above.

Extra-Philippine distribution. Taiwan, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Borneo, and Sulawesi (Dixon, 1924; Tan, 1994; Gradstein *et al.*, 2005; Suleiman *et al.*, 2006; Yong *et al.*, 2013; Shevock *et al.*, 2014; Ho *et al.*, 2015). **New to the Philippines.**

Specimen examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 1300 m elev., on bark, 21 February 1989, J.R. Cabalquinto & B.O. van Zanten *s.n.* (PNH).

2. *Trichosteleum pseudomamosum* M. Fleisch., Musci Buitenzorg 4: 1319. 1923. **Fig. 2**

Description. Medium-sized, yellowish brown plants in dense tufts. Stems elongate, irregularly branched; branches spreading, up to 5.0 mm. Stem and branch leaves similar, oblong-lanceolate to ovate-lanceolate, 0.80–1.30 mm long and 0.30–0.42 mm wide, abruptly constricted into a long and narrow acumen 2–4 cells wide, concave; margins plane and denticulate below, reflexed and dentate to serrulate above especially along the acumen; ecostate. Leaf cells elongate-rhomboidal to linear, 50–60 μ m long and 6–10 μ m wide, with a prominent single papilla 6–8 μ m in diameter, thin-walled; alar cells oblong, usually 2–3 cells in one row, inflated, thick-walled, reddish brown. Perichaetial leaves ovate-lanceolate, up to 1.20 mm long and up to 0.43 mm wide, long acuminate; apices dentate; leaf cells unipapillose. Setae up to 10 mm long, smooth. Capsules ovoid, 0.80–1.20 mm long and 0.40–0.50 mm wide, horizontal to pendant; exothecial cells mammillose.

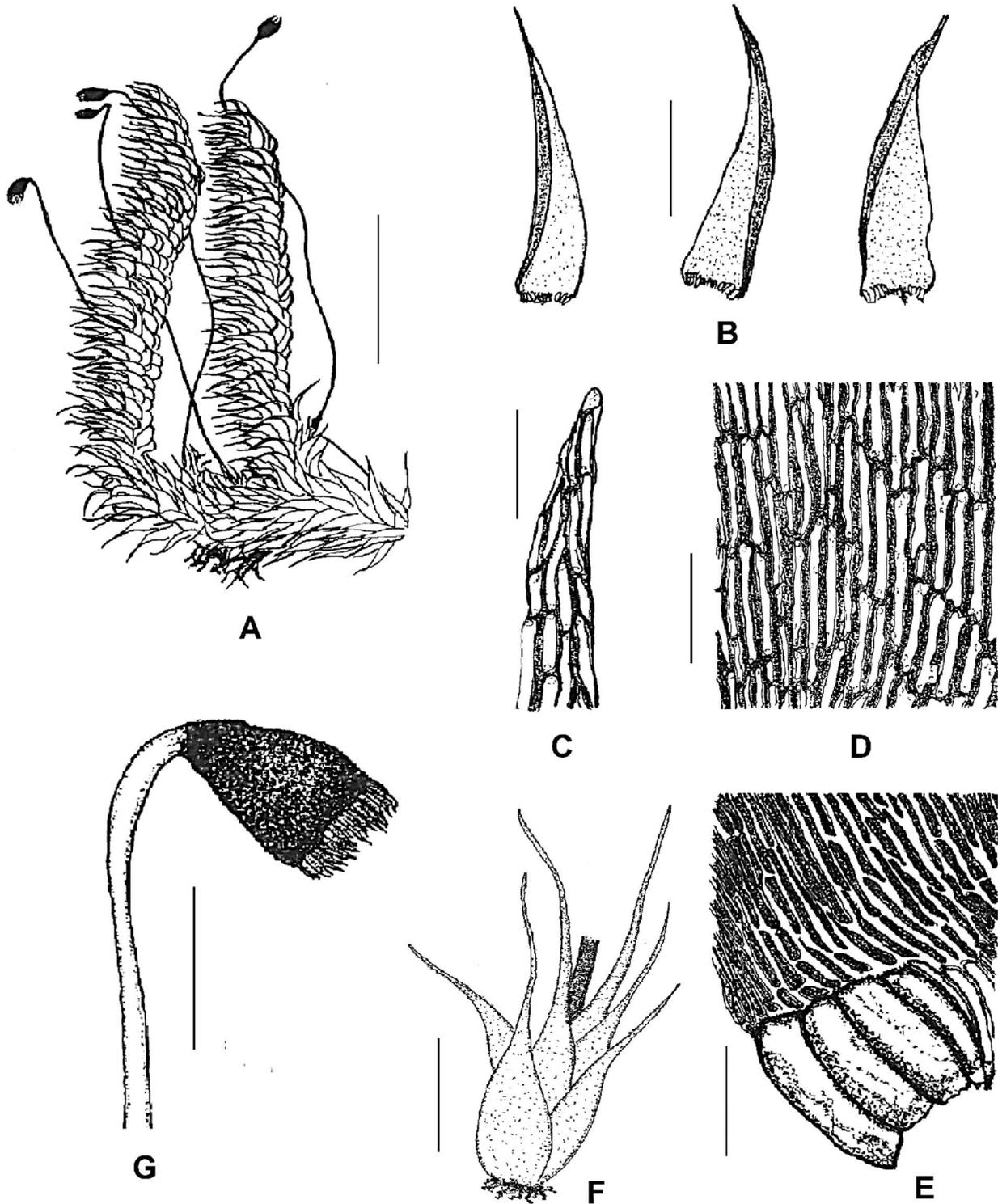


Fig. 1. Illustration of *Acroporium downii* (Dixon) Broth. A. Plant habit. B. Leaves. C. Leaf apex. D. Median leaf cells. E. Alar region. F. Perichaetium with bracts and a portion of seta. G. Capsule. Scale bars: A = 10 mm; B, F, G = 1 mm; C, D, E = 100 μ m. Illustrated by V.C. Linis based on J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

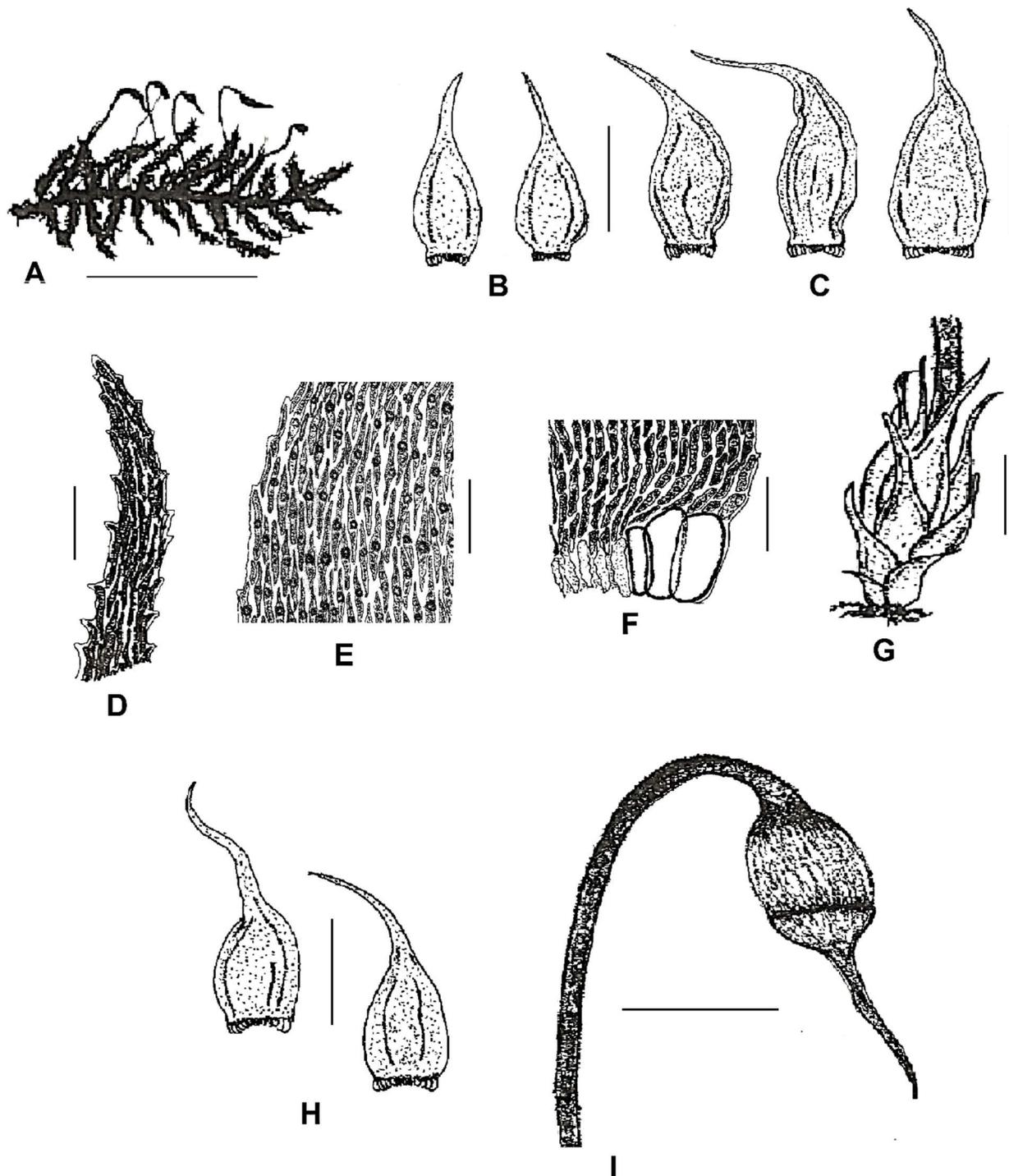


Fig. 2. Illustration of *Trichosteleum pseudomamosum* M. Fleisch. **A.** Plant habit. **B.** Branch leaves. **C.** Stem leaves. **D.** Leaf apex. **E.** Median leaf cells. **F.** Alar region. **G.** Perichaetium with bracts and a portion of seta. **H.** Perichaetial leaves. **I.** Capsule. Scale bars: A = 5 mm; B, C, G, H, I = 0.5 mm; D, E, F = 50 µm. Illustrated by V.C. Linis based on J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

Comments. *Trichosteleum pseudomamosum* can be confused with *T. stigosum* Mitt. However, the former is a smaller plant with ovate-lanceolate leaves reaching about 1 mm in length that end into long, narrow leaf apices with sharp teeth. In contrast, the leaves of *T. stigosum* are

generally oblong-lanceolate, reaching up to 2 mm in length. Furthermore, the leaf cells of *T. stigosum* are oblong-linear, whereas the leaf cells of *T. pseudomamosum* are elongate-rhomboidal to linear. As noted by Tan *et al.* (2007), *Trichosteleum pseudomamosum* can also be



mistaken for the variable *T. boschii* (Dozy & Molke.) A. Jaeger, but the latter is a larger plant with branches up to 10 mm long with more extended, slightly pitted leaf cells reaching up to 100 µm.

Extra-Philippine distribution. Sri Lanka, Taiwan, Laos, Vietnam, Thailand, Cambodia, Borneo, Java, Nusa Tenggara Islands, and New Guinea (Fleischer, 1923; Touw, 1992a; Tan and Iwatsuki, 1993; Li and Sinikka, 1994; O'Shea, 2002; Suleiman and Edwards, 2002; Suleiman *et al.*, 2006; Tan *et al.*, 2007; Shevock *et al.*, 2014). **New to the Philippines.**

Specimen examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 750 m elev., on a boulder along the stream, 21 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

New Palawan Moss Records

Bartramiaceae Schwägr.

3. *Breutelia arundinifolia* (Duby) M. Fleisch., Musci Buitenzorg 2: 630. 1904.

Comments. This is a robust moss with elongated stems easily recognized by its big antheridial head, patent to somewhat squarrose and sheathing plicate leaves, and densely tomentose stems (Virtanen, 1997). A ground dweller on open sites at high elevations in the Philippines, this species was found growing in a montane heath in southern Palawan.

Intra-Philippine distribution. Luzon, Mindoro, and Mindanao (Tan and Iwatsuki, 1991; Tan and Mandia, 2001; Linis, 2009).

Specimen examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, montane thicket-over-ultramafic rocks, ca. 1600 m elev., on forest litter, 26 July 2019, E.L.R. Logatoc 19-0308 (CAHUP, PPC, VBGJ).

4. *Philonotis falcata* (Hook.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 62. 1859.

Comments. As noted by Eddy (1996), plants of *Philonotis falcata* are distinguished from their congeners by the strictly 5-ranked, triangular leaves with relatively short leaf apices and plane upper leaf margins. This species is similar to *P. turneriana* (Schwägr.) Mitt., a congener also reported on Palawan Island (Tan, 1996). However, the leaves of *P. turneriana* are much narrower with long excurrent costae.

Intra-Philippine distribution. Luzon and Catanduanes (Tan and Iwatsuki, 1991; Linis, 2014).

Specimens examined. Palawan Island, Puerto Princesa City, Irauan, So. Tagkanarum, ca. 250 m elev., on a sand pile along the road, 19 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH). Loc. cit., on soil, 19 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

Brachytheciaceae Schimp.

5. *Palamocladium leskeoides* (Hook.) E. Britton, Bull. Torrey Bot. Club 40(12): 673. 1913[1914].

Comments. *Palamocladium* Müll. Hal. is a small tropical genus with a single species in Southeast Asia, and differs from local species of other genera of Brachytheciaceae found in the region by having an erect

capsule, deeply plicate leaves, and a relatively well-defined group of alar cells at leaf base (see Hofmann, 1997). There are three names previously applied to Asiatic materials of *Palamocladium*: *P. leskeoides*, *P. macrostegium* (Sull. & Lesq.) Z. Iwats. & Takaki, and *P. nilgheriense* (Mont.) Müll. Hal. Hofmann (1997) later placed all three of these names as synonyms of *P. leskeoides*, and this synonymy is accepted here.

Intra-Philippine distribution. Luzon and Mindanao (Tan and Iwatsuki, 1991 as *P. nilgheriense*).

Specimen examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 1050 m elev., on exposed roots, 21 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

Bryaceae Rchb.

6. *Gemmabryum apiculatum* (Schwägr.) J.R. Spence & H.P. Ramsay, Phytologia 87(2): 65. 2005.

Comments. *Gemmabryum apiculatum* is distinguished from other members of *Bryum* sensu lato occurring in the Philippines by its 1) very long leaf cells, 2) usually pinkish tinge of plants, 3) small brown pyriform tubers, and 4) small distinct groups of quadrate alar cells. Sterile plants of this species resemble *Imbibryum clavatum* (Schimp.) J.R. Spence & H.P. Ramsay but is differentiated from the latter by its 1) poorly defined leaf border with the marginal leaf cells scarcely different from interior cells, and 2) solid and reddish costae which are usually percurrent or shortly excurrent.

Intra-Philippine distribution. Batan, Luzon, Lubang, Polillo, Catanduanes, Mindoro, Panay, and Mindanao (Tan and Iwatsuki, 1991 as *Bryum apiculatum* Schwägr.; Linis, 2009 as *B. apiculatum*, 2014 as *B. apiculatum*; 2019b).

Specimen examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on ultramafic rock, 27 July 2019, E.L.R. Logatoc 19-0313 (CAHUP, VBGJ).

Calymperaceae Kindb.

7. *Calymperes porrectum* Mitt., J. Linn. Soc., Bot. 10: 172. 1868.

Comments. *Calymperes porrectum* is a robust species with shoots reaching 6 cm in height. In the field, the strongly dimorphic leaves will easily separate *C. porrectum* from other species of similar sizes, such as *C. taitense* (Sull.) Mitt. In *Calymperes taitense*, most leaves possess linear, apical proboscises —whereas, in *C. porrectum*, the leaves produce either special, gemma-bearing apices (gemmaiferous leaves) or without apical modification of this kind (non-gemmaiferous leaves). The almost erect, bristle-like gemmaiferous leaves of *C. porrectum* mostly have subelliptical hyaline bases abruptly narrowing into long linear chlorophyllose limbs. Other *Calymperes* species, such as *C. fasciculatum* Dozy & Molke. and *C. lonchophyllum* Schwägr. have similar intramarginal bands of thick-walled, linear cells as in *C. porrectum*, but the two former species have non-dimorphic leaves.



Intra-Philippine distribution. Luzon, Mindoro, Mindanao, and Basilan (Tan and Iwatsuki, 1991; Ellis and Tan, 1999; Linis, 2009, 2014).

Specimens examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 850 m elev., on stone, 21 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH). Loc. cit., Mt. Kalantiaw, ca. 550 m elev., on a boulder along the stream, 23 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

Daltoniaceae Schimp.

8. *Calypstrochaeta parviretis* (M. Fleisch.) Z. Iwats., B.C. Tan & Touw, J. Hattori Bot. Lab. 44: 150. 1978.

Comments. Among its Philippine congeners, *Calypstrochaeta parviretis* is often confused with *C. remotifolia* (Müll. Hal.) Z. Iwats., B.C. Tan & Touw. — the latter is a larger plant with leafy stems over 4 mm wide. In *Calypstrochaeta remotifolia*, the leaf borders, especially near the apex, consist of (2)3-4 rows of elongate-linear cells with stronger marginal teeth, whereas the leaf borders of *C. parviretis* consist only of 2(-3) rows of elongate-linear cells with weaker marginal teeth. Furthermore, the upper leaf cells of *C. remotifolia* are mostly rhomboidal, not collenchymatous, while those of *C. parviretis* are shorter and often collenchymatous. As noted by Tan and Robinson (1990), *C. parviretis* can also be challenging to separate from *C. ramosa* (M. Fleisch.) B.C. Tan & H. Rob. as both are similar in terms of leaf areolation and the acuminate perichaetial leaf morphology. The latter, however, is much larger than *C. remotifolia*, with secondary stems up to 10 cm in height.

Intra-Philippine distribution. Luzon and Mindoro (Tan and Iwatsuki, 1991; Linis, 2009).

Specimen examined. Palawan Island, Brooke's Point Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on an ultramafic boulder, 08 January 2020, E.L.R. Logatoc 20-0113, pro parte (CAHUP, VBG).

9. *Distichophyllum cuspidatum* var. *subcuspidatum* (Nog. & Z. Iwats.) B.C. Ho, T.T. Luong & B.C. Tan, Bryoph. Diversity & Evol. 37(1): 3. 2015.

Comments. As noted by Tan and Robinson (1990 as *Distichophyllum subcuspidatum* Nog. & Z. Iwats.), this taxon differs from *D. brevicuspis* M. Fleisch. by possessing a concave, more expanded leaf blade in the upper half and a leaf base that is not carinate. In addition, *D. cuspidatum* var. *subcuspidatum* is also reported to produce fusiform and falcate brood bodies in Bornean plants (Noguchi and Iwatsuki, 1972 as *D. subcuspidatum*), which were never observed in *D. brevicuspis*.

Intra-Philippine distribution. Sibuyan and Mindanao (Tan and Robinson, 1990; Tan and Iwatsuki, 1991; Shevock and Yorong, 2018).

Specimen examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1700 m elev., on a fallen twig, 09 January 2020, E.L.R. Logatoc 20-0136 (CAHUP, VBG).

Fissidentaceae Schimp.

10. *Fissidens serratus* Müll. Hal., Bot. Zeitung (Berlin) 5: 804. 1847.

Comments. With its small size and cells of vaginant lamina possessing a distinct central papilla, *Fissidens serratus* is like a miniature version of *F. taxifolius* Hedw. However, *F. serratus* is recognized from the latter by its 1) smaller size, 2) regularly sharp margins of the vaginant lamina, and 3) stout, light yellow costa which ends a few cells below the leaf apex, often dividing the leaf unequally.

Intra-Philippine distribution. Luzon and Negros (Tan and Iwatsuki, 1991).

Specimens examined. Palawan Island, Puerto Princesa City, Irauan, So. Tagkanarum, ca. 250 m elev., on soil, 19 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH). Loc. cit., Mt. Beauport [Mt. Beaufort], ca. 1300 m elev., on exposed roots, 21 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH). Loc. cit., Mt. Venture, ca. 850 m elev., on a boulder, 24 February 1989, J.R. Cabalquinto & B.O. van Zanten s.n. (PNH).

Grimmiaceae Arn.

11. *Racomitrium lanuginosum* (Hedw.) Brid., Muscol. Recent. Suppl. 4: 79. 1819[1818].

Comments. *Racomitrium lanuginosum* can be easily recognized from *Bucklandiella subsecunda* (Hook. & Grev. ex Harv.) Bedn. -Ochyra & Ochyra, recorded in northern Luzon by Iwatsuki and Tan (1980 as *R. subsecundum* (Hook. & Grev. ex Harv.) Mitt. & Wilson), by its whitish and strongly erose leaf awns. The open heath vegetation at the summit of Mt. Mantalingahan in Palawan Island is the third locality in the Philippines for *R. lanuginosum*. Its other Philippine records came from Mt. Giting-Giting in Sibuyan Island (Tan, 1993) and Mt. Halcon in Mindoro Island (Tan and Mandia, 2001) in the central Philippines.

Intra-Philippine distribution. Mindoro and Sibuyan (Tan, 1993; Tan and Mandia, 2001; Linis, 2009).

Specimens examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical subalpine forest, ca. 1900 m elev., on a litter-covered ultramafic boulder, 27 July 2019, J.T. Adorador & E.L.R. Logatoc 19-0326 (CAHUP, PPC, VBG). Loc. cit., tropical subalpine forest near the summit, ca. 2000 m elev., on a litter-covered ultramafic boulder, 09 January 2020, E.L.R. Logatoc 20-0131 (CAHUP, PPC, VBG).

Hypnaceae Schimp.

12. *Ectropothecium moritzii* A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877-78: 262. 1880.

Comments. In Palawan, *Ectropothecium moritzii* can be confused with *E. striatulum* Dixon ex E.B. Bartram due to their plant habits. *Ectropothecium moritzii*, however, is a larger plant with stems reaching up to 12 cm, while *E. striatulum* is much shorter, reaching slightly over 5 cm in length. The distinctively large stem leaves in *E. moritzii* can reach up to 5 mm in length, generally flat and with plane margins that gradually narrow into apices not ending in piliferous points. Stem leaves in *E. striatulum* are shorter, up to 1.5 mm in length, striated,



and gradually acuminate into long and fine piliferous points, which are somewhat reminiscent of the leaves found in *E. elegantipinnatum* (Müll. Hal.) A. Jaeger but lacking the striations. In addition, the setae of *E. moritzii* are more prolonged, reaching above 2 cm in length, whereas, in *E. striatulum*, setae only attain lengths between 1.2–1.5 cm. *Ectropothecium moritzii* also resembles the equally large *E. pseudocyperoides* M. Fleisch., recently reported in Mindanao Island—with their differences also discussed in detail by Linis (2019a). As noted by the author, these two species may turn out to be synonymous. The present authors are maintaining these as separate species herein until definitive evidence becomes available to prove otherwise.

Intra-Philippine distribution. Luzon (Tan and Iwatsuki, 1991; Linis, 2019b).

Specimens examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on humus and forest litter, 27 July 2019, *E.L.R. Logatoc 19-0315* (CAHUP, PPC, VBG). Loc. cit., *E.L.R. Logatoc 19-0320* (CAHUP, VBG). Loc. cit., tropical upper montane rainforest-over-ultramafic substrate, ca. 1700 m elev., on humus and forest litter, 27 July 2019, *J.T. Adorador & E.L.R. Logatoc 19-0335* (CAHUP, VBG).

Leucobryaceae Schimp.

13. *Campylopus schmidii* subsp. *hemitrichius* (Müll. Hal.) J.-P. Frahm, *Bryologist* 94: 64. 1991.

Comments. *Campylopus schmidii* subsp. *hemitrichius* is among the several Philippine members of the genus with stereids only found in the dorsal side of the median guide cell row of the costa. *Campylopus austrosubulatus* Broth. & Geh., *C. comosus* (Schwägr.) Bosch & Sande Lac., *C. ericoides* (Griff.) A. Jaeger, and *C. laxitextus* Sande Lac. similarly shared this characteristic. However, the concolorous, excurrent costa will already separate *C. schmidii* subsp. *hemitrichius* from the others except for *C. austrosubulatus*. As a much smaller plant, *C. austrosubulatus* lacks the differentiated alar cells in *C. schmidii* subsp. *hemitrichius*.

Intra-Philippine distribution. Luzon, Mindoro, and Mindanao (Tan and Iwatsuki, 1991; Tan and Mandia, 2001; Linis, 2009).

Specimens examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on soil, 27 July 2019, *E.L.R. Logatoc 19-0307* (CAHUP, PPC, VBG). Loc. cit., *E.L.R. Logatoc 19-0319* (CAHUP, VBG). Loc. cit., montane heath-over-ultramafic rocks, on ultramafic rock, 27 July 2019, *E.L.R. Logatoc 19-0312* (CAHUP, VBG). Brooke's Point Municipality, Mt. Mantalingahan, ultramafic outcrops, ca. 1200 m elev., on ultramafic rock, 07 January 2020, *E.L.R. Logatoc 20-0077* (CAHUP, VBG).

14. *Cladopodanthus heterophyllus* (M. Fleisch.) E.B. Bartram, *Farlowia* 1: 43. 1943.

Comments. In the field, *Cladopodanthus heterophyllus* is easily recognized by the tightly julaceous habit in relatively compact tufts and the truncate leaf apices. In addition, the non-piliferous leaf apices are

unique to *C. heterophyllus* within the genus, which readily separates it from other *Cladopodanthus* Dozy & Molk. reported in the country.

Intra-Philippine distribution. Luzon, Panay, and Mindanao (Tan and Iwatsuki, 1991).

Specimen examined. Palawan Island, Puerto Princesa City, eastern slope of Mt. Beauport [Mt. Beaufort], ca. 550 m elev., on decaying log, 20 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

15. *Leucobryum bowringii* Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1: 26. 1859.

Comments. A widespread and highly variable species in the Philippines, *Leucobryum bowringii* is differentiated from most of its Philippine congeners by the broad hyaline lamina near the leaf base consisting of narrow, linear to long rectangular cells. Among its congeners in Palawan, this species may be confused with prominent forms of *L. javense* (Brid.) Mitt. However, the former is differentiated from the latter by the costal hyalocysts near the leaf base in 2 layers abaxially and in 1 layer adaxially, and smooth leaf tips. *Leucobryum sericeum* Broth. ex Geh. was treated by Tan and Iwatsuki (1991) as a synonym of *L. bowringii*, which we do not follow here. As noted by Yamaguchi (1993), *L. sericeum* is differentiated from *L. bowringii* by the papillose-prorate abaxial surface of leaves at apical parts and perichaetia usually terminal on short lateral branches.

Intra-Philippine distribution. Batan, Luzon, Catanduanes, Mindoro, Sibuyan, Panay, and Negros (Tan and Iwatsuki, 1991; Linis, 2009, 2014, 2019b).

Specimens examined. Palawan Island, Mt. Ibusi, on a tree trunk, 03 August 1947, *Ebalo & Conklin s.n.* (PNH). Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 800 m elev., on decaying log, 21 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH). Brooke's Point Municipality, Mt. Mantalingahan, tropical semi-evergreen rainforest, ca. 900 m elev., on litter-covered rock, 05 January 2020, *E.L.R. Logatoc 20-0019* (CAHUP, PPC, VBG).

Meteoriaceae Kindb.

16. *Meteorium crispifolium* Herzog, *Hedwigia* 66: 348. 1926.

Comments. According to Noguchi (1976), this medium-sized plant has an external appearance similar to some members of another meteoriaceous genus, *Chrysocladium* M. Fleisch. However, *Meteorium crispifolium* has terete branches and its leaves have auriculate leaf bases, while plants belonging to *Chrysocladium* have flattened branches and leaves lacking auriculate leaf bases. Among its Philippine congeners, *Meteorium crispifolium* is similar to *M. polytrichum* Dozy & Molk due to their large plant sizes and plicate leaves with long subulate acumen. The ovate-oblong to oblong leaves which are never imbricate and only slightly plicate differentiate *M. crispifolium* from the latter.

Intra-Philippine distribution. Luzon and Mindanao (Tan and Iwatsuki, 1991).



Specimen examined. Palawan Island, Brooke's Point Municipality, Mt. Mantalingahan, tropical lower montane rainforest, ca. 1000 m elev., on a fallen branch, 05 January 2020, *E.L.R. Logatoc 20-0056* (CAHUP, VBG1).

Mniaceae Schwägr.

17. *Plagiomnium succulentum* (Mitt.) T.J. Kop., Ann. Bot. Fenn. 5: 147. 1968.

Comments. Resembling *Plagiomnium integrum* (Bosch & Sande Lac.) T.J. Kop., plants of *Plagiomnium succulentum* are differentiated from this Philippine congener by its 1) non-decurrent leaves, 2) larger leaf dimensions, 3) less developed leaf borders, and 4) larger, thinner-walled leaf cells. Albeit collected in 1947, the specimen presented herewith represents the first record of this species on Palawan Island. However, we failed to locate this species in our recent field works in Mt. Mantalingahan.

Intra-Philippine distribution. Luzon, Catanduanes, Mindoro, Negros, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009, 2014).

Specimen examined. Palawan Island, Mt. Mantalingahan, summit, 13 May 1947, *G.E. Edaño s.n.* (PNH).

Myuriaceae Broth. ex M. Fleisch.

18. *Ctenidium luzonense* Broth., Philipp. J. Sci., C. 8: 85. 1913.

Comments. An exceedingly small soft plant, *Ctenidium luzonense* is sometimes similar in appearance to the similarly small *C. andoi* N. Nishim. reported in Luzon and the nearby island of Mindoro (Tan and Iwatsuki, 1991; Linis, 2009). Under the microscope, however, the leaves of *C. andoi* are more like *C. malacobolum* (Müll. Hal.) Broth. in terms of the shape and features of alar cells. According to Nishimura (1985), *C. luzonense* can be distinguished from *C. andoi* by its 1) suberect to patent, julaceous stem and branch leaves, 2) very narrow stem leaves, 3) very small alar region of stem leaves, with a few alar cells, and 4) elongate median leaf cells.

Intra-Philippine distribution. Luzon and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009).

Specimen examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1700 m elev., on the base of hardwood, 09 January 2020, *E.L.R. Logatoc 20-0148* (CAHUP, VBG1).

Pilotrichaceae Kindb.

19. *Thamniopsis utacamundiana* (Mont.) W.R. Buck, Brittonia 39: 219. 1987.

Comments. Vaz-Imbassahy and Costa (2009) synonymized *Hookeriopsis wichurae* M. Fleisch. with *Thamniopsis utacamundiana* based on their examination of types and other specimens deposited at JE, NY, and BM; and this synonymy is accepted here. As noted by the authors, the species is characterized by 1) lateral and dorsal leaves with different symmetries, 2) lanceolate or oblong-lanceolate leaves, 3) leaf margins that are serrate

above and serrulate below, bordered by 1 to 4 rows of narrower cells, usually with swollen teeth, and 4) costa reaching 1/2 to 2/3 leaf length.

Intra-Philippine distribution. Luzon, Mindoro, Negros, and Mindanao (Tan and Iwatsuki, 1991 as *Hookeriopsis utacamundiana* (Mont.) Broth. and *H. wichurae*; Linis, 2009 as *H. utacamundiana*).

Specimens examined. Palawan Island, Brooke's Point Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on an ultramafic boulder, 08 January 2020, *E.L.R. Logatoc 20-0113, pro parte* (CAHUP, VBG1). Loc. cit., *E.L.R. Logatoc 20-0123* (CAHUP, PPC, VBG1).

Plagiotheciaceae M. Fleisch.

20. *Pseudotaxiphyllum pohliicarpum* (Sull. & Lesq.) Z. Iwats., J. Hattori Bot. Lab. 63: 449. 1987.

Comments. *Pseudotaxiphyllum pohliicarpum*, like other East and Southeast Asian propagule-bearing species traditionally placed under *Pseudotaxiphyllum*, have no paraphyllia and pseudoparaphyllia. Schwarz (2020) has shown that *P. pohliicarpum* can be separated from *P. anniae* U. Schwarz, the second *Pseudotaxiphyllum* species recorded in the Philippines, quite well by the propagule morphology and median leaf cells. As discussed by Schwarz (2020), *P. pohliicarpum* can be separated from *P. anniae* U. Schwarz, the second *Pseudotaxiphyllum* species recorded in the Philippines, quite well by the 1) green to yellowish-green propagules in clusters of 5-20 in the leaf axils at the branch ends of plants, 2) strongly twisted propagule arrangement, 3) 350–700 × 25 µm propagule size, and 4) 90–135 × 8–10 µm size of median leaf cells.

Intra-Philippine distribution. Luzon, Catanduanes, Mindoro, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009; Tan *et al.*, 2015).

Specimen examined. Palawan Island, Quezon Municipality, Lipu-on Point, on rock, 14 April 1988, *J.R. Cabalquinto & N.B. Diego s.n.* (PNH).

Pottiaceae Hampe

21. *Hydrogonium consanguineum* (Thwaites & Mitt.) Hilp., Beih. Bot. Centralbl., Abt. 2, 50(3): 626. 1933.

Comments. Specimens of *Hydrogonium consanguineum* collected from Palawan exhibit the typical yellowish green habit with stems up to 2 cm in height. With the densely papillose leaves with obscure lamina, densely papillose on the adaxial side, and the presence of axillary gemmae, plants of this species superficially resemble *H. orientale* (F. Weber) Jan Kučera, another widespread species in the country. Compared to *H. orientale*, however, *H. consanguineum* has longer leaves, more or less plane leaf margins, and peristome teeth spirally twisted in several turns.

Intra-Philippine distribution. Luzon and Mindoro (Bartram, 1939 as *Barbula consanguinea* (Thwaites & Mitt.) A. Jaeger; Linis, 2009 as *B. consanguinea*).

Specimens examined. Palawan Island, Puerto Princesa City, Mt. Venture, ca. 550 m elev., on soil, 24 February 1989, *J.R.*



Cabalquinto & B.O. van Zanten s.n. (PNH). Brooke's Point Municipality, Sabsaban, ca. 100 m elev., on soil, 27 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH). Loc. cit., along Kabinbin River, ca. 50 m elev., on a boulder, 28 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

22. *Oxystegus tenuirostris* (Hook. & Taylor) A.J.E. Sm., *J. Bryol.* 9: 393. 1977.

Comments. In light of differing views on the taxonomy of this species (*i.e.* Alonso-García *et al.*, 2016; Zander and Eckel, 2019), we decided to adopt the former name *Oxystegus tenuirostris* (Hook. & Taylor) A.J.E. Sm. for this species until the above issue in Pottiaceae is resolved. In Palawan, *Oxystegus tenuirostris* is often difficult to distinguish from *Pseudosymblepharis angustata* (Mitt.) Hilp, as some forms of both species usually have expanded leaf bases and caducous leaf apices. Under the microscope, however, the former can easily be distinguished from the latter by its 1) shorter, dark-green leaves, 2) whitish coloration of the basal, clasping region of the leaf, 3) less in-rolling of the leaf when dry so as not to obscure the costa, and 4) distinctly thickened transverse walls of the juxtacostal cells immediately above the differentiated leaf region (Norris and Koponen, 1989).

Intra-Philippine distribution. Luzon, Lubang, and Mindoro (Tan and Iwatsuki, 1991; Linis, 2009, 2019b).

Specimens examined. Palawan Island, Puerto Princesa City, eastern slope of Mt. Beauport [Mt. Beaufort], ca. 500 m elev., on rocks, 20 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH). Narra Municipality, Stella Falls, ca. 200 m elev., on a boulder, 26 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH). Rizal Municipality, Mt. Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, ca. 1600 m elev., on humus-covered ultramafic rock, 27 July 2019, *E.L.R. Logatoc 19-0315* (CAHUP, PPC, VBG). Brooke's Point Municipality, Mt. Mantalingahan, ultramafic outcrops, ca. 1200 m elev., on ultramafic rock, 07 January 2020, *E.L.R. Logatoc 20-0076* (CAHUP, VBG).

Pterobryaceae Kindb.

23. *Pterobryopsis gedehensis* M. Fleisch., *Hedwigia* 45: 57. 1905[1906].

Comments. Although closely resembling *Pterobryopsis crassicaulis* (Müll. Hal.) M. Fleisch. in habit and appearance, plants of *P. gedehensis* can be differentiated from the former by their 1) less robust habit, 2) less robust secondary stems, which are more stipitate toward the bases, 3) smaller stipe leaves, which are appressed and scale-like, and 4) smaller and ecostate branch leaves.

Intra-Philippine distribution. Luzon, Camiguin, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2010).

Specimens examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical semi-evergreen rainforest, ca. 650 m elev., on the trunk of hardwood, 24 July 2019, *E.L.R. Logatoc 19-0272* (CAHUP, VBG). Brooke's Point Municipality, Mt. Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, ca. 1300 m elev., on the trunk of hardwood, 07 January 2020, *E.L.R. Logatoc 20-0112* (CAHUP, PPC, VBG).

Pterobryellaceae W.R. Buck & Vitt

24. *Pterobryella speciosissima* (Sull.) Müll. Hal., *Bull. Soc. Bot. France* 25: 65. 1878.

Comments. Despite being synonymized by H.N. Dixon in 1923, the name *Pterobryella longifrons* (Müll. Hal.) A. Jaeger has been used to refer to Philippine specimens up until recently (see Meagher, 2011). Superficially resembling some prominent members of *Hypnodendron* sensu lato, plants of *Pterobryella speciosissima* are differentiated by the 1) more robust habit, 2) extremely narrow and longer branch leaves, 3) sub-percurrent to short-excurrent costa, and 4) large, long-subulate perichaetial leaves.

Intra-Philippine distribution. Luzon, Mindoro, Negros, and Mindanao (Tan and Iwatsuki, 1991 as *Pterobryella longifrons*).

Specimen examined. Palawan Island, Brooke's Point Municipality, Mt. Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, ca. 1200 m elev., on the trunk of hardwood, 07 January 2020, *E.L.R. Logatoc 20-0085* (CAHUP, VBG).

Ptychomniaceae M. Fleisch.

25. *Garovaglia plicata* (Brid.) Bosch & Sande Lac., *Bryol. Jav.* 2: 79. 1863.

Comments. As noted by Hyvönen (1989), *Garovaglia plicata* is similar to some forms of *G. angustifolia* Mitt. with its medium size and distinctly decurrent, plicate leaves. However, the former is differentiated from the latter by the 1) erect-spreading and slightly rugose leaves and 2) plane margins at the leaf base.

Intra-Philippine distribution. Luzon, Negros, and Mindanao (Tan and Iwatsuki, 1991).

Specimens examined. Palawan Island, Rizal Municipality, Mt. Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, ca. 1100 m elev., on the trunk of hardwood, 26 July 2019, *E.L.R. Logatoc 19-0285* (CAHUP, PPC, VBG). Brooke's Point Municipality, Mt. Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, ca. 1000 m elev., on the trunk of hardwood, 07 January 2020, *E.L.R. Logatoc 20-0072* (CAHUP, VBG).

Pylaisiadelphaceae Goffinet & W.R. Buck

26. *Clastobryum caudatum* (Sande Lac.) M. Fleisch., *Musci Buitenzorg* 4: 1190. 1923.

Comments. The sometimes tristichous leaves of *Clastobryum caudatum* are reminiscent of *C. spiculiferum* (Dixon) B.C. Tan, Z. Iwats. & D.H. Norris reported in northern Luzon (Tan and Iwatsuki, 1991). However, the former species is distinguished from the latter by its relatively larger size and entire leaf margins. This species also resembles *C. cuculligerum* (Sande Lac.) Tixier in terms of plant size and the filiform unbranched gemmae that both plants produce either on branch tips or in the upper axils of leaves. The narrowly ovate-lanceolate leaves which have abruptly long acuminate leaf apices and smooth margins throughout differentiate *C. caudatum* from *C. cuculligerum*.

Intra-Philippine distribution. Luzon, Catanduanes, Mindoro, Camiguin, and Mindanao (Tan and Iwatsuki,



1991; Linis, 2009, 2010, 2014, 2018).

Specimen examined. Palawan Island, Puerto Princesa City, Irauan, Kalantiaw slope, ca. 300 m elev., on decaying log, 20 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

27. *Isopterygium albescens* (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876–77: 433. 1878.

Comments. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger, a species previously reported in Palawan, was synonymized by Iwatsuki and Ramsay (2009) with *I. albescens* based on variability in leaf shape and color as well as Australian plants exhibiting two types of leaves. However, as far as Philippine materials are concerned, we find that the characters used to differentiate these two are consistent across their range in the country; hence, we treat these as two distinct species until new information is available to prove otherwise.

Intra-Philippine distribution. Batan, Luzon, Catanduanes, Mindoro, Negros, and Camiguin (Tan and Iwatsuki, 1991; Linis, 2009, 2010, 2014).

Specimen examined. Palawan Island, Narra Municipality, Mt. Victoria, lower montane rainforest along the trail to summit, ca. 1200 m elev., on decaying log, 22 December 2022, *Linis 5885-22* (CAHUP, PPC, VBGI).

Sematophyllaceae Broth.

28. *Acroporium convolutum* (Sande Lac.) M. Fleisch., Musci Buitenzorg 4: 1276. 1923. **var. convolutum**

Comments. *Acroporium convolutum* is a medium to robust-sized plant for the genus forming soft tufts of glossy green to golden-colored patches. It is like *A. johannis-winkleri*, another species of *Acroporium* reported in Palawan, with bristly, falcate leaves. However, *Acroporium convolutum* is distinguished by its 1) larger size, 2) ovate-lanceolate to lanceolate leaves, mostly less than 2.5 mm long, 3) long acuminate to subtubular, serrulate to serrate leaf apices, and 4) unipapillose leaf cells.

Intra-Philippine distribution. Luzon (Linis, 2014).

Specimen examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 900 m elev., on a tree trunk, 21 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

29. *Papillidiopsis complanata* (Dixon) W.R. Buck & B.C. Tan, Acta Bryolichenol. Asiat. 1: 12. 1989[1990].

Comments. *Papillidiopsis complanata* is somewhat similar to *P. ramulina* (Thwaites & Mitt.) W.R. Buck & B.C. Tan, another member of the genus reported in the Philippines. However, the larger plant size and longer constricted leaf acumen of about 1/5 to 1/6 of the length of the leaf lamina differentiates *P. complanata* from the latter—these characteristics are excellently illustrated by Noguchi (1994 as *Rhaphidostichum longicuspidatum* Seki). As noted by Tan and Jia (1999), Chinese specimens of *P. complanata* were collected on tree trunks and branches, while *P. ramulina* is a ground dweller. In supplement to this, we report here the occurrence of *P. complanata* on decaying log in Mt. Beaufort.

Intra-Philippine distribution. Mindanao (Buck and Tan, 1989).

Specimens examined. Palawan Island, Puerto Princesa City, eastern slope of Mt. Beauport [Mt. Beaufort], ca. 300 m elev., on tree bark, 19 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH). Loc. cit., ca. 750 m elev., on a decaying log, 20 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

Spiridentaceae Broth.

30. *Touwiodendron diversifolium* (Broth. & Geh.) N.E. Bell, A.E. Newton & D. Quandt, Bryologist 110: 557. 2007.

Comments. *Touwiodendron diversifolium* is easily recognized by the 1) tristichous branch leaves which are differentiated into larger, spreading lateral leaves and smaller dorsal leaves, 2) spreading to squarrose stipe leaves with long, strongly reflexed acumens, and 3) stipes with conspicuous foliose pseudoparaphyllia. In the field, this species resembles *Dendro-hypnum milnei* (Mitt.) N.E. Bell, A.E. Newton & D. Quandt. The latter, however, has leaves with clasping bases, a character that no other members of *Hypnodendron* sensu lato possessed. *Touwiodendron diversifolium* is also similar to *Mniodendron dendroides* (Brid.) Wijk & Margad. in plant habit, but the latter has entirely tomentose stipes, and divergent stipe leaves with auriculate bases composed of isodiametric alar cells.

Intra-Philippine distribution. Luzon and Mindanao (Tan and Iwatsuki, 1991 as *Hypnodendron diversifolium* Broth. & Geh.).

Specimen examined. Palawan Island, Brooke's Point Municipality, Mt. Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, ca. 1300 m elev., on humus, 07 January 2020, *E.L.R. Logatoc 20-0109* (CAHUP, VBGI).

Symphyodontaceae M. Fleisch.

31. *Chaetomitrium elmeri* Broth., Leafl. Philipp. Bot. 6: 1974. 1913.

Comments. Among the five species of *Chaetomitrium* Dozy & Molke reported in the Philippines having blunt or truncate branch leaves, only the leaves of *C. elmeri* has leaf cells with knob-like tubercles arranged in transverse rows on the adaxial surfaces. Only *Chaetomitrium perarmatum* Broth. has similar projections over similar surfaces, but these projections are spine-like, not trabecular. The rest of the Philippine *Chaetomitrium* species with blunt or truncate branch leaves have smooth adaxial leaf surfaces. Mohamed (1985) described *Chaetomitrium elmeri* in detail and compared it with *C. borneense* Mitt., a rare species found only in Indonesia and Malaysia (see Akiyama and Suleiman, 2001). As the author reported, the branches and leaves of *C. borneense* have terete foliations and are distinctly imbricated, whereas in *C. elmeri*, the leaves and branches are variously foliated and never imbricated. Apart from the terete foliations, blunt or truncate branch leaves, and the presence of knob-like tubercles on the adaxial surfaces of

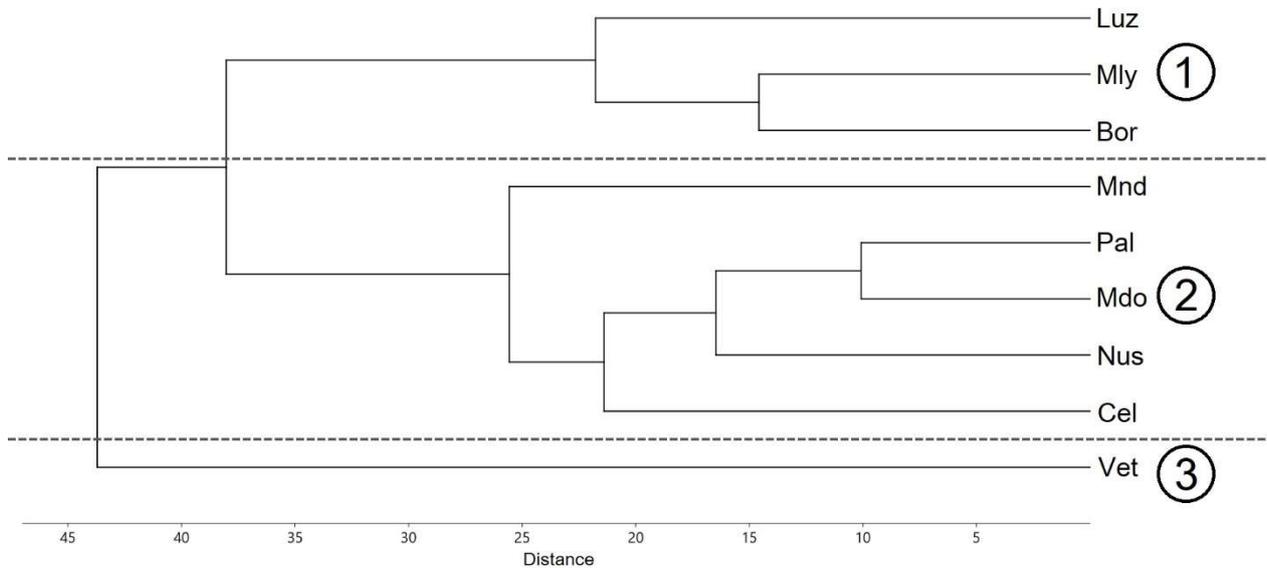


Fig. 3. Dendrogram showing the floristic affinity of the Palawan moss flora with neighboring islands or regions (linkage method: Ward's Method, Euclidean Distances). Abbreviations: Luz = Luzon; Mly = Peninsular Malaysia, Bor = Borneo; Mnd = Mindanao; Pal = Palawan; Mdo = Mindoro; Nus = Nusa Tenggara Islands; Cel = Sulawesi; and Vet = Vietnam.

leaves, other diagnostic features of *C. elmeri* are 1) calyptra entire with long cilia at the base and 2) seta up to 25 mm in length, weakly papillose above, entire below.

Intra-Philippine distribution. Sibuyan, Panay, Samar, and Mindanao (Tan and Iwatsuki, 1991; Shevock and Yorong, 2018).

Specimen examined. Palawan Island, Puerto Princesa City, Mt. Beauport [Mt. Beaufort], ca. 1050 m elev., on a tree trunk, 21 February 1989, *J.R. Cabalquinto & B.O. van Zanten s.n.* (PNH).

Notes on the phytogeography of Palawan mosses

The floristic affinities of the moss flora of the Philippines (Linis and Tan, 2008) and a number of its composite islands and terranes such as the Zambales Mountains (Linis, 2019b), Bicol Peninsula and Catanduanes (Linis, 2014), Mindoro (Linis, 2009), and Camiguin (Linis, 2010) have been studied in detail. In addition, recent publications have significantly increased the number of mosses known to occur in the islands of Luzon and Mindanao (*i.e.* Linis and Tan, 2010, 2013; Tan and Shevock, 2014, 2015; Azuelo *et al.*, 2015; Tan *et al.*, 2015, 2017; Linis, 2018, 2019a, 2021; Shevock and Yorong, 2018; Koponen and Schwarz, 2022). These, in addition to recently published works on the mosses of neighboring areas in Southeast Asia, provided updated and comprehensive information for the re-examination of the floristic affinity of the Palawan moss flora.

The similarities, in terms of Kroeber's Similarity Index (%K) and both at generic and species levels, between the moss floras of Palawan and neighboring islands or regions are summarized in Table 1. Whereas Fig. 3 shows the overall floristic distances between Palawan and the areas under comparison based on Ward's

Method and Euclidean Distances.

In general, the moss flora of Palawan is most similar to those of other areas in West Malesia (*sensu van Steenis, 1950*)—especially to that of Mindoro with 60.73, Luzon with 58.86, and Borneo with 58.85 %K values at the species level. Likewise, it is most similar at the genus level to Peninsular Malaysia with 76.52, Mindoro with 75.54, and Borneo with 72.91 %K values. Tan (1996) observed that this may be attributed to the richness of widespread taxa with pantropical, Indo-Pacific, and widespread Malesian distribution in Palawan such as *Gemmabryum apiculatum*, *Calymperes porrectum*, and *Breutelia arundinifolia*, respectively. The relatively low %K values at the species level for Sulawesi and the Nusa Tenggara Islands may be attributed to the apparent absence of widespread West Malesian species in areas beyond the Wallace Line, such as *Acroporium convolutum*.

The high similarity and close floristic affinity between Palawan and Mindoro came as no surprise given their geographical proximity and the similarity in climate, especially along the drier west coast of Mindoro. Species such as *Calymperes porrectum*, *Calypstrochaeta parviretis*, *Hydrogonium consanguineum*, *Oxystegus tenuirostris*, and *Racomitrium lanuginosum* appear to have entered Mindoro through Palawan—the discovery of the latter in Palawan bridged the gap in its distribution between the alpine regions of Sumatra and Borneo and the ultramafic, subalpine summits of Mindoro and Sibuyan. On the other hand, Linis (2009) noted that taxa occurring in Mindoro that are not found in Palawan are wet-loving species belonging to genera like *Daltonia*, *Hymenodon*, and *Neolindbergia* as well as species that reached Mindoro from Luzon but not Palawan. Unshared



Table 1. Summary of shared and unshared taxa, both at generic and species levels, found in Palawan and other islands or regions in Southeast Asia. Kroeber's Similarity Index (%K) was used for computing the similarity between areas. For the unshared taxa, the numerator indicates the number of taxa in the area under comparison while the denominator indicates those for Palawan.

		Vietnam	Peninsular Malaysia	Borneo	Luzon	Mindoro	Mindanao	Sulawesi	Nusa Tenggara Islands
Genera No.		243	166	218	249	136	181	177	176
Species No.		747	515	680	653	282	425	402	355
Palawan									
106 genera	Shared	91	99	104	103	90	97	88	86
	Unshared	152/15	67/7	114/2	146/3	46/16	84/9	89/18	90/20
	% K	61.65	76.52	72.91	69.27	75.54	72.55	66.37	65.00
225 species	Shared	153	183	199	197	152	161	141	133
	Unshared	594/72	332/42	481	456/28	130/73	264/64	261/84	222/92
	% K	44.24	58.43	58.85	58.86	60.73	54.72	48.87	48.29

species also include drought-tolerant species not found in Mindoro, species that failed to reach or are yet to be found in Mindoro such as *Acroporium downii* and *Trichosteleum pseudomamosum*, and species located in Luzon and Palawan but not Mindoro such as *Acroporium convolutum*, *Ectropothecium moritzii*, and *Philonotis falcata*.

Hierarchical clustering based on presence/absence data of 1,458 moss species in 365 genera for the nine islands or regions resulted in three clusters roughly corresponding to the Sunda Shelf (plus Luzon; Cluster 1), Wallacea (except Luzon; Cluster 2), and Indochina (Cluster 3). Expectedly, Vietnam has the most negligible floristic affinity to Palawan—the mosses of the country being characteristic of Indochina, having instead a close affinity to the Yunnan-Hainan moss flora (Tan and Iwatsuki, 1993). Contrastingly, the dendrogram topology observed for Clusters 1 and 2 did not correspond to the internal division of Malesia based on seed plant distributions (*cf.* Raes and van Welzen, 2009).

The division of Malesia into three phylogeographical areas, namely the Sunda Shelf, Wallacea, and Sahul Shelf, was proposed by van Welzen *et al.* (2005) and was supported by van Welzen and Slik (2009) in their analysis of the distributions of 7,043 seed plant species. These studies recognized the close floristic affinity of the Philippines, as a whole, to the rest of Wallacea. With this, the close affinities of the moss floras of Palawan, Mindoro, and Mindanao to Sulawesi and the Nusa Tenggara Islands are expected (Cluster 2)—likely as a result of the dry monsoon climate characteristic of Wallacea and historical processes occurring during the Plio-Pleistocene (van Welzen *et al.*, 2005; Touw, 1992). On the other hand, the closer floristic affinity of Luzon with Peninsular Malaysia and Borneo (Cluster 1) than the other Philippine islands may appear peculiar. This may be explained by considering the geography of this island. Luzon is a rectangular island with a north-south orientation. It is characterized by various geographic

features ranging from valleys and plains to high mountains well above 2000 m elev. In addition to its composite geology and a mosaic of climate types, these resulted in distinct phylogeographic units across its vast area (*cf.* Linis, 2019b)—catering to a variety of widespread lowland and montane taxa which are also found in the Sunda Shelf such as *Callicostella papillata* var. *prabaktiana* (Müll. Hal.) Streimann, *Distichophyllum armatum* (E.B. Bartram) B.C. Ho & L. Pokorny, and *Neolindbergia rigida* (Bosch & Sande Lac.) M. Fleisch. as well as the island endemic *Merrillibryum fabronioides* Broth. An analysis of the similarities of these units within the Philippines by Linis (2019b) revealed that the moss flora of Palawan is most similar to that of Sierra Madre. As such, the observed dendrogram topology is likely an outcome of this apparent heterogeneity. An analysis using these phylogeographic units may lead to a better resolution of the affinities of the Luzon moss floras with other areas in Malesia.

Two emerged as notable among the species reported here as new records for Palawan. The distribution of *Clastobryum caudatum* exhibits a disjunct pattern between Indochina and the Philippines—the species occurs in areas with pronounced dry season (*i.e.* Indochina, Palawan, Mindoro, and parts of Mindanao) and is absent in Borneo, Sumatra, and wet parts of the Philippines. To explain this, we echo the hypothesis presented by Tan (1996) that this species may have had a broader range in West Malesia during the drier periods of the Pleistocene glaciation, eventually contracting into dry pockets as the West Malesian everwet core expands after the Last Glacial Maximum. Similarly, sea level and climate fluctuations in the Quaternary may have resulted in the present-day distribution of *Meteorium crispifolium*. This species may have had a wider distribution east of the Merrill-Dickerson Line up to Papua New Guinea during the Last Glacial Maximum—subsequently retreating into what van Welzen *et al.* (2005) designated as Wallacea as



well as in dry pockets in the everwet Sahul Shelf. In addition, a similar hypothesis was presented by Touw (1992b) in explaining the distribution of species disjunct between continental Asia and the Nusa Tenggara Islands. Further studies on the influence of the events of the Quaternary glaciation are therefore needed to better understand its consequences on the present-day distribution of mosses in Malesia.

ACKNOWLEDGMENTS

We thank the Mt. Mantalingahan Protected Landscape (MMPL) Management Board, CENRO-Quezon, and CENRO-Brooke's Point for their assistance; P.L. Malabrigo Jr., J.T. & Z.M. Adorador, A.G.A. Umali, A.B. Tobias, F. Escala III, B. Lumpon, R. Sendacan, and the local field guides from Ransang and Aribungos for their help and companionship. Recent collections from the MMPL were covered by Gratuitous Permit No. 2019-25 issued by the Palawan Council for Sustainable Development (PCSD). Field works in 2019 and 2020 were generously funded by the Forest Foundation Philippines (FFP) through the Pro-Seeds Development Association, Inc. Reviews of the draft manuscript by our colleagues brought to light several bryological articles overlooked during the study, as well as suggestions for its improvement. The authors are obliged to make the material available to the herbaria mentioned in the text.

LITERATURE CITED

- Akiyama, H., Suleiman, M. 2001 Taxonomical notes on the genus *Chaetomitrium* (Hookeriaceae, Musci) of Borneo. *Hikobia* **13**: 491–509.
- Alonso-García, M., Jiménez, J.A., Nylinder, S., Hedenäs, L., Cano, M.J. 2016 Disentangling generic limits in *Chionoloma*, *Oxystegus*, *Pachyneuropsis* and *Pseudosymblypharis* (Bryophyta: Pottiaceae): an inquiry into their phylogenetic relationships. *Taxon* **65**(1): 3–18.
- Ariyanti, N.S., Gradstein, S.R., Sporn, S.G., Angelika, R., Tan, B.C. 2009 Catalogue of the bryophytes of Sulawesi. Supplement 1: new species records. *Blumea* **54**(1): 287–289.
- Azuelo, A.G., Tan, B.C., Shevock, J.R., Manual, A., Yorong, A., Sariana, L.G. 2015 Mosses new for the Mindanao Island, Republic of the Philippines. *Proc. Calif. Acad. Sci.*, ser. 4, **62**: 127–134.
- Bartram, E.B. 1939 Mosses of the Philippines. *Philipp. J. Sci.* **68**: 1–423.
- Brinda, J.C., Atwood, J.J. 2022–continuously updated The Bryophyte Nomenclator. <https://bryonames.org>. Accessed 27 December 2022.
- Buck, W.R., Tan, B.C. 1989 [1990] The Asiatic genera of Sematophyllaceae associated with *Trichosteleum*. *Acta Bryolichenol. Asiat.* **1**: 5–19.
- Dixon, H.N. 1924 New species of mosses from the Malay Peninsula. *Bull. Torrey Bot. Club* **51**(6): 225–259.
- Ellis, L.T., Tan, B.C. 1999 The moss family Calymperaceae (Musci) in the Philippines. *Bull. Nat. Hist. Mus. London, Bot.* **29**: 1–46.
- Fleischer, M. 1923 Die Musci der Flora von Buitenzorg. Volume 4. E.J. Brill, Leiden, the Netherlands. 625 pp.
- Gradstein, S.R., Tan, B.C., Zhu, R.-L., Ho, B.-C., King, S.-H.C., Drübert, C., Pitopang, R. 2005 A catalogue of the bryophytes of Sulawesi, Indonesia. *J. Hattori Bot. Lab.* **98**: 213–257.
- Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001 PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* **4**(1): 1–9.
- He, S., Khang, N.S. 2012 New records and an updated checklist of the mosses of Vietnam. *Trop. Bryol.* **34**(1): 32–88.
- Ho, B.-C., Luong, T.-T., Tan, B.C., Dinh, N.-L. 2015 Additional new and noteworthy moss (Bryophyta) records from Vietnam and Laos. *Bryophyte Diversity Evol.* **37**(1): 1–11.
- Hofmann, H. 1997 A monograph of the genus *Palamocladium* (Brachytheciaceae, Musci). *Lindbergia* **22**: 3–20.
- Hyvönen, J. 1989 Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXVI. Pterobryaceae (Musci). *Acta Bot. Fenn.* **137**: 1–40.
- Iwatsuki, Z., Tan, B.C. 1980 Noteworthy Philippine mosses at the Hattori Botanical Laboratory (NICH), Japan. *Kaliskan* **9**: 267–282.
- Iwatsuki, Z., Ramsay, H.P. 2009 The genera *Isopterygium* Mitt. (Bryopsida, Hypnaceae) and *Isopterygiopsis* (Hedw.) Z. Iwats. (Bryopsida, Plagiotheciaceae) in Australia. *Telopea* **12**(3): 371–384.
- Koponen, T., Nguyen, T.-L., Luong, T.-T., Huttunen, S. 2019 Revision and checklist of the moss families Bartramiaceae and Mniaceae in Vietnam. *Hattoria* **10**: 69–107.
- Koponen, T., Schwarz, U. 2022 A collection of *Philonotis* (Musci, Bartramiaceae) from the Philippines, with *P. norristii*, *P. pseudomollis*, and *P. vescoana* new to the country, and *P. vescoana* var. *flexuosa*, var. *nov.* *Acta Bryolichenol. Asiat.* **10**: 102–118.
- Li, Z.-H., Sinikka, P. 1994 Preliminary list of bryophytes of Heishiding Nature Reserve, Guangdong Province, China. *Bryophyte Diversity and Evolution* **9**(1): 35–41.
- Linis, V.C. 2009 Biogeography of Mindoro mosses. *Blumea* **54**(1): 290–296.
- Linis, V.C. 2010 The moss flora of Camiguin Island, Philippines and their floristic relations to adjacent islands in the archipelago. *Telopea* **12**(4): 525–542.
- Linis, V.C. 2014 Biogeographical notes on the moss floras of Bicol Peninsula in Luzon and the Catanduanes Islands, The Philippines. *Philipp. J. Sci.* **142**: 119–133, Special Issue.
- Linis, V.C. 2018 A new country record and additions to the moss floras of Luzon and Mindanao islands, Philippines. *Telopea* **21**: 91–99.
- Linis, V.C. 2019a New Philippine moss records for Luzon and Mindanao Islands. *J. Bryol.* **41**(1): 48–58.
- Linis, V.C. 2019b Notes on the diversity and floristic affinity of mosses (Musci, Bryophyta) from Zambales Mountain Range, Luzon Island, Philippines. *Phytotaxa* **388**(1): 69–97.
- Linis, V.C. 2021 New Philippine moss records and additions to the Luzon moss flora. *Telopea* **24**: 383–394.
- Linis, V.C., Tan, B.C. 2008 Progress of studies on phytogeography and biodiversity of the Philippines moss flora from 1991 to 2006. In Mohamed, H., Baki, B.B., Nasrulhaq-Boyce, A., Lee, P.K.Y. (eds.). *Bryology in the New Millennium*. University of Malaya, Kuala Lumpur, Malaysia. pp. 13–22.
- Linis, V.C., Tan, B.C. 2010 Eleven new records of Philippine mosses. *Acta Bryolichenol. Asiat.* **3**: 35–100.
- Linis, V.C., Tan, B.C. 2013 Eight additional new records of Philippine mosses. *Telopea* **15**: 45–49.



- Meagher, D.A.** 2011 *Pterobryella longifrons*, an overlooked synonym of *Pterobryella speciosissima*. Australasian Bryological Newsletter **59**: 23.
- Mohamed, H.** 1985 [1986] On the identity of *Chaetomitrium borneense* Mitt., *C. seriatum* Broth., *C. seriatum* Broth. ex Bartr. and *C. elmeri* Broth. Lindbergia **11**: 80–82.
- Nishimura, N.** 1985 A revision of the genus *Ctenidium* (Musci). J. Hattori Bot. Lab. **58**: 1–82.
- Noguchi, A.** 1994 Illustrated moss flora of Japan, Part 5. Hattori Botanical Laboratory, Japan. 241 pp.
- Noguchi, A., Iwatsuki, Z.** 1972 [1973] Mosses of North Borneo. J. Hattori Bot. Lab. **36**: 455–486.
- Noguchi, A.** 1976 A taxonomic revision of the family Meteoriaceae of Asia. J. Hattori Bot. Lab. **41**: 231–358.
- Norhazrina, N., Aisyah, M., Syazwana, N., Maideen, H., Nor, S.M.** 2020 Mosses of the lowland forest in vicinity of Pergau Dam, Jeli, Kelantan. IOP Conf. Ser.: Earth Environ. Sci. **549**: 012035.
- Norris, D.H., Koponen, T.** 1989 Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXVIII. Pottiaceae (Musci). Acta Bot. Fenn. **137**: 81–138.
- O'Shea, B.J.** 2002 Checklist of the mosses of Sri Lanka. J. Hattori Bot. Lab. **92**: 125–164.
- Raes, N., van Welzen, P.C.** 2009 The demarcation and internal division of Flora Malesiana: 1857–present. Blumea **54**(1): 6–8.
- Schwarz, U.** 2020 *Pseudotaxiphyllum annii* sp. nov., a new species of Plagiotheciaceae from Philippines. Frahmia **18**: 1–8.
- Shevock, J.R., Yang, J.-D., Tan, B.C.** 2014 New moss records for Taiwan. Telopea **17**: 223–228.
- Shevock, J.R., Yorong, A.P.** 2018 New additions to the moss flora of Mindanao Island, Republic of the Philippines. Philipp. J. Syst. Biol. **12**(1): 67–72.
- Suleiman, M., Akiyama, H., Tan, B.C.** 2006 A revised catalogue of mosses reported from Borneo. J. Hattori Bot. Lab. **99**: 107–183.
- Suleiman, M., Edwards, S.R.** 2002 Mosses of Mt. Trus Madi, Sabah, Malaysia. Trop. Bryol. **21**(1): 57–64.
- Suleiman, M., Masundang, D.P., Akiyama, H.** 2017 The mosses of Crocker Range Park, Malaysian Borneo. PhytoKeys **88**: 71–107.
- Tan, B.C.** 1993 Noteworthy range extension of Malesian mosses. J. Hattori Bot. Lab. **74**: 227–233.
- Tan, B.C.** 1994 The bryophytes of Sabah (North Borneo) with special reference to the BRYOTROP transect of Mount Kinabalu. XIX. The genus *Acroporium* (Sematophyllaceae, Musci) in Borneo, with notes on species of Java and the Philippines. Willdenowia **24**: 255–294.
- Tan, B.C.** 1996 Biogeography of Palawan mosses. Austral. Syst. Bot. **9**(2): 193–203.
- Tan, B.C., Iwatsuki, Z.** 1991 A new annotated Philippine moss checklist. Harvard Pap. Bot. **1**(3): 1–63.
- Tan, B.C., Iwatsuki, Z.** 1993 A checklist of Indochinese mosses. J. Hattori Bot. Lab. **74**: 325–405.
- Tan, B.C., Jia, Y.** 1999 A preliminary revision of Chinese Sematophyllaceae. J. Hattori Bot. Lab. **86**: 1–70.
- Tan, B.C., Koponen, T., Norris, D.H.** 2007 Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXIX. Sematophyllaceae (Musci) 1. *Acanthorrhynchium*, *Acroporium*, *Clastobryophilum*, *Pseudopiloecium*, *Radulina* and *Trichosteium*. Ann. Bot. Fenn. **44**: 35–78.
- Tan, B.C., Mandia, E.H.** 2001 New and noteworthy records of mosses from Mindoro, Philippines, and their biogeographical implication. Gard. Bull. Singapore **53**: 315–322.
- Tan, B.C., Robinson, H.** 1990 A review of the Philippine Hookeriaceae taxa (Musci). Smithsonian Contr. Bot. **75**: 1–41.
- Tan, B.C., Shevock, J.R.** 2014 Noteworthy mosses and a new variety collected from the 2014 joint expedition of CAS and CMUH new to Mindanao Island of the Philippines. Bryophyte Diversity and Evolution **36**(1): 22–30.
- Tan, B.C., Shevock, J.R.** 2015 Species of *Macromitrium* (Orthotrichaceae) new to the Mindanao Region and the Philippines with one species new to science. Proc. Calif. Acad. Sci., ser. 4, **62**(3): 541–549.
- Tan, B.C., Shevock, J.R., Azuelo, A.G., Lubos, L.** 2017 Additions to the moss floras of Mindanao and the Philippines with a focus on the rediscovery of *Euptychium setigerum*. Nat. Hist. Bull. Siam Soc. **62**(1): 15–20.
- Tan, B.C., Shevock, J.R., Coritico, F.P., Amoroso, V.B.** 2015 Mosses new for Mindanao Island, the Philippines, III. Bull. Natl. Mus. Nat. Sci., Tokyo, B. **41**(3): 91–97.
- Touw, A.** 1992a A survey of the mosses of the Lesser Sunda Islands (Nusa Tenggara), Indonesia. J. Hattori Bot. Lab. **71**: 289–366.
- Touw, A.** 1992b Biogeographical notes on the Musci of South Malesia, and of the Lesser Sunda Islands in particular. Bryobrothera **1**: 143–155.
- Van Steenis, C.G.G.J.** 1950 The delimitation of Malaysia and its main plant geographic divisions. Fl. Males., Ser. 1, Spermat. I: LXX–LXXV.
- Van Welzen, P.C., Slik, J.W.F.** 2009 Patterns in species richness and composition of plant families in the Malay Archipelago. Blumea **54**(1): 166–171.
- Van Welzen, P.C., Slik, J.W.F., Alahuhta, J.** 2005 Plant distribution patterns and plate tectonics in Malesia. Biol. Skr. **55**: 199–217.
- Vaz-Imbassahy, T.F., Costa, D.P.** 2009 New combinations and new synonyms in Pilotrichaceae (Bryophyta) II. Nova Hedwigia **88**(3–4): 465–474.
- Yamaguchi, T.** 1993 A revision of the genus *Leucobryum* (Musci) in Asia. J. Hattori Bot. Lab. **73**: 1–123.
- Yong, K.-T., Tan, B.C., Ho, B.-C., Ho, Q.-Y., Mohamed, H.** 2013 A revised moss checklist of Peninsular Malaysia and Singapore. Research Pamphlet 133. Forest Research Institute Malaysia, Malaysia. 152 pp.
- Zander, R.H., Eckel, P.M.** 2019 *Pseudosymblypharis* and *Oxystegus* species (Pottiaceae) new to northwestern North America, and refutation of molecular *Chionoloma*. Bryologist **122**(4): 568–577.