

ADDITIONS TO THE MOSS FLORAS OF MINDANAO AND THE PHILIPPINES WITH A FOCUS ON THE REDISCOVERY OF *EUPTYCHIUM SETIGERUM*

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ABSTRACT

Four species of mosses new to the Philippines and two species records new for the island of Mindanao are reported from the 2015 joint botanical expedition of the CEBREM Office of Central Mindanao State University (CMUH) and the California Academy of Sciences (CAS). The rediscovery of new populations of *Euptychium setigerum* after 80 years of searching represents a significant extension of local range from Mt. Manalsal on Palawan Island bordering the South China Sea to Mt. Hamiguitan on eastern Mindanao bordering the Pacific Ocean.

Keywords: Garovagliaceae, Mindanao, moss flora, new species records, Philippines

INTRODUCTION

This is the 5th report of new records of Philippine mosses obtained from two joint botanical expeditions of the CEBREM Office of Central Mindanao State University (CMUH) and the California Academy of Sciences (CAS) conducted in 2014 and 2015. Among the various large island groups in the Malesian floristic region, the Philippine archipelago has at present 246 genera and 743 species of mosses reported from it. The number of moss species in the country has increased with each new botanical exploration conducted, especially in places not well collected (TAN & SHEVOCK, 2014, 2015; AZUELO *ET AL.*, 2015; TAN *ET AL.*, 2015). At present, the moss flora of the Philippines rivals Borneo Island for second place in the Malesian region in terms of the total number of species after the island of New Guinea that leads the count of species (see LINIS & TAN, 2008).

There is a good explanation why the Philippine archipelago, with a total land area of 298,170 km², less than that of Thailand (510,890 km²), Sumatra (473,481 km²), Malaysia (328,550 km²) and Vietnam (310,070 km²), has a moss flora, in comparison, higher in the diversity of taxa and also in the variety of phytogeographical elements. It is now known that the archipelago has a unique and complex tectonic history that produced the present day

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composite island groups which have their origins from both Laurasia and Gondwana (HALL, 1998). This has resulted in the presence of a high number of continental Asiatic moss taxa in the northern part, but not in southern half of the Philippines. These same species also are absent in Borneo, Java and Sumatra, farther to the south. Equally significant, a good number of Australasian moss taxa present on Mindanao Island do not reach Luzon Island of the Philippines; neither are they reported from Peninsular Malaysia and Indochina in continental Asia (LINIS & TAN, 2008).

Here we report an additional four species of mosses new to the Philippines and two species as new records for the island of Mindanao. These findings are new outcomes of the 2015 joint botanical expedition of CMUH and CAS. The presence of these species in Mindanao further re-enforces the already known Gondwana floristic affinity of the southern Philippine moss flora (see also TAN, 1992).

NEW PHILIPPINE MOSS RECORDS

Callicostella armata Herzog [Pilotrichaceae]

Specimens examined: **Camiguin Island**. Mt. Timpoong, on shaded root stump along trail to summit, at 950 m elev., 26 May 2009, *B.C. Tan 2009-B770* (UC) and Mt. Hibok-Hibok, on volcanic boulder, at 885 m elev., 8 July 2015, *J.R. Shevock & B.C. Tan 47165* (CAS, CMUH).

This species is close to *Callicostella papillata* (Mont.) Mitt., but differs in having (many) leaves with a gradually long acuminate apex, leaf cell with a tall, sharp and single papilla, and a strongly papillose or scabrous seta (HERZOG, 1916; AKIYAMA, 1997). This taxon was included in the morphological variation of *C. papillata* by TAN & ROBINSON (1990), and as a form of *C. papillata* in FLEISCHER (1908, see form *longifolia* M.Fleisch.). As a species, it is a new record for the Philippine moss flora. We thank Dr. B.-C. Ho at the Herbarium of Singapore Botanic Gardens for calling our attention to the distinction of this taxon as a species. AKIYAMA (1997) reported this species to be confined to Seram, but our interpretation of this species today reveals that it is widely scattered in the Malesian region.

Garovaglia powellii Mitt. [Garovagliaceae]

Specimen examined: **Mindanao Island**. Polomolok Town, Maligo Sitio, Mt. Matutum, on tree trunk, between 700–900 m elev., 10 Sept. 2013, *A. Azuelo et al. s.n.* (CMUH, UC).

This new species record for the Philippines is best identified by its broadly ovate and plicate leaves with acute apices. The leaf base is slightly recurved and decurrent with a small area of alar cells. The laminal cells develop a few dorsal spines abaxially. The best illustration of this taxon is published in DURING (1977, fig. 38). The species is widespread in SE Asia, including Thailand, extending to Malesia and Australasia, and reaching several islands in Oceania (HYVÖNEN, 1989). Its presence in the Philippines is a welcome addition.

Radulina laevihamata (Dixon) B. C. Tan, T. J. Kop. & D. H. Norris [Sematophyllaceae]

Specimens examined: **Luzon Island**. Quezon Province, Lucban Town, Mt. Banahao de Lucban, slope above the Forestry Field Station, in mixed tropical hardwood rainforest, 1275 m elev., on rotten log, 17 May 2011, *J.R. Shevock & I. Lambio 38075* (CAHUP, CAS, PNH,

UC). **Camiguin Island.** Trail to Binangawan Waterfalls, in disturbed lowland forest, on log, 3 Feb. 2008, *L. Lubos s.n.* (UC). **Mindanao Island.** Bukidnon Province, Malaybalay City District, Mt. Kiamo near Kibalabag Village, in mixed hardwood forest, ca. 1500 m elev., 7 May 2014, *J.R. Shevock & B.C. Tan 45118* (CAS, CMUH, UC).

This is a difficult species to place in a genus with satisfaction on the basis of leaf morphology. The large and inflated single row of basal leaf alar cells and the falcate, narrowly lanceolate leaf shape, coupled with, at times, elongate to linear, pluripapillose, upper leaf cells, allow its placement in the genus *Radulina*, and yet, its mitrate calyptra will place it in *Warburgiella*. O'SHEA (2006) suggested a return to its original inclusion as a species of *Trichosteleum* proposed by DIXON (1942). But the latter genus is now defined by having unipapillose leaf cells. Moreover, the Philippine collections have mature capsules with collenchymatous exothecial cells, justifying its inclusion in *Radulina*, and not *Warburgiella*.

The Philippine specimens, like the specimens from Papua New Guinea that we examined, exhibit a range of variation from having leaves with smooth to weakly pluripapillose leaf cells. The weakly developed pluripapillose leaf cells, if present, are located mostly at the upper half of leaves (especially near the apex) forming the branch tip. This feature is difficult to observe even under a compound light microscope, which has led to its questionable generic placement in *Radulina* (see comment in O'SHEA 2006). TAN *ET AL.* (2007) published a good illustration of this species.

Radulina laevihamata is known from Papua New Guinea and, now, the Philippines. It is probably also present in the Indonesian islands situated between New Guinea and the Philippine archipelago awaiting discovery.

Trismegistia complanatula (Müll. Hal.) Broth. [Pylaisiadelphaceae]

Specimens examined: **Camiguin Island.** Mambajao Municipality, Mt. Timpoong, along Kantembay Trail to summit at 1380 m elev., on root stump in forest with filtered light, 10 July 2015, *J.R. Shevock & B.C. Tan 47274* (CAS, CMUH, HYO, MO, UC). **Mindanao Island.** Davao Oriental Province, Hamiguitan Range Wildlife Sanctuary, along trail from Camp 2 to summit of Mt. Hamiguitan, at 1040 m elev., on hardwood trunk along intermittent streamlet, 22 June 2015, *J.R. Shevock & A.P. Yorong 46896* (CAS, CMUH, HYO, UC).

According to AKIYAMA (2010), who did the latest revision of the genus, the species is best identified by having leaves with fusiform to linear apical leaf cells. In the Philippines, *Trismegistia complanatula* can only be confused with *T. calderensis* (Sull.) Broth. The two species can be differentiated, in many cases, by the outline of their stem leaves. In *T. calderensis* the leaves have predominantly a wide, rounded base with a suddenly narrowed long apex. The stem leaves of *T. complanatula* have predominantly an ovate base with gradually narrowed leaf apex. However, the linear apical leaf cells are the best diagnostic character of *T. complanatula*. See AKIYAMA (2010) for an illustration of *T. complanatula*.

Trismegistia complanatula is a species widespread in Papua New Guinea and New Caledonia, reaching many islands in Oceania. Its presence in southern part of the Philippine archipelago is not a surprise.

NEW MINDANAO MOSS RECORDS

Ectropothecium penzigianum M. Fleisch. [Hypnaceae]

Specimen examined: **Mindanao Island**. Bukidnon Province, Malaybalay City District, Mt. Limbawon, trail to summit through montane forest, on log, 1750 m elev., 30 June 2015, *B.C. Tan 2015-554* (CAS, UC).

Among the Philippine species of *Ectropothecium* Mitt., this species is easily identified by having several enlarged and thin-walled alar cells forming the decurrent leaf base. The leaves are bicostate, smooth, concave, and strongly falcate-secund, reminiscent of *E. falciforme* (Dozy & Molk.) A. Jaeger in plant size and habit, but the latter has only one or two small alar cells.

In the Philippines, *Ectropothecium penzigianum* was known previously from one locality in the northern highlands of Luzon and a second locality on Negros Is. (see TAN & IWATSUKI, 1991). It is here reported for the first time from Mindanao Island.

Euptychium setigerum (Sull.) Broth. [Garovagliaceae]

Specimens examined: **Mindanao Island**. Davao Oriental Province, Mt. Hamiguitan Range Wildlife Sanctuary, along trail from Camp 2 to Twin Falls and beyond toward the pygmy forest at summit of Mt Hamiguitan, in mixed hardwood and scrub forests on tree trunks and small branches between 950 to 1200 m elev., 22–23 June 2015, *J.R. Shevock & A.P. Yorong 46908* (CAS, CMUH, UC), *46923* (CAS, CMUH, FH, PNH), *46926* (CAS, CMUH, MO), *46938* (CAS, CMUH, TNS, UC), *46962* (BOL, CAS, CMUH, H, HYO, KRAM, KUN, MEL, NY, PTBG, UC).

The discovery of this rare Philippine moss on Mt. Hamiguitan more than 80 years after its first collection made from the summit of Mt Manalsal on Palawan Island (see BARTRAM, 1939; DURING, 1977) shows a significant extension of its local range from the Palawan Island bordering the South China Sea to the eastern coast of Mindanao Island bordering the Pacific Ocean.

It appears that this species is rather common on Mt. Hamiguitan as shown by the many collections listed above. Fortunately, all the Mindanao collections bear sporophytes for a definite species identification. The sessile capsule covered by perichaetial leaves with long setaceous apices is the diagnostic character for this moss species. The presence of an endostome with a high basal membrane and keeled segments differentiates the genus *Euptychium* from *Garovaglia*. The latter has filamentous endostomial segments with no basal membrane. DURING (1977) noted that the perichaetial leaf apex has a thick, distally formed “costa-like cusp” made up of several layers of cells, which helps identify this species. The capsules of Mindanao populations of *Euptychium setigerum* produced many green, oblong-shaped spores that are of one or two cells. Without sporophytes, plants of *Euptychium setigerum* look similar to *Garovaglia elegans* (Dozy & Molk.) Bosch & Sande Lac. with small leaf marginal teeth, but in *G. elegans*, the leaves are not as densely arranged and the reddish tinged stems are readily observed. In *Euptychium setigerum*, the leaves are so densely packed along the stem that makes it look obscured, giving the plant a bottle-brush appearance.

Euptychium setigerum is a widespread Australasian species reaching Borneo (Mt. Kinabalu) and southern Philippines (Palawan and Mindanao). It is also the most variable species in the genus (DURING, 1977).

NOTEWORTHY NEW LOCALITY INFORMATION OF MINDANAO MOSSES

Garovaglia bauerlenii (Geh.) Paris [Garovagliaceae]

Specimens examined: **Mindanao Island**. Bukidnon Province, Malabalay City District, Pantaron Range, Mt. Limbawon, trail to summit from Kibalabag Village, on trunk at 1300 m, 2 July 2015, *B.C. Tan 2015-572* (CAS, CMUH, UC); North Cotabato Province, Makilala Town, New Israel Barangay, Mt. Apo National Park, trail to Makalangit site, 5 Feb. 2015, *Azuelo et al. 778* (CMUH, UC).

Our newly made moss collections from Mindanao have yielded several species of *Garovaglia*. Most of them are the common and widespread species known from the country. Two, however, are noteworthy new species records for Mindanao. A revisional treatment of this genus for the country's flora is under preparation with a key to the species to be published later.

Garovaglia bauerlenii is a rather robust plant with a somewhat complanate habit formed by crowded and appressed leaves that are strongly rugose, undulate and plicate. Its acuminate leaf acumina are long and dentate, with occasionally large teeth. DURING (1977) has a good illustration of this species. Small plants of *G. bauerlinii* can be confused with *G. punctidens*, which shares similar rugulose and plicate leaves. But the two can be separated by the structure of perichaetial buds. The inner perichaetial leaves of *G. bauerlenii* are erect-spreading with long acuminate apices, while those of *G. punctidens* are recurved with acute apices.

Garovaglia bauerlenii is an uncommon moss species in the Philippines, mainly found on Mindanao Island. Past localities reported included Mt. Kalatungan in Bukidnon Province and Mt. Lumot in Misamis Oriental Province (see TAN *ET AL.*, 2000). The species is widespread in many parts of Malesia (HYVÖNEN, 1989) outside the Philippines.

Garovaglia punctidens R. S. Williams [Garovagliaceae]

Specimens examined: **Luzon Island**. Rizal Province, Sept. 1909, *A. Loher s.n.* (UC). **Mindanao Island**. Bukidnon Province, Malabalay City District, Pantaron Range, Mt. Limbawon, trail to summit from Kibalabag Village, in secondary mixed forest with *Pandanus* and tree ferns, on trunk at 1480 m elev., 2 July 2015, *J.R. Shevock et al. 47103A* (CAS, CMUH, UC).

For reasons not clearly stated, DURING (1977) treated this as a subspecies of *Garovaglia plicata* (Brid.) Bosch & Sande Lac. The two species are distinctively different in several aspects which include plant habit, foliation, leaf marginal serration, and perichaetial structure. In fact, the important differences between the two taxa are sufficiently stated in the taxonomic key couplet shown on p. 103 in DURING (1977). We prefer to treat them as two separate species.

In the Philippines, *G. punctidens* has numerous confirmed records from Luzon Island (BARTRAM, 1939). The reports of *G. punctidens* from Mindanao listed in TAN & IWATSUKI (1991) are uncertain records with no voucher specimens. We report here authenticated specimens of this species from Mindanao.

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REFERENCES

- AKIYAMA, H. 1997. Taxonomic studies of mosses of Seram and Ambon (Moluccas, East Malasia) collected by Indonesian-Japanese Botanical Expeditions VIII. Meteoriaceae, Hookeriaceae, and Trachypodaceae. *Nature & Human Activity* 2: 9–31.
- AKIYAMA, H. 2010. Taxonomic revision of the genus *Trismegistia* (Pylaisiadelphaceae, Musci). *Humans & Nature* 21: 1–77.
- AZUELO, A. G., B. C. TAN, J. R. SHEVOCK, A. MANUEL, A. YORONG, AND L. G. SARIANA. 2015. Mosses new for Mindanao Island, Republic of the Philippines. *Proceedings of the California Academy of Sciences* 62: 127–134.
- BARTRAM, E. B. 1939. Mosses of the Philippines. *Philippine Journal of Science* 68: 1–437.
- DURING, H. J. 1977. A taxonomical revision of the Garovaglioideae (Pterobryaceae, Musci). *Bryophytorum Bibliotheca* 12: 1–244.
- FLEISCHER, M. 1908. *Die Musci der Flora von Buitenzorg*. Vol. 3. E. J. Brill, Leiden. xxiv+ 459 pp., 63 pls.
- HERZOG, T. C. J. 1916. Neue Laubmoose aus Ostasien und Südamerika. *Hedwigia*. 57: 233–250.
- HYVÖNEN, J. 1989. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXVI. Pterobryaceae (Musci). *Acta Botanica Fennica* 137: 1–40.
- LINIS, V. C., AND B. C. TAN. 2008. Progress of studies on phytogeography and biodiversity of Philippine moss flora from 1991 to 2006. Pages 13–22 in H. Mohamed, B. B. Baki, A. Nasrulhaq-Boyce, and P. K. Y. Lee (eds.). *Bryology in the New Millennium*. University of Malaya, Kuala Lumpur.
- O'SHEA, B. J. 2006. A revision of the genus *Radulina* W. R. Buck & B. C. Tan (Sematophyllaceae, Bryopsida). *Tropical Bryology* 27: 25–43.
- TAN, B. C. 1992. Philippine Muscology (1979–1989). *Bryobrothera* 1: 137–141.
- TAN, B. C., AND Z. IWATSUKI. 1991. A new annotated Philippine moss checklist. *Harvard Papers in Botany* 3: 1–64.
- TAN, B. C., T. KOPONEN, AND D. H. NORRIS. 2007. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXX. Sematophyllaceae (Musci) 1. *Acanthorrhynchium*, *Acroporium*, *Clastobryophilum*, *Pseudopiloecium*, *Radulina* and *Trichostealum*. *Annales Botanici Fennici* 44: 35–78.
- TAN, B. C., L. LUBOS, AND U. SCHWARZ. 2000. New and biogeographically noteworthy records of Philippine mosses from Mindanao Island. *Tropical Bryology* 18: 27–37.
- TAN, B. C., AND H. ROBINSON. 1990. A review of Philippine hookeriaceous taxa (Musci). *Smithsonian Contributions to Botany* 75: 1–41.
- TAN, B. C., AND J. R. SHEVOCK. 2014. Noteworthy mosses collected from the 2014 joint expedition of CAS and CMU new to Mindanao Island of the Philippines. *Bryophyte Divers. Evol.* 36: 22–30.
- TAN, B. C., AND J. R. SHEVOCK. 2015. Species of *Macromitrium* (Orthotrichaceae) new to the Mindanao Region and the Philippines with one species new to science. *Proceedings of the California Academy of Sciences*, ser. 4, 62: 541–549.
- TAN, B. C., J. R. SHEVOCK, F. CORITICO, AND V. AMOROSO. 2015. Mosses new for Mindanao Island, The Philippines III. *Bulletin of the National Museum of Nature and Science, Series B (Botany)*, Tokyo 41: 91–97.