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# Mosses in the karst forest of Puting Bato, Polillo Island, the Philippines

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## ABSTRACT

The mosses of the Puting Bato karst area –one of the remaining patches of forest-over-limestone in the Polillo Group of Islands, the Philippines –are here documented. A total of 31 species and two varieties of mosses in 21 genera and 12 families are reported based on the examination of earlier and recent collections from the area. Of these, 18 taxa are recorded for the first time in the Polillo Group of Islands. The most species-rich families are Neckeraceae (eight species), Fissidentaceae (five species), and Thuidiaceae (four species). Grouping of species based on their affinity to the limestone habitat proposed by Mohamed (1987) is here applied to taxa occurring on calcareous substrates, *i.e*. Exclusives (one species), Preferents (four species), Indifferents (18 taxa), and Casuals (four taxa). Relevant information on habitat, substrate preferences, and new distribution records are provided.

**Keywords:** Limestone karsts, bryophytes, bryophyte inventory, new records.

## INTRODUCTION

Limestone karsts are regarded as "arks of biodiversity" in Southeast Asia due to their high species diversity and site-specific endemism on the surface and subsurface habitats (Clements *et al*., 2006). In the Philippines, around 35 000 km$^2$ or 10% of the total land area is covered by limestone karsts, of which only about 29% are protected (Restificar *et al*., 2006).

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Studies on vascular plant diversity and vegetation in the forests-over-limestone in the country revealed a rather unique species assemblage (*e.g*. Barcelona *et al*., 2006; Fernando *et al*., 2009; Adorador and Fernando, 2017) as well as a number of species new to science (*e.g*. Adorador and Fernando, 2019; Meneses and Cootes, 2019; delos Angeles *et al*., 2022). On the other hand, information on bryophytes on karsts in the Philippines is scattered amongst flora, taxonomic revisions, and checklists (*e.g*. Bartram, 1939; Tan, 1996; Linis, 2009, 2014, 2019a).

Polillo Island, the largest in a group of islands of the same name, is located off the central east coast of Luzon Island and is under the jurisdiction of Quezon Province. In view of biodiversity and conservation, the island group is regarded as Priority Important Bird Area (PH021; Mallari *et al*., 2001), Biodiversity Conservation Priority Area (CPA 34; DENR-CI-UPCIDS, 2002), and Key Biodiversity Area (KBA 20; CI-DENR PAWB-Haribon, 2006). However, it is noticeable that the bryophytes of the islands remain understudied (see Tan and Engel, 1986; Tan and Iwatsuki, 1991).

The Puting Bato karst area (14° 55' N 121° 59' E), located in barangays Aluyon and Cabungalunan of Burdeos Municipality on the east coast of Polillo Island, caters to one of the few remaining patches of forests-over-limestone in the island group (see also Clements, 2003). The site is generally coastal and low-lying with an elevational range of zero to 100 m and is characterized by seaside limestone cliffs, inland hills, and caves. Geologically, the limestone outcrops approximate the late Oligocene to middle Miocene Burdeos Formation and the middle Miocene Langoyen Limestone (see JICA-MMAJ, 1990). Based on the modified Corona's climate classification, the area, as with the rest of the islands, is characterized by the Type II climate which has little to no dry season and a very pronounced maximum rain period from November to January. The annual rainfall is 342.02 mm and the average temperature is 27.28 °C based on climate data (1981-2010) from the agro-meteorological station in Infanta, Quezon Province. Recently, a number of species new to science have been described from the caves of Puting Bato (*i.e*. Barrion-Dupo *et al*., 2014; Lucañas and Lit, 2016).

With an apparent scarcity on available information on the mosses of the Puting Bato karst area, we aimed to provide an account of the mosses occurring in its forest-over-limestone –including details on their habitat and substrate preferences –as well as a number of new distribution records for the Polillo Group of Islands.

## MATERIALS AND METHODS

This study is based primarily on previous collections deposited at the UPLB Museum of Natural History Botanical Herbarium (CAHUP) and on extensive field surveys carried out by the first and third author in eight (8) sites and along existing trails in the area (Table 1; Fig. 1). Collections were made following standard methods (Vanderpoorten *et al*., 2010;

**Table 1**. Surveyed sites in the forest-over-limestone of Puting Bato, Polillo Island and associated locality and habitat information.

| No. | Locality | Habitat Information | Elevation, m a.s.l. | Coordinates, WGS 84 |
|---|---|---|---|---|
| I | collapse doline in the vicinity of inland entrance of Cave 1 | cave entrances and near vertical slopes present; *Gnetum gnemon*, *Celtis* sp., and *Ficus* sp. dominant | 40.0 | 14°55'00.0"N, 121°59'49.8"E |
| II | seaside cliff entrance of Cave 1 | *Gomphandra* sp., *Sterculia* sp., and *Drynaria* sp. present along cliffside | 26.0 | 14°54'51.4"N, 121°59'49.6"E |
| III | entrance and vicinity of Cave 2 | cave entrances and near vertical slopes present; *Sterculia* sp., *Palaquium* sp., and *Sandoricum* sp. dominant | 27.0 | 14°55'04.4"N, 121°59'50.8"E |
| IV | basin-like entrance of Cave 3 | basin of cave entrance about 10 m deep with large boulders; most likely a collapsed chamber | 22.0 | 14°55'08.4"N, 121°59'55.8"E |
| V | vicinity of Cave 3 | sinkholes present; *Elaeocarpus* sp. and *Pterocymbium* sp. dominant | 32.0 | 14°55'08.8"N, 121°59'55.6"E |
| VI | forest-over-limestone in the vicinity of a bowl-like doline | sinkholes and near vertical slopes present; *Elaeocarpus* sp. and *Pterocymbium* sp. dominant | 28.0 | 14°55'10.7"N, 121°59'55.2"E |
| VII | entrance and vicinity of Cave 4 | cave entrances and near vertical slopes present; *Sterculia* sp., *Palaquium* sp., and *Sandoricum* sp. dominant | 25.0 | 14°55'05.5"N, 121°59'50.5"E |
| VIII | collapse doline in the vicinity of Cave 5 | cave entrances present; *Ficus* sp. and *Pterocymbium* sp. dominant in forested areas; species of *Alocasia*, *Ficus*, *Macaranga*, *Musa*, sedges, and grasses present in open areas | 45.0 | 14°55'00.0"N, 121°59'55.5"E |

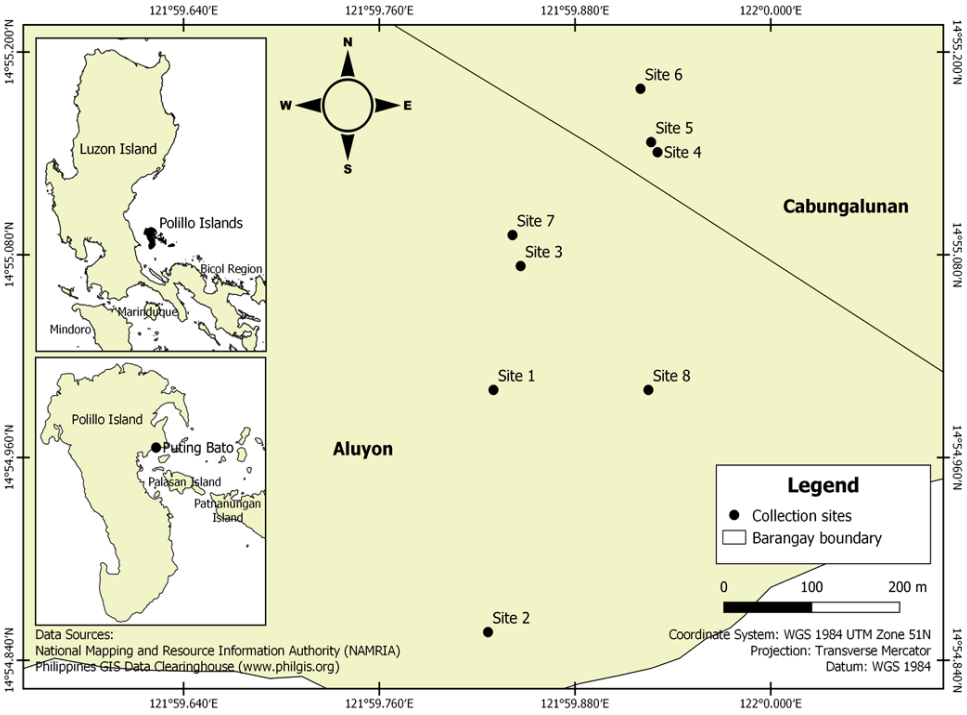


**Figure 1.** Collection sites in the forest-over-limestone of Puting Bato, Polillo Island.

Shevock *et al*., 2014) in nearly all meso- and microhabitats present. Due to the inaccessibility of high forest canopies, epiphytic mosses were only sampled up to two meters from the base of the phorophyte. A total of 212 specimens were collected. The specimens were transported, processed, and identified in the Institute of Biological Sciences, University of the Philippines Los Baños. All specimens were deposited at CAHUP, with duplicates to be deposited at the Herbarium of Northwestern Luzon, Northwestern University Inc., Ilocos Norte (HNUL) and the Herbarium of the Botanical Garden-Institute, Far East Branch of the Russian Academy of Sciences, Vladivostok (VBGI)**.**

## RESULTS AND DISCUSSION

A total of 31 species and two varieties of mosses in 21 genera and 12 families were recorded in the forest-over-limestone of Puting Bato, Polillo Island (Table 2). Neckeraceae is the most species-rich family with eight species, followed by Fissidentaceae with five species, then Thuidiaceae with four species. Among genera, *Fissidens* is the most species-rich (five species), followed by *Calymperes* (three species). Out of these, 18 taxa are newly recorded for the moss flora of the Polillo Group of Islands.

### Enumeration of Species

**Table 2.** Summary of mosses found in the karst forest of Puting Bato, Polillo Island, the Philippines.

| Families | Genera | Species & varieties |
|---|---|---|
| 1. Brachytheciaceae | 1 | 1 sp. |
| 2. Calymperaceae | 1 | 3 spp. |
| 3. Fissidentaceae | 1 | 5 spp. & 2 var. |
| 4. Hypnaceae | 2 | 2 spp. |
| 5. Mniaceae | 1 | 1 sp. |
| 6. Neckeraceae | 6 | 8 spp. |
| 7. Pilotrichaceae | 1 | 1 sp. |
| 8. Pottiaceae | 1 | 1 sp. |
| 9. Pylaisiadelphaceae | 2 | 3 spp. |
| 10. Splachnobryaceae | 1 | 1 sp. |
| 11. Taxiphyllaceae | 1 | 1 sp. |
| 12. Thuidiaceae | 3 | 4 spp. |
| | 21 genera | 31 species and 2 varieties |

The families, genera, and species are presented alphabetically for ease of reference. Classification and nomenclature follow Brinda and Atwood (2023), except for *Isopterygium minutirameum* (see Linis and Logatoc, 2023). Entries marked with an asterisk (*) indicate new records for the Polillo Group of Islands. Each taxon is annotated with information on locality (Sites I-VIII, see Table 1), collection number of representative specimens, habitat and substrate notes as well as intra-Philippine distribution for noteworthy taxa. Collection numbers preceded by ELRL and IAFL are of the first and third author, respectively.

**Brachytheciaceae**

***Sciuro-hypnum plumosum* (Hedw.) Ignatov & Huttunen —** On limestone wall (IV: ELRL 137). Intra-Philippine Distribution: Luzon and Mindanao (Tan and Iwatsuki, 1991 as *Brachythecium plumosum*; Linis, 2019b as *B. plumosum*).

**Calymperaceae**

***Calymperes aeruginosum* Hampe ex Sande Lac. —** On limestone boulder (V: ELRL 085; VI: ELRL 181; VII: ELRL 154) and wall (V: ELRL 090, 102). Intra-Philippine Distribution: Luzon, Palawan, and Mindanao (Tan and Iwatsuki, 1991; Tan, 1996).

***Calymperes robinsonii* B.C. Tan & W.D. Reese —** On limestone boulder (V: IAFL 152, 178), rock-slab (I: IAFL 209; V: IAFL 164, 176), underhang (IV: ELRL 069, 130), and wall (V: ELRL 091). Intra-Philippine Distribution: Luzon, Palawan, and Bohol (Tan and Iwatsuki, 1991; Tan, 1996).

***Calymperes taitense* (Sull.) Mitt**. **—** On limestone boulder (I: ELRL 161; VII: IAFL 192),

rock-slab (III: IAFL 183; V: IAFL 172), and wall (V: ELRL 099, IAFL 169; VII: ELRL 072). On base (VIII: ELRL 112), trunk (V: IAFL 175 with *Caduciella mariei*; VII: ELRL 117), and branch of hardwood (VI: ELRL 060). On fallen log (VII: IAFL 198a).

**Fissidentaceae**

***Fissidens ceylonensis* Dozy & Molk. —** On base of hardwood (VII: ELRL 076). Intra-Philippine Distribution: Luzon, Mindoro, Balabac, and Palawan (Tan and Iwatsuki, 1991; Tan, 1996; Linis, 2009, 2019b).

***Fissidens crenulatus* var. *elmeri* (Broth.) Z. Iwats. and Tad. Suzuki —** On limestone rock-slab (V: IAFL 165) and wall (VIII: ELRL 116). On base of hardwood (V: ELRL 142).

***Fissidens crispulus* Brid. —** On limestone boulder (I: ELRL 171; IV: ELRL 139; V: ELRL 088, 108, 147, 178; VII: ELRL 158, IAFL 194), rock-slab (I: IAFL 205, 214; III: IAFL 181; V: IAFL 148; VI: ELRL 067; VII: IAFL 185), underhang (IV: ELRL 068), and wall (I: ELRL 169, IAFL 203; IV: ELRL 128, 135; VII: ELRL 071; VIII: ELRL 056, 114, 123, IAFL 200). On base of hardwood (VIII: ELRL 113).

***Fissidens crispulus* var. *robinsonii* (Broth.) Z. Iwats. and Z.H. Li —** On limestone boulder (IV: ELRL 138), rock-slab (VIII: IAFL 199), and wall (I: ELRL 168; IV: ELRL 134; VIII: ELRL 055, 120). Intra-Philippine Distribution: Luzon, Palawan, Panay, and Mindanao (Tan and Iwatsuki, 1991 as *F. zippelianus* var. *robinsonii*; Tan, 1996 as *F. zippelianus* var. *robinsonii*).

***Fissidens tenellus* Hook. f. and Wilson —** On limestone boulder (V: ELRL 096) and wall (VIII: ELRL 083). Intra-Philippine Distribution: Luzon and Negros (Tan and Iwatsuki, 1991 as *F. papillosus*; Linis, 2019b as *F. papillosus*).

***Fissidens* sp. —** On calcareous soil (IV: ELRL 136, pro parte). Notes: This species was found mixed with specimens of *Splachnobryum* and resembles *Fissidens guangdongensis* Z. Iwats. and Z.H. Li, previously recorded in the Philippines from Mindanao (Tan *et al*., 2000). To confirm its identity may require additional field work and further examination of collections from the study site since only a handful were extracted from the packet.

**Hypnaceae**

***Ectropotheciella distichophylla* (Hampe ex Dozy and Molk.) M. Fleisch. —** On limestone boulder (VII: ELRL 153), rock-slab (I: IAFL 204; V: IAFL 153; VII: ELRL 157), and wall (I: IAFL 163; IV: ELRL 126; V: ELRL 095, 103).

***Vesicularia vesicularis* (Schwägr.) Broth. —** On limestone boulder (I: IAFL 212; III: IAFL 182; V: ELRL 094, 177, IAFL 167; VII: IAFL 197; VIII: IAFL 198), rock-slab (I: IAFL 210), and wall (I: ELRL 164; VIII: ELRL 054, 115). On trunk of hardwood (VI: ELRL 064). On fallen log (VI: ELRL 059).

**Mniaceae**

****Plagiomnium succulentum* (Mitt.) T.J. Kop. —** On limestone boulder (I: ELRL 162, IAFL 216; V: IAFL 171; VII: IAFL 195) and rock-slab (I: IAFL 206; V: IAFL 158; VI: ELRL 063, 180). On base of hardwood (VI: ELRL 062). On fallen log (V: IAFL 166). Intra-Philippine Distribution: Luzon, Catanduanes, Mindoro, Palawan, Negros, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009, 2014, 2019b; Linis and Logatoc, 2023).

**Neckeraceae**

****Caduciella mariei* (Besch.) Enroth —** On limestone boulder (III: IAFL 211a). On base (VII: ELRL 077) and trunk of hardwood (I: ELRL 175b). On fallen log (V: IAFL 154a). Intra-Philippine Distribution: Luzon, Catanduanes, Palawan, and Mindanao (Tan and Iwatsuki, 1991 as *Pinnatella mariei*; Tan, 1996; Lubos, 2010 as *P. mariei*; Linis, 2014).

****Circulifolium exiguum* (Bosch and Sande Lac.)** S. Olsson, Enroth and D. Quandt **—** On limestone boulder (III: IAFL 211; V: ELRL 086, 106, 143, 176; VII: ELRL 074, 155), rock-slab (V: IAFL 161), and wall (V: ELRL 104). On base (V: ELRL 141) and trunk of hardwood (I: ELRL 175a, IAFL 208). Intra-Philippine Distribution: Batan, Luzon, Catanduanes, Mindoro, Palawan, and Mindanao (Tan and Iwatsuki, 1991 as *Homaliodendron exiguum*; Tan, 1996 as *H. exiguum*; Linis, 2009 as *H. exiguum*, 2014, 2019b).

****Circulifolium microdendron* (Mont.) S. Olsson, Enroth and D. Quandt —** On limestone boulder (I: ELRL 165; V: ELRL 089; VI: ELRL 182; VII: ELRL151) and rock-slab (III: IAFL 184; V: IAFL 163). On trunk of hardwood (VII: ELRL 119). Intra-Philippine Distribution: Luzon, Mindoro, Palawan, Negros, Mindanao, and Sulu (Tan and Iwatsuki, 1991 as *Homaliodendron microdendron*; Tan, 1996 as *H. microdendron*; Linis, 2009 as *H. microdendron*, 2019b).

****Himantocladium plumula* (Nees) M. Fleisch. —** On trunk of hardwood (V: IAFL 64). Intra-Philippine Distribution: Luzon, Mindoro, Samar, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009; Lubos, 2010).

***Neckeromnion lepineanum* (Mont.) S. Olsson, Enroth, Huttunen and D. Quandt —** On limestone wall (V: ELRL 093, 101, IAFL 155; VII: ELRL 078, IAFL 186).

***Neckeropsis cyclophylla* (Müll. Hal.) S. Olsson, Enroth & D. Quandt —** On limestone wall (V: IAFL 149). On base (VII: ELRL 075) and trunk of hardwood (IV: ELRL 149).

****Pinnatella ambigua* (Bosch and Sande Lac.) M. Fleisch. —** On limestone wall (V: ELRL 100). On trunk of hardwood (I: ELRL 175c). Intra-Philippine Distribution: Luzon, Mindoro, Palawan, Negros, and Mindanao (Tan and Iwatsuki, 1991; Tan, 1996; Linis, 2009).

****Pinnatella kuehliana* (Bosch and Sande Lac.) M. Fleisch. —** On limestone rock-slab (VII: ELRL 156) and wall (V: ELRL 098). Intra-Philippine Distribution: Luzon, Mindoro, Palawan, Negros, and Mindanao (Tan and Iwatsuki, 1991 as *Pinnatella nana*; Tan, 1996; Linis, 2009).

**Pilotrichaceae**

***Callicostella papillata* (Mont.) Mitt. —** On fallen log (V: IAFL 168; VII: IAFL 187, 191) and trunk (VI: ELRL 061).

**Pottiaceae**

****Weissia controversa* Hedw. —** On calcareous soil (VII: IAFL 188). Intra-Philippine Distribution: Luzon, Lubang, Mindoro, and Mindanao (Tan and Iwatsuki, 1991; Linis, 2009, 2014; Lubos, 2010).

**Pylaisiadelphaceae**

****Isopterygium albescens* (Hook.) A. Jaeger —** On limestone wall (VIII: ELRL 058). Intra-Philippine Distribution: Batan, Luzon, Catanduanes, Mindoro, Palawan, Negros, and Camiguin (Tan and Iwatsuki, 1991; Linis, 2009, 2010, 2014; Linis and Logatoc, 2023).

***Isopterygium minutirameum* (Müll. Hal.) A. Jaeger —** On fallen tree (VII: IAFL 196).

***Taxithelium instratum* (Brid.) Broth. —** On stump of hardwood (V: ELRL 145).

**Splachnobryaceae**

***Splachnobryum* sp. —** On calcareous soil (I: ELRL 173; IV: ELRL 131, 136). Notes: These specimens resemble *Splachnobryum limbatum* D.H. Norris & R.H. Zander, previously reported in the Philippines from Cebu (Tan and Iwatsuki, 1991). To confirm its identity may require additional field work since only sterile specimens are currently available.

**Taxiphyllaceae**

****Taxiphyllum taxirameum* (Mitt.) M. Fleisch. —** On limestone wall (I: ELRL 174). In-

tra-Philippine Distribution: Luzon, Catanduanes, and Panay (Tan and Iwatsuki, 1991; Linis, 2014, 2019b).

**Thuidiaceae**

***Indothuidium kiasense* (R.S. Williams) Touw —** On limestone boulder (I: IAFL 203a, 215; V: ELRL 087, 105, 146), rock-slab (I: IAFL 207; III: IAFL 180; V: IAFL 145, 177; VI: ELRL 066; VII: IAFL 189), and wall (I: ELRL 160, IAFL 204a; IV: ELRL 125, 132; VII: ELRL 079, IAFL 193; VIII: ELRL 109, 122, IAFL 201). On trunk of hardwood (I: ELRL 175d). Intra-Philippine Distribution: Luzon (Tan and Iwatsuki, 1991 as *Thuidium kiasense*; Linis, 2019b).

***Pelekium bifarium* (Bosch and Sande Lac.) M. Fleisch. —** On limestone boulder (I: ELRL 159; V: ELRL 092, 107, 148, 179), rock-slab (V: IAFL 146, 157), and wall (VI: ELRL 065; VII: ELRL 070); VIII: ELRL 053a, 111). On fallen log (V: IAFL 154b, 179) and tree (VII: IAFL 196a). Intra-Philippine Distribution: Luzon, Mindoro, Palawan, and Panay (Tan and Iwatsuki, 1991 as *Lorentzia bifaria*; Tan, 1996 as *L. bifaria*; Linis, 2009 as *Aequatoriella bifaria*, 2019b as *A. bifaria*).

***Pelekium velatum* Mitt. —** On limestone wall (V: IAFL 159, pro parte).

***Thuidium plumulosum* (Dozy and Molk.) Dozy and Molk. —** On limestone wall (VII: ELRL 118).

**DISCUSSION**

The moss flora of limestone karsts in East and Southeast Asia has been documented in detail –particularly in China (*e.g*. Zhang, 1996; Zhang *et al*., 2005; Liu *et al*., 2018) and Malaysia (*e.g*. Mohamed, 1987; Mohamed and Yong, 2005; Mohamed *et al*., 2005; Norhazrina *et al.*, 2019, 2020). In the Philippines, mosses occurring in limestone sites have been documented in various localities such as Mt. Kalugong in Benguet Province (Linis, 2019a), the limestone hills of the Zambales Mountain Range (Linis, 2019b), different limestone sites in Mindoro (Linis, 2009) and the Bicol Region (Linis, 2014), and the Puerto Princesa Subterranean River National Park in Palawan (Tan, 1996). This is in addition to numerous specimens cited by Bartram (1939) and by taxonomic works such as Tan and Robinson (1990) and Ellis and Tan (1999). In contribution to this, we provide the first account of mosses occurring in limestone sites in the Polillo Group of Islands –together with information on their substrate preferences and an assessment of their affinity to the limestone habitat vis-à-vis Mohamed (1987).

Restating, the mosses of the Puting Bato karst area consists of 31 species and two vari-

eties in 21 genera and 12 families. Out of these, 18 taxa are recorded for the first time in the Polillo Group of Islands –highlighting the importance and need for continued studies on the moss flora of the island group. With this in mind, it is expected that further explorations in other parts of Polillo Island –such as Mt. Malulod and the Panukulan Watershed Reserve –as well as in neighboring islands may yield additional species records.

Looking into substrate preferences, 24 taxa were observed to be calcosaxicolous –of which, 12 taxa were collected only on limestone (*i.e*. *Calymperes aeruginosum*, *C. robinsonii*, *Ectropotheciella distichophylla*, *Fissidens crispulus* var. *robinsonii*, *F. tenellus*, *Isopterygium albescens*, *Neckeromnion lepineanum*, *Pelekium velatum*, *Pinnatella kuehliana*, *Sciuro-hypnum plumosum*, *Taxiphyllum taxirameum*, and *Thuidium plumulosum*). This is followed by corticoles with 13 species, of which two occur only on bark of trees (*i.e*. *Fissidens ceylonensis* and *Himantocladium plumula*). On the other hand, seven species occur as lignicoles, with three species occurring solely on dead wood (*i.e*. *Callicostella papillata*, *Isopterygium minutirameum*, and *Taxithelium instratum*). Three species were found growing solely on calcareous soil (*i.e. Fissidens* sp., *Splachnobryum* sp., and *Weissia controversa*).

Following the criteria set by Mohamed (1987), taxa growing on limestone and calcareous soil were grouped arbitrarily into four categories based on their affinity to the limestone habitat. Information on the occurrence of these taxa on limestone and non-limestone areas were taken from published literature (*e.g*. Ellis and Tan, 1999; Touw, 2001; Linis, 2009, 2018, 2019b; Alcala *et al*., 2020) as well as from specimens examined at CAHUP and the personal collection of the authors.

1. Exclusives, *i.e*. species restricted to limestone (1 sp.): *Splachnobryum* sp.

2. Preferents, *i.e*. species occurring mainly on limestone (50–75% of the time; 4 spp.): *Ectropotheciella distichophylla*, *Pelekium velatum*, *Pinnatella ambigua*, and *Thuidium plumulosum*.

3. Indifferents, *i.e*. species with no particular preference for either limestone or non-limestone habitats (18 taxa): *Calymperes aeruginosum*, *C. taitense*, *Circulifolium exiguum*, *C. microdendron*, *Fissidens crispulus*, *F. crispulus* var. *robinsonii*, *Fissidens* sp., *Indothuidium kiasense*, *Isopterygium albescens*, *Neckeromnion lepineanum*, *Neckeropsis cyclophylla*, *Pelekium bifarium*, *Pinnatella kuehliana*, *Plagiomnium succulentum*, *Sciuro-hypnum plumosum*, *Taxiphyllum taxirameum*, *Vesicularia vesicularis*, and *Weissia controversa*.

4. Casuals, *i.e.* non-limestone mosses occasionally collected on limestone (4 taxa): *Caduciella mariei*, *Calymperes robinsonii*, *Fissidens crenulatus* var. *elmeri*, and *F. tenellus*.

With the currently available information on the moss flora of the Puting Bato karst area, it is hoped that further explorations and continuous comprehensive inventory of species will be carried out, especially in the high limestone cliffs along its coast and in unexplored limestone peaks, dolines, and sinkholes further inland. Additional data, coupled with the

assemblage of mosses documented here, may provide better insights on the composition and distribution of these organisms in this coastal low-lying karst formation. Furthermore, this may also provide baseline data in documenting the mosses of topographically and geologically similar sites –with these studies all geared towards the formulation of conservation actions for these structurally-fragile and unique habitats.

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**REFERENCES**

Adorador, J.T. and E.S. Fernando. 2017. Palms of Samar Island, Philippines. *Palms* 61(4): 161–195.

Adorador, J.T. and E.S. Fernando. 2019. *Orania zheae* (Oranieae, Arecoideae, Arecaceae), a new species from the Philippines, with notes on another slender-stemmed species. *Phytotaxa* 391(1): 69–80.

Alcala, A.A., M.L. Castillo, P.L. Malabrigo Jr., E.L.R. Logatoc, B.O. Pasion and R.S. Alcala. 2020. Mosses from the Greater Sipit Subwatershed, Mt. Makiling Forest Reserve, the Philippines. *Journal on New Biological Reports* 9(2): 262–268.

Barcelona, J.F., N.E. Dolotina, G.C. Madroñero, W.G. Granert and D.D. Sopot. 2006. The ferns and fern allies of the karst forests of Bohol Island, Philippines. *American Fern Journal* 96(1): 1–20.

Barrion-Dupo, A.L.A, A.T. Barrion and J.B. Rasalan. 2014. A new cave-dwelling mygalomorph spider of the genus *Phlogiellus* Pocock, 1897 (Araneae: Theraphosidae: Selenocosmiinae) from Burdeos, Polillo Island, Quezon Province, Philippines. *Philippine Journal of Systematic Biology* 8: 1–15.

Bartram, E.B. 1939. Mosses of the Philippines. *Philippine Journal of Science* 68: 1–437.

Brinda, J.C. and J.J. Atwood (eds.). 2023. *The Bryophyte Nomenclator*. Available from https://bryonames.org. Accessed last 08 August 2022.

Clements, R., N.S. Sodhi, M. Schilthuizen and P.K.L. Ng. 2006. Limestone karts of Southeast Asia: Imperiled arks of biodiversity. *BioScience* 56(9): 733-742.

Clements, T. 2003. Inventory of forest fragments in the Polillo Islands. In: K. Hampson, D. Bennet, P. Alviola, T. Clements, C. Galley, M.V. Hilario, M. Ledesma *et al*., *Wildlife and conservation in the Polillo Islands, Final report*. Multimedia CD (ISBN 1-904589-00-6), Viper Press, Glossop, United Kingdom.

Conservation International-Department of Environment and Natural Resources Protected Areas and Wildlife Bureau-Haribon Foundation [CI-DENR PAWB-Haribon]. 2006. *Priority sites for conservation in the Philippines: Key Biodiversity Areas*. Quezon City. 24 pp.

delos Angeles, M.D., I.E. Buot Jr., C.B. Moran, A.S. Robinson and D.N. Tandang, 2022. *Corybas kaiganganianus* (Orchidaceae), a new, rare helmet orchid from Samar Island, Philippines. *Phytotaxa* 543(2): 127–134.

Department of Environment and Natural Resources-Conservation International-University of the Philippines Center for Integrative Development Studies [DENR-CI-UPCIDS]. 2002. *Philippine Biodiversity Conservation Priorities: A second iteration of the National Biodiversity Strategy and Action Plan final report*. Department of Environment and Natural Resources, Conservation International-Philippines, and Foundation for the Philippine Environment, Quezon City. 113 pp.

Ellis, L.T. and B.C. Tan. 1999. The moss family Calymperaceae in the Philippines. *Bulletin of the Natural History Museum London (Botany)* 29(1): 1–46.

Fernando, E.S., M.J.M. Bande, R.A. Piollo, D.D. Sopot, N.E. Dolotina and W.G. Granert. 2009. Dipterocarpaceae of Bohol Island, Philippines. *Asia Life Sciences* 18(1): 121–138.

Japan International Cooperation Agency-Metal Mining Agency of Japan [JICA-MMAJ]. 1990. *The mineral exploration- Mineral deposits and tectonics of two contrasting geologic environments in the Republic of the Philippines, Consolidated report on Southern Sierra Madre-Polillo area*. Japan. 46 pp.

Linis, V.C. 2009. Biogeography of Mindoro mosses. *Blumea* 54: 290–296.

Linis, V.C. 2014. Biogeographical notes on the moss floras of Bicol Peninsula in Luzon and the Catanduanes Islands, the Philippines. *Philippine Journal of Science* 142: 119–133.

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. *Journal of Bryology* 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. and E.L.R. Logatoc. 2023. Additions to the mosses of Palawan Island, with notes on the phytogeography of the Palawan moss flora. *Taiwania* 68: 166–179.

Liu, R., Z.-H. Zhang, J.-C. Shen and Z.-H. Wang. 2018. Community characteristics of bryophyte in karst caves and its effect on heavy metal pollution: A case study in Zhijin Cave, Guizhou Province. *Biodiversity Science* 26(12): 1277–1288. (in Chinese, with English abstract)

Lubos, L.C. 2010. Species richness, distribution, and status of mosses in selected mountains in Mindanao, Philippines. *Asian Journal of Biodiversity* 1(1): 72–90.

Lucañas, C.C. and I.L. Lit Jr. 2016. Cockroaches (Insecta, Blattodea) from cave of Polillo Island (Philippines), with description of a new species. *Subterranean Biology* 19: 51–64.

Mallari, N.A.D., B.R. Tabaranza and M.J. Crosby, 2001. *Key conservation sites in the Philippines: A Haribon and Birdlife International directory of Important Bird Areas*. Bookmark Inc., Makati City. 485 pp.

Meneses, Z.D. and J.E. Cootes, 2019. *Pseuderia samarana* (Orchidaceae), a new species and genus record from the Philippines. *Taiwania* 64(4): 353–356.

Mohamed, H. 1987. The limestone moss flora of Malaya. *Symposia Biologica Hungarica* 35: 649–663.

Mohamed, H. and K.-T. Yong. 2005. A checklist of mosses for the North-Eastern Region of the Langkawi Islands, Peninsular Malaysia with additional records for the Langkawi Group of Islands. *Malaysian Journal of Science* 24: 111–117.

Mohamed, H., K.-T. Yong, A. Damanhuri and A.L. Qistina. 2005. Moss diversity of Langkawi Islands, Peninsular Malaysia. *Malayan Nature Journal* 57(2): 243–254.

Norhazrina, N., M. Aisyah, N. Syazwana, W. Shazwani and H. Maideen. 2020. Mosses of Gunung Machinchang and its vicinity, Pulau Langkawi, Kedah, Peninsular Malaysia. *Malayan Nature Journal* 72(1): 103–111.

Norhazrina, N., N. Syazwana, M. Aisyah, H. Aznani, H. Maideen and M.S. Nizam. 2019. Mosses of Gunung Senyum Recreational Forest, a tropical limestone forest in Pahang, Peninsular Malaysia. *PhytoKeys* 128: 57–72.

Restificar, S.D.F., M.J. Day and P.B. Urich. 2006. Protection of karst in the Philippines. *Acta Carsologica* 35(1): 121–130.

Shevock, J.R., I.A.F. Lambio and B.C. Tan. 2014. Collection and preparation techniques of bryophyte specimens in biodiversity inventories. In: G.C. Williams and T.M. Gosliner (eds.), *The Coral Triangle: The 2011 Hearst Philippine Biodiversity Expedition*. California Academy of Sciences, San Francisco, pp. 395–405.

Tan, B.C. 1996. Biogeography of Palawan Mosses. *Australian Systematic Botany* 9: 193–203.

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.J. Engel. 1986. An annotated checklist of Philippine Hepaticae. *Journal of the Hattori Botanical Laboratory* 60: 283–355.

Tan, B.C. and Z. Iwatsuki. 1991. A new annotated Philippine moss checklist. *Harvard Papers in Botany* 1(3): 1–64.

Touw, A. 2001. A taxonomic revision of the Thuidiaceae (Musci) of Tropical Asia, the Western Pacific, and Hawaii. *Journal of the Hattori Botanical Laboratory* 91: 1–136.

Vanderpoorten, A., B. Papp and R. Gradstein, 2010. Sampling of bryophytes, Chapter 13. In: J. Eyman, J. De Greef, C. Häuser, J.C. Monje, Y. Samyn and D. van den Spiegel (eds.), *Manual on field recording techniques and protocols for all taxa biodiversity inventories and monitoring, Volume 8*. AbcTaxa, Belgium, pp. 331–345. Available from: http://issuu.com/ysamyn/docs/abctaxa_vol_8_part2_lr/.

Zhang, Z.-H. 1996. Contributions to the bryoflora of Guizhou, S.W. China: New records and habitat notes on mosses from Huangguoshu karst area. *Journal of Bryology* 19(1): 149–152.

Zhang, Z.-H., C.-H. Zhao, X.-N. Li, T. Peng, W.-H. Huang and H. Jiang. 2005. Bryophytes of karst caves in Guilin area, China. *Guihaia* 25(2): 107–111.