Journal of Ecosystem Sciences and Eco-Governance (JESEG)
www.jeseg.carsu.edu.ph

Vol. 2, No. 2 | December 2020
PRINT ISSN 2704 4394 | ONLINE ISSN 2782 8522

Species Richness of Moss Flora on the Montane Vegetation of Mt. Apo Natural Park, Philippines

Andrea G. Azuelo, Ehlrich Ray J. Magday, Lalaine G. Sariana, Alven A. Manual, Razel L. Salinasal, Welven C. Segumpan, and Roselynn Grace G. Montecillo*

College of Education, Central Mindanao University,
Musuan, Maramag, Bukidnon, Philippines

*Corresponding Author
*Email: azuelonenecmu@yahoo.com
Received: November 5, 2020
Revised: December 28, 2020
Accepted: December 31, 2020

Cite this article: Azuelo, A.G., Magday, E.R.J., Sariana, L.G., Manual, A.A., Salinasal, R.L., Segumpan, W.C., & Montecillo, R.R.G. (2020). Species Richness of Moss Flora on the Montane Vegetation of Mt. Apo Natural Park, Philippines. *Journal of Ecosystem Science and Eco-Governance*, **2**(2):18-29.

ABSTRACT

Taxonomic and ecologic assessment of moss flora in the montane forest of Mt. Apo Natural Park, Davao, Philippines was conducted. It aimed to determine the species richness, composition, taxonomy and ecology of the species; and recognize some medicinal properties and species identified as rare, endemic and endangered. Transect method was used and a quadrat of eight randomly sampled plots in a 20 x 20 m along 12 hectares of the montane forest sectioned into lower and upper montane was established. Results of the study revealed 136 mosses belonging to 56 genera and 26 families. The family with the most species-rich is Orthotrichaceae and the least species-rich are the families belonging to Ditrichaceae, Ephimeropsidaceae, Garovagliaceae, Lembophyllaceae, Mniaceae, Neckeraceae, and Spiridentaceae. Moreover, the distribution of species and life forms in different microhabitats reflect the variation of humidity and light regimes. The family Leucobryaceae is strongly epiphytic on decayed logs while the family Ephemeropsidaceae is strongly epiphytic on leaf surfaces. Local assessment further revealed 33 moss species as new record in the park, with 2 endangered species namely: *Pogonatum cirratum* subsp. *macrophyllum* (Dozy & Molk.) Hyvonen. and *Dawsonia becarri* Broth. & Geh; and 4 Philippine endemic species namely: *Ectropothecium ferrugineum* (C. Müll.) Jaeg., *Calyptrochaeta microblasta* (Broth.) Tan & Robins., *Symphysodontella subulata* Broth. and *Thuidium benguetense* Broth. Ex Bartr. Of the collected species, 5 moss species were noted to have medicinal properties namely: *Dawsonia becarri* Broth. & Geh., *Fissidens nobilis, Pogonatum cirratum* subsp. *macrophyllum* (Dozy & Molk.) Hyvonen, *Rhodobryum giganteum* and *Plagiomnium integrum* (Bosch & Lac.) T. Kop. Taxonomically, the mosses showed distinct variation on their morphology structures and forms based on microscopy and field examinations. Further, cryptogam studies are needed to extract information specifically from moss diversity and understand their ecological distribution and functions on the montane forest ecosystem.

Keywords: *Assessment, Microhabitat, Montane, Taxonomic Characters*

1 Introduction

The current speed of taxonomic research is slow without dramatic improvement of the working methods and will most likely fail the discovery of many bryophytes such as the moss species before

their extinction. The distribution of epiphytic mosses and its assemblage in the montane forest of Mt. Apo Natural Park have been poorly documented. In fact, very little is known about moss diversity and their distribution within the park ecosystem. Literature search reflect no research data as to its taxonomic and assessment studies. Recent evidence on studies of tropical montane forest are among the biologically richest ecosystems worldwide, both in terms of flora and fauna (Bruijnzeel et al. 2011).

Bryophytes are a diverse group of primitive plants with about 25,000 species worldwide and the second largest group of land plants (Mishler 2001, Shaw and Renzaglia 2004). They differ from the flowering plants primarily by lacking vascular system for transporting fluids throughout the plant and reproduce by spores (Shevock et al. 2014). Bryophytes included the mosses, liverworts and hornworts. Ecologically, they are an important component of tropical montane forests, both in terms of ecosystem functioning, biomass and biodiversity (Holtz et al. 2002).

Mount Apo is a large solfataric, potential-active stratovolcano in Mindanao. The altitude is 2,945 meters (9,692 ft.). It is the highest mountain in the country and is located between Davao City and Davao Del Sur province in Region XI and Cotabato province in Region XII. The peak overlooks Davao City 40 kilometers (25 mi.) to the northeast, Digos City 25 kilometers (16 mi.) to the southwest and Kidapawan City 20 kilometers (12 mi.) to the west. Apo, which means "ancestor", is flat-topped mountain with three peaks and is capped by a 500-meters wide (1,600 ft.) volcanic crater containing a small crater lake. Along the trail include Lake Venado one of the highest lakes in the Philippines, the solfataras and the old crater near its summit.

The present state of the Philippine montane forest ecosystem requires taxonomic data analysis on non-vascular groups such as the moss flora as they played significant role in water balance and nutrient cycling. Because of their complexity and variety of microhabitats, they usually harbor rich biodiversity and had played significant role in the forest ecosystem. However, very few studies have dealt on floristic composition along natural parks and no source of descriptions of assessment, species richness and vertical distribution pattern of the moss floral species, thus the research study was conducted.

2 Materials and Methods

Study Area

The study site was conducted on the montane forest section of Mt. Apo Natural Park, passing through the Barangay of New Israel trail to Makalangit (06º 56″ N and 125º 13″ E), Makilala, North Cotabato. The local climate is cool and humid, with the mean daily temperature for the months of February and December 2015 ranging from 17ºC – 19ºC and 16ºC – 17ºC respectively. The forest is sectioned into lower and upper montane and dominated by 20 – 30 m tall trees. The montane elevation ranges from 1500 to 2010 masl. Its understory vegetation is characterized by tree ferns, shrubs, herbs, vines and palm trees. The canopy and subcanopy branches showed distinct and rich vascular and non-vascular epiphytes including orchids, ferns, vines, bryophytes and lichen species. Generally, the forest landscape appears undisturbed with old growth forest on the forest floor and the persistent ground-level cloud or fog development are usually observed.

Field Sampling

The field work was carried out employing a transect walk and a quadrat of eight (8) sampled plots with 20x20 meters each. The total area sampled is approximately 12 ha. A GPS was used to give the exact geographical locations of the study area (Figure 1).

Mosses were sampled randomly in all microhabitats within the plots and along the trail and outside plots. Each species of mosses was assessed by noting their habitat preferences. These serve as their substratum confined at tree trunks, soil, logs, rocks, twigs, branches, litter, exposed roots and on upper leaf surfaces. The voucher specimens were placed in their individual packet and properly labelled with detailed and accurate information gathered at the time of collection

Species Nomenclature

Identification of the specimens was based on taxonomic characters and microscopic examinations was done on those specimens that exhibited unique characters using field lens and dissecting microscopes. Some standard manuals, books, keys, checklist, monographs and related literatures were used.

A collaborative work and linkages of bryophytes

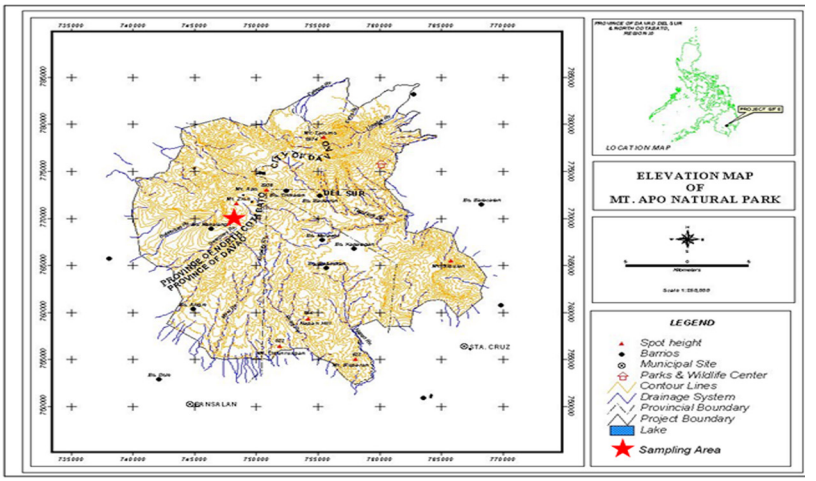

Figure 1. The study site in Mt. Apo Natural Park

experts was established. Those unidentified species and preliminary identified by the researchers were confirmed by Dr. Benito C. Tan and Mr. James R. Shevock, Bryology experts of the CAS (California Academy of Science) at the Education Science Laboratory Room.

Vouchers of specimens were deposited at the Science Laboratory Room of the College of Education, Central Mindanao University. Database was made for all the mosses collected for future examination and research. Likewise, photo documentation was performed in the field and in the laboratory. More importantly, a checklist of the bryophytes in the form of Information Education and Communication (IEC) materials were prepared for accessibility of profile of the species.

Assessment of Conservation Status

An assessment of conservation status of moss species as to its endemicity, threatened or endangered was also employed using existing literature from the 2000 International Union for Conservation of Nature (IUCN) Red List and the New Annotated Philippine Moss Checklist of Tan and Iwatsuki (1991). Local assessment on moss species was carried out as to its medicinal and potential properties was given preference. The data was taken from secondary resources obtained from literatures and science reviews.

Data Analysis

Descriptive statistics were used to describe as frequency counts, and percentage distribution of species in different microhabitats of the forest. Comparison of the random quadrat plots as to species richness and life forms of mosses was performed.

3 Results and Discussion

Species Richness

The present investigation on mosses revealed a collection of 136 species belonging to 56 genera and 26 families (Table 1).

Inventory of moss species in their order with the most numbered families are Orthotrichaceae, Sematophyllaceae, Leucobrayceae, Dicranaceae, Hookeriaceae, Hypnaceae, Meteoriaceae, Rhizogoniaceae, Calymperaceae, Fissidentaceae Hypnodendraceae,Thuidiaceae, Polytrichaceae, Pterobryaceae, and Hypopterygiaceae (Table 2).

An assessment of the mosses and their distribution for each quadrat plot is reflected in Table 2. As noted, the epiphytic floral species exhibited were closely linked to their habitats on the landscape. It appears that one should consider the pattern of moss diversity and assessing each to include its potential habitats in an ecosystem (Newsmaster et al. 2003). The data indicated that the mosses were found in close association with their substrate similarity. The study presents similar findings with Vitt & Belland (1997) that bryophyte species richness is closely related to microhabitat diversity.

Table 1. Summary of families, genera, and species of mosses collected in Mt. Apo Natural Park

Family	Genera	Species
BRACHYTHECIACEAE	1	1
BRYACEAE	1	1
CALYMPERACEAE	2	6
DICRANACEAE	4	13
DITRICHACEAE	1	1
EPHEMEROPSIDACEAE	1	1
FISSIDENTACEAE	1	6
GAROVAGLIACEAE	1	1
HOOKERIACEAE	4	10
HYPNACEAE	6	8
HYPNODENDRACEAE	1	6
HYPOPTERYGIACEAE	2	2
LEMBOPHYLLACEAE	1	1
LEUCOBRYACEAE	1	14
METEORIACEAE	5	7
MNIACEAE	1	1
NECKERACEAE	1	1
ORTHOTRICHACEAE	3	18
POLYTRICHACEAE	2	2
PTEROBRYACEAE	2	2
RACOPILACEAE	1	3
RHIZOGONIACEAE	3	6
SEMATOPHYLLACEAE	7	15
SPIRIDENTACEAE	1	1
THUIDIACEAE	1	6
TRACHYPODACEAE	1	2
UNIDENTIFIED SP.	1	1
TOTAL 26	56	136

Table 2. List of moss species found within and outside the plots in the Montane forest of Mt. Apo Natural Park

Family	Genera/Species	Substratum	Quadrat Plot							
			I	II	III	IV	V	VI	VII	VIII
			1866	1846	1868	1835	1823	1808	1814	1820
			(Elevation masl)							
1. BRACHYTHECIACEAE	*Eurhynchium asperisetum* (C. Mull) Bartr.	DLo, Tr	+	-	-	-	-	+	-	-
2. BRYACEAE	*Rhodobryum giganteum* (Schwaegr.) Par.	DLi, DLo, S	-	+	-	-	-	-	-	+
3. CALYMPERACEAE	*Calymperes fasciculatum* Dozy & Molk	Tr	-	-	+	-	-	-	-	-
	Calymperes sp. 1	Dlo, R	-	-	-	+	-	-	-	-
	Syrrhopodon croceus Mitt.	DLo, FL, Tr, R	-	-	-	-	+	-	-	+
	Syrrhopodon gardneri (Hook.) Schwaegr.	DLo, Tr	-	+	+	-	+	-	-	+
	Syrrhopodon tristichus Nees ex Schwaegr.	Br, DLo, ER, Tr	-	+	+	-	+	-	+	+
	Syrrhopodon sp. 1	Dlo, R	-	-	-	-	-	-	-	+

4. DICRANACEAE	*Campylopus* sp. 1	S, R	-	-	-	-	-	-	-	+
	Campylopus sp. 2	Dlo	-	-	-	-	-	-	+	-
	Dicranoloma blumii (Nees) Par	DLo, Tw	-	-	-	+	-	+	-	+
	Dicranoloma braunii (C. Mull.) Ex (Dozy & Molk.) Par.	DLi, DLo, FL, Tr, Tw	+	+	+	+	+	+	+	+
	Dicranoloma brevisetum (Dozy &Molk.) Par.	FB, R	-	+	-	-	-	-	-	-
	Dicranoloma reflexum (C. Mull.) Ren.	Br, FB, Tr	+	-	+	-	-	+	+	+
	Dicranodontium fleischerianum Schulze. Motel	Br, FL, Tw	-	-	+	+	-	-	-	-
	Dicranoloma sp. 1	FL, Tr	-	-	-	-	-	+	-	+
	Dicranoloma sp. 2	Tr, R	-	+	-	-	-	-	-	-
	Dicranoloma sp. 3	FL, Tr	-	-	-	-	-	+	-	-
	Dicranoloma sp. 4	DLo	-	-	-	-	-	-	-	+
	Leucoloma molle (C. Mull.) Mitt.	Br, DLo, FB, Tr, Tw	+	+	+	-	+	-	+	+
	Trematodon longicollis Michx.	Tr	-	-	-	-	-	-	-	+
5. DITRICHACEAE	*Ditrichum difficile* (Duby) Fleisch.	DLo	-	-	-	-	-	+	+	-
6. EPHEMEROPSIDACEAE	*Ephemeropsis tjibodensis* Goeb.	L, R	-	-	-	-	-	+	-	-
7. FISSIDENTACEAE	*Fissidens guangdongensis*	DLo, Tr, R	-	-	-	-	-	+	-	-
	Fissidens nobilis Griff.	R	-	+	-	-	-	-	-	-
	Fissidens robinsonii Broth.	S, Tr	+	-	-	-	-	+	-	-
	Fissidens sylvaticus auct. non Griff.	ER, R, S, Tr	+	+	+	-	-	+	-	-
	Fissidens anomalous Mont.	S	-	-	-	-	-	-	+	-
	Fissidens areolatus Griff	Tr	-	-	-	-	-	+	-	-
8.GAROVAGLIACEA	*Garovaglia elegans*									
9. HOOKERIACEAE	*Achrophyllum javense* Dix.ex Froehl	DLi, DLo, S	-	+	-	-	-	-	+	+
	Calyptrochaeta microblasta (Broth.) Tan & Robins. * (En)	DLi, R	-	-	+	-	-	-	-	-
	Calyptrochaeta remotifolia (C. Mull.) Iwats., Tan & Touw	Dli	-	-	+	-	-	-	-	-
	Calyptrochaeta sp.	Tr	-	-	+	-	-	-	-	-
	Distichophyllum catinifolium Froehl.	Dlo, R	-	-	+	-	-	-	-	-
	Distichophyllum mittenii Bosch & Lac.	DLi, ER, DLo, S, Tr	-	+	+	+	+	+	+	+
	Distichophyllum osterwaldii Fleisch.	Dlo	-	-	+	-	-	-	-	-
	Distichophyllum sp. 1	DLo, S	+	-	+	-	-	-	-	-
	Distichophyllum sp. 2	S, R	-	-	+	-	-	-	-	-
	Metadistichophyllum rhizophorum	Tr	-	+	+	-	-	+	+	-
10. HYPNACEAE	*Ctenidiadelphus* sp.	Dlo, R	+	-	-	-	-	-	-	-
	Ectropothecium falciforme (Dozy and Molk) Jaeg.	Br, Tr	-	-	-	-	-	+	-	+
	Ectropothecium *ferrugineum* (C. Mull.) Jaeg.* (En)	DLi, DLo, FL, Tw	+	-	+	+	+	+	+	+
	Ectropothecium sp. 1	Dlo, R	+	-	-	-	-	-	-	-
	Ectropothecium sp. 2	Br, Dli, R	+	-	-	-	-	-	-	-
	Isopterygium minutirameum (C.Mull.) Jaeg	Tr, Tw	+	-	-	-	-	+	-	+
	Trachythecium verrucosum (Jaeg.) Fleisch.	Tw	-	-	-	-	-	-	+	-
	Vesicularia reticulata (Dozy & Molk) Broth.	Tw	-	-	-	-	-	+	-	-
	Unidentified sp.	Tr, Tw	-	-	-	+	-	-	+	-
11. HYPNODENDRACEAE	*Hypnodendron dendroides* (Brid.)	Dli	-	-	-	-	+	-	+	-

	Hypnodendron diversifolium Broth & Geh.	DLi, DLo, R, S, Tr	+	+	+	+	+	+	+	-
	Hypnodendron reinwardtii (Schwaegr.) Jaeg.	Br, DLi, DLo, S	+	-	+	-	-	+	+	-
	Hypnodendron vitiense Mitt. in Seem.	DLo, R	-	-	+	-	-	+	+	+
	Hypnodendron arborescens (Mitt.) Lindb.	Dlo	-	-	-	-	-	-	+	-
	Hypnodendron sp. 1	S	-	-	-	-	-	-	+	-
12. HYPOPTERYGIACEAE	*Hypopterygium tenellum* C. Mull	DLo, ER	-	-	-	-	+	-	-	-
	Lopidium struthiopteris (Brid.) Fleisch.	Br, DLo, ER, Tr, Tw	+	+	+	-	+	+	+	+
13. LEUCOBRYACEAE	*Leucobryum arfakianum* C. Mull. Ex. Geh.	Br, DLi, DLo, Tr	+	+	+	+	+	+	+	+
	Leucobryum boninense Dull. S. Lesq.	Br, DLo, FL	-	-	+	+	-	-	-	-
	Leucobryum bowringii Mitt.	DLo, Tr	+	+	-	+	-	-	-	+
	Leucobryum candidum (Schwaegr.) Lindb.	DLi, DLo, ER, Tr	+	+	+	+	+	-	-	-
	Leucobryum javense (Brid.) Mitt.	DLi, DLo, Tr	-	-	-	-	+	-	+	+
	Leucobryum sanctum (Brid.) Hampe	DLi, DLo, FL, Tr, Tw	+	+	+	-	+	+	+	+
	Leucobryum sp. 1	Tr, R	-	-	-	+	-	-	-	-
	Leucobryum sp. 2	Dlo, R	-	-	-	+	-	-	-	-
	Leucobryum sp. 3	DLi, DLo, Tr	-	-	+	+	-	-	-	-
	Leucobryum sp. 4	DLi, Dlo	-	-	-	-	+	-	-	+
	Leucobryum sp. 5	Dlo	-	+	+	-	-	-	-	-
	Leucobryum sp. 6	FL, R	-	-	-	-	-	-	-	+
	Leucobryum sp. 7	DLi, Dlo	-	-	+	-	+	-	-	-
	Cladopodanthus speciosus (Dozy & Molk.) Fleisch.	Tr, R	-	-	-	+	-	-	-	-
14. METEORIACEAE	*Aerobyropsis wallichii* (Brid.) Fleisch	DLo, FB, L, Tr, Tw	+	+	-	+	+	+	+	-
	Aerobryum speciosum (Dozy & Molk.)	Br, DLo, Tr, Tw	+	+	-	+	-	+	-	-
	Barbella enervis (Thwait. & Mitt.) Fleisch ex. Broth	FTw, Tw	+	-	-	-	-	+	+	+
	Barbella flagellifera (Card.) Nog.	DLo, Tr, Tw	+	-	-	-	+	-	-	+
	Floribundaria floribunda (Dozy & Molk.) Fleisch.	Br,Tw	+	+	-	+	-	-	-	-
	Floribundaria pseudofloribunda Fleisch.	Tw	+	-	-	-	-	-	-	-
	Papillaria fuscencens (Hook.) Jaeg.	Tw	-	-	-	-	-	-	+	-
15. MNIACEAE	*Plagiomnium integrum* (Bosch & Lac.) T. Kop.	DLi, DLo, Tr	-	+	-	-	-	-	+	-
16. NECKERACEAE	*Homaliodendron flabellatum* (Sm.) Fleisch.	DLo, FL, Tr, Tw	+	+	+	+	+	+	+	+
17. ORTHOTRICHACEAE	*Callicostella papillata* (Mont.) Mitt.	FB	+	-	-	-	-	-	-	-
	Macromitrium cuspidatum Hampe	FB, Br	-	-	-	-	-	+	-	-
	Macromitrium longicaule C. Mull.	FB, Tr	-	-	-	-	+	+	+	+
	Macromitrium ochraceum (Dozy and Molk) C. Mull	FB	-	-	-	-	-	+	-	-
	Macromitrium semperi C. Mull.	FB	-	+	-	-	+	+	-	-
	Macromitrium nepalense (Hook and Grev.) Schwaegr.	FB	-	-	-	-	+	-	-	-
	Macromitrium robinsonii Williams	FB	-	-	-	-	+	-	-	-
	Macromitrium sp. 1	FB	-	-	-	-	+	-	-	-
	Macromitrium sp. 2	FB	-	-	-	-	-	-	-	+
	Macromitrium sp. 3	FB	+	-	-	-	-	-	-	-
	Macromitrium sp. 4	DLo, E	+	-	-	+	-	-	-	-
	Macromitrium sp. 5	FB	-	-	-	-	+	+	-	-
	Macromitrium sp. 6	FB	-	-	-	-	+	-	-	-

	Macromitrium sp. 7	FB	-	-	-	-	-	+	-	-
	Macromitrium sp. 8	FB	-	-	-	-	-	+	-	-
	Macromitrium sp. 9	FB	-	-	-	-	-	+	-	-
	Macromitrium benguetense Williams	FB	+	-	-	-	-	-	-	-
	Schlotheimia wallissi C. Mull.	FB	-	-	-	-	-	+	-	-
18. POLYTRICHACEAE	*Pogonatum macrophyllum* (Dozy & Molk.) Lindb.*(End)									
	Dawsonia becarii Broth. & Geh.* (End)	DLi, S	+	+	+	+	+	+	+	+
19. PTEROBRYACEAE	*Pterobryopsis crassicaulis* (C.Mull.) Fleisch.	FB, Tr	-	-	-	-	-	+	-	-
	Symphysodontella subulata Broth.* (En)	Dlo, Tr	-	-	-	-	+	+	-	-
	Trachyloma indicum Mitt.	DLo, Tr, Tw	+	+	-	+	-	+	+	+
20. RACOPILACEAE	*Racopilum johannis- winkleri* Broth.	DLo, FL	+	-	-	-	-	-	-	-
	Racopilum spectabile Reinw & Hornsch.	DLi, R	-	+	-	-	-	-	-	-
	Racopilum sp.	Tr	-	-	-	-	-	-	-	+
21. RHIZOGONIACEAE	*Hymenodon angustifolius* Lac.	Tr	+	-	-	-	-	-	-	-
	Pyrrhobryum latifolium (Bosch. & Lac.) Mitt.	Br, Tr	-	-	-	+	+	-	-	-
	Pyrrhobryum spiniforme (Hedw.) Mitt.	DLi, DLo, ER, S, Tr	+	-	+	+	+	+	+	+
	Pyrrhobryum sp.	DLo	-	+	-	-	-	-	-	-
	Rhizogonium sp. 1	Tr	-	+	+	+	-	-	+	-
	Rhizogonium sp. 2	Dlo	-	-	+	-	-	-	-	-
22. SEMATOPHYLLACEAE	*Acroporium altopungens* (C. Mull.) Broth.	DLo, FTw	-	-	-	+	-	-	-	+
	Acroporium hamulatum (Fleisch.) Fleisch	DLo, Tw	+	+	+	+	+	-	+	+
	Acroporium johannis-winkleri Broth.	DLo, ER, FB	-	-	+	+	+	-	-	-
	Acroporium lamprophyllum Mitt.	FB	-	-	-	-	-	-	-	+
	Acroporium sp.	ER	-	-	-	-	-	-	+	-
	Acroporium stramineum (Reinw. & Hornch.) Fleisch.	DLi, DLo, FB, Tr, Tw	+	-	+	+	+	+	+	+
	Clastobryum sp.	Tw	-	-	+	-	-	-	-	-
	Mastopoma sp.	Dlo	-	-	-	+	-	-	-	-
	Radulina hamata (Dozy & Molk.) Buck & Tan.	Br, Dlo	-	+	-	-	-	-	-	-
	Trichosteleum brevisetum Broth.	Tr	-	-	+	-	-	-	-	-
	Trichosteleum hamatum (Dozy & Molk.) Jaeg.	FL	-	-	-	+	-	-	-	-
	Trichosteleum sp.	TR, Tw	-	-	-	-	-	-	-	+
	Trismegistia calderensis (Sull.) Broth	DLi, DLo, E, S, Tr	+	+	+	+	+	-	-	+
	Trismegistia rigida (Mitt.) Broth.	Br, DLo, DLi, R, S, Tr, Tw	+	+	+	+	+	+	+	+
	Trismegistia sp.	Dli	-	-	+	-	-	-	-	-
	Warburgiella philippinensis (Williams.) Broth.	Tr	-	-	-	-	-	-	-	+
23. SPIRIDENTACEAE	*Spiridens reindwardtii* Nees	Tr	+	+	+	+	+	+	+	+
24. THUIDIACEAE	*Thuidium benguetense* Broth ex. Bartr.* (En)	Br, DLo, Tr	-	-	+	+	-	-	-	+
	Thuidium cymbifolium (Dozy & Molk) Dozy & Molk	DLi, DLo, ER, Tr	+	-	+	-	-	+	+	+
	Thuidium pristocalyx (Mull.) Jaeg.	DLo, ER, FL, Tr	+	+	-	-	+	+	+	-
	Thuidium sp. 1	FL, S	+	-	-	-	-	-	+	-
	Thuidium sp. 2	Tr	-	+	-	-	-	-	-	-
	Thuidium sp. 3	Br, Tr	+	-	+	-	-	-	-	-

25. TRACHYPODACEAE	*Trachypus* sp. 1	FB, Tw	-	-	-	-	-	-	+	-
	Trachypus sp. 2	DLo	-	+	-	-	-	-	-	-
UNIDENTIFIED	Unidentified sp. 1	R	-	+	-	-	-	-	-	-
	Unidentified sp. 2	DLo	-	+	-	-	-	-	-	-
TOTAL	136 Species									

Substratum code: Br- Branch; DLi- Decayed litter; DLo- Decayed log; ER- Exposed root; FB- Fallen branch; FL- Fallen Log; FTw- Fallen twig; L- Leaves; R- Rocks; S- Soil; Tr- Trunk; Tw-Twig; Quadrat plot code: + (present), - (absent) Conservation Status code (IUCN Red List except (R)): (R) - Rare, (En) - Endemic, (End) - Endangered

Further results indicated that mosses are generally epiphytic growing on trees, decayed litter and logs, fallen branches, twigs and rocks, soil and surface leaves. The data results reflect that several moss species were present in all the quadrat plots while others were not confined to some quadrat plots. This explains that mosses are substrate specific for some and may occur temporarily available to small microhabitats such as on decayed logs, soil, leaves and rocks. However, the microclimate of the prevailing area of the species is suitable thus the bryophytes grow on almost tree trunk and in all substrates which might be attributed to its most favorable climate and ecological environment.

Species Composition

A comparison of the species per quadrat plot is presented with microhabitats/substratum. As shown, the distribution of mosses differs in their microhabitats in each plot. At the montane forest, decayed log, litters and trunks are the richest microhabitats of epiphytic mosses.

According to Holtz et al. (2002) the understorey or forest floor plays a much more important role as habitat for bryophytes. Thus, the difference in terms of species richness and microhabitat differentiation of the species correlate with differences in climate and forest composition.

As noted, the moss species were recorded along the transect walk and outside plot (Table 2) in relation to their substratum preferences. The families in their order of dominance are Dicranaceae Fissidentaceae, Leucobryaceae, Orthotrichaceae, and Sematophyllaceae with 6 species each, Calymperaceae (5), Meteoriaceae and Polytrichaceae with 4 species each. It is essential to document and record the non-vascular species within potential sites as added information. More importantly, the total number of mosses has been shown to be strongly associated with moisture and vegetation types (Dynesius 2006).

The given floristic studies noted that diversity of the bryoflora can be explained in terms of large number of different habitats found on large green old forest growth. Likewise, the diversity of bryophytes assemblages was assessed through species richness and species distribution – range type growth forms and life strategies (Stevanovic and Svetlana 2006).

Some mosses displayed uniqueness on their external and anatomical morphology features (Figure 2-9). Each species was described on the bases of their taxonomic characters such as habit, habitat, leaf arrangement, leaf cells, sporophyte characters and rhizoids (Yamaguchi 1993). Further, the present study identified the moss life forms such as cushions, mats, pendant, tails, turfs and feathers. They are both pleurocarpous and acrocarpous as noted. Likewise, some lives and grow on the leaf surfaces and are called epiphyllous.

Each quadrat is about 200 meters from each other. In the present study, the upper montane forest showed low species number than the lower montane forest. The present study area is characterized by a difference in heights or elevation, microclimate structure, particularly in moisture (humidity) which is about 91%, light availability and the exposure of the species between canopy of trees. These findings obtained similar results with the study by Gehrig-Downie et al. (2013), that the high species in the lowland forest may be due to their complex architecture of the area and its epiphytic diversity coincided with the high moisture level. More importantly, the meteorological observations in lower montane showed daily occurrences of moving fogs thus causing high relative humidity.

Cryptogam Microhabitats

The distribution of mosses as to microhabitat/ substratum preferences is also shown in Table 2. The distribution of moss species in microhabitats/ substratum differ with each other. The decayed logs were found the most species-rich (23%) followed

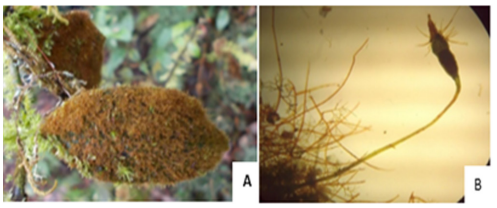

Figure 2. *Ephemeropsis tjibodensis* Goeb. Description: Plant small, epiphytic on leaves (A). Brown when fresh and dry. Calyptra hairy (B). Substratum: leaf surface

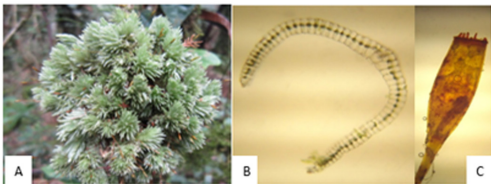

Figure 3. *Cladopodanthus speciosus* (Dozy & Molk.) Fleisch. Description: Plant medium in size. Whitish green when fresh and dry (A). Leaves spreading/ patent, ovate lanceolate. Leaf margin entire (B). Leaf cell two (2) layers thick. Sporophyte symmetrical, cylindrical, brown (C). Substratum: On vine

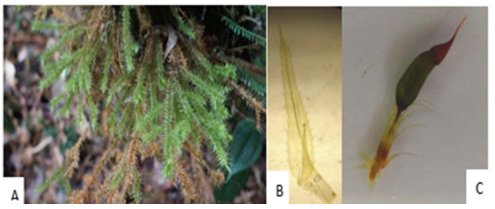

Figure 4. *Spiridens reinwardtii* Nees. Description: Plant large in size, erect, branched (A). Light green when fresh and dark green when dry. Leaves spreading/patent, ovate-lanceolate. Leaf margin deeply serrulate all throughout. Leaf cells smooth, linear rhomboidal. Costa excurrent (B). Sporophyte green, asymmetrical (C). Substratum: On cyathea trunk

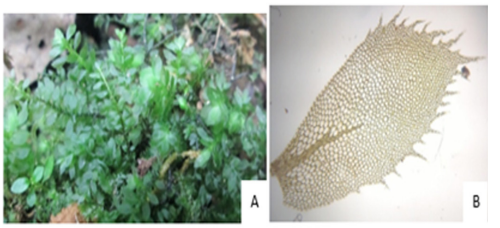

Figure 5. *Achrophyllum javense* Dix.ex Froehl. Description: Plant medium in size, creeping (A). Green when fresh, dark green to black when dry. Leaves spreading/patent. Costa forking below middle. Leaf margin irregularly toothed (B). Leaf cells smooth, rounded to oblong. Substratum: On decayed litter

Figure 6. *Macromitrium* sp. Description: Plant medium in size, creeping, deeply plicate. Brown when fresh and dry (A). Leaves spreading/patent, oblong-lanceolate. Leaf margin entire. Leaf base plain. Costa excurrent in a long acuminate point (B). Leaf cells unipappilate at one end of the cells, linear-rhomboidal (C). Substratum: On trunk

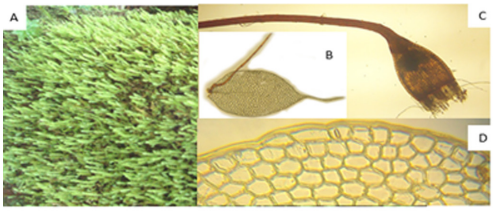

Figure 7. *Matadistichophyllum rizopharum* Description: Plant mall in size, creeping (A). Yellow green when fresh and dry. Leaves spreading/patent. Costa ending below middle (B). Leaf margin bordered with two elongated cells extending toward apex forming in a long acuminate setaceous (C). Leaf cells quadrate to hexagonal. Sporophyte upright (D). Substratum: On cyathea trunk

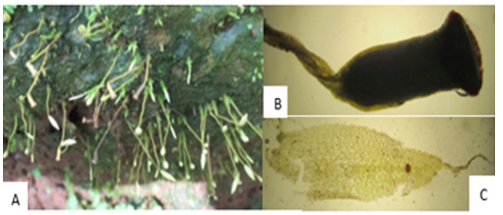

Figure 8. *Pogonatum camusii* (Ther.) Description: Plant small (A). Gametophyte hidden. Perichaetial leaf ovate-lanceolate with long acuminate point, imbricate in seta (B). Leaf margin protruded. Leaf apex wavy, setaceous. Leaf base plain. Ecostate. Sporophyte cylindrical, dominant over gametophyte, upright in a long seta covered with white calyptra (C). Substratum: On decayed litter

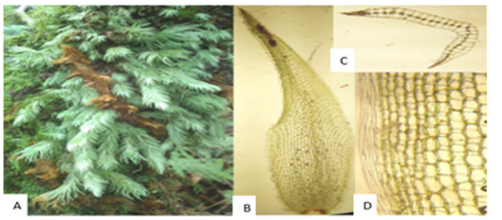

Figure 9. *Leucubryum candidum* (Schwaegr.) Lindb.* Description: Plant medium in size. Whitish green when fresh and dry (A). Leaves spreading/patent forming 4-5 rows around the stem, ovate-lanceolate (B). Leaf margin entire. Leaf base semi-cordate. Leaf cells quadrate-rectangular (C), basal cells elongate (D). Substratum: On tree trunk

by tree trunks (21%), twigs and decayed litters (10%) respectively followed by fallen branch (9%), branch (7%), soil (6%), fallen log (5%), exposed root (4%), rocks (3%) and the least species-rich is on leaves and fallen twigs (1%) respectively. The results showed similar findings with Holtz et al. (2002) that the forest floor plays an important role as habitat for epiphytic mosses.

During the field work there was a low temperature range (16°C–18°C) and humidity (90-91%). The distribution and species composition appeared to be correlated with humidity and light regimes in determining the composition of the moss and lichens communities.

The type and number of microhabitats are important predictors of the number and type of species present. In fact, important habitat for bryophytes include large rotten logs, large trees and snags and consistently higher in old-growth compared to young forest in both the Interior Cedar-Hemlock Zone (Arsenault 2000).

Assessment of Status

Local assessment of mosses revealed 33 new record of moss species in the Natural Park, belonging to 16 families. Of these, Sematophyllaceae family obtained the most family-rich species and Brachytheciaceae, Dicranaceae, Ditrichaceae, Hypnaceae, Hypnodendraceae, Mniaceae, Pterobryaceae and Rhizogoniaceae, with single species each (Table 3). Four (4) endemic species in the Philippines namely: *Ectropothecium ferrugineum* (C. Müll.) Jaeg., *Calyptrochaeta microblasta* (Broth.) Tan & Robins., *Symphysodontella subulata* Broth. and *Thuidium benguetense* Broth ex Bartr.were reported by Tan and Iwatsuki (1991). Two endangered species namely: *Pogonatum cirratum* Subsp. *macrophyllum* (Dozy & Molk.) Hyvonen and *Dawsonia becarri* Broth. & Geh.

Medicinal Value: An Ethnobotanical Perspective

Some medicinal mosses collected were identified based on literature search. The ethnobotanical health practices were recorded for each moss species This include 5 medicinal mosses namely: *Dawsonia becarri* Broth. & Geh., *Fissidens nobilis* Griff., *Pogonatum cirratum* Subsp. *macrophyllum* (Dozy & Molk.) Hyvonen, *Rhodobryum giganteum* (Schwaegr.) Par. and *Plagiomnium integrum* (Bosch & Lac.) T. Kop. These species exhibited antimicrobial activity, antipyretic, diuretic, antiseptic, antihypertensive, anticancer and healing effects (Table 4).

Table 3. Local assessment of moss species listed as new record in Mt. Apo Natural Park

Family	Genera/Species
1. BRACHYTHECIACEAE	*Eurhynchium asperisetum* . (Mull. Hal) E. B. Bartram.
2. CALYMPERACEAE	*Calymperes fasciculatum* Dozy & Molk
	Syrrhopodon gardneri (Hook.) Schwaegr.
3. DICRANACEAE	*Trematodon longicollis* Michx.
4. DITRICHACEAE	*Ditrichum difficile* (Duby) Fleisch.
5. FISSIDENTACEAE	*Fissidens anomalus* Mont.
	Fissidens areolatus Griff.
	Fissidens guangdongensis Z. Iwats & Z.H.U
6. HOOKERIACEAE	*Distichophyllum osterwaldii* M. Fleisch.
	Metadistichophyllum rhizophorum
7. HYPNACEAE	*Isopterygium minutirameum* (.Mull.. Hal.) A. Jaer
8. HYPNODENDRACEAE	*Hypnodendron arborescens* (Mitt.) Lindb.
9. LEUCOBRYACEAE	*Cladopodanthus speciosus* (Dozy & Molk.) Fleisch.
	Leucobryum bowringii Mitt.
10. METEORIACEAE	*Barbella enervis* (Thwaits. & Mitt.) M. Fleisch
	Barbella flagillefera (Card.) Nog.
11. MNIACEAE	*Plagiomnium integrum* (Bosch & Sande Lac.) T. J. Kop.
12. ORTHOTRICHACEAE	*Macromitrium benguetense* R.S. Williams

	Macromitrium cuspidatum Hampe
	Macromitrium nepalense (Hook. and Grev.) Schwaegr.
	Macromitrium robinsonii R. S. Williams
	Macromitrium semperi C. Mull.
13. PTEROBRYACEAE	*Pterobryopsis crassicaulis* (Mull. Hal) M. Fleisch.
14. RHIZOGONIACEAE	*Pyrrhobryum latifolium* (Bosch. & Lac.) Mitt.
15.SEMATOPHYLLACEAE	*Acroporium hyalinum var hamulatum* (M. Fleisch.) M.S Chua & B. C. Ho
	Acroporium longicuspis Dixon
	Acroporium lamprophyllum Mitt
	Acroporium hyalinum (Reinw.ex Schwagr.) Mitt.
	Warburgiella breviseta (Broth.) Broth.
	Radulina hamata (Dozy & Molk.) W. R. Buck & B.C. Tan
	Warburgiella philippinensis (Williams.) Broth.
16. THUIDIACEAE	*Thuidium benguetense* Broth ex. Bartr.
	Thuidium cymbifolium (Dozy & Molk) Dozy & Molk

Table 4. List of mosses with medicinal uses

Medicinal Moss Species	Medicinal Uses	Active Components
1. *Dawsonia becarii* Broth & Geh.	Diuretics and hair growth stimulation; for treating colds	
2. *Fissidens nobilis* Griff.	Diuretics and hair growth stimulation tonics	
	As antibacterial agent for swollen throats and other symptoms of bacterial infection	
3. *Pogonatum cirratum* Subsp. *Macrophyllum* (Dozy & Molk.) Hyvonen	Reduce inflammation and fever, as detergent diuretic, laxative and hemostatic agent	
4. *Rhodobryum giganteum* (Schwaegr.) Par.	For cardiovascular problem and nervous prostration; to cure angina; anti-hypoxia. Antipyretic, diuretic and antihypertensive (Asakawa, 2007)	P-hydroxycinnamic Acid. 7-8dihydroxy coumarin
5. *Plagiomnium integrum* (Bosch & Lac.) T. Kop.	For infections and swelling (Azuelo et al., 2010)	

4 Conclusion and Recommendations

The montane forest of Mt. Apo have shown high moss species richness and with great diversification of their microhabitats; A total taxa of 136 moss species belonging to 56 genera and 26 families;

At the time of sampling, the lower montane exhibited high species richness since the forest is characterized by mixed tall trees and closed canopy and high humidity. The moss species is closely related to large and varied microhabitats than in the upper montane characterized with scattered trees and restricted habitats, thus some of the species show remarkably distinct and diverse in their morphology structures.

Local assessment revealed 33 mosses as new record in Mt. Apo Natural Park, belonging to sixteen (16) families, four (4) Philippine endemic species, twenty seven (27) rare species and two (2) endangered species. Some species of mosses were ethnobotanically recorded with medicinal properties based on literature search.

It is noteworthy that these species have played taxonomic and economic importance in the natural forest parks. The present findings on ethnobotanical knowledge would provide information on the potential medical uses from these indigenous plants. This will guide biotechnologist to investigate further scientific research and explore bryotechnology as new avenues for applied research.

Moreover, further research is needed to carefully understand the taxonomy and ecological distribution and identify the key species represented by these groups that would provide an accurate measure of biodiversity research.

5 Acknowledgement

Sincere gratitude is extended to Central Mindanao University for funding the research, Makilala LGU, Barangay Israel Officials, DENR Personnel, Local Guides and Researchers.

Statement of Conflict of Interest

The authors declare no conflict of interest.

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