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Bryophyte flora of Mt. Matutum protected landscape, South Cotabato, Philippines

Andrea G. Azuelo[*1], Alven A. Manual[1], Christine Dawn G. Obemio[2], Edna P. Oconer[2], Renan B. Gubalane[2], Gerald G. Lobredo[2]

[1]Professional Education Department, College of Education, Central Mindanao University, Bukidnon, Philippines

[2]Science Department, College of Natural Sciences and Mathematics, Mindanao State University, General Santos City, Philippines

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Abstract

An inventory of Mt. Matutum's bryophyte flora as to its species richness and composition on the three vegetation types namely: lowland (mixed dipterocarp), montane and mossy forests was conducted. A floristic survey through alpha taxonomy was employed by recording all the species within the study area. The bryophytes were collected through alpha taxonomy and sampling plots. Site validations were employed to establish two sample plots with a 20x20 m quadrat in each vegetation type. Each species was classified, identified and described according to its diagnostic characters using field lens and microscopy examinations. Findings of the study revealed a total of 185 species, 70 genera, and 35 families. There are 129 species of mosses belonging to 48 genera and 23 families. The liverwort showed 43 species, 19 genera, and 11 families. Three species belonging to 3 genera and one family were noted for the hornworts. Four endemic species namely: *Ectropothecium ferrugineum* (C. Mull.) Jaeg., *Symphysodontella subulata* Broth., *Thuidium benguetense* Broth ex. Bartr., *Leucobryum bowringii* Mitt., On the species currently listed, *Leucobryum bowringii* Mitt. was evaluated as endangered. Two species of mosses namely: *Pogonatum macrophyllum* (Dozy & Molk.) Lindb. and *Leucobryum arfakianum* C. Mull. Ex. Geh. had shown uniqueness in their morphology and distribution, and clearly showed that their life forms are adaptations to special ecological niches and reflect habitats. Three species of mosses were found as new record in Mt. Matutum such as *Neolindbergia rugosa* (Lindb.) Fleisch., *Bescherellia cryphaeoides* (C. Müll.) Fleisch., and *Aerobryopsis sp*. Further research is essential in monitoring several important species and providing baseline information on its distribution and taxonomic classification.

***Corresponding Author: Andrea** G. Azuelo ✉ azuelonenecmu@yahoo.com

Introduction

The current state of knowledge on the bryophyte flora in the Philippines is still incomplete and poorly documented. As noted, the conversion of a significant portion of the land base to second-growth forest may result in the loss of these species hence species assemblage vanishes, and no taxonomic treatment was considered as to its floristic composition.

Bryophytes are the diverse group of land plants that usually colonize habitats with moist or extremely variable conditions (Nikolajeva *et al*., 2012). They are non-vascular plants that are remarkably small, green, simple, spore-bearing and unique among land plants. Bryophytes are relatively large perennial, photosynthetic, and free-living, haploid gametophytes, unbranched diploid sporophytes that remain attached to the maternal gametophyte throughout their lifespan, thus, it is heteromorphic (Shaw and Beer, 1999; Cox *et al*., 2010). Most of the bryophytes are ideal for addressing both the ecological and evolutionary impacts of habitat destruction due to global ubiquity, fast generation times, substrate specificity, and dominant haploid condition (Pharo and Zartman, 2006).

Recently, the bryophytes are approximately 24,000 species worldwide and are divided into three separate phyla: Bryophyta (mosses) with 15,000 species worldwide; the Hepatophyta (liverworts) with 8,500 species and Anthocerotophyta (hornworts) with approximately 300 species. These groups are all moisture-loving plants and inhabit an astounding diversity on a wide variety of substrates and habitats, but differ in their anatomical features (Shaw and Goffinet, 2000).

On its importance, bryophytes are a significant component of moist tropical montane forests and play a major role in the water balance and nutrient cycling of these forests types (Gradstein and Culmsee, 2010). The mosses are valuable in controlling erosion; they assist in the accumulation of humus on branches and twigs; an important role in water storage, nutrient uptake from rain, as soil stabilizers in areas where ground surface conditions have declined as a result of increased infiltration (Eldridge, 1993).

Bryophytes communities are critical to the survival of a tremendous diversity of organisms. In fact, various arthropods are dependent on mosses and liverwort as habitats, or as a food source.

The nutrient-rich, spore-producing capsules are particularly palatable to mollusks, insects, birds and mammals in a cold environment and are eaten by reindeer, geese ducks, sheep and other rodents (Longton, 1992; Shevock, 2001). They are also important as nesting material for birds and act as protective habitat for amphibians; and likewise provide suitable substances for blue-green algae, cyanobacteria.

Plant richness patterns and diversity had been used extensively for global-scale conservation prioritizing and have almost exclusively focused on higher plants yet other groups such as bryophytes. Bryophyte flora is also critical and an important environmental and ecological indicator of most climate change to substantiate climate models and measure global warming (Gradstein, 2001; Ginac, 2001).

More importantly, bryophytes act as good indicators of pollution of air and water, heavy metal contamination, and radioactivity; for some species have been found to be closely associated with particular mineral or metal deposits such as copper ore. Therefore, it assisted in geobotanical survey work and used as indicators of ecological continuity (Hodgetts, 1992; Frahm, 2003).

Presently, the Philippine forests seem to be ecologically disturbed for some are transformed into agricultural land. Thus, it is evident that most bryophyte flora shows emphasis on their distribution in a limited number of classes of land use intensity (Zechmeister, 2001).

Moreover, the continued forest denudation activities and the alarming natural calamities affecting bryophyte flora need immediate attention before they disappear in the biosphere.

Mt. Matutum is an active volcanic cone and is dominated by andesitic rocks. The geographical feature of the mountain is straddling the four municipalities of South Cotabato (Tupi, Tampakan, Polomolok) and one in Sarangani province (Malungon). It has a total area of 14,773 hectares and a maximum elevation of 2,286 masl., and with montane forest stands.

The mountain is declared as a Protected Landscape hence, requiring the preservation of its genetic diversity and maintaining its natural ecological conditions. More importantly, it is identified as an ecological landscape and key biodiversity area by the Conservation International. With its rich vegetation types, observable species were noted for each vegetation type indicating a higher degree of association on their host trees and their natural substrates.

The current research attempted to include a floristic inventory specifically on the species composition and richness of the bryophyte flora of the three vegetation types namely: lowland (mixed dipterocarp), montane, and mossy forests.

The research attempted to inventory the bryophyte diversity of Mt. Matutum as to its species richness and composition on the three vegetation types namely: lowland (mixed dipterocarp), montane and mossy forests.

The present report would provide a status of the current bryophyte diversity at the three sites allowing more floristic knowledge specifically on its cryptogamic inventory since scientific data on bryophytes is incomplete on the said mountain. More so, the study would allow future reexaminations to assess the development in bryophyte species diversity of the natural park.

Further, this research study would serve as baseline data in the formulation of policies and management plan for the protection and conservation of bryophytes and their associated habitats in the forests.

Materials and methods

Study sites

Field reconnaissance and secondary data gathering were done to determine two (2) major sites: the disturbed and undisturbed areas in MMPL.

Fig. 1. Philippine Map.

The disturbed sites were at Sitio Glandang, Barangay Kablon, Tupi, South Cotabato (A1=6°22'10.98":125°4'8.71"E;3=6°21'1.00"N:125°3'35.40"E;A5=6°21'19.00"N:125°4'8.00"E). Undisturbed sites were at Sitio Kawit, Barangay Maligo, Polomolok, South Cotabato (A2=6°20'40.10"N:125°6'3.80"E;A4=6°21'15.70"N:125°5'39.60"E;A6=6°21'21.70"N:125°5'8.40"E). (Fig. 1-4).

In each site, three sampling areas were established representative of different altitude and forest vegetation types namely: lowland dipterocarp (below 1000 masl), montane (1000 to 1500 masl) and mossy (> 1500 masl) forests.

Sampling

The established plots were made based on the vegetation types. In each vegetation type, two (2) samplings were made. With eight plots (8) per sampling and totaled sixteen (16) plots with 20 x 20 m quadrat square. A 5 x 5 m quadrat square was established within the plots using a calibrated plastic cord. The field area plot has a distance of 20 meters. The inventory and assessment of the bryophytes was done through a transect walk across the vegetation types.

Fig. 2. Mindanao Map.

Bryophytes were collected on different substrates (trunk, twigs, logs, rocks, soil, and litters). Specimens collected were placed in a labeled plastic bag. The label includes the altitude, collection number, date of collection and their ecology and associated habitats. Also, other microhabitats of the bryophyte species were recording using the field notes. Likewise, secondary data on the respective air temperature and relative humidity using laboratory thermometer was undertaken.

Bryophyte specimens were identified using latest taxonomic treatments by Yamaguchi (1995) and Gradstein *et al.,* (2005). The morphology and diagnostic characters such as habit, habitat, leaf arrangement, stem structure, sporophyte characters, and rhizoids were used to classify into its biological classification. Identification was made using the existing herbaria and keys from books, scientific articles, and journals.

Fig. 3. Map showing the relative position of Mt. Matutum in Southern Mindanao.

Herbarium and vouchers specimens which is finally placed in the paper packet envelope were properly labeled and deposited at the MSU Laboratory Botanical Section of Mindanao State University, General Santos City.

Assessment of Conservation Status

The local assessment was noted for those collected species found to be rare, abundant or widespread, endemic, threatened or endangered. Assessment was done using the literature based on the International Union for Conservation of Nature (IUCN) and from scientific journals and websites search. The new Annotated Philippine Moss Checklist by Tan and Iwatsuki (1991) was also used. Local assessment includes the rarity and distribution pattern (Widespread) of the species.

Photo-documentation

Photographs were taken from actual observations in the field using a digital camera. The collected species as voucher specimens were compared from the existing herbarium of Central Mindanao University, Musuan, Bukidnon.

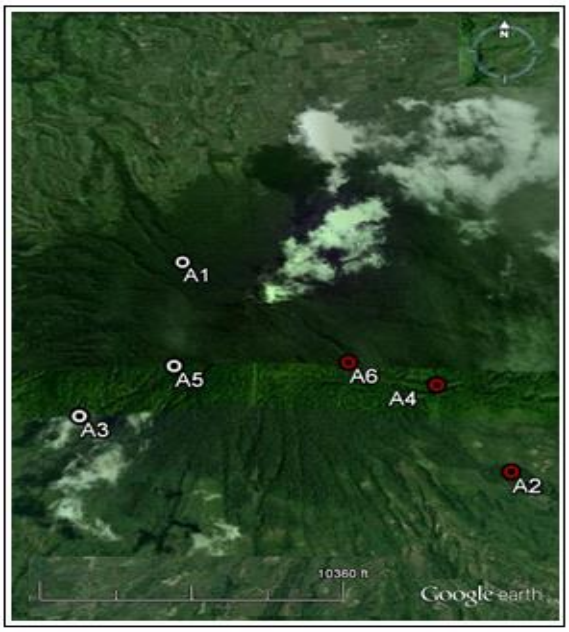

Fig. 4. The six (6) study sites in Mt. Matutum. Red plots (undisturbed sites); White plots (disturbed sites).

The number of species was all listed accurately, photographed, and stored in a database for valuable species information. Also, a checklist of the bryophytes in the form of Information Education and Communication (IEC) materials was prepared for accessibility of profile of Mt. Matutum Bryophyte flora.

Data Analysis

Species richness of bryophyte flora was enumerated and tallied. Each vegetation type was represented with a candidate species categorized according to family, genera, and species.

Species composition of each vegetation type was then recorded and done through species count thus the frequency of bryophyte incidence was determined; to guarantee on the substrate preference for each species, ocular inspection was done on the specified habitat and was then recorded.

A modified graphical analysis was also used to indicate relationships between species composition (Arsenault, 2000).

The bryophyte assessments included the percent cover for each quadrat and vegetation type which was done through visual estimation (Yakubik, 2000).

Results and discussion

The assessment of diversity patterns and distribution of species per vegetation type was recorded. Likewise, the identification of the bryophyte species includes habit, habitat, leaf arrangement and orientation, stem structure, sporophyte and gametophyte character and rhizoid features.

Species richness

Inventory of bryofloral species in all the sampling areas (sampling plots and transect walk) shown a total of 185 species belonging to 70 genera and 35 families. As presented, there are 129 moss species with 48 genera and 23 families. On the other hand, the liverworts had a total of 53 species with 19 genera and 11 families.

The hornworts, on the contrary, showed three (3) species, collected in Mt. Matutum (Table 1).

Table 1. Summary of families, genera, and species of bryophytes collected in Mt. Matutum, South Cotabato.

Bryophytes	Family	Genera	Species
Mosses	23	48	129
Liverworts	11	19	53
Hornworts	1	3	3
Total	35	70	185

Table 2. Family, Genera, and Species Count of Bryophytes in Disturbed and Undisturbed Areas in Mt. Matutum, Natural Park, South Cotabato.

Bryophytes	Disturbed Area			Undisturbed Area		
	Family	Genera	Species	Family	Genera	Species
Mosses	20	34	53	21	44	111
Liverworts	8	11	18	10	16	40
Hornworts	1	1	1	1	2	2
Total	29	46	72	32	62	153

These bryophytes species were found mostly along trails of the transects and sampling plots from the base (500 masl) to the mossy region (1700 masl.) Each species is noted to confine at different restricted microhabitats such as on rotten logs, fallen branches/ twigs, moist soil, and rocks, decayed litters and tree trunks, the total number of bryophytes was shown to be strongly associated with moisture and vegetation types (Dynesius *et al.,* 2006). However, several species remained unidentified.

Table 3. Family, genera and species count of bryophytes in Mt. Matutum, Natural Park, South Cotabato.

	Families	Genera	Species
Mosses	Bartramiaceae	1	1
	Bryaceae	3	5
	Calymperaceae	3	9
	Cyrtopodaceae	1	1
	Daltoniaceae	1	1
	Dicranaceae	4	9
	Fissidentaceae	1	3
	Hookeriaceae	3	6
	Hypnaceae	1	6
	Hypnodendraceae	1	2
	Hypopterygiaceae	1	1
	Leucobryaceae	3	12
	Meteoriaceae	6	25
	Neckeraceae	4	4
	Orthotrichaceae	1	4
	Polytrichaceae	1	1
	Prionodontaceae	1	1
	Pterobryaceae	5	10
	Racopilaceae	1	5
	Rhizogoniaceae	1	3
	Sematophyllaceae	3	14
	Spiridentaceae	1	1
	Thuidiaceae	1	5
Total	23	48	129
Liverworts	Aneuraceae	2	6
	Frullaniaceae	1	2
	Lejeuneaceae	4	4
	Lepidoziaceae	3	14
	Marchantiaceae	2	6
	Metzgeriaceae	1	1
	Pallaviciniaceae	2	2
	Plagiochilaceae	1	14
	Radulaceae	1	1
	Schistochilaceae	1	2
	Trichocoleaceae	1	1
Total	11	19	53
Hornworts	Anthocerotaceae	3	3
Total	1	3	3

The list of species count is presented in Table 2. As gleaned from the data, the total bryophytes in the disturbed area showed a total of 72 species, with 46 genera and 29 families while 153 species of bryophytes, 62 genera, and 32 families in the undisturbed field site. The results of bryophyte diversity data are attributed to the high topographical relief of the mountain which provided the maximum number of habitats, and ecological conditions (Magill, 2010). Further results of the species richness of the mountain indicated that the forest exhibited different species which we found to show to occupy different habitats and ecological niches.

Table 4. Distribution and abundance of bryophyte species according to habitat preferences.

Habitat	Mosses	Liverworts	Hornworts	TOTAL
Decayed litter	2	5	0	7
Decayed log	45	21	3	69
Fallen branch/twig	6	7	0	13
Hanging (Epiphytic)	26	2	0	28
Rocks (Petrophytic/Saxicolous)	1	7	0	8
Soil (Terricolous)	5	1	0	6
Trunk (Corticolous)	46	9	0	55

Table 5. Medicinal bryophytes in Mt. Matutum, Natural Park, South Cotabato.

Medicinal Bryophytes Species	Medical Uses	Active Components
Mosses		
1. Bartramiaceae		
Philonotis mollis (Dozy & Molk.) Mitt.	Heal burns; For adenopharyngitis, antipyretic and antidotal (Asakawa, 2007)	Triterpenoidal saponins
2. Bryaceae		
Rhodobryum giganteum (Schwaegr.) Par.	For cardiovascular problem and nervous prostration; to cure angina; anti-hypoxia, antipyretic, diuretic and antihypertensive (Asakawa,2007)	P-hydroxycinnamic Acid, 7-8 dihydroxy coumarin
Bryum sp.	Healing of wounds, burns, and bruises; cure of fungal infections (Beike *et al.*, 2010)	Triterpenoidal saponins
3. Fissidentaceae		
Fissidens nobilis Griff.	Diuretics and hair growth stimulation tonics, As antibacterial agent for swollen throats and other symptoms of bacterial infection	
4. Polytricaceae		
Pogonatum macrophyllum Dozy & Molk.	To reduce inflammation and fever, as hemostatic agent, detergent diuretic, and laxative.	
Liverworts		
1. Aneuraceae		
Riccardia sp.	Exhibits anti-leukemic activity	Riccardins A (57) and B (58), Sacullatal (15)
2. Marchanticeae		
Dumortiera hirsuta (Sw.) Nees	As source for antibiotics	
Marchantia polymorpha L.	As diuretics, for liver ailments, insect's bites, boils, and abscesses; treat pulmonary tuberculosis; with growth-inhibiting substances; used to cure poisonous snake bites, burns, cuts, fractures, scalds and open wounds; for cardiovascular disease (Beike *et al.*, 2010)	Marchantin A (61); MB-G (35a) Marchantin D (56) and E (66)
3. Pallaviciniaceae		
Pallavicinia sp.	Extracts for antimicrobial activity	Sacullatal (15)
4. Plagiochilaceae		
Plagiochila sp.	Exhibits anti-leukemic activity/ anti-microbial activity	Bicyclohumulenone (3), Plagiochiline A (13), Plagiochilide (81), Plagiochilal B (19); Menthan monoterpenoids

The diversity patterns of bryophytes suggest that this might be due to the net effect and dependent on the vegetation type and the response to environmental gradients among groups of species (Pharo *et al.,* 1999).

As reflected in the data (Table 3), the most species-rich is shown in their order by the family Metoriaceae, followed by Sematophyllaceae, Leucobryaceae, Dicranaceae and the least species is represented by Bartramiaceae, Cyrtopodaceae, Daltoniaceae, Hypopterygiaceae, Polytrichaceae, Prionodontaceae, and Spiridentaceae respectively. Based on the data, the most species-rich of the liverworts is represented by the family of Plagiochilaceae and Lepidoziaceae, followed by Marchantiaceae and Aneuraceae respectively. The least species is represented by the family of Metzgeriaceae, Radulaceae, and Trichocoleaceae. On the hornworts, the family Anthocerotaceae is the only species of hornworts.

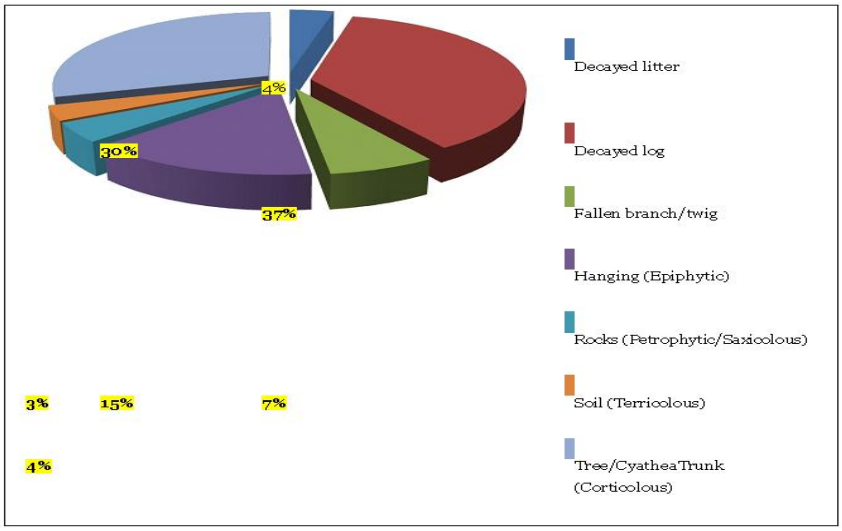

Fig. 5. Habitat preferences of Bryophytes.

This floristic survey provided that each species along the transect and sampling plots occurred in their respective microhabitats and ecological environments (Arsenault, 2000). Furthermore, the importance of the community structure and the comparison of their patterns of species diversity on species habitat relationships are very beneficial in determining their growth and survival.

Habitat Preferences of Bryophyte Species and Distribution

Moss species dominated the distribution and abundance of bryophyte species based on the substrate or habitat preference.

They are restricted or confined on decayed log (37%) followed by tree trunk (30%), epiphytic or hanging (15%), fallen branch/twigs (7%) rocks and decayed litter (4%), and soil habitats (3%), respectively (Table 4 & Fig. 5).

These assemblages of bryophyte species are an important factor to explain that the habitat preferences among moss species are influenced by the vegetation structure and their ecological environment. More so, great variety of microhabitats and permanently humid microclimate favor the growth of bryophytes in the forests.

Bryophyte Cover

As can be seen, the diversity of species varies much within vegetation types and in different altitudes. The present occurrence of the bryophyte species in the undisturbed area is much higher in number (153) than in the disturbed area with lower in species number (72).

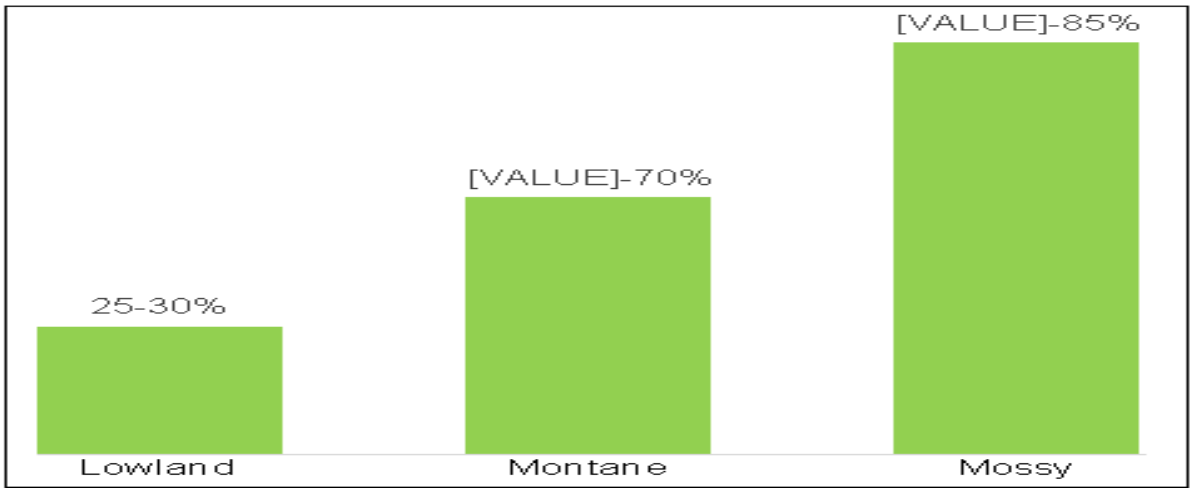

Fig. 6. Bryophyte Cover in three vegetation types.

According to Gradstein (1995), the species number of bryophytes raises with the elevation in general. He added that the different diversity is determined by climatic, edaphic, physiological and phytogeographical factors. It is noteworthy that most of the bryophytes characteristic is associated with cold environmental conditions, and the lowland taxa are relatively young adaptations to the harsh physiological conditions thus giving rise to low species number. In the mossy and upper montane forests, the bryophyte moss cover reaches 80- 85% growth cover, while 50-70% was noted on montane forest and 25-30% bryophyte cover for the lowland (Fig. 6).

Fig. 7. Some Medicinal Bryophytes in Mt. Matutum Natural Park, South Cotabato.

Assessment of Status

The status of assessment of the bryopfloral species in Mt. Matutum revealed four (4) endemic species namely: *Ectropothecium ferrugineum* (C. Mull.) Jaeg., *Symphysodontella subulata* Broth., *Thuidium benguetense* Broth ex. Bartr. and *Leucobryum bowringii* Mitt.

On the species currently listed, *Leucobryum bowringii* Mitt. was evaluated as endangered. Two (2) species of mosses namely: *Pogonatum macrophyllum* (Dozy & Molk.) Lindb. and *Leucobryum arfakianum* C. Mull. Ex. Geh. had shown uniqueness in their distribution and is found in the mossy region.

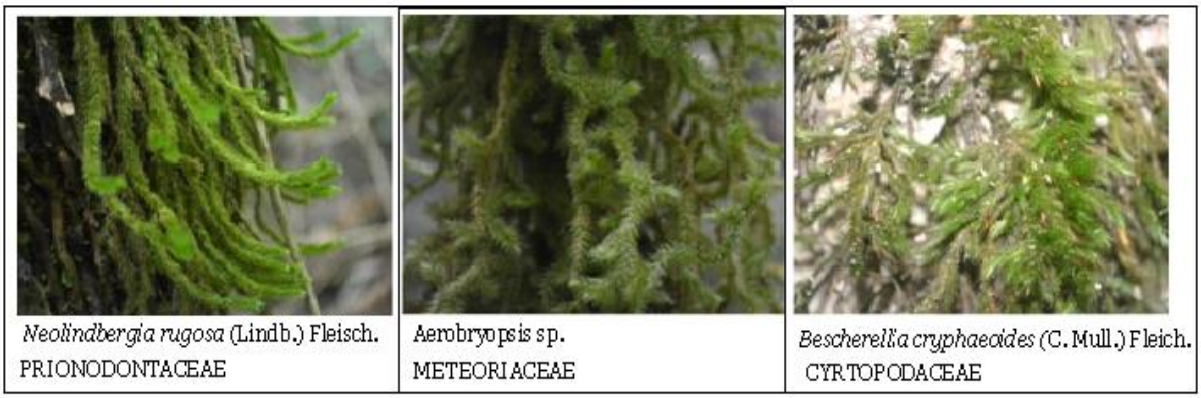

Fig. 8. New Record of Bryophyte Species in Mt. Matutum Natural Park, South Cotabato.

These species clearly show that their life forms are adaptations to particular ecological niches and reflect habitats. Even if the species are not exactly known, an analysis of morphological adaptations provides useful insights in the altitudinal zonations of rain forests. More importantly, the life and growth forms are mainly related to the species reaction upon environmental conditions. (Frahm, 2003). Three (3) species of mosses were found as a new record in Mt. Matutum. These are *Neolindbergia rugosa* (Lindb.) Fleisch., *Bescherellia cryphaeoides* (C. Müll.) Fleich., and *Aerobryopsis sp.*

Results of the study noted some bryophyte species were identified potential for medicinal use (Table 5). These moss species include *Philonotis mollis* (Dozy & Molk.) Mitt., *Rhodobryum giganteum* (Schwaegr.) Par., *Bryum sp.*, *Fissidens nobilis* Griff. and *Pogonatum macrophyllum hirsuta*, *Marchantia polymorpha* L., *Pallavicinia sp.*, and *Plagiochila sp.* It is known that various bryophytes as herbal medicines by the traditional Chinese use some species for the treatment of cardiovascular diseases, boils, eczema, cuts, bites, wounds and burns (Wu, 1977, Ding, 1982, Ando, 1983).

Chemical analysis has revealed that many bryophytes, notably the liverworts contain biologically active substances indicating antibiotic properties (Banerjie, 1974).

Conclusions

The following conclusions are made from the study:

The vegetation types under study exhibited different bryophyte taxa with a total of 185 species distributed into 70 genera and 35 families. The moss flora totaled 129 species belonging to 48 genera and 23 families. The liverworts showed 53 species belonging to 19 genera and 11 families. The hornworts had three (3) species belonging to 3 genera and one (1) family.

The bryophyte floral species exhibited high species richness in undisturbed than the disturbed region. These results are attributed to the quite high topographical relief of the mountain which provided some habitats like tree trunks, decayed logs, twigs, rotted litters and wet rocks. Bryophyte cover increases with gradient and elevations. The inclination of moisture level in the mossy forest reflects the highest species population.

Local assessment on bryophyte species was noted endemic, widespread, new record and evaluated endangered. Some representative taxa showed potential medicinal properties. Four (4) endemic species was recorded namely: *Ectropothecium ferrugineum* (C. Mull.) Jaeg., *Symphysodontella subulata* Broth., *Thuidium benguetense* Broth ex. Bartr. and *Leucobryum bowringii* Mitt. of these, *Leucobryum bowringii* Mitt. was evaluated as endangered.

Two (2) moss species such as *Pogonatum macrophyllum* (Dozy & Molk.) Lindb. and *Leucobryum arfakianum* C. Mull. Ex. Geh. had shown uniqueness in their morphology and distribution. Three (3) species of mosses namely: *Neolindbergia rugosa* (Lindb.) Fleisch., *Bescherellia cryphaeoides* (C. Müll.) Fleich., and *Aerobryopsis* sp. were found a new record in Mt. Matutum.

There is an urgent floristic survey work to further investigate the pattern of species diversity, composition and ecological importance.

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