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Moss and lichen diversity in Mt. Kalatungan Range Natural Park, Bukidnon, Philippines

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Abstract

The study aimed to identify the mosses and lichens in terms of species richness and composition; document their distribution across different habitats; assess the conservation status; and identify several conservation strategies affecting the floral species and recognize its ecological importance in the ecosystem. Samples were collected through transect walk along the established 2-hectare biodiversity monitoring plot. Each species was classified, identified and described according to its diagnostic characters using field lens and microscopy examinations. Findings of the study revealed an overall total of 136 nonvascular species of these, 65 mosses, belonging to 35 genera and 19 families. The lichens had 71 species belonging to 18 genera and 11 families. Taxonomic characters based on habitats, leaf arrangement and orientation, stem structure, and sporophyte characters for the mosses and the growth form for the lichens were used to identify into families, genera and species. The species are confined on tree trunks, decayed logs, twigs and litters and on moist rocks. Moss and lichen cover ranges 30-85% within study sites. The trend of moisture level at the montane forest reflects the highest species population. Likewise, different microclimate regimes and substrates strongly influenced its cover and species composition. Local assessment for the species was observed as endemic, threatened, endangered and possibly new. Three moss species were found endemic, 1 endangered and 1 species as possibly new. The overall floristic assessment should be carried out to establish a foundation for their protection and ecological impact to the environment.

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Introduction

The distribution of epiphytic mosses and lichens assemblage in the montane forest of natural parks in the Philippines have been poorly documented. In fact, very little is known about moss and lichen diversity and their distribution within the forest ecosystem of Mt. Kalatungan Range Natural Park (MKaRNP). Literature search reflect very few research data as to its richness, composition and distribution pattern of nonvascular flora.

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 diverse group of primitive plants and the second largest group of land plants to angiosperms (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). These groups 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). And play a significant role in the water balance and nutrients cycling.

Generally, the bryophytes are nonvascular plants, small, green, simple, spore-bearing and unique among land plants in having 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 in their lifespan (Shaw and Beer, 1999). Recently, they include approximately 25,000 species worldwide and was divided into three separate divisions, namely: Bryophyta (mosses) with 15,000 species, the Marchantiophyta (liverworts) with 8,500 species and Anthocerophyta (hornworts) with approximately 300 species. These groups are all moisture-loving plants and grow on a wide variety of substrates but differ in their anatomical features. Most importantly, the bryophytes play significant role in the ecosystem in a variety of ways such as biological indicator of air pollution since they are vulnerable to environmental change and are excellent indicators of climate change; and as model system for research; some species are used in herbal medicine; invaluable in the construction of moss gardens; few species plays a 'keystone' role in mineral cycling and regulation of microclimate in the forests canopy; they provide food and habitat for a host of invertebrates (Shevock, 2001). They play important role in the dynamics of understory vegetation as well as soil structure, soil stability and interception and retention of water (Bates *et al*., 2000).

Lichens are also nonvascular plants, small with slow growth and thrive in cool environment in higher forest elevation with about 20,000 species worldwide. They are a symbiosis between a fungus, the mycobiont, and a photosynthetic organism, either a green alga or cyanobacteria species, the photobiont. They have a wide variety of growth forms, the main morphology types such as crustose, foliose and fruticose. These groups also grow on a wide range of substrate both natural and man-made and obtain their required nutrients and water quality from the atmosphere thus, are highly sensitive to atmospheric changes and are excellent bioindicators of environmental quality (Dyer and Letourneau, 2007; McCune, 2000).

Foliose, crustose and fruticose group of lichens comprise about 18,000 to 20,000 species worldwide. In the Philippines, the lichens are about 1,108 taxa distributed in 137 genera, 789 species and 253 varieties. Some species are of great medicinal value such as their antibiotic properties, some with protolichesteric acid such as use in the preparation of some anti-cancer drugs. Others are for food for many animals, for dying purposes, perfume industry and some as acid-alkaline indicators (Wolesly, 1960).

Mt. Kalatungan Range Natural Park is considered as a natural park in May 5, 2000, under Presidential Proclamation 305. It has an estimated area of 55,692 hectares (ha), of which 24,732.18 ha consist of the strict protection zone or the protected area (PA) while approximately 30,889.25 ha make up the buffer zone

(DENR-PENR Bukidnon, 2018) located in the central section of Bukidnon with the Mindanao Central Cordillera. The park covers the City of Valencia and the three municipalities of Pangantucan, Talakag, and Maramag, all in the province of Bukidnon. The land within the boundary of the mountain of Mt. Kalatungan Range is still declared as timberland with identical vegetation cover. Its terrestrial status is considered extremely highly critical. The environment exhibits richness in vegetation reflecting the diversity of the montane forests. However, the said forest in the buffer zone of the protected area was found dramatically disturbed with pressing issues and concerns relative to land cover conversion for agro-industrial use.

Recently, the current state of knowledge of the mosses and lichen taxa in the Philippines need to be crypto magically explored. This should include the identification of its unique and micro-environmentally niches that are very limited in extent and threatened by various factors, In fact, as observed Philippine Forests seemed to be ecologically disturbed for some are converted into agricultural landscape. Thus, it is seen that most nonvascular life-forms show emphasis of their distribution in a limited number of classes of land use intensity. More so, the continued forest denudation activities and the alarming natural calamities affecting mosses and lichens flora need immediate attention before they are lost in the biosphere. Taxonomic data on mosses and lichens could hardly be obtained. Thus the present research report looks into their systematics and ecological status distributed in Mt. Kalatungan Natural Park, Bukidnon.

Materials and methods

Study Area

The study area was conducted at MKaRNP, Bukidnon, Philippines, passing through Barangay Portulin, Pangantucan, Bukidnon. The site is also within the upper portion of the Muleta Watershed, the study site of the Integrated Watershed Research and Development Project funded by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD) (Fig. 1.). The local climate is cool and humid, with the mean daily temperature during the conduct of the study ranges from 15°C (night) and 25°C (day). The elevation of the study site ranges from 1340-1650 meters above sea level (masl). Its understory vegetation is characterized by tree ferns, shrubs, herbs, vines palm, and bamboo trees. The canopy and subcanopy branches showed distinct and rich vascular and non-vascular epiphytes. Generally, the forest landscape appears undisturbed with old growth forest on the forest floor. Several species of fauna were noted such as unique species of invertebrates such as the insects, ants, and moths in association living with the bryophytes and lichens. Likewise, some vertebrates were observed during the conduct of the study such as bats, birds, snakes and amphibians.

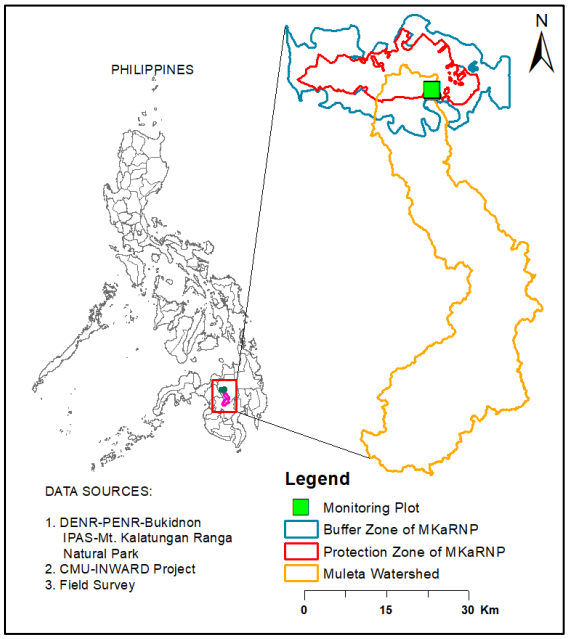

Fig. 1. Location of the study site.

Field Sampling

The fieldwork was carried out employing a transect walk from the campsite to the identified area. A handheld global positioning system (GPS) was used to collect coordinate points for the exact geographical locations of the study area. The mosses and lichens species were sampled randomly in all microhabitats within the study sites. Each species was assessed by noting their habitat preferences.

These serve as their substratum confined at tree trunks, soil, logs, rocks, twigs, branches, litter, and exposed roots and on upper leaf surfaces, the voucher specimens were placed in their individual packet and properly labeled with detailed and accurate information gathered at the time of collection.

Species Nomenclature

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

Assessment of Conservation Status

Assessment of conservation status as to endemicity, threatened or endangered was also employed using existing literature from the International Union for Conservation of Nature (IUCN) Red List. More importantly, local assessment on both moss and lichens 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 such as frequency counts and percentage distribution of species in different microhabitats of the forest were used to analyze the data.

Results and discussion

Species Richness

The collected nonvascular flora mosses and lichens revealed a total of 136 species. Of these, it comprised 65 species of mosses belonging to 35 genera and 19 families. For the lichens, there are 71 species belonging to 18 genera and 11 families (Table 1). These data was s gathered through alpha taxonomy.

Table 1. Total count of family, genera and species of moss and lichen flora in Mt. Kalatungan Range Natural Park, Bukidnon.

Plant	Family	Genera	Species
Mosses	19	35	65
Lichens	11	18	71
Total	30	53	136

Inventory of moss species in their order with most numbered families are: Meteoriaceae, Orthotrichaceae, Fissidentaceae Hypnaceae, Pterobryaceae, Leucobrayceae, Hypnodendraceae, Racopilaceae, Polytrichaceae, Thuidiaceae, Sematophyllaceae, Neckeraceae, Mniaceae, Dicranaceae, Calymperaceae, Bryaceae, and the least species is represented by the families of Entodontaceae and Hookeriaceae (Fig. 2). Similarly, the most species-rich among the lichen species is represented by their order of families namely: Parmeliaceae, Lobariaceae followed by Physiaceae, Pertusariaceae, Lecanoraceae, Collemataceae, Gyalectaceae, Cladoniaceae, Ramalinaceae, unidentified, and the least species is represented by Coccocarpiaceae and Graphidaceae (Fig. 3.). There are species under study belonging to unidentified species. These group of species need further verifications on their distinct morphology characters.

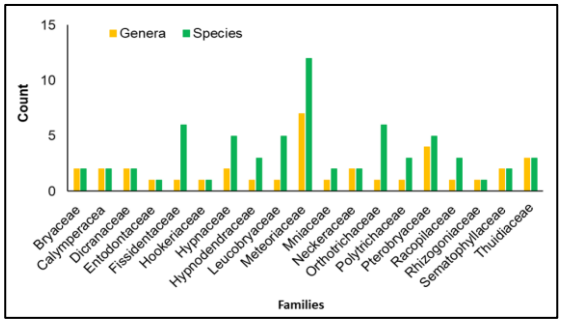

Fig. 2. Families, genera and species count of mosses in Mt. Kalatungan Range Natual Park, Bukidnon.

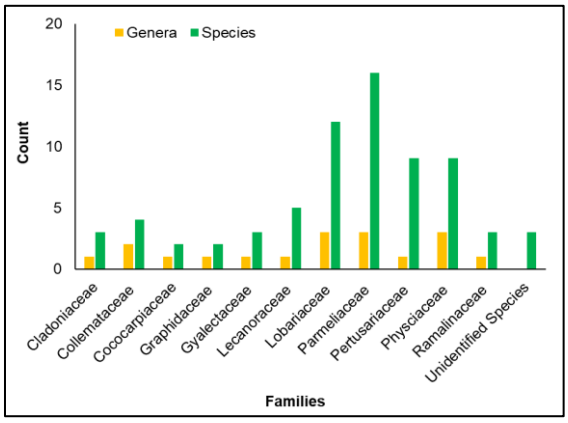

Fig. 3. Families, genera and species count of lichens in Mt. Kalatungan Range Natual Park, Bukidnon.

The epiphytic floral species exhibited were closely linked to their habitats on the landscape. It appears that one should consider the pattern of the species

diversity and assessing each to include its potential habitats in an ecosystem. 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 moss species richness is closely related to microhabitat diversity.

Further results indicated that mosses 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 and lichen species were present and are confined to different microhabitats.

This explains that mosses are substrate specific for some may occur temporarily available to small microhabitats such as on decayed logs, soil, leaves and rocks (Fig. 4 and 5). However, the microclimate of the prevailing area of the species is significant thus they grow on almost fallen twigs/branch and tree trunk and in all substrates which might be attributed for its most favorable climate.

Species Composition

A comparison of the nonvascular species is presented with microhabitats / substratum. The distribution of mosses differ in their microhabitats in the study site.

At the montane forest site, decayed log, litters and trunks are the richest microhabitats of epiphytic mosses. Similarly, fallen branch, trunks and logs are the richest habitats for lichens (Fig. 4 and 5.).

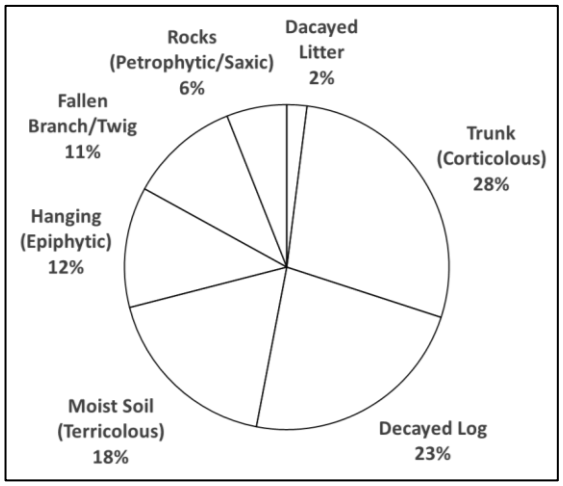

Fig. 4. Habitat preferences of mosses.

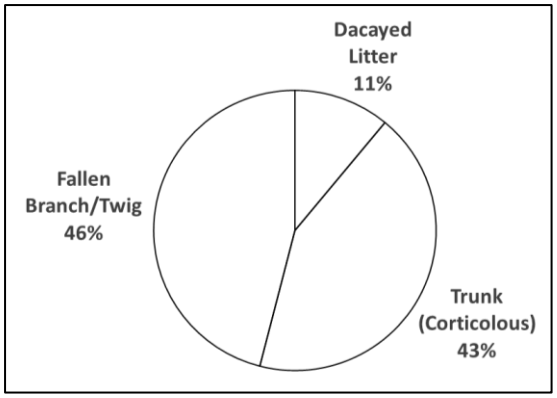

Fig. 5. Habitat preferences of lichens.

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

As reported, it is very essential to document and record non-vascular species within potential sites as added information.

For the lichens, a total of 71 species under 18 genera and 11 families were collected along the transect walk. The largest family belongs to Parmeliaceae and the least is represented by family Cococarpiaceae and Graphidaceae with single species. Lichens collected are moisture dependent and shade-adapted.

The presence of Lobariaceae and Collemataceae in the transect walk indicated that the two families are more frequent in humid forests (Balaji and Hariharan, 2013). More importantly, the total number of mosses and lichens has been shown to be strongly associated with moisture and vegetation types (Dynesius and Zinko, 2006).

The given floristic studies noted that diversity of the nonvascular flora 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.

Fig. 6. Some mosses in Mt. Kalatungan Range Natural Park: A) *Pogonatum macrophyllum* Dozy & Molk.; B) *Fissidens nobilis* Griff.; C) *Rhodobryum giganteum (*Schwaegr.) Par.; D) *Neckeropsis lepineana* (Mont.) Fleisch.; E) *Syrrhopodon tristichus* Nees ex Schwaegr.; F) *Hypnodendron vitiense* Mitt. in Seem.; G) *Symphysodontella subulata* Broth.; H) *Hypnodendron diversifolium* Broth & Geh.; I) *Pterobryopsis gedehensis* Fleisch; J) *Leucobryum arfakianum* C. Müll. Ex Geh.; K) *Macromitrium semperi* C. Müll.; L) *Racopilum johannis-winkleri* Broth.

Some mosses displayed uniqueness on their external and anatomical morphology features. 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 identified life forms of the mosses were noted such as cushions, mats, pendant, tails, turfs and feathers as shown in Fig. 6. They are both pleurocarpous and acrocarpous. Further, other significant information reflect to show potential medicinal values of some moss species collected in the area studied (Fig 6A, 6B and 6C).

These include *Pogonatum macrophyllum* Dozy & Molk., *Fissidens nobiis* Griff., and *Rhodobryum giganteum* (Schwaegr.) Par. The lichen taxa in the montane forest had exhibited unique features with respect to growth forms and substratum preference. Some examples of the lichens are examined during the study is presented in Fig. 7. As gleaned on the data, visual assessment such as color, size and shape and reproductive structures such as apothecia structured forms differs among the macrolichens. It was found out that more prevalent are the foliose lichen during the time of collection. Further, some lichens species collected in the area were identified to have some medicinal potentials (Fig 7A, 6B and 6C).

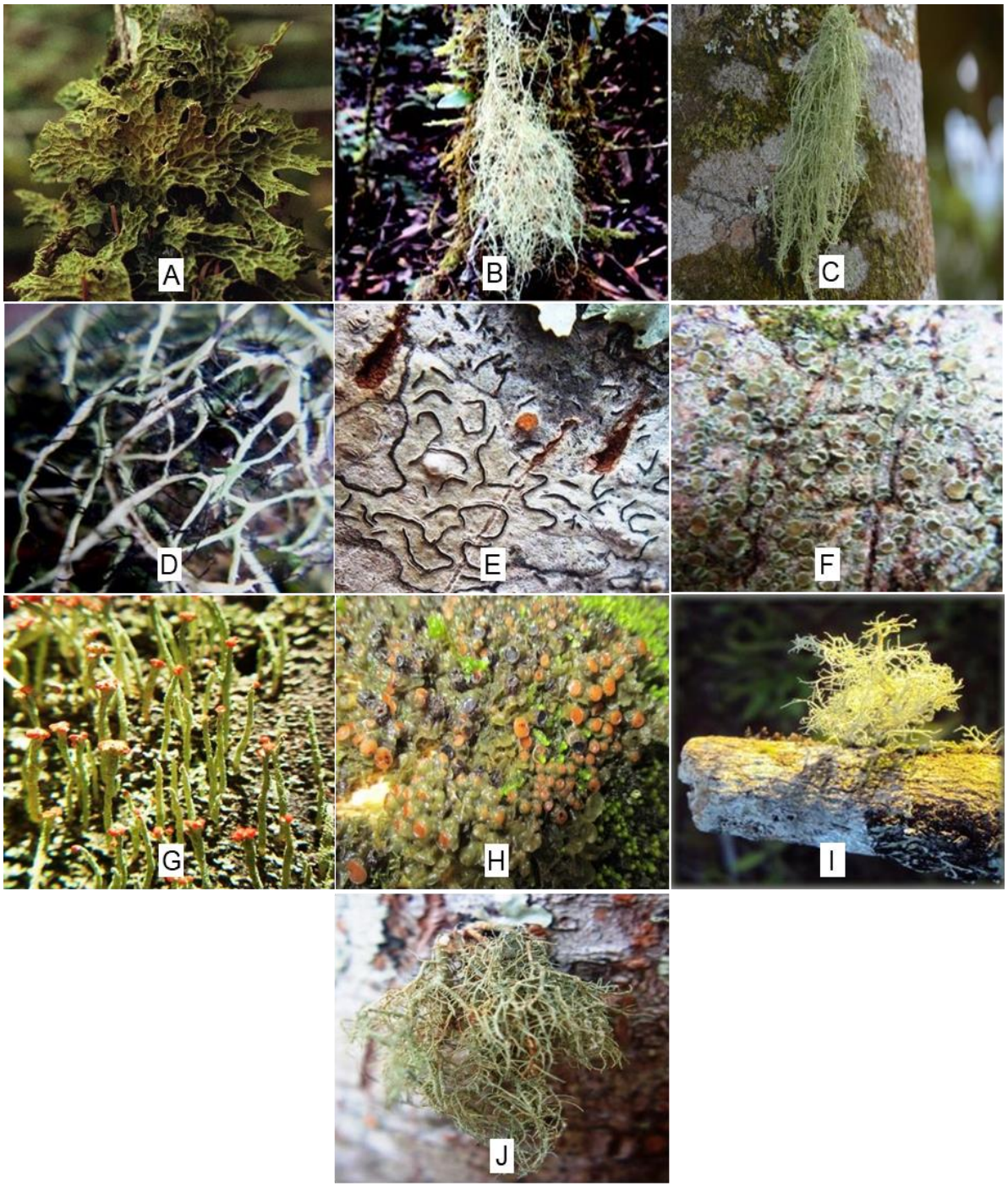

Fig. 7. Some Lichens in Mt. Kalatungan Range Natural Park: A) *Lobaria pulmonaria (*L) Hoffm; B) *Usnea longissima* Ach.; C) *Usnea articulate* L. Hoffm.; D) *Heterodermia echinata* (Taylor) Culb.; E) *Graphis hiascens* Fée; F) *Lecanora leprosa* Fée; G) *Cladonia sp.;* H) *Lecanora sp.;* I) *Usnea flammea* Stirt*;* J) *Usnea nidulans* Motyka.

The present investigation via transect walk of the moss and lichen flora within the two-hectare biodiversity monitoring plot is characterized by a difference in heights or elevation, microclimate structure, particularly in moisture (humidity) which is about 85%, light availability and the exposure of the species between canopy of trees. This findings obtained similar results with the study conducted 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 during the field work is associated with the daily occurrences of moving fogs thus causing high relative humidity.

Cryptogam Microhabitats

The distribution of mosses as to habitat differentiation (Fig. 4.) reflects the microhabitat preferences of the species. The distribution showed that the most species-rich microhabitats are on trunk (Corticolous; 28%), followed by decayed log (23%), moist soil (18%), hanging or epiphytic (12%), fallen branch (11%), moist rock (6%) and decayed litter (2%) respectively. The results showed similar findings with Holtz *et al.* (2002) that the forest floor plays an important role as habitat for epiphytic mosses.

On the lichens species (Fig. 5.), these findings show remarkably distinct for the species of lichens and appeared differently due to differences in structural characters between the forest floor habitat and those on epiphytic on tree trunks. As shown, the distribution of the lichens with the most species-rich microhabitats are on fallen branch (46%), followed by trunk (43%), and decayed log (11%) respectively.

During the fieldwork, there was a low-temperature range (16-18^{0}C) and humidity (70-95%). As noted, the distribution and species composition appeared to show 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 and lichens include large rotten logs, large trees and snags and consistently higher in old-growth compared to young forest (Arsenault and Goward, 2000).

Assessment of Status

Local assessment of mosses revealed 1 possibly new species belonging to Fissidentaceae family (Table 2) and 1 species for the lichens belonging to the family of Physiaceae (Table 3). Three (3) endemic species namely: *Ectropothecium ferrugineum* (C. Müll.) Jaeg., *Symphysodontella subulata* Broth. and *Thuidium beguetense* Broth. ex Bartr. were reported by Tan and Iwatsuki (1991). One endangered species namely: *Pogonatum macrophyllum* (Dozy & Molk.) Lindb.

Table 2. Some medicinal mosses in Mt. Kalatungan Range Natural Park, Bukidnon.

Species	Medical Uses	Active Components
Rhodobryum giganteum (Schwaegr.) Par. BRYACEAE	For cardiovascular problem and nervous prostration; to cure angina; anti-hypoxia antipyretic, diuretic and antihypertensive (Asakawa, 2007)	P-hydroxycinnamic acid 7-8 dihydroxy coumarin
Fissiden snobilis Griff. FISSIDENTACEAE	Diuretics and hair growth stimulation tonics as antibacterial agent for swollen throats and other symptoms of bacterial infection	
Pogonatum macrophyllum Dozy & Molk. POLYTRICACEAE	To reduce inflammation and fever, as detergent diuretic, laxative and hemostatic agent	
Plagiomnium sp. MNIACEAE	For infections and swelling (Azuelo *et al.*, 2010)	

Table 3. Some medicinal lichens in Mt. Kalatungan Range Natural Park, Bukidnon.

Species	Medical Uses	Active Components
Lobaria pulmonaria (L.) Hoffin. LOBARIACEAE	Applied to cuts as antiseptic and healing agent (Guarrera *et al.*, 2008). Used for indigestion, malnutrition in children, abdominal distention, ascarid infestation, burns and scald, edema due to kidney inflammation, local swelling, reducing inflammation, relieving pain, and severe aching of skin. Drink decoction or apply powder to affected area (Hu *et al.*, 1980; Wang and Qian, 2013).	Stictic acid, consictic acid, and norstictic acid
Parmotrema Reticulatum (Taylor) M. Choisy PARMELIACEAE	Tea drunk to relieve discomfort from kidney disorder or venereal disease. The tea is commonly prepared in late afternoon and left for one night before being drunk (Pennington, 1969).	Catechin, purpurin, tannic acid and reserpine
Usnea articulate L. Hoffm. PARMELIACEAE	Treatment for stomachache. A handful is chewed fresh and the juice swallowed, it is bitter but relieves the pain after a while (Kokwaro, 1976). Used for wounds and skin bruises (Brooker *et al.*, 1987).	Fumarprotoccetraric acid
Usnea longgisima Ach. PARMELIACEAE	For treating cancer, tuberculosis and ulcers (Yazici and Aslan, 2003; Odabasoglu *et al.*, 2006). Used to heal bone fractures. Washed, air dried, soaked overnight in salted water, and placed over affected part (Sharma, 1997).	Evernic, diffractaic, barbatic, and 4-0 demethylbarbati acids

Medicinal Value: An Ethnobotanical Perspective

Some medicinal mosses and lichens collected were identified based on literature search. The medicinal uses and their active components is presented in Tables 7 & 8. For the moss species, this include 3 medicinal mosses namely: *Fissidens nobilis* Griff., *Pogonatum macrophyllum* (Dozy & Molk.) Lindb., *Rhodobryum giganteum* (Schwaegr.) Par. and *Plagiomnium* sp. For macrolichens species, 4 plants were noted with medicinal properties namely: *Lobaria pulmonaria* (L.) Hoffm., *Parmotrema reticulatum* (Taylor) M. Choisy, *Usnea articulata* L. Hoffm., and *Usnea longissima* Ach. (Table 8). Both species exhibited antimicrobial activity, antipyretic, diuretic, antiseptic, antihypertensive, anticancer and healing effects.

Conclusion

The montane and mossy forest of MKaRNP have exhibited diversity on the presence of mosses and macrolichens species and with great diversification of their microhabitats. Results revealed a total taxa of 136 of mosses and lichens species belonging to 65 species, 35 genera and 19 families, while 71 macrolichen species with 18 genera and 11 families.

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

Generally, the distribution of mosses are strongly epiphytic on tree trunks which is represented by the family Meteoriaceae and the least families are represented by Hookeriaceae and Entodontaceae while macrolichens distribution are closely epiphytic which is represented by Parmeliaceae and the least is Cococarpiaceae and Graphidaceae on the tree trunks and fallen branch.Local assessment of status of mosses and lichens revealed one possibly new species.

One endangered species namely: Pogonatum macrophyllum (Dozy & Molk.) Lindb. and three endemic species namely: Ectropothecium ferrugineum (C. Müll.) Jaeg., Symphysodontella subulata Broth and Thuidium benguetense Broth. ex Bartr while on macrolichens, three species are of medicinal value such as Lobaria pulmonaria (L.) Hoffm., Parmotrema reticulatum (Taylor) M. Choisy, Usnea articulata L. Hoffm and Usnea longissima Ach. Both species exhibited antimicrobial activity, antipyretic, diuretic, antihypertensive, and anticancer or healing effects.

The distribution of species and life forms in different forest microhabitats are correlated with humidity and light regimes in the forest hence, there was a clear morphological variations of the species in relation to their taxonomic characters.

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