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# Diversity of Lichen Flora in Mt. Kitanglad Range Natural Park, Kaatuan, Lantapan, Bukidnon

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**ABSTRACT:** This study was conducted to identify and classify the lichens; determine the diversity index and richness of lichens. A total of 36 species belonging to six genera under three families was identified. Lichen species were mostly found at moderate high altitudinal range with an elevation of 1,131 meters above sea level and open areas where they received adequate sunlight with high moisture and humidity contents. Diversity, composition and altitudinal distribution of lichens was evaluated in Mt. Kitanglad Range, Kaatauan, Lantapan, Bukidnon, Philippines a wet forest type forest. The maximum species richness was reported on *Usnea rubicunda* Stirt. The abiotic factors were shown to be essential in adapting the relative abundance of lichens for it is capable to survive in the range of light levels, it appears that drier and lighter conditions competitively favored. Additionally, lichen diversity is dependent on the climatic and environmental conditions which makes them as an excellent biological indicators of ecosystem changes in the forests of Mindanao Island, Philippines.

**Keyword:** morphology, ecological status, microhabitat preferences.

## INTRODUCTION

Lichens are often used to evaluate air quality, climate change, as well as an effective early-warning system to detect accumulation of heavy metals and radioactive materials in terrestrial ecosystems (Aptroot and van Herk, 2007). Their use as environmental phytometers (Boonpragop and Polyiam, 2007) is due to their specialized ecological and physiological requirements making them very sensitive to environmental changes and are therefore excellent indicators of ecosystem health (Gradstein et al., 2003; Aptroot and van Herk, 2007; Wolseley, 2002). Lichens therefore form an important component of the complex web of life and their disappearance affects the balance of nature to a great extent, but despite their importance in nature their conservation has not been given much emphasis (Nash, 2008). Requisite moisture and light, unpolluted air and undisturbed substratum often favor optimum growth and abundance of lichens (Awasthi, 2000). The topography and varied altitude also contributes towards the rich

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lichen diversity and its endemism. The region is exceedingly rich in lichens, mosses and liverworts (Ramakantha et al. 2003). Specifically, some of them on growing lichen rates and environmental conditions such as humidity, temperature, or precipitation (Innes, 1985; Sancho and Hawksworth et al., 2005). Lichens are valued as biological indicators to climatic conditions mainly due to its sensitivity to its environment. Thus lichens are sensitive to changes in atmospheric and micro-climatic conditions making them one of the valued biological indicators to determine the environmental stress in tropical and temperate countries (De Silva & Senanayake, 2015; Wolseley & Aguire-Hudson, 1997). They exhibit three major growth forms: crustose (cluster shaped and are slightly flattened in structure), foliose (have leaf-like structures and are made out of flat tissue) and fruticose (resembles branching tube-like structures). Lichens are found growing as three primary types: foliose, fruticose, and crustose.

Lichens are numerous in numbers and is essential source of food for herbivore in certain ecosystem (Ellis, 2012). Lichens exhibit three major growth forms: crustose, foliose and fruticose. Crustose are cluster shaped and are slightly flattened in structure. Fruticose resembles branching tube-like structures.Foliose lichens have leaf-like lobe and can merge with other lichen species. Fruticose lichens have a “shrubby” growth form. Crustose lichens have crust-like bodies attached deeply to its substrates (Beeching & Hill, 2007).

Biological monitoring using lichen as indicator may be considered a very effective tool for early warning system to monitor and detect climate change and air pollution (Loppi, 2000). Specifically, some of them on growing lichen rates and environmental conditions such as humidity, temperature, or precipitation (Sancho and Pintado, 2004; Hawksworth et al., 2005). Lichens are highly diverse group and because of its universal distribution, they play very significant roles in the ecosystem. However, their highly diverse assemblage in tropical forests lacks detailed taxonomic and ecological studies (Rivas Plata et al., 2007). This is especially the case in the Philippines where many forest trees are richly studded with lichens but not sufficient taxonomic studies have been conducted.

Lichens are being used as biomonitors of air pollution (Nimis, 2002). The use of lichens as early warning indicators of air pollution suggests that a large number of lichen species in the study area may be considered efficient bioclimatic indicator which maybe effectively used to monitor climatic changes, in a long-term perspective. Gupta et al. concluded that macro-scale environmental variables such as altitude, relative humidity and temperature have influence on diversity and distribution pattern of lichens in Badrinath valley of Western Himalaya (Gupta, 2014). Lichens have been often described as treasure chest of natural goods due to its series of efficacy for diverse drives since long back. Lichens have used as food, natural remedies, in perfume and dying industry, fermenting and distillation and for beautifications. Different tree species vary in their bark characteristics, hence, may vary in lichen epiphytes. Studies have shown that bark structure affects epiphyte colonization and growth (Boudreault et al., 2008). Our current knowledge of lichens in Philippines is among the poorest in the world and studies in lichen diversity and its ecology are rare. For example, currently, there is no known study of altitudinal distribution of lichens in Philippines at least to the best of my knowledge.

Barangay Kaatuan is situated at Lantapan Bukidnon which 36 km away from Sayre National Highway and it is located 8°3’N, 124°59’E. It has a land area of 3,680 hectares. Kaatuan forested area is part of Kitanglad Mountain Range. This forested area was considered to constitute as a potential area for floristic assessment such as short range ecosystem and river banks which is known for somehow affects the species richness of both flora and fauna due to continuous human exploitation.

The study of morphological structures of lichen served as baseline information on the lichen species inhabiting Kaatuan, Lantapan, Bukidnon in terms of distribution, diversity status and environmental factors affecting the growth of lichen species. The gathered data is useful to teachers, future researchers and amateur lichenologists as to taxonomy of the lichens. Lichens in the Hundred Islands like Philippines are subjected to excessive radiation and saline water splashes that can bring about desiccation and osmotic stress (Dobson, 2010; Nash, 2008).

Further, the assessment of the conservation status of lichens in Kaatuan, Lantapan, Bukidnon became the basis for the current status of the three lichen families. The main objective of this paper is to enumerate the lichens and their distribution within the forest types of Mt. Kitanglad Range, Kaatuan, Lantapan, Bukidnon, Philippines.

## MATERIALS AND METHODS

The researchers sent a letter to the secondary school principal and Barangay Chairman of Kaatuan, Lantapan, Bukidnon to seek approval for the conduct of the study. This research study employed a descriptive survey. Both quantitative and qualitative research values were given descriptions to the existing lichen species found in Mt. Kitanglad Natural Park, Kaatuan, Lantapan, Bukidnon.

The study site is situated in the forested area of Mt. Kitanglad Natural Park, Kaatuan, Lantapan, Bukidnon located. Six quadrats were employed with 20 by 20 meter long calibrated rope. Lichens were found six meters high in the trunk of the tree and on different microhabitat such as decayed logs, rocks, fallen branches and others. Physico-parameters such as elevation, relative humidity, temperature, topography, light and water content was also recoded.

Specimens collected from the study site were placed in plastic bags together with primary identification information such as collection number, quadrat number, color, substrate and name of collectors. After which, specimens were air dried. The sample specimens were then placed in individual paper packets and properly labelled.

The specimens were collected, classified and described using the taxonomic keys of Randlane (2009) for family *Parmaliaceae* Usnea, Eversham (2015) for *Cladoniaceae* and Elix (1965) for *Physciaceae.*

The given data of each species includes the description based on observed morphology and diagnostic characters using dissecting microscope and field lens. For *Cladoniaceae* it includes: substrate, type of thallus, presence or absence of apothecia and cups, type of podetia, surface of podetia, and color of podetia and apothecia; for the genus *Usnea*, it includes characteristics such as substrate, color of the thallus, color of medulla, color of base, occurrence of cortex, segmentation of thallus, shape of thallus in transverse section, presence or absence of isidia, soralia, and type of medulla; and for *Physciacea*, it includes: substrate, type of thallus, margin, color of the upper and lower surface, texture, lobes, and the presence or absence of apothecia, isidia, soredia, and rhizines.

Distribution of the species was determined through altitude in with the use of GPS (Global Positioning System). Distribution of lichen species was established with three (3) stations having two quadrats each. Microhabitat preference was determined through identifying its substrate such as tree bark, rock, soil, leaves or mosses. Lichens collected from tree bark and trunk were termed as corticolous, those collected from rocks were saxicolous, those collected from soil were terricolous, those collected from leaves were folicolous and those collected on or among mosses musicolous, on twig ramicolous and on dead wood legnicolous.

The data gathered were then analysed using Biodiversity Professional version 2 to obtain the Shannon Diversity Index.

The ecological status of lichens was assessed locally based on abundance. It was determined by counting the number of clumps in which species with 1-3 clumps were considered as rare and 4 and above were considered common (Adapted from Ejem, 2006). Conservation status of lichens was based on International Union for Conservation of Nature (IUCN, 2018)

The lichen species were identified and described, the analysis of species distribution and diversity was done using application software BioDiversity Professional Latest Version 2.0 for Shannon Diversity Index (Azuelo et. al., 2014).

## RESULTS AND DISCUSSION

The preliminary assessment of three lichen family in forest area of Kaatuan Lantapan, Bukidnon was done through quadrat sampling. Results of the study revealed thirty-six species belonging to six genera (Table 1). The following are the morphology structure of three (3) lichen family is here by presented:

Family Cladoniaceae is a lichen body, or thallus which is a composite structure of fungal and green algal cells. The primary reindeer lichen thallus is prostrate and squamulose (comprised of scaly, flaky, rounded pieces). The secondary thallus (podetium) is more conspicuous, being upright and fruticose. Fruticose forms are three-dimensional and have been described as shrubby and/or stringy. Podetia are hollow, highly branched, and capable of trapping wind-blown algae. They grow upward at the tip and die back at the base, similarly to sphagnum and other mosses. The spore-producing fungal bodies (apothecia) are produced at the tips of the podetia (Hale, 1961 and McCune, 1997).

The genus Usnea Dill. ex Adans. consist of more than 300 which includes macrolichens (Kirk et al., 2008) belonging to Parmeliaceae. Diagnostic features of the genus include a fruticose thallus with a thallus habit, branching, base, segments, fibrils, isidia/isdiomorphs, soralia, medulla, papillae and color of the thallus, medulla, base.

Family Physiaceae the distinguishing features of Thallus foliose. Lobules, isidia and soredia present or absent. Upper cortex prosoplectenchymatous,paraplectenchymatous or absent. Photobiont a unicellular green alga. Medulla poorly to well developed or absent. lower surface with or without rhizines. Prothallus present or absent. Ascomata apothecia. Apothecia immersed, sessile or short-stalked, Thalline exciple present or absent. Proper exciple thin and weakly pigmented to well developed and dark-pigmented; composed of conglutinated radially-oriented hyphae (Elix, 1965)

**Table1. Lichens Present in Lantapan Kaatuan, Bukidnon, Philippines.**

| Lichen Flora | Family | Genera | Species |
|---|---|---|---|
| | 3 | 6 | 36 |

The preliminary assessment of three lichen family in forest area of Kaatuan Lantapan, Bukidnon was done through Quadrat Sampling. Results of the study revealed thirty-six (36) species belonging to six (6) genera of three (3) families (Table 1). Depletion of lichen populations is a matter of concern from conservation standpoint because of several reasons; being unique symbiotic organisms they contribute to biodiversity; they are ecologically important as food, shelter and nesting material for a variety of wild animals and birds (Mc Cune and Geiser 1997).

**Table 2. Classification of Lichen species in Kaatuan, Lantapan, Bukidnon.**

| Family | Species |
|---|---|
| Cladoniaceae | *Cladonia caespiticia* (Pers.) Flörke |
| | *Cladonia floerkeana* (Fr.) Florke |
| | *Cladonia polydactyla* (Florke) Spreng. |
| | *Cladonia* sp. |
| Parmaliaceae | *Usnea articulata (*L.) Hoffm. |
| | *Usnea barbata* (L.) Fr. |
| | *Usnea chaetophora* Stirt. |
| | *Usnea dasea* Stirt. |
| | *Usnea flammea* Stirt, |
| | *Usnea fragilescens* Hav. Ex Lynge |
| | *Usnea lapponica* Vain. |
| | *Usnea longissima* Ach. |
| | *Usnea rubicunda*Stirt. |
| | *Usnea subcornuta* Stirt. |
| | *Usnea subfloridana* Stirt. |
| | *Usnea subscabrosa* Nyl. Ex Motyka |
| | *Usnea* sp. *1* |
| | *Usnea* sp. 2 |
| Physciaceae | *Heterodermia appalachensis* (Kruok.) Culb. |
| | *Heterodermia echinata* (Taylor) Culb. |
| | *Heterodermia leucomelos* (L.) Poelt |
| | *Heterodermia speciosa* (Wulfen) Trevis |
| | *Hyperphyscia adglutinata* (Florke) H. Mayrhofer & Poelt |
| | *Physcia adscendens (Fr.) H. Olivier* |
| | *Physcia aipolia* (Ehrh. *ex* Humb.) Fürnr. |
| | *Physcia dubia* (Hoffin.) |
| | *Physcia integrata* Nyl. |
| | *Physcia sinuosa* Moberg |
| | *Physcia sorediosa* (Vain.) Lynge |
| | *Physcia* sp. 1 |
| | *Physcia* sp. 2 |
| | *Physcia* sp. 3 |
| | *Pyxine cocoes* (Sw.) Nyl. |
| | *Pyxine philippina* Vain. |
| | *Pyxine* sp. 1 |
| | *Pyxine* sp. 2 |

Table 2 shows the species collected at Mt. Kitanglad Range, Natural Park, Kaatuan, Lantapan, Bukidnon. Data revealed one genera with three species collected on family *Cladoniaceae*, one genera under fourteen species under *Parmaliaceae* and eighteen species under four genera on family *Physciaceae*.

In addition, environmental factors play a significant role in the growth of lichens which include, precipitation, light and shady conditions, humidity and dryness, air quality and wind current. Hence, lichen diversity is dependent on the climatic conditions and changes of lichen diversity indicates the changes of environmental condition (Shukla et al, 2014).

Besides many other uses, lichens are also used as pollution monitors. They are the plants which occur in most adverse conditions of climate and substrate. Thus the importance of this group in an ecosystem is very high in its own way. Lichens are just like little sponges that take up everything that comes their way, including air pollution (Fleishner 1994).

Table 3 showed the diversity index of Shannon H' Log Base 10, of three (3) lichen families present in Kaatuan Lantapan, Bukidnon at six (6) different sampling stations. Quadrat I (0.857), Quadrat II (0.931), Quadrat III (0.54), Quadrat IV (0.724), Quadrat V (0.678) and Quadrat VI (0.822) shows almost diverse lichen. The data also reveals that the range of the diversity index of the six Quadrats did not reach the acceptable value of 1.5 to 3.5 (Magurran, 2004).

The results also implied that the difference in the three lichen family composition of the said study sites were diverse to its topographic settings. Furthermore, the results may be attributed to the wider geographic ranges of lichens and that certain species are typically restricted to more specific microhabitats, causing them to often have widely disjunct distribution patterns and are prone to localize extirpation (Shevock, 2001).

**Table 3. Shannon Diversity Index. of Lichen Flora in Kaatuan, Lantapan, Bukidnon, Philippines.**

| Index | Q I | QII | Q III | Q IV | Q V | Q VI |
|---|---|---|---|---|---|---|
| Shannon H' Log Base 10. | 0.857 | 0.931 | 0.54 | 0.724 | 0.678 | 0.822 |

**Table 4. Lists of Lichen Species, Their Corresponding Number of Individual, Density, Relative Density, Frequency, Relative Frequency, Dominance, Relative Dominance and Species Importance Value.**

| Species | Ni | D | RD | Present in how many sites | F | RF | C | RC | SIV |
|---|---|---|---|---|---|---|---|---|---|
| *Cladonia caespiticia* (Pers.) Flörke | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Cladonia floerkana* (Fr.) Florke | 2 | 0.005 | 0.028 | 2 | 0.333 | 4.435 | 0.060 | 0.623 | 5.086 |
| *Cladonia polydactyla* (Florke) Spreng. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Cladonia* sp. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea articulata (*L.) Hoffm. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea barbata* (L.) Fr. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea chaetophora* Stirt. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea dasaea* Stirt. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea flammea* Stirt. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea fragilescens* Hav. Ex Lynge | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea lapponica* Vain. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea longissima* Ach. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea rubicunda* Stirt. | 24 | 0.06 | 0.331 | 5 | 0.833 | 11.09 | 8.727 | 90.59 | 102.0 |
| *Usnea subcornuta* Stirt. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea subfloridana* Stirt. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea subscabrosa* Nyl. Ex Motyka | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea* sp. 1 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Usnea* sp. 2 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Heterodermia appalachensis* (Kruok.) Culb. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Heterodermia echinata* (Taylor) Culb. | 2 | 0.005 | 0.028 | 2 | 0.333 | 4.435 | 0.060 | 0.623 | 5.086 |
| *Heterodermia leucomelos* (L.) Poelt | 2 | 0.005 | 0.028 | 2 | 0.333 | 4.435 | 0.060 | 0.623 | 5.086 |
| *Heterodermia speciosa* (Wulfen) Trevis | 3 | 0.008 | 0.044 | 2 | 0.333 | 4.435 | 0.136 | 1.412 | 5.891 |
| *Hyperphyscia adglutinata* (Florke) H. Mayrhofer & Poelt | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia adscendens* (Fr.) *H. Olivier* | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.2 24 | 0.015 | 0.155 | 2.396 |
| *Physcia aipolia* (Ehrh. *ex* Humb.) Fürnr. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia dubia* (Hoffin.) | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia integrata* Nyl. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia sinuosa* Moberg | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia sorediosa* (Vain.) Lynge | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia* sp. 1 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Physcia* sp. 2 | 3 | 0.008 | 0.044 | 2 | 0.333 | 4.435 | 0.136 | 1.412 | 5.891 |
| *Physcia* sp. 3 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Pyxine cocoes* (Sw.) Nyl. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Pyxine philippina* Vain. | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Pyxine* sp. 1 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| *Pyxine* sp. 2 | 1 | 0.003 | 0.017 | 1 | 0.167 | 2.224 | 0.015 | 0.155 | 2.396 |
| Total | 66 | 0.181 | 1.013 | 45 | 7.508 | 99.99 | 9.63 | 99.93 | 200.94 |

The summary shows the diversity indices of lichen flora found in Mt. Kitanglan Range, Natural Park, Kaatuan, Lantapan, Bukidnon. *Usnea rubicunda* Stirt shows high diversity. Thus to Lutwig (1956) there are certain differences in the frequency value of the species affected by a slight difference in topography and microclimate of the same study stations. Its topography described some slightly undulating and rolling upland areas cut by deep and wide valleys. This was claimed to be one of the reasons on its variability in its frequency value index. In addition, the variation of species importance value was caused by the differences in response of various species to the same environmental conditions (Cabaneros, 2002). Additionally, In relation to Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) the month of April and May has the highest significance to the growth and formation of lichens since that time was the highest environmental temperature recorded since El niño was observed.

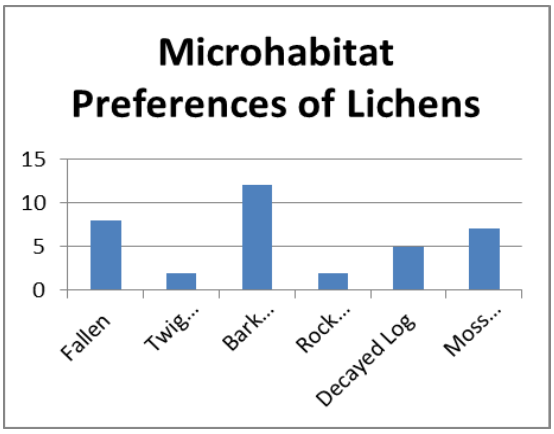


**Fig. 1. Habitat Distribution of Lichens in Kaatuan, Lantapan, Bukidnon, Philippines.**

Figure 1 revealed the number of lichen flora collected from different microhabitat preferences. The highest number of lichen species was collected from tree bark (corticolous) with a total of twelve (12) species. Then, eight (8) species are fallen, followed by moss (muscicolous) that has seven (7), decayed log (5), and both rock (saxicolous) and twig (ramicolous) has two (2) species. As supported by Nakaya (2014) lichens are very slow growing organisms they grow just few millimeters or centimeters in a year. Lichens can grow in diverse climatic condition and on various substrates. The lichens are widely distributed in almost all the phytogeographical regions of the world. Adequate moisture, light, altitude, unpolluted air, and undisturbed stratum favor luxuriant growth of lichens. Trees are excellent habitat for lichens, the older the trees the better they are for lichen diversity (Purvis, 2000).

## CONCLUSION

The inventory of lichens revealed a total of thirty-six species, six genera under three families. It is showed that Quadrat I (0.857), Quadrat II (0.931), Quadrat III (0.54), Quadrat IV (0.724), Quadrat V (0.678) and Quadrat VI (0.822) did not reach the acceptable value of 1.5 to 3.5. The overall implication of lichen species is that it plays a major role in monitoring changes in Earth's atmosphere. Based on the results gathered, lichen growth and formations was based on parameters such as elevation, relative humidity and temperature. Data revealed that as the elevation increases, the temperature decreases that would probably increase its relative humidity and to have a result of lichens increase of formation and growth. *Usnea rubicunda* Stirt. exhibited the highest species richness due to the number of species collected in all quadrats.

For these reasons, several biological traits of lichens as such as photobiont type, growth, reproduction, and development can be affected by environmental changes (Giordani, 2012). In this manner, these functional traits can be used as a complementary approach to better understand ecosystems because they allow us to assess the biodiversity and their relationship with ecosystem functioning Thus, the results implied that the difference in the three lichen families' composition of the said study sites were significantly different. Lichen diversity is dependent on the climatic and environmental conditions which makes them as an excellent biological indicators of ecosystem changes in the forests of Mindanao Island, Philippines.

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## CONFLICT OF INTEREST
The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

## LIFE SCIENCE REPORTING
No life science threat was practiced in this research.

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