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Species Diversity of Lichens in the Province of Abra, Philippines

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ABSTRACT

The province of Abra is rich in natural resources. Environmental sustainability has been one of the advocacies to sustain enough resources to meet our needs. The study was conducted to determine the species diversity of lichens in the province of Abra, Philippines. Specifically, the study documented the species of lichens found in the study sites. The taxonomic classification of the lichen species was documented and identified using the Dichotomous Key for Lichens. Samples of lichens were collected by scraping them from the substrate. Results revealed that Abra could be a rich culture ground for lichens. From 10,659 collected individuals of lichens, 44 species came out. Parmtotremarubifaciens lichen appeared to have potential medicinal properties since phytosterol, phenolic compounds, and flavonoid were positive within it. Crustose type of lichens was the most abundant type having 25 species. Of all the 44 species of lichens, there were five species commonly found in all the 27 study sites. Lichens and their natural habitats should not be destroyed by logging, and the use of toxic chemicals that could contaminate the air should be avoided as well as burning of wastes.

Keywords **–** Botany, Lichens, descriptive design, Abra, Philippines.

INTRODUCTION

Lichens are interesting life forms which comprised of part algae and part fungus. The two live symbiotically, each contributing to the survival of the other. The fungi are responsible for protecting the photosynthetic organism by producing a vegetative body called thallus. The photosynthetic alga produces food and energy for itself and the fungi. These plants thrive in rocks and other surfaces exposed to air and moisture take a long time to develop lichen colonies. Once a colony has been established, it will be easier for other colonies to grow and flourish.

The three types of lichens are crustose, foliose, and fruticose. Within these three types of lichens, scientists have found around 13,500 species on earth. Each species has distinguishing characteristics as compared to other species (TERC, 1997).

About 75% of lichens in the world belong to Cr*ustose* type. These lichens vary in color. These lichens are encrusted in stone or rocks. They grow so tightly into the rock that it is nearly impossible to pull them off. Crustose edges are flat, unlobed closely attached to substrate, hard to remove without damaging substrate or lichen, algae usually dispersed. Crustose lichens have the slowest growth rate in all species, thus, used in stone wall dating. They grow about one millimeter per year, thus, make dating on stones and other artifacts easier. Sometimes crustose lichens can show no increase in size for ten years.

Foliose lichens connect loosely to stones and have a leaf-like shape. The bottom part of lichens is a root-like structure called a rhizine. These rhizines attach the lichen to the rock. As these lichens are not adequately attached to the rock, they can be easily removed using a knife or other tools. Foliose lichens are usually yellow-green, orange, brown, or gray in color. Foliose is a sandwich of fungal layer with algal mat in middle, circular growth, lobes, and the top and bottom layers are different;

Fruticose lichens appear more branch-like and bushy in appearance. Many Fruticose lichens stand upright on a leaf-like base. Many times, they do not have a distinguishing top or bottom. Fruticose is not attached to its surface as securely as the others. These lichens are easily pulled off by hand. There are round branches with their fungal layer outside, its algal layer within, no rhizines, vertical growth pattern, odd-shaped structures such as goblets; threads.

Bartoli, Cardarelli, Achilli, Campanella, Ravera and Massari (1997) mentioned that air quality assessment is important. Lichen characteristics are

well suited for biomonitoring. Study on lichen diversity is far cheaper in cost than chemical analysis with regards to the purpose of monitoring air quality.

Furthermore, Boonpragob and Nash (1990) stressed that the diversity of lichens are used to identify disturbed areas due to pollution, land use, and other anthropogenic related activities. Recent years showed that efforts had been made to develop a feasible protocol for lichen use for biomonitoring.

In addition, Mendez, Monge-Nájera, González and Rossi (2002) supports that lichens are excellent bioindicators and biomonitors. As bio-indicators, the presence or absence of sensitive species is used to search for distribution patterns that show pollutant deposition. Voids in distributions may indicate whether lichens have died out due to heavy metals or sulfur oxide pollution. These observations were achieved by conducting taxonomic inventories or surveys, which include sampling many species in many localities in the study area.

Nash (1991) stated that lichens have been used worldwide as air quality indicator. Relatively low levels of sulfur, nitrogen, and fluorine-containing pollutants greatly affect many species of lichens in terms of their structure and functions, composition, growth rates, and reproduction.

In the work of Johnson et al. (2011), it was found out that lichens have species-specific response patterns to increasing levels of atmospheric pollutants, ranging from relative resistance to high sensitivity. The majority of early lichens and studies on air pollution involved sulfur dioxide. Lichens are sensitive to this kind of pollutant. Lichen species were damaged and killed in areas where there is a great concentration of sulfur dioxide.

Will-Wolf, Esseen, and Neitlich (2002) also emphasized that myriad of pollution effects on lichens have been described in studies to date. At the level of the whole plant, investigators have described decreases in thallus size and fertility bleaching and convolution of the thallus, restriction of lichens to the base of vegetation, and mortality of sensitive species. Microscopic and molecular effects include reduction in the number of algal cells in the thallus, ultrastructural changes of the thallus and changes in chlorophyll fluorescence parameters, degradation of photosynthetic pigments and altered photosynthesis and respiration rates. Early signs of air pollution were indicated through increased electrolyte leakage, inhibition of nitrogen fixation, and decreased respiration and photosynthetic activity of the algae. More resistant species tolerate regions with higher concentrations of these pollutants, but may exhibit changes in internal and external morphology.

Humphrey, Davey, Peace, Ferris, Harding (2002) and Schmull, Hauck, Vann, Johnson, and Runge (2002) presented that the factors known to affect lichens include climate and air quality. Additional factors that can influence lichens occurrence are tree species, stand age, site history and the amount of dead wood present.

Diversity of foliicolous lichens is high in neotropical rainforest that include central American rainforest (Cáceres, Maia, Lücking, Schroeter, Schlensog, & Green, 2000). For Southeast Asia, Papong, Boonpragob and Lücking (2007) reported 8 species of foliicolous lichens from Nepal, 53 species from Sri Lanka, 60 species from China, 70 species from Vietnam, 83 species from Japan, 90 species from India, 106 species from Thailand, 210 species from Indonesia, 120 species from Malaysia, 191 species from Papua New Guinea, and 224 species fro, Philippines. The number of foliicolous lichens recorded from Kakamega and Budongo forests of Africa is higher in number than the number of species reported from most of these in tropical countries. The number of foliicolous lichens recorded from Godere Africa is higher than the number reported at a country level for Nepal, Sri Lanka, China and Vietnam.

Several studies, have documented high foliicolous lichen diversity in undisturbed primary forests as compared to disturbed secondary forest (Lücking, 1998; Sipman 1991). The result of their study shows high foliicolous lichen diversity in forests with relatively little disturbance. In the more disturbed secondary forest sites, foliicolous lichen diversity is substantially reduced.

Lepp (2011) stated that lichens show a great ability to concentrate nutrients from very dilute sources and indiscriminately absorb many toxic substances from the atmosphere (e.g. sulfur dioxide, fluorides and heavy metals). Many lichen species are highly susceptible to air pollution, especially to pollution by sulfur dioxide. Most species of lichens found in areas containing sulfur dioxide show an increased concentration of sulfur in their thalli.

The province of Abra has 27 municipalities namely: Baay, Bangued, Boliney, Bucay, Bucloc, Daguioman, Danglas, Dolores, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa. It is rich in natural resources where abrenians obtain their necessities. Environmental sustainability has been one of the advocacies to sustain enough resources satisfying their needs. Protecting and conserving the natural resources is a must to maintain the richness of the Mother Nature, but due to the increasing population, greediness, lack of discipline etc. environmental degradations is

inevitable. Landslides and river siltation and pollution happen due to illegal mining. Deforestations due to illegal logging and kaingin farming have resulted into many environmental problems. With this, the occurrence of different types of pollution leading to the acquisition of health problems had been experienced by abrenians prevalently. The study of lichens as bio indicators could be one step to help assess the quality of the ecosystems and environments and finding possible solution in the restoration of the original natural resources.

OBJECTIVES OF THE STUDY

The study aimed to determine the species diversity of lichens in the province of Abra. Specifically, the study aimed to: 1) document, identify, and characterize the species of lichens found in each municipality in the province of Abra; 2) determine the chemical and medicinal properties of lichen/s found in the province of Abra; 3) assess the species diversity of lichens in the province of Abra; and 4) determine the index of similarity of the types of lichens found in the province of Abra.

METHODOLOGY

Research Design

The descriptive analysis research design was used in the study. It employed the investigatory method using fieldworks. It involved the collection, preservation, identification, and description of lichens in the province of Abra.

Data Gathering Tools

The following materials were used in the conduct of the study:

For lichen collection, hand lens, paper bags or small white envelope, rock hammer (or a stone chisel and hammer), safety glasses, and spray bottle were used while for lichen preservation, the researcher made used of white paper envelopes.

For lichen identification and description of its morphology, dissecting kit that includes fine forceps, dropper bottle filled with distilled water (so the color of the lichen does not change when moistened), slides and coverslips, binocular microscope and dissecting microscope, razor blades, and chemicals for color tests of lichens were utilized.

Data Gathering Procedure

1. **Fieldworks**

a. Ocular inspection – The researcher identified the different study sites and made documentations on the possible study sites found in the 27 municipalities of Abra by actual ocular inspection. Each study site was divided into three sampling stations.

b. Selection of Study Sites – Lichens commonly thrive in forested areas where there is an abundant number of trees and sufficient moisture. The selection of study sites in the different municipalities was done through interviews. The researcher interviewed the farmers and residents. They were asked to identify forested areas in their municipalities where they saw abundant lichens. After identifying, the researcher selected the sampling sites based on the information from the interviewees.

c. Collection of lichens – Before collecting, the researcher sought permission from the local officials to the conduct the study in the different sampling sites. The researcher considered ethics on collecting lichens that they should only be collected in small amount or should not be collected when there is only limited number of that particular species. This is because lichens served as natural air quality indicator and should not be collected out from their natural habitat. Lichens growing on any substrate in the three sampling stations of each study site were collected. To collect very dry and brittle lichens, the researcher misted it with a spray bottle to obtain them easily. The lichens were mainly collected by scraping them from the substrate where they are attached using a rock hammer. Lichens that were closely attached to rocks were simply collected by taking a portion of the attached substrate. For lichens growing on trees, the lichens were collected only in a small amount of bark or a piece.

d. Preservation of lichens – Preservation of lichens was done in situ. They were moistened overly especially the dry and deformed shaped lichens with a spray bottle, and gently work into the required form. The moisture of the lichens collected was removed by air drying to keep their three-dimensional form. For further drying, lichens were stored in white paper envelopes. Some lichens were lightly pressed to retain their superiority.

2. Laboratory work

a. Identification of lichens

The researcher identified the collected lichens by studying their morphological, anatomical and chemical properties. Dichotomous Key of Lichens was used to identify the species of collected lichens.

b. Characterization of lichens

The collected lichens were then brought to laboratory for further analysis. Each species was examined through the use of binocular microscope. Forceps was used to pick and position the collected lichens into the glass slide before covering it with cover slip. Examination through the microscope was done by the researcher to describe the morphological characteristics of the collected lichens based on their size, color, and texture.

c. Phytochemical Screening

The lichen/s collected was subjected to phytochemical screening to trace its constituents and medicinal properties. Lichens screening for alkaloids, carbohydrates, glycosides, saponins, phytosterol, phenolic compounds, flavonoids, and proteins was done using standard tests just like plant constituents

3. Biodiversity Indices

a. Diversity of Lichens

Species diversity of lichens found in each of the three sampling stations in each study site was computed through the use of diversity indices. These indices include the Shannon-Weiner's index, Simpson's index, and Margalef's index.

b. Occurrence and Distribution of Lichens

The occurrence and distribution of lichens in the province of Abra was determined by frequency. This refers to the number of stations on which species will occur divided by the total station samples. The relative frequency was used to determine changes in lichens and their distribution wherein *f*1 refers to the total number of stations where the species occur over the total frequency or value for all species times 100. *J* refers to the evenness of the species distribution in the selected municipalities with the formula of h/hmax. The species diversity of lichens was determined using the indices, Shannon Weiner (H), Simpson (D_s), and Margalef index (D_a).

c. Index of Similarity

The index of similarity is calculated to present the percentage of similarity of the different municipalities of Abra on the different types of lichens. The greater percentage value that will be computed, the greater the similarity of the different municipalities on the different types of lichens. Index of similarity can be computed using the formula

$$IS = \frac{N\ (C)}{(S1+S2+S3+S4\ldots)}\ x\ 100$$ where: N refers to the total number of community or site, C refers to the number of species common to all communities or sites, and S refers to the total number of species in each community or site

Data Gathered

1. Characterization of the character states of lichens
2. Identification of the taxonomic classification of lichens
3. Phytochemical screening of lichens
4. Species diversity
   4.1 Diversity indices
   4.2 Occurrence and distribution of lichens
5. Index of similarity

RESULT AND DISCUSSION

The identification and taxonomic classification were based on the dichotomous key for lichens authored by Buck (1998). The morphological characteristics were based on the actual structure. There were 45 species of lichens of different types found in the province of Abra. There were 25 species under crustose type, 17 species under foliose types, and 2 species under Fruticose type.

1. Crustose (25 species)

Figure 1

Scientific Name: Graphis scripta
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Lagayan, Langiden, Malibcong, Manabo, Penarubia, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tineg, Tubo, Villaviciosa
Morphological Description:
This crustose lichen appear as thread-like structure that is closely attached to the substrate making it not that smooth, gray to black in color, measuring 10-20mm long,

Figure 2

Scientific Name: Graphis scripta
Substratum: Tree Bark
Collection Site:
Collected from the 27municipalities of Abra
Morphological Description:
The thallus is granular, yellowish-green in color, extending all throughout with in the bark of tree, not smooth

Figure 3

Scientific Name: *Calenia sp.*
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Danglas, Lacub, Malibcong, Pilar, Sallapadan, San Isidro, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is light brown, apothecia that is dark brown at the center, 10-30mm, slightly smooth

Figure 4

Scientific Name: *Arctoparmelia sp.*
Substratum: Rock
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Danglas, Dolores, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Malibcong, Manabo, Pilar, Sallapadan, San Isidro, San Quintin, Tineg, Tubo
Morphological Description:
The thallus is light green with white margin, 10mm-2.5 feet covering a substrate, not smooth for the substrate where it is closely attached is rough

Figure 5

Scientific Name:*Dyplolabia afzelii*
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Manabo, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is white thread-like structure, 2-10mmlong, and smooth

Figure 6

Scientific Name:*Biatora hypophaea*
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Daguioman, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
This is round pimple-like crustose lichen where it forms in clump, black in color, 20-50mm, not smooth

Figure 7

Scientific Name:*Phlyctis argena*
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Danglas, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is white to light brown extending to its margin, 60-100mm, rough

Figure 8

Scientific Name:*Pertusaria sp.*
Substratum: Tree Bark
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Danglas, Lacub, Luba, Malibcong, Pilar, Sallapadan, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is white with light brown spots or verrucose, about 60-110mm in size, smooth

Figure 9

Scientific Name:*Lepraria sp.*
Substratum: combination of rock and soil
Collection Site:
Baay, Bangued, Boliney, Bucay, Bucloc, Daguioman, Danglas, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, San Quintin, Villaviciosa
Morphological Description:
The thallus is white, no apothecia observed, about 1 foot in size, rough because of its substrate

Figure 10

Scientific Name:*Cryptothecia striata*
Substratum: Tree bark
Collection Site:
27 municipalities of Abra
Morphological Description:
The thallus is light green, white to light brown thallus margin, about 3 feet in size, rough

Figure 11

Scientific Name:*Dirinaria applanata*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Lagangilang, Lagayan, Langiden, Malibcong, Sallapadan, San Juan, San Quintin, Villaviciosa
Morphological Description:
Light green in color, contains round granules concentrated at the center of its thallus making it rough, 90-120mm in size

Figure 12

Scientific Name:*Tephromela atra*
Substratum: Tree bark
Collection Site:
Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Manabo, Sallapadan, Tineg Tubo,
Morphological Description:
The thallus is white to light green, has apothecia, black in color, found at the center of thallus, 50-200mm in size, rough

Figure 13

Scientific Name:*Staurothele aureolata*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucay, Bucloc, Lagayan, Langiden, Luba, Malibcong, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
Pimple crustose lichen, could be white to brown in color, abot 60-100mm in size, rough

Figure 14

Scientific Name:*Arthonia ilicina* **Substratum:** Tree bark
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Lagangilang, Lagayan, Langiden, Luba, Malibcong, San Isidro, San Quintin, Tineg, Tubo, Villaviciosa,
Morphological Description:
Lichens that are splashed in appearance, thallus is not sorediate, black in color, 0.5-1mm in size, rough

Figure 15

Scientific Name:*Sigridea californica* **Substratum:** Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Manabo, Pilar, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is light green containing white pimple-like structure suspended all over the thallus, 20-45mm in size, rough

Figure 16

Scientific Name:*Bathelium Carolinianum*
Substratum: Tree bark
Collection Site:
Boliney, Daguioman, Langiden, Luba, Malibcong, Manabo, Sallapadan, Tubo
Morphological Description:
The thallus is not sorediate, splashed in appearance, black in color, encrusted totally aroud tree stem, 0.5-0.8mm in size, rough

Figure 17

Scientific Name:*Fuscopannaria sp.*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Pilar, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is mineral gray and black margin in color, has lobes that are closely attached to the substrate, has a powdery structure at its center, 15-50mm in size, rough

Figure 18

Scientific Name:*Phlyctis argena.*
Substratum: Tree bark
Collection Site:
Collected in the 27 municipalities of Abra
Morphological Description:
The thallus is light green containing and white margin, 30-55mm in size, rough

Figure 19

Scientific Name:*Pertusaria sp.*
Substratum: Tree bark
Collection Site:
Collected in the 27 municipalities of Abra except in Bangued
Morphological Description:
The thallus is light green containing powdery yellowish structure at it, thallus margin is quite loosely attached twhite margin, 30-55mm in size, rough

Figure 20

Scientific Name:*Cryptothecia sp..*
Substratum: Tree bark
Collection Site:
Collected in the 27 municipalities of Abra except in Bangued
Morphological Description:
The thallus is whitish in color covering tree stem completely encrusted to it, no apothecia, and rough

Figure 21

Scientific Name:*Coccocarpia sp.*
Substratum: Tree bark
Collection Site:
Boliney, Bucay, Bucloc, Danglas, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is dark green having linear projections upward at its center; thallus margin is a hair-like structure, 110-140mm in size, rough

Figure 22

Scientific Name:*Dictyonema sp.*
Substratum: Tree bark
Collection Site:
Collected in the 27 municipalities of Abra
Morphological Description:
The thallus whitish gray in color with a white structure at its center, 40-90mm in size, slightly rough

Figure 23

Scientific Name:*Phaeographis smithii*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucay, Daguioman, Danglas, Dolores, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Manabo, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
Linear thallus with round structures at its margin, black in color, extends from 15-60mm long and rough

Figure 24

Scientific Name:*Enterographa aldabrensis Sparrius*
Substratum: Tree bark
Collection Site:
Collected in the 27 municipalities in Abra
Morphological Description:
The thallus is appalanate, whitish brown in color, 60mm-1.5 feet in size, rough

Figure 25

Scientific Name:*Chrysothrix sp.*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lagayan, Langiden, Luba, Malibcong, Manabo, Pilar, Sallapadan, San Isidro, San Quintin
Morphological Description:
The thallus is yellowish green in color, appalanate, rough, 90mm- 2 feet in size

2. Foliose (17 species) Figure 26

Scientific Name:*Parmotrema chinense.*
Substratum: Rock
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Malibcong, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is yellowish gray in color, broad lobes at its margin; contain isidia at its surface center, 80-145mm in size, and rough

Figure 27

Scientific Name:*Peltigera gowardii*
Substratum: Tree bark
Collection Site:
Boliney, Bucloc, Daguioman, Malibcong, Sallapadan, Tineg
Morphological Description:
The thallus is brownish gray, shiny in appearance, 70-180mm broad with lobes, semi-erect forming colonies, soft

Figure 28

Scientific Name:*Relicina eximbricata*
Substratum: Rock
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Malibcong, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is light green in color, has loosely attached lobe to rock, 60-145mm, smooth

Figure 29

Scientific Name:*Parmeliopsis ambigua*
Substratum: Rock
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Danglas, La Paz, Lacub, Luba, Malibcong, Manabo, Pilar, Sallapadan, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa,
Morphological Description:
The thallus is gray green, closely attached to tree bark, lobes are 0.5-1mm wide, no apothecia observed, smooth in texture.

Figure 30

Scientific Name:*Brigantiaea sp.*
Substratum: Rock
Collection Site:
Baay, Boliney, Daguioman, Dolores, Langiden, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum,
Morphological Description:
The thallus is gray to black in color, lower cortex is brown, 10-15mm in diameter, smooth in its surface, ciliated thallus margin, 70-180mm broad with lobes, semi-erect forming colonies, soft

Figure 31

Scientific Name:*Ephebe hispidula*
Substratum: Rock
Collection Site:
Baay, Boliney, Bucloc, Daguioman, La Paz, Lacub, Lagangilang, Lagayan, Langiden, Luba, Malibcong, Manabo, Penarubia, Pidigan, Pilar, Sallapadan, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is brownish gray in color, rough suface or upper cortex because of tiny hair-like structures or cilia erected on it, about 120mm-1 foot wide, rough.

Figure 32

Scientific Name:*Collema fuscovirens* **Substratum:** Tree bark
Collection Site:
Baay, Boliney, Bucloc, Malibcong, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is black closely attached to the bark; 40-80mm broad, upper surface is smooth.

Figure 33

Scientific Name:*Letharia vulpina* **Substratum:** Tree bark
Collection Site:
Tineg
Morphological Description:
The thallus is greenish gray, braches are moderately papillate, 20-35mm long, smooth cortex, and has no apothecia

Figure 34

Scientific Name:*Athiana Aurescens*
Substratum: Tree bark
Collection Site:
Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Tineg, Tubo
Morphological Description:
The thallus is brownish gray in color; marginal lobes are loosely attached to the tree bark, smooth thallus surface and margin without cilia, 55-70mm broad.

Figure 35

Scientific Name:*Canoparmelia carroliniana*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Daguioman, Luba, Malibcong, Manabo, Pilar, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is green in color, 40-90mm broad, No apothecium observed, upper thallus surface is isidiate and finely cracked to the margin, smooth

Figure 36

Scientific Name:*Pannaria sp*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc Daguioman, Lacub, Luba, Malibcong, Manabo, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is gray in color, lobes are finely cracked towards the margin, apothecia is observed in orange color at the center of the thallus, 20-35mm broad, smooth in texture at its surface.

Figure 37

Scientific Name:*Parmotrema rubifaciens*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Luba, Malibcong, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is greenish gray in color, lobes are round, margin has no cilia, and thallus surface is with isidia, 100-190mm broad.

Figure 38

Scientific Name:*Coccocarpia Erythroxyli*
Substratum: Rocks
Collection Site:
Baay, Boliney, Bucloc, Lacub, Malibcong, Tineg
Morphological Description:
The thallus is dark gray in color, 30-60mm broad, lobes broad2-4mm wide and flat, upper surface is smooth

Figure 39

Scientific Name:*Relicina abstrusa* **Substratum:** Rocks
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Lacub, Malibcong, Sallapadan, Tineg
Morphological Description:
The thallus is greenish gray in color, applanate towards the margin, lobes cracked finely and 1-2mm wide, isidia is observed, no apothecia, smooth surface

Figure 40

Scientific Name:*Heterodermia hypoleuca*
Substratum: Tree bark
Collection Site:
Daguioman, Lacub, Malibcong,
Morphological Description:
The thallus is whitish gray in color, 60-70mm broad, upper cortex is smooth and shiny, apothecia is abundant at the thallus center

Figure 41

Scientific Name:*Leptogium corticola*
Substratum: Tree bark
Collection Site:
Baay, Boliney, Bucloc, Daguioman, Langiden, Luba, Malibcong, Tineg, Tubo
Morphological Description:
The thallus is light brown color, apothecia is observed in orange color, thallus lobes are loosely attached to the substrate 2-3mm broad, margin has no cilia, smooth

Figure 42

Scientific Name:*Catolechia wahlenbergii*
Substratum: Logs
Collection Site:
Baay, Boliney, Bucay, Bucloc, Daguioman, Dolores, La Paz, Lacub, Lagangilang, Langiden, Luba, Malibcong, Manabo, Pidigan, Pilar, Sallapadan, San Isidro, San Juan, San Quintin, Tayum, Tineg, Tubo, Villaviciosa
Morphological Description:
The thallus is white in color, lobes are closely attached to the log, 10-30mm broad, thallus surface is smooth, no apothecia is observed

3. Fruticose (2 species)

Figure 43

Scientific Name:*Bryoria fremontii*
Substratum: Tree bark
Collection Site:
Malibcong, Sallapadan, Tineg, Tubo
Morphological Description:
The thallus is pendulous, brown in color, smooth cortex, numerous perpendicular branches, no apothecia is observed

Figure 44

Scientific Name: Letharia **vulpina Substratum:** Tree bark
Collection Site: Tineg
Morphological Description:
The thallus is greenish gray, braches are moderately papillate, 20-35mm long, smooth cortex, and has no apothecia

Based on the result of phytochemical screening of *Parmotremarubifaciens*, detected that this lichen was positive to have the following:

1. Carbohydrates – This means that *Parmotremarubifaciens* may be edible and could be an alternative food source.

2. Phytosterols – These are also called as plant sterols. These are natural compounds found in the cells and membranes of plant that have several industrial uses. Phytosterols are used as additives or components in thermoplastic resins to manufacture tires and other rubber products. According to the studies of Moreau, Hicks, and Whitaker (2002), phytosterols can prevent the absorption of cholesterol and therefore reduce blood cholesterol levels. It can also treat benign prostatic hyperplasmia and slow down colon cancer development. Furthermore, Moreau et al. (2002) stressed that sterols could help the surface skin to recover from dryness and irritations caused by humidity and use of detergent soaps to skin and therefore speed the overall skin recovery. Thus, the presence of phytosterol to Parmotremarubifaciensimplies that it could be a potential source of the uses mentioned above.

3. Phenolic Compounds – Phenols is used in industry as antioxidants, chemical intermediates, disinfectants, tanning agents, photographic developers, and additives to lubricants and gasoline. They are widely used in the photography, petroleum, paint, explosive, rubber, and plastics, pharmaceutical and agricultural industries. Phenol is also used in the manufacture of a variety of compounds, including drugs, dyes and colorless or light-colored artificial resins. It is a general disinfectant for toilets, stables, cesspools, floors and drains, as well as an extractive solvent for petroleum refining.
4. Flavonoid – a naturally occurring phenolic compound belonging to a large group that includes many plant pigments. It functions for changing or neutralizing the effects of reactive substances called free radicals that can damage body tissue and lead to heart disease, strokes and cancer. This means that *Parmotremarubifaciens* lichen can be used as an antioxidant.
5. Proteins - Proteins have many functions within human body. They serve as catalyst for enzymatic activity and used to transport molecules like hemoglobin transporting oxygen to different parts of our body. Proteins also serve as storage molecules. They are also used for body movements as they are the major components of our muscles. Proteins are needed for mechanical support like skin and bone containing collagen-a fibrous protein. Cell responses are mediated through proteins. Antibodies, control of growth, and cell differentiation also use proteins.

All of the substances that were found in the screening test were normal to such species. Air pollutants e.g. sulfur dioxide, carbon monoxide and nitrogen dioxide that could kill lichen species were not found out because the screening test was only limited on the detection of the substances mentioned above.

The phytochemical screening on the presence of medicinal properties was supported by some studies. Tanooc (2002) found out in her study that lichens containing a variety of acids exhibited antibacterial action against some bacteria like Staphylococcus aurea, Bacillus cereus and Streptococcus pyogene. It also contains lichen acids which have antifungal action against *Candida albicans*.

Furthermore, Behera, Gaikwad, Verma, Sharma (2009) and Kosanic, Rankovic, Stanojkovic, Vasiljevic and Manojlovic (2014), tested lichen compounds and found out to have a strong antioxidant activity against various oxidative systems. Number of previous studies also found out that lichens have higher content of

phenols that exert stronger antioxidant activity. Furthermore, Burlando, Ranzato, Volante, Appendino, Pollastro and Verotta (2009), concluded in their study that tested lichen compounds have a strong antioxidant, antimicrobial and anticancer activity in vitro, which suggest that lichens could be good natural antioxidant, antimicrobial and anticancer agents.

Species Diversity of Lichens in the Province of Abra

Table 1. Computations of Biological Indices

	Computed Value
Species Richness	**44**
Number of Individuals	**10659**
Shannon-Weiner's Index (H')	**1.2742**
Evenness (J)	**0.7753**
Simpson's Index (D_s)	**0.9242**
Margalef's Index (D_a)	**10.6758**

Species richness of lichens is 44. This means that there were 44 species identified lichens in the study with 10,659 total number of individuals.

The computed value of Shannon-Weiner Index (H') is 1.2742. This means that there is a diverse number of lichen in the province of Abra. This was supported by Magurran (2004) which stated that obtained values of Shannon-Weiner range from 0 – 5, where values ranging from 1.5 – 3.5 have a biologically diverse site.

The evenness (J) of lichens which measures their relative abundance in given site has a computed value of 0.7753, this means that some species of lichens in the province of Abra appeared to be dominant over the other having greater number of individuals. Thus, species of lichens in the province of Abra were not evenly distributed for some species of lichens contain a great number of individuals compared to some that contain only a few.

Margalef's Index (D_a) with a computed value of 10.6758 implies that there are species richness and relative abundance of lichens in the province of Abra.

The computed value of Simpson Index (Ds) (0.9242) implies that the abundance of individuals across species is not that much even and that there is a moderate probability that two individuals to be sampled will belong to different species. Simpson's Index values range from 0 to 1, with 1 representing perfect evenness wherein all species present in equal numbers. This supports the computation of evenness wherein the 44 species of lichens identified do not have

the same or an equal number of individuals. Some species appeared to have a great number of individuals compared to the other species that may have only a few. There could be a probability that two individuals may belong to same species.

Table 2. Species Diversity of Lichens in the Different Municipalities of Abra

	Municipalities of Abra	Number of Species	Number of Individuals
1.	Malibcong	41	602
2.	Boliney	40	791
3.	Daguioman	39	591
4.	Tineg	38	662
5.	Baay	37	704
6.	Sallapadan	37	491
7.	Bucloc	36	622
8.	Tubo	34	459
9.	Lacub	32	491
10.	Luba	28	504
11.	Manabo	26	449
12.	Pilar	25	478
13.	Langiden	24	373
14.	San Quintin	23	357
15.	Villaviciosa	21	210
16.	Lagayan	20	280
17.	San Isidro	20	470
18.	San Juan	20	254
19.	Bucay	19	297
20.	Lagangilang	18	305
21.	Tayum	16	286
22.	Danglas	15	204
23.	La Paz	15	176
24.	Penarubia	14	236
25.	Pidigan	14	163
26.	Dolores	11	163
27.	Bangued	6	41
	TOTAL		**10659**

Malibcong appeared to have the most diverse species of lichens having 41 with a total number of 602 individuals, while Bangued having only 6 lichen species

with total number of 46 individuals appeared to be the least diverse municipality in terms of lichen species in the province of Abra. This implies that Malibcong, one of the upland municipalities of Abra, has the cleanest air quality as compared to other municipalities of Abra. As you move farther away from Bangued, capital of Abra, where there is great number of population, to rural areas of Abra, there is a clear gradient of increasing number of lichen species. This result was supported by Best (1999) in his study stating that lichens increase as it moves away from a city. Furthermore, he added that lichens have different sensitivities to pollution so the cleaner the air, the more species are present.

The index of similarity of the different types of lichens in the 27 municipalities of Abra which served as study sites is 20.18%. This means that among the different species of lichens found in the province of Abra, there was similarity of species of lichens in the 27 municipalities, namely: *Candelariapacifica, Cryptotheciastriata, Phlyctis sp., Dictyonema sp.,* and *EnterographaaldabrensisSparrius.* Similarity of species in the different study sites could be attributed to some similarities of their topographical structure, for majority of the 27 municipalities in the province of Abra, is mountainous and of forested areas. Survival of lichens could be affected mainly by climate and air quality. Additional factors that can influence lichens occurrence are tree species, stand age, site history, substrate where they are attached to, moisture level in the air, habitat and abundance of flora and fauna, and their adaptation to a particular environment.

Diversity of the common species found in the 27 municipalities of Abra could be due to the factors mentioned above. All of the five species were found almost in same substrate or tree species. Their habitat is usually in a terrain sloping structure. All of the common lichens were located in an area where floras are abundant around them. The 27 municipalities in Abra where the five common lichens were found were far from urbanization and are still free from severe air pollution.

CONCLUSIONS

Species of lichens in the province of Abra differ in colors, sizes, structures, and substrates that served as their habitat. Based on the presented chemical composition, lichen/s in the province of Abra can serve as an alternative food source and a possible source of potent medicine. The province of Abra is a rich culture ground for lichen species. The province of Abra is considered to still have good air quality for lichens are bio-indicators, sensitive to pollution, indicating

air quality. Their diversity and abundance in a given community imply a healthy environment.

TRANSLATIONAL RESEARCH

The outcome of the study may be translated into use in the community by sending the result to the Department of Environmental and Natural Resources. Further analyses on the diversity of lichens will help identify areas with low air quality. The DENR may create clearer guidelines on the protection of forests taken into consideration the presence of lichens as air quality indicator and that air contaminants produced by a community must be regulated.

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