International Journal of Research Studies in Management
2023 Volume 11 Number 1, 1-16

ISSN: 2243-7770
Online ISSN: 2243-7789

OPEN ACCESS

Phorophyte preference of Corticolous Lichens in experimental Agro-Forestry Center of Occidental Mindoro State College

Pablo, Lara Lyn A.
Divine Word College of San Jose, Philippines (laralyn.aranda@deped.gov.ph)
Pablo, Robert Angelo C.
Divine Word College of San Jose, Philippines
Bawingan, Paulina A.
Divine Word College of San Jose, Philippines
Pagayonan, Ephegenia N.
Divine Word College of San Jose, Philippines
Limos-Galay, Jenny A.
Divine Word College of San Jose, Philippines

Received: 1 February 2023 **Revised**: 3 April 2023 **Accepted**: 14 April 2023
Available Online: 25 April 2023 **DOI**: 10.5861/ijrsm.2023.1001

Abstract

This study is focused on the lichen diversity and their phorophyte preference at the Experimental Agro-Forestry Center of the Occidental Mindoro College. A descriptive ecological survey was utilized. The researcher gathered data from 30 tree phorophytes belonging to ten species: Akleng-Parang, Calamansi, Cashew, Gmelina, Jackfruit, Mahogany, Mambog, Mango, Narra, and Sampaloc. The most number is from the Graphidaceae family, and the least numbered are from Lecanoraceae, Mycoporaceae, Pilocarpaceae, Porinaceae, Stereocaulaceae, and Strigulaceae. Different parameters were also included in determining the phorophyte preference of the lichens; the age of the tree, pH of the bark, bark structure, presence of milk sap, and trunk illumination. Data were analyzed through cross-tabulations, frequencies and relative frequencies, and Shannon-Weiner Diversity Index. An analysis of Variance was applied to examine if there is a significant difference in the phorophyte preference of the lichens, species richness, and diversity. The computations were anchored at the 0.05 level of significance. The result showed that there were, eighty (80) collected lichens from which thirty-eight (38) species were identified. There is no significant difference in the species richness and species diversity between the tree phorophytes since the trees only have one (1) to three species, the Narra tree has the highest diversity index, and Akleng-Parang and Mambog resulted in a low diversity index. (Phorophyte preference is highly significant as affected by the tree's age, bark pH, presence of milk sap, and trunk illumination; however, there is no significant difference as affected by bark structure.

Keywords: phorophyte, lichen diversity, species, lichens, experimental agro-forestry

Phorophyte preference of Corticolous Lichens in experimental Agro-Forestry Center of Occidental Mindoro State College

1. Introduction

The Philippines is one of the world's eighteen (18) mega-biodiverse nations, hosting 70% to 80 % of the world's plant and animal species, accounting for two-thirds of the planet's biodiversity (Convention on Biological Diversity, n.d.). As stated by convention biological diversity, the Philippines ranked fifth in plant species conservation, with (5%) of the world's flora preserved. It has a high percentage of species endemism, 25% of plant genera, and 49% of terrestrial wildlife, and is ranked fourth in bird endemism. Among the organisms that are expected to abound in the Philippines due to its diverse forest ecosystems are lichens. A lichen, also known as a lichenized fungus, is a symbiosis of two or more organisms: a fungal (non-photosynthetic) component known as mycobiont and an alga or cyanobacterium (or both in some instances) known as photobiont (photosynthetic component) (Vidsayagar, 2016). Lichens are the most successful symbiosis known in nature, with nearly twenty thousand (20,000) different species and diverse morphologies not known from the individual partners (Lucking, et al. 2014).

Lichens are found in a wide variety of terrestrial ecosystems, from the tropics to the poles (Büdel & Scheidegger, 2008). Most people encounter lichens growing on trees, rocks, power lines, and decaying wood, they mistake them for plants (Bajpai & Upreti, 2011). Lichens are typically small contributors, but in certain forests, drylands, and tundras, they can make up the majority of ground layer biomass. Lichens cover roughly 8% of the Earth's terrestrial area. Despite their potential relevance in driving ecosystem biogeochemistry, lichens' effects on ecological processes and ecosystem functioning have garnered little attention (Asplund & Wardle, 2016). They could colonize extremely cold regions such as the arctic, rocky coastal areas, forests, and urban and rural areas. Temperate lichens are abundant in countries on the equator's upper half or in countries with four seasons, but their diversity is limited. The highest species richness of lichens is found in tropical rainforests around the world; there is a great deal of diversity among them (Lücking, 2009). However, there are limited studies on tropical lichens, especially in Southeast Asia like the Philippines.

In general, lichens are one of the organisms that are least studied. Yet, these organisms are important components of terrestrial ecosystems. Ecologically, lichens play an important role as pioneer communities. They help prevent soil erosion by holding soil particles together. Cyanolichens (those with cyanobacteria as their photobiont) contribute to nitrogen fixation. The sensitivity of many lichens to pollutants makes them good indicators of atmospheric conditions, and many studies have dwelt on their use as bioindicators. Moreover, lichens produce unique substances that are proven to have medicinal importance. Furthermore, distinct lichen species play different functions in the environments in which they live. According to a famous lichenologist Trevor Goward, "Lichens are fungi that have discovered agriculture" (Bajpai & Upreti, 2011). This statement explains that lichens are keystones in many of the ecosystems in which they live. A keystone species is an organism that is critical to the overall health and well-being of an ecosystem. Many ecosystems' health and survival are generally connected to specific lichen species (National Park Service, 2018).

There are a few recent studies to document lichens in the Philippines. Moreover, Domingo, et. al., (2015), in their rapid biodiversity survey of the Mainit Hot Spring Protected Landscape (Azuelo et al., 2013). Another is in Mt. Kalatungan Natural Park, Bukidnon, and the Hundred Islands, Alaminos (Bawingan, et al., 2014). The MIMAROPA Region composed of the provinces of Marinduque, Occidental Mindoro, Oriental Mindoro, Palawan, and Romblon has a total land area of 2,745,601 hectares, of which 998,563 hectares (36.36 %) are certified Alienable and Disposable (A and D) lands and the remaining 1,747,038 hectares (63.63 %) are listed as forest land (Environmental Protection Agency/Department of Natural Resources; MIMAROPA, 2012).

There have been few studies on lichen diversity in MIMAROPA. In Palawan Island, a total of 162 species of lichenized fungi with 53 new species of lichens were cataloged by Sipman, Diederich, and Aptroot in 2013. Also, a total of nine (9) lichen species were documented and collected from Romblon State University, Odiongan Romblon (Maulion, 2015). However, there is no study on lichens that had been done in the province of Mindoro. Mindoro is located in southern Luzon. It is composed of Oriental Mindoro and Occidental Mindoro. Approximately 19.36 percent (193, 372 hectares) of Mindoro's total land area is covered by different forest types, classified as broad-leaved closed forest (49, 495), broad-leaved forest plantation (38, 441 hectares), broad-leaved open forest (103, 608 hectares), open coniferous forest (695 hectares) and mangrove forest (1,133 hectares) (Gatumbato, 2009).

The researcher studied lichens found in an agroforestry ecosystem. Agroforestry is a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels. It refers to land-use systems and technologies in which woody perennials (trees, shrubs, palms, bamboo, and so on) are intentionally planted with crops and animals in the same land-management units (Food and Agriculture Organization of the United Nations, 2015). The agroforestry ecosystem is potential habitat for the Lichens. Related studies show that lichens tend to prefer some types of trees (Caceres, et al., 2007). Various kinds of trees are grown in agroforestry; hence, there could be various lichens that grow on these different types of trees. Moreover, agroforestry is seen as one method of avoiding deforestation to minimize Carbon dioxide emissions into the atmosphere and thereby ameliorate climate change (Verchot et al., 2007; Mbow et al., 2012; Minang et al., 2014). Deforestation is a major issue in many developing nations, owing mostly to subsistence and commercial agriculture (Hosonuma, et al., 2012; Weatherly-Singh & Gupta, 2015). Deforestation generates around 17% of global CO2 emissions (IPCC, 2007), greatly contributing to climate change (Van der Werf et al., 2009; Pachauri et al., 2014). As a result, it is essential to implement agroforestry practices to alleviate the ongoing loss of forest resources while simultaneously improving the livelihoods of forest communities.

In line with this, since agroforestry systems largely contribute to the biosphere, especially in forest restorations, the organisms living on trees should also be given importance and priority. One of these organisms is the lichens, Lichens can grow on a variety of different surfaces. Some can be found on tree bark (corticolous), rocks (saxicolous), soil (terricolous), mosses (muscicolous), and even animal exoskeletons. The distribution of lichens is influenced by environmental factors. These factors include tree age, sunlight exposure, and airborne dust, all of which affect the lichens that live on tree bark (Cornelissen & Gradstein, 1990; Wolf, 1993). The lichens that grow on trees were the corticolous lichens. Corticolous lichen species are purely endo peridermal; they penetrate the dead cork but not the underlying live bark tissues (Lakatos et al., 2006). The agroforest ecosystem of OMSC contains several species of hardwood trees. Lichens grow on the bark of many of these trees. Corticolous is considered the biggest group of lichens but at the same time, the least known. There are limited studies that have been conducted on corticolous lichens. Keen studies on this species are needed. (Lücking et al., 2009). The characteristics of being small and firmly attached to the substrate cause damage to the thallus when detaching from it, making the crustose species hard to study (Kaasalainen et al., 2019). Furthermore, as cited in the study of Rosabal et al. (2013), despite the significance of substrate factors in the distribution of corticolous lichens, there is little evidence in tropical forests for lichen-phorophyte specificity.

Aside from the benefits gained from existing agroforestry use, several developing prospects may increase agroforestry's contributions to supporting sustainable and resilient land management. These options leverage the distinct characteristics of agroforestry: because of its woody and long-lived character; its capacity to deliver a range of valuable forest/tree-derived services to farmers, ranchers, and communities. Agroforestry is not a new activity; it has been done for millennia all over the world. Its application and research base (Patel-Weynand et al., n.d.).

With these problems arising in an agroforest system, particularly on trees, the presence and existence of organisms living on them are affected, since corticolous lichens grow on tree trunks the environmental distress in its surrounding might affect them. There were surveys on lichen diversity in the Philippines, but no study on the lichens' phorophyte preference was ever conducted. Phorophyte refers to the tree where the lichen lives as an epiphyte. In this study, the researcher identified the diversity of lichen species on the different trees in the agroforest ecosystem. In addition, the phorophyte that the lichen species prefer to inhabit was also determined. The environmental parameters used were the age of the tree, bark texture, pH level of bark, presence of milk sap, and truck illumination earlier stated in other studies to affect the distribution and growth of lichens (Caceres, et al., 2007). In so doing, the study results can be used to predict the type of lichens that are expected to grow on certain species of trees after the preferences of certain lichen species were established. Some lichen species may be rare. If these lichens are only found in certain types of trees, then the study results can support the protection of phorophytes that harbor these rare or unique lichen species. In short, the study results can serve as baseline data and guidance for the conservation of trees that are beneficial to man and serve as habitats for many other organisms, including the epiphytes such as corticolous lichens.

Lichen communities may be used to investigate interactions between the environment and the biosphere. As a result, using geostatistical models and functional lichen diversity (green algal and cyanobacterial LDV indexes) as indicators of complex interactions between atmospheric nutrients deposition and the biosphere, as well as microclimatic changes due to forestry and land-use practices is a viable option (Maguas et al., 2013).

Objectives of the Study - The main objective of this study is to determine the species diversity of corticolous lichens in ten (10) tree species in the Experimental Agro Forestry Center of Occidental Mindoro State College, San Jose Occidental Mindoro and to analyze the phorophyte preference of corticolous lichens as affected by the of the age of trees, pH of the bark, the bark texture, presence of milk sap, and trunk illumination. In so doing, the results of the study can be used as the basis for predicting lichen inhabitants of the different tree phorophytes not only in the Agroforestry Center but in other man-made or natural forest ecosystems with similar tree phorophytes.

Statement of the Problem - The purpose of this study is to determine the species diversity of the lichens in ten (10) tree species in the Experimental Agro-Forestry Center of Occidental Mindoro State College, San Jose Occidental Mindoro. Specifically, it aims to answer the following questions: (1) What are the species of corticolous lichens inhabiting the trunk of 10 species of trees found in Occidental Mindoro State College's Experimental Agro Forestry Center? (2) What is the phorophyte preference of the different species of lichens in terms of (a) Age of tree; (b) pH level of Bark; (c) Bark Texture; (d) Presence of Milk Sap; and, (5) Trunk Illumination. (3) Is there a significant difference in the species richness and diversity indices of corticolous lichens on the ten species of trees? (4) Is there a significant difference in the phorophyte preference of the different species of corticolous lichens in terms of (a) Age of the tree; (b) pH level of Bark; (c) Bark Texture; (d) Presence of Milk Sap; and, (e) Trunk Illumination.

Significance of the Study - The main purpose of this study is to determine the species diversity and phorophyte preference of Corticolous lichens on 10 species of trees existing at the Experimental Agro-Forestry Center of Occidental Mindoro State College, San Jose Occidental Mindoro. Since there have been few studies on lichens in MIMAROPA, this serves as a foundation for new knowledge and information on lichen morphology and phorophyte preferences.

The findings of this study could provide pertinent information to the following agencies or parties whose nature of work concerns the following: First, Occidental Mindoro State College, this study would benefit the school since they offer agricultural courses. The presence of Lichens in the Agro-Forestry would enable them to know the condition of their area, it would encourage them to study the lichens in the area and plant more trees. The more lichens the fewer the pollutants. Second, Researcher, the study would allow her to join the group of lichenologists. The study gave her the chance to know, identify and classify the lichens. This study would enable the researcher to be aware and familiar with the different benefits and contributions of lichens to humans and within the ecosystem. Third, Education**,** the lichens, their nature, and importance are not well-known to many people. Science lessons in schools seldom tackle this group of organisms.

The results of the study can be used to enhance the knowledge of teachers, who can incorporate them in their discussion on the importance of the diversity of life that includes lichens. This can pave the enhancement of the syllabi of biology and general science subjects. It can also be a basis for providing workshops for students in partnership with agencies such as the Department of Science and Technology (DOST) aiming for the students to gain an understanding of various aspects of lichens such as nature and types, how to collect and identify, and benefits and importance of lichens. Fourth, students, this study would provide students with information concerning the existence and importance of lichens, through attending workshops, seminars, and symposiums emphasizing the lichen species. In doing so, interest in this unique group of fungi among the students may be encouraged. Lichen herbaria would also be established so that these may be used by students in their future lessons and research on lichens.

Fifth, community, this study would benefit society, considering that lichen species are proven as bioindicators of air pollution. Through initiatives using administering and organizing programs within the community to introduce the nature of lichens and their importance and benefits to the environment. Residents near the area would be aware of their presence, and they will be informed of the importance of the lichens which would lead to tree-planting activities, protection, preservation, and conservation of these organisms. Moreover, this study would provide the common folks the reasons to protect and conserve trees in the forests, not to cut or burn them irresponsibly thus encouraging the residents to support the agroforestry by planting more trees that can support the survival of epiphytes like the lichens, hence, discourages them to collect epiphytes like the lichens because of their environmental and medicinal importance. Sixth, the Department of Environment and Natural Resources, this study would serve as their guide to be aware of the existence of lichens, thus promoting programs and action plans to conserve these organisms.

Seventh, Pharmaceutical Industry**,** this study would benefit the medical industry since lichens possess chemical substances that can be used as a medication for various types of skin diseases. Lichens are used to produce antibiotics, anti-mycobacterial, antiviral, and anti-inflammatory products. Eighth, Silviculturists and Land Managers can utilize the available lichen data in developing conservation and management strategies regarding the areas in and around the Occidental Mindoro State College, Experimental Agroforestry Center. Ninth, Taxonomist**,** Additional information on the identified and classified lichens in Occidental Mindoro will be added to their taxonomical list. Tenth, Lichenologist, the study would serve as the basis for comparison of lichens found in the different tropical areas and it would open an opportunity for collaboration with other lichenologists in the country, Asia, and worldwide. Lastly, Future Researchers**,** this study would serve as a source of reference for future researchers who will be interested to conduct studies regarding lichens.

Scope and Delimitation of the Study **-** Due to restrictions caused by the COVID-19 pandemic, the study was conducted at the Experimental Agro Forestry Center, Occidental Mindoro State College, which was most accessible for the researcher and assistants. Based on the initial ocular inspection of the area, and due to time limitations, the study considered only 30 tree phorophytes belonging to 10 species as sampling sites. Only three phorophyte characteristics such as the age of trees, pH of the bark surface, the bark texture, presence of milk sap, and trunk illumination were considered as parameters. Quadrants were placed on the aspect (North, East, South, West) with the most diverse lichens on the selected trees. Collection and Identification of species were from October 2020-March 2021 after the Gratuitous Permit was issued by the Department of Environment and Natural Resources (DENR). Due to the lack of more sophisticated equipment and available laboratories, the identification of the lichens was solely based on the microscopic examination of taxonomic features. Determination of lichen chemistry used the standard spot test reagents and UV lamp exposure. Thin-layer chromatography was not undertaken.

2. Methodology

Research Design **-** This study used a descriptive correlational design. It is descriptive in the sense that it tells what lichens are present in the Agroforestry of the OMSC as well as the diversity of lichens growing on the bark of trees. It is a correlational design in a manner since it is focused on how to determine if lichens have a preference for a certain type of tree, and if lichens in a particular phorophyte are affected by the different parameters such as the age of the tree, bark texture, presence of milk sap, pH level of bark, and trunk illumination., as well as the factors that affect their growth and abundance on specific types of trees and their significant differences on their phorophyte preferences.

Data Gathering Procedure **-** To gather specimens, the Department of Environment and Natural Resources granted a Wildlife Gratuitous Permit to the researcher, and the Office of the Campus Director of Occidental Mindoro State College, Murtha Campus approved the letter of request to collect such specimens in their facility. Ten species of trees were studied: Calamansi, Akleng-Parang, Cashew, Gmelina, Jackfruit, Mahogany, Mambog, Mango, Narra, and Tamarind Trees.

Surveying Lichen Diversity on Tree Trunks **-** Lichen diversity was surveyed on selected trees using a surveying quadrant. There were four independent quadrant segments: 50 cm in height and 10 cm in width. This quadrant segment was placed on the side (Aspect) of the trunk with the most diverse lichens (North, East, South, and West). The quadrant segments were subdivided into five quadrat squares 10x10 cm. Lichens on each quadrant square were recorded. The orientation of the sample grid was towards the side of the tree showing the highest visible lichen diversity (Caceres et al., 2007).

Collection and Preservation of Lichens **-** Standard protocol in collecting lichens was strictly followed. All specimens were placed in paper packets and properly labeled for identification and characterization. Identification of the lichens can be done only through microscopic analysis and chemical tests, which can only be done in the laboratory. Hence, the lichens were collected and packed appropriately for further study in the laboratory. Micro and macro lichens are visible to the naked eye, yet a hand lens, with 10x magnification, is advisable to be used to examine the structure of the thallus while collecting. A chisel (1 to 2-inch wide edge) and a hammer (1 kg weight) are the tools required for collecting lichens from barks. Polyethylene packets (6x12 inches, and bigger sized), rubber bands, labeling stickers, notebook, pen, pencil, secateurs (twig cutter), hand lenses, old newspapers, or blotters, ropes (nylon), collection bags, herbarium packets were used. Lichens that are loosely attached to the substratum are scraped out and collected. Superficial bark was removed using a chisel or knife to avoid damage to trees. The wound scar on the trunk was covered with nail polish. A sufficient amount of specimens was collected. Lichens collected in a single tree were kept together. The collected lichens were transferred to herbarium packets, labeled, and closed. Packets were transferred to larger herbarium packets or collection bags or in newspaper or blotter packets. Collected lichens were put in different packets to avoid mixture. Lichen specimens were not kept in packets for a longer duration since they get spoiled due to fungal attacks when wet and even change in color as they dry. In case when the tree barks are wet, the lichen specimens were kept in a plant press and tied tightly to prevent the bark from curling up as it dries, which will make it inconvenient to preserve in herbarium packets. To preserve lichens, the collected specimens were air-dried. If insects were evident in the collected specimen, these were killed, since they damage the lichen thallus. The lichens were also either dried openly in the hot sun or placed in polythene in a deep freezer (-20 C) for three days.

Statistical Treatment of Data **-** A diversity index is a mathematical measure of species diversity in an area (Begon, Harper, & Townsend, 1996). Diversity indices provide more information not only about species richness (i.e., the number of species present) but also take into account the relative abundances of different species found in an area. In this study, the tree phorophytes are considered the collection area. In this study, each tree type was considered a sampling area. Each sampling area contains three trees. The diversity index of corticolous lichens for each tree type was computed using the Shannon-Wiener Diversity Index formula. To determine the significant difference in the species richness and diversity indices of corticolous lichens on the ten species of trees, Analysis of Variance (ANOVA) with Tukey's HSD calculator. The significant difference in the phorophyte preference of corticolous lichens in terms of the age of a tree, bark pH, bark texture, presence of milk sap, and trunk illumination was analyzed using Analysis of Variance (Oneway).

3. Results and Discussions

Corticolous Lichens Collected from Tree Phorophytes at the Agro-forest Ecosystem at OMSC- A total of eighty (80) lichens have been collected from thirty (30) tree phorophytes belonging to 10 tree species and the survey revealed 38 species of lichens that belong to twelve (12) families and twenty-one (21) genera. Table 1 shows that Graphidaceae has the highest number of species (16); Arthoniaceae has seven identified species. Three identified lichens belong to the family Malmideaceae while two lichen species each belong to Physciaceae and Trypetheliaceae. The families Lecanoraceae, Megalosporaceae, Mycoporaceae, Pilocarpaceae, Porinaceae, Stereocaulaceae, and Strigulaceae have one lichen species each. As expected, Graphidaceae has the highest number of species since it is the largest family of tropical crustose lichens (Frisch, Kalb & Grube 2006a; Lücking 2008; Rivas-Plata et al., 2012a; Hodkinson 2012). The genus *Graphis* in the family Graphidaceae has 10 species. All the lichens are crustose type except *Dirinaria aplanatic* and *Heterodermia cf. chilensis*, which are narrow-lobed lichens foliose. Only thirty (30) trees were surveyed but thirty-eight (38) lichen species were identified. This implies that many lichens inhabit the trees present in the agroforestry ecosystem.

Also, some lichens are common showing many individuals occupying a tree bark but a few are represented by one individual only, and lichens have occasional occurrence on the phorophytes. A study has shown that number of lichens varied significantly among host tree species (Kirika et al., 2018). Moreover, it confirms the fact that Graphidaceae lichens, especially those belonging to the genus *Graphis* are the most common and most diverse lichens in tropical forests, even in agroforestry ecosystems like the collection area for this study. Not all the lichens were identified at the species level. This is due to any of the following reasons. One, many of the specimens lack reproductive structures (apothecia) and if they have, no spores were isolated from them because some insects have damaged the apothecia. This is the case for the lichens belonging to the Arthoniaceae family. Two, there is also a lack of taxonomic keys up to the species level for certain groups of lichens like Pilocarpiaceae and Mycoporaceae. Three, for some lichens, there is a need to do further tests for their specific lichen acids through thin-layer chromatography but due to a lack of chemicals and equipment, this was not undertaken. Fourth, a few lichens (like some Graphis species) have traits not observed in described species in references, which suggests that these could be putative new species.

Lichens belonging to the family Graphidaceae have the highest frequency like Graphis pinicola (12) followed by G. leptogramma (11). This is closely followed by lichens belonging to the family Arthoniaceae, like the different species of Cryptothecia. Malmidea cf. aurigera also manifests high frequency (10). These are the lichens that appear to be common. The others with lower frequency appear occasional while a few seem to be rare. Looking at the different tree phorophytes, the jackfruit tree has the highest number (8) of lichen species collected and identified followed by Calamansi, Mahogany, and Sampalok where seven (7) lichen species were collected. Cashew, Mango, and Narra trees come next with six (6) lichen species. Only two (2) lichen species were identified from Akleng-parang and Mambog. Lichens belonging to the family Graphidaceae were collected from all tree phorophytes except Akleng-Parang and Sampaloc. Lichens in the family Arthoniaceae were also collected from seven (7) tree phorophytes, namely: Akleng-Parang, Gmelina, Mahogany, Jackfruit, Mambog, Mango, and Sampalok. Uncommon lichens like Malcomiella sp., Phaeographis caesoradians, and Pseudopyrenula subgregaria were only collected from the cashew tree. Other uncommon lichens were also collected from the sampalok tree-like, like Herpothallon sp., Megalospora tuberculosa, and Narra tree like the lichen species, Polymeridium subcinereum.

Table 1

List of Lichen Species Identified from 10 Tree phorophytes

Family	No. of species/ family	Species	No. of indiv. /species
Arthoniaceae	7	Arthothelium sp.	1
		Coniocarpon cinnabarinum DC	1
		Cryptothecia sp. 1	5
		Cryptothecia sp. 2	9
		Cryptothecia sp. 3	11
		Cryptothecia sp. 4	4
		Herpothallon sp.	1
Graphidaceae	16	Diorygma confluens (Fée) Kalb, Staiger & Elix	3
		Diorygma hieroglyphic (Pers.) Staiger & Kalb	7
		Dyplolabia afzelii A. Massal.	4
		Glyphis scyphulifera (Ach.) Staiger	2
		Graphis sp.1	1
		Graphis dendrogramma Nyl.	1
		Graphis cf. fournierii	1
		Graphis fujianensis Z.F. Jia & J.C. Wei	1
		Graphis furcata Fee	7
		Graphis immersella Müll. Arg.	5
		Graphis leptogramma Nyl.	11
		Graphis subdisserpens Nyl.	4
		Graphis pinicola Zahlbr.	12
		Graphis xanthospora Müll. Arg	6
		Myriotrema cf. eminens	1
		Phaeographis caesoradians (Leight.) A.W. Archer	1
Lecanoraceae	1	Lecanora lacteola Muell. Arg.	1
Malmideaceae	3	Malmidea granifera (Ach.) Kalb, Rivas Plata & Lumbsch.	1
		Malmidea cf. aurigera	10
		Malmidea sp.	6
Megalosporaceae	1	Megalospora tuberculosa (Fee) Sipman	1
Mycoporaceae	1	Mycoporum sp.	1
Pilocarpaceae	1	Malcolmiella sp.	1
Physciaceae	2	Dirinaria applanata (Fée) D. D. Awasthi	2
		Heterodermia cf. chilensis	1
Porinaceae	1	Porina internigrans (Nyl.) Müll. Arg	1
		Porina sp.	1
Stereocaulaceae	1	Lepraria sp. 1	1
Strigulaceae	1	Strigula phaea (Ach.) R.C. Harris	3
Trypetheliaceae	2	Polymeridium subcinereum	1
		Pseudopyrenula subgregaria Müll. Arg.	2

Based on the results of the study shown in Table 2, implies that lichens seem to prefer to inhabit some tree phorophytes than others. This suggests that some trees have features that favor the growth of lichens on their barks more than others. Surprisingly, some tree phorophytes that harbor fewer lichens are those that have rare or not common species of lichens. The result of the survey supports the need for more studies and publications on Philippine lichens to add to the very limited references for researchers interested in this endeavor. Also, it indicates that there are a lot of lichen species awaiting to be discovered in Mindoro in particular, and in the Philippines in general.

Graphidaceae constitutes the largest family of crustose tropical lichens. Lichens belonging to the family are recognized by their lirellae (elongated, simple to branched) or rounded apothecia. Species identification requires careful evaluation of sections of the apothecia and details of the spores as well as the presence of a type of lichen acids present in the thallus. Figure 1 shows some examples of the Graphidaceae lichens identified. Arthoniaceae is another family of crustose lichens that are prevalent in the tropics. Lichens belonging to four genera were collected and identified: *Arthothelium*, *Coniocarpon*, *Cryptothecia*, and *Herpothallon.* Figure 1 shows images of lichens belonging to the family. While the images of some lichens with low frequency belonging to the other families noted in Table 2 are also shown in Figure 2.

Figure 1. Some Graphidaceae Lichens Collected and Identified
A-Diorygma confluens; B- Diorygma hieroglyphical; C-Dyplolabia afzelii; D-Graphis dendrogramma; E-Graphis fujianensis; F- Graphis pinicola; G- Myriotrema cf. eminens; H- Phaeographis caesoradians

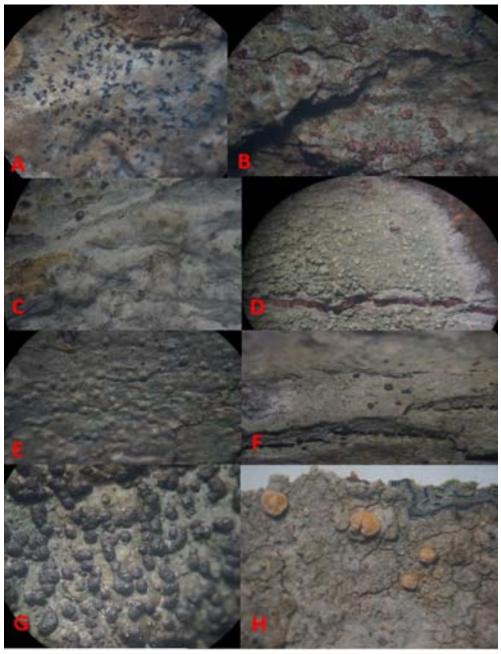

Figure 2. More Samples of Lichens Collected and Identified
A-D belong to Arthoniaceae: A-Arthothelium; B-Coniocarpon cinnabarinum: C-Cryptothecia Sp. 2; D- Herpothallon sp.; E- Porina internigrans (Porinaceae)
F- Megalospora tuberculosa (Megalosporaceae);
G- Pseudopyrenula subgregaria (Trypetheliaceae);
H- Lecanora lacteola (Lecanoraceae).

Phorophyte Preference of Lichens -According to Age of the Tree; The age of the trees found in the sampling was determined using the method adapted from the Forestry Society (2015). In this method, the circumference of the tree is measured then the obtained measurement was divided by 1.5, 2, or 2.5 to get the estimated tree age. This process is known as "Mitchell's Rule, which was named after the famous UK tree expert, Alan Mitchell. The age of the trees in the collection site ranged from the youngest (6 to 9 years) to the oldest (42 to 72) years. These results show that the older and more mature trees harbor more lichens than the younger trees. Johansson, Rydin & Thor (2007) indicated in their study that there is a positive relationship between tree age and lichens, meaning the younger the trees, the fewer lichens present in them. Conversely, the older the trees, the more lichens are present in them. Fewer lichens in very young trees may indicate that lichens have only started to colonize them. On the other hand, there are more lichens in older trees because lichens have adapted to the tree barks and have established successful colonization, growth, and reproduction.

Table 2

Lichen Species Collected from Each Tree Phorophyte

Tree Phorophyte	No. of lichen species	Lichen Species	Family	No. of Indiv.
Akleng-Parang	2	Cryptothecia sp. 1	Arthoniaceae	5
		Malmidea sp.	Malmideaceae	1
Calamansi	7	Diorygma confluens	Graphidaceae	2
		Diorygma hieroglyphicum	Graphidaceae	4
		Graphis furcata	Graphidaceae	5
		Lepraria sp. 1	Stereocaulaceae	2
		Malmidea granifera	Malmideaceae	1
		Malmidea sp.	Malmideaceae	2
		Porina internigrans	Porinaceae	2
Cashew	6	Diorygma hieroglyphicum	Graphidaceae	1
		Dyplolabia afzelii	Graphidaceae	4
		Graphis pinicola	Graphidaceae	1
		Malcolmiella sp.	Pilocarpaceae	1

		Phaeographis caesoradians	Graphidaceae	1
		Pseudopyrenula subgregaria	Trypetheliaceae	2
Gmelina	4	Arthothelium sp.	Arthoniaceae	1
		Graphis xanthospora	Graphidaceae	4
		Graphis sp.1	Graphidaceae	1
		Strigula phaea	Strigulaceae	3
Jackfruit	8	Cryptothecia sp. 2	Arthoniaceae	2
		Cryptothecia sp. 4	Arthoniaceae	2
		Diorygma hieroglyphicum	Graphidaceae	1
		Graphis dendrogramma	Graphidaceae	1
		Graphis immersella	Graphidaceae	3
		Graphis leptogramma	Graphidaceae	3
		Graphis subdisserpens	Graphidaceae	4
		Lecanora lacteola	Lecanoraceae	1
Mahogany	7	Cryptothecia sp. 2	Arthoniaceae	2
		Dirinaria applanata	Physciaceae	2
		Graphis immersella	Graphidaceae	2
		Graphis leptogramma	Graphidaceae	3
		Graphis xanthospora	Graphidaceae	2
		Malmidea cf. aurigera	Malmideaceae	10
		Mycoporum sp.	Mycoporaceae	2
Mambog	2	Cryptothecia sp.3	Arthoniaceae	8
		Graphis pinicola	Graphidaceae	8
Mango	6	Cryptothecia sp. 2	Arthoniaceae	4
		Diorygma confluens	Graphidaceae	1
		Diorygma hieroglyphicum	Graphidaceae	1
		Graphis cf. fournierii	Graphidaceae	1
		Malmidea sp.	Malmideaceae	3
		Myriotrema cf. eminens	Graphidaceae	1
Narra	6	Coniocarpon cinnabarinum	Arthoniaceae	1
		Glyphis scyphulifera	Graphidaceae	2
		Graphis fujianensis	Graphidaceae	1
		Graphis furcata	Graphidaceae	2
		Graphis leptogramma	Graphidaceae	5
		Graphis pinicola	Graphidaceae	3
		Polymeridium subcinereum	Trypetheliaceae	1
Sampaloc	7	Cryptothecia sp. 2	Arthoniaceae	1
		Cryptothecia sp. 3	Arthoniaceae	3
		Cryptothecia sp. 4	Arthoniaceae	2
		Herpothallon sp.	Arthoniaceae	1
		Heterodermia cf. chilensis	Physciaceae	1
		Megalospora tuberculosa	Megalosporaceae	1
		Porina sp.	Porinaceae	1

According to Bark, pH-The pH level shows the measure of how acidic/basic water is. The range starts from 0 to 14 with seven (7) indicating the neutral level. A pH of less than seven (7) indicates acidity whereas a pH of higher than seven (7) indicates alkalinity. Figure 10 presents the distribution of the number of lichens according to bark pH. The results indicate that lichens prefer a slightly acidic environment (around 5.0 pH) to a highly acidic or alkaline environment. There are a few lichens though that preferred a more acidic environment. The results of the study do not support a study that showed that the pH level of bark directly affects the cover and distribution of lichens, where the more acidic the bark the greater number of lichens present (Palharini et al., 2020). According to some studies, many lichen species are unable to photosynthesize efficiently on bark with low pH (McDonald et al.,2017). This sensitivity is most likely due to photosystem II inefficiency in the photosynthetic pathway responsible for the generation of chlorophylls a and b in acidic conditions.

According to Bark Texture- The bark structure of the trees with uneven substructures <1 cm in diameter recorded the highest lichen frequency of 34 or 42.5%. The completely smooth bark shows a lichen frequency of 32 or 40%. There are only fourteen (14 or 17.5%) trees with uneven to sculptured and with substructures 1-3 cm in diameter. The bark texture has an immediate effect on the growth of lichens (Daniel & Polanin, 2013; Caceres et al., 2007; Ilondu, 2019). One of the studies has shown that the occurrence of lichens is more evident on trees with a lot of bark peeling. (Hinds, J. and Hinds, P., 2007). More fissures and uneven surfaces in the bark allow lichens to attach themselves more easily. As bark ages, its chemistry, texture, and capacity to hold water vary, impacting the sort of lichen that may live there (Daniel & Polanin, 2013).

According to the Presence of Milk Sap- As discussed above, milk sap refers to the fluid that is emitted by the stem of the plant when the bark is broken. As shown in this study, there were more lichens collected from the trees without milk sap fifty-four (54 or 67.5%) at the Experimental Agro Forestry Center at Occidental Mindoro State College than those with milk sap. To date, there were no studies regarding the high frequency of lichens on tree host species characterized by the absence of milk sap. As cited by Kaffer et al. (2009), sap-producing tree bark can restrict lichen development. Some milk saps are highly toxic; hence, trees with milk sap may not support lichen growth.

According to Trunk Illumination- A measurement of 1 lux is equal to the illumination of 1 square meter surface (1 lumen/m^2). Lower lux measurement means less light intensity. As shown in the data, the highest frequency of lichens (23; 28.7%) was collected from trees that have a trunk illumination from 305 to 509 lux while the least frequency of lichens (6;7.5%) was collected from trees with trunk illumination of 920 to 1124 lux. The results reveal that the trunk of the trees that receive not-so-low and not-so-high illumination, meaning with not-so-low and not-so-high light intensity has more lichen inhabitants.

Studies have shown that the light on the trees significantly affects the high sustainability of trees for lichen growth (Jönsson et al., 2011). As mentioned in the study of Lakatos et al. (2006), corticolous crustose lichens are abundant due to their adaptation to the existing microenvironmental conditions, such as low light intensities. Light is essential for lichens because of its photosynthetic component, the algae. The algal component needs light to be able to manufacture food for both of them with the fungus. However, too much illumination can cause the drying up of the lichens. Hence, they prefer not so strong illumination or high-intensity light.

Table 3

ANOVA Table on the Species Richness of Corticolous Lichens

ANOVA Summary					
Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	9	8.8003	0.9778	2.4443	0.0461
Within Groups	20	8.0009	0.4		
Total:	29	16.8012			

***Significant at p< 0.05*

Analysis of variance on the species richness per tree phorophytes (Table 3) shows that there is no significant difference in the number of lichen species found in each tree (df=10; F= 2.4443; p= 0.0461). This means that despite showing differences in their diversity species richness or diversity indices, per tree the difference does not vary significantly. This could be due to the fact only one to three species of lichens were collected from each tree phorophyte. Also, collectively, there are more lichen species collected from Jackfruit, Calamansi, Mahogany, and Sampaloc trees because each tree sampled from these tree types gave different types of lichen species. On the other hand, the same lichen species were found in the three trees of Akleng-Parang and Mambog. Referring back to the diversity index of corticolous lichens for the tree phorophytes, Akleng-Parang and Mambog have the lowest species diversity indices. However, the Narra tree shows a slightly higher diversity index than the Jackfruit tree although it has only six (6) lichen species while the Jackfruit tree has eight (8). This means that there are more lichen individuals found growing on the Narra tree bark than on the Jackfruit tree bark. The computation of the diversity index considers the number of species and several individuals per species. This implies that there may be fewer species found in the Narra trees than in Jackfruit but there were more individuals representing some of the species than those found in Jackfruit.

Table 4

ANOVA on the Phorophyte Preference of the Corticolous Lichens Species

Analysis of Variance by	F	Sig. (p-value)	Decision	Interpretation
Tree Age	5.868	.000	Reject Ho	Highly Significant
pH Level of Tree Bark	5.938	.000	Reject Ho	Highly Significant
Bark Texture	1.326	.271	Accept Ho	Not Significant
Presence of Milk Sap	24.999	.000	Reject Ho	Highly Significant
Trunk Illumination	7.853	.000	Reject Ho	Highly Significant

***Significant at p< 0.05*

As displayed in Table 4, four of the p-values recorded .000 which did not exceed the 0.05 significance level, considering tree age, the pH level of bark, milk sap presence, and trunk illumination. Hence, the hypothesis of no significant difference in the lichen species when grouped by the indicators aforementioned is rejected. This is supported by the large variances (F-values) which ranged from 5.868 to 24.999. This indicates a highly significant difference that exists in the phorophyte preference of the corticolous lichens species characterized by age of trees, amount of pH level in the bark of the trees, bark structure, presence of milk sap, and trunk illumination in terms of lux. While differences in the lichen species have been proven in terms of the age of trees, findings by Marmor et al. (2011) also revealed that tree age poses a positive effect on the occurrence of several lichen species and their richness. While a difference exists in lichen species based on the presence of milk sap in tree bark, the findings of Caceres et al. (2007) revealed that species richness was positively correlated with the presence of milk sap but negatively with bark pH. Meanwhile, no significant difference is recorded in the lichen species as characterized by the bark structure of the trees. The p-value of .271 exceeded the .05 level corresponding to the low variance (F) of 1.326. This proves that the phorophyte preference of the corticolous lichens species is comparable, considering the bark structure of the trees. This implies that regardless of the structure of the tree bark, the phorophyte preference of the corticolous lichens species recorded similarity. The result on the bark structure was then supported by the study of Cáceres et al. (2007), which states that the bark shedding (bark structure) does not affect the phorophyte preference of lichens. Implying that corticolous lichens are more evident to tree phoropters that are older, with slightly acidic bark, without milk sap, and moderately illuminated.

Based on the analysis, shows that the successful colonization and growth of lichens on three phorophytes do not depend on a single factor. Many factors interplay that affect the ability of lichens to establish successful colonization of tree bark. One must also consider the tree species as shown by the earlier finding presented that some tree species have more lichen species than others.

4. Conclusions

The Experimental Agro-Forestry Center has exhibited the presence of corticolous crustose and foliose lichens. Generally, the distribution of corticolous lichens is strongly epiphytic on the tree which is represented by the family Graphidaceae followed by Arthoniaceae, and the least families are Malmideaceae, Physciaceae, Trypetheliaceae, Lecanoraceae, Mehalosporaceae, Pilacarpaceae, Porinaceae, Stereocaulaceae, Strigulaceae, and Trypetheliaceae. Some of the identified species were *Dirinaria applanata, Heterodermia cf. chilensis, and Graphis leptogramma Nyl. Phaeographis caesoradians (Leight.) A.W. Archer* and *Diorygma hieroglyphicum* (Pers.) Staiger & Kalb.

There are more lichen species and individuals in trees that are older, with slightly acidic bark, without milk sap, and moderately illuminated. At the time of sampling and collection, the Agro-Forestry manifested varied climatic conditions, since the forest is characterized by upland and lowland areas, varied light intensities, and with closed and open canopies. The corticolous lichens were closely attached to the substratum, thus the collection of specimens followed standard procedure and protocols. In addition, some species were evident on some specific types of trees but not on others. There are more lichen species collected from Jackfruit, Calamansi, Mahogany, and Sampaloc trees because each tree sampled from these tree types gave different types of lichen species. On the other hand, the same lichen species were found in the three trees of Akleng-Parang and Mambog. Calculation of the diversity index for the tree phorophytes also shows that Akleng-Parang and Mambog have the lowest species diversity indices. The lichen diversity index showed that the Narra tree has a slightly higher diversity index than the jackfruit tree, hence, this could mean that there are more lichen individuals found growing on the Narra tree bark than on the Jackfruit tree bark. The computation of the diversity index considers the number of species and several individuals per species. The phorophyte preference of lichens differ significantly (highly) in terms of tree age, pH of bark, presence of milk sap, and trunk illumination but not for the bark texture, which indicate that the successful colonization and growth of lichens on the bark are affected by many factors.

4.1 Recommendations

The researcher recommends the following: Agroforestry is a vast area housing several hundreds of trees. It is highly recommended that more studies on the lichen inhabitants of these trees should be continued, with the sampling of more trees and more tree types. A comparison of two or more areas with lichen inhabitants should be done. Other factors that could affect the growth of lichens may also be considered such as the tree size, water repellence, and presence of bark lenticels, and types of trees are also recommended to determine the phorophyte preference of the lichens. The lichen diversity and abundance in the area could also be used to assess the environmental health of the Agro-Forestry Center at Occidental Mindoro State College. Some of the lichens were suspected to be new species or new records; intensive study of the features including the possible use of molecular techniques may be employed to identify them. This could result in new records for the province of Mindoro. A study on the other uses of lichens, like their medicinal uses may also be conducted. A chemical component of the Lichens should be considered in the next study, a basis for pharmacological importance. The protection and conservation of lichens and their phorophytes should be prioritized due to the benefits they can give to the environment. More agroforestry should be established not only by the DENR but also by the local government.

The result of this study would benefit persons that dedicated their time to the conservation, protection, and utilization of the forest. For instance, the farmers, rice fields were commonly situated in an area with the presence of trees, thru proper campaigns and initiatives they will be able aware that there are lichens that can be found in their respective farms and be informed of what are the benefits that they can acquire from these organisms. Lichens are abundant in forested areas, and the result of the study would be of benefit, especially to the Mangyan communities, which are commonly situated in mountainous and forested areas thru advocacies such as community extension programs to introduce the lichens and their ecological and economic importance. Moreover, the Mangyans thrive on the vegetation found in the forests. Introducing to them the importance of lichens could stimulate their interest and participation to protect and conserve trees that serve as habitats for the lichens. Lichens also abound in Mindoro; hence, the study of these lichens should be incorporated into biology lessons to stimulate the interest of more students. This could inspire future researchers to conduct studies not only on the diversity of lichens but on their ecological and economic importance. The science group should request the local legislative body, provincial, municipal, and barangay levels to formulate resolutions and ordinances on protecting trees that have lichens and the importance of it in balancing the environment and being a pioneer in ecological succession.

5. References

Asplund J., & Wardle, D. (2016). *How lichens impact on terrestrial community and ecosystem properties*. https://doi.org/10.1111/brv.12305

Azuelo, A., Sariana, L., Magday, E. and Montecillo, R. (2013). *Distribution and Biodiversity of Lichens and their Associated Vegetation Types in Mt. Kalatungan Natural Park, Bukidnon,* Philippines.

Bajpai, R., & Upreti, D. (2011). *Lichens –A potential organism for sustainable agriculture*. https://isebindia.com/09-12/11-10-2.html

Bawingan, P. A., Pinas, A., Amoncio, R., Amilao, D., Beniking, R., Caliway, A., Büdel, B., & Scheidegger, C.

(2008). Thallus morphology and anatomy. In Nash, T. H. III (ed.), *Lichen Biology*. Second Edition. pp. 40–68. Cambridge University Press,

Brazil. *Biodiversity and Conservation*. 18. 3543-3561.

Cáceres, M., Lücking, R., & Rambold, G. (2007). Phorophyte specificity and environmental parameters versus stochasticity as determinants for species composition of corticolous crustose lichen communities in the Atlantic rainforest of northeastern Brazil. *Mycological Progress*, pp. 117-136.

Callaway, R. M. (2007). Positive Interactions and Interdependence in Plant Communities. Springer, Dordrech. https://searchworks.stanford.edu/view/7190108.

Convention on Biological Diversity (n.d.). Biodiversity Facts Status and trends of biodiversity, including benefits from biodiversity and ecosystem services. https://www.cbd.int/countries/profile/?country=ph#:~:text=The%20Philippines%20is%20one%20of,5%25%20of%20the%20world's%20flora.

Cornelissen, J.H.C., & Gradstein, S.R. (1990). On the occurrence of bryophytes and macrolichens in different lowland rain forest types at Mabura Hill, Guyana. *The Bryology, 3*, 29-35.

Daniel, G.H. and Polanin. N. (2013). Tree Dwelling Lichens. https://njaes.rutgers.edu/fs1205/

Domingo, W.J.M., Medina, N.D. & Leano, E.P. (2015). Annotated List of Bryophytes and Lichens from Mainit Hot Spring Protected Landscape, Nabunturan, Compostela Valley, Mindanao, Philippines. International

Francisco, T.M., Garbin, M.L., De Toledo, C., Castanho, & Miranda, C.R.R. (2018). An overview on epiphytism as a direct mechanism of facilitation in tropical forests. *Tropical Ecology 59*(1): 1–9.

Frisch, A., Kalb, K. & Grube, M. (2006a) Contributions towards a new systematics of the lichen family Thelotremataceae. Bibliotheca New Species Of Graphidaceae Phytotaxa 189 (1) Magnolia Press *Lichenologica* 92: 1–556.

Gatumbato, E. A. (2009). Mindoro Biodiversity Conservation Foundation,Inc.Promoting Shared Responsibility toward the Conservation of Mindoro's Biologcial and Cultural Diversity. https://docplayer.net/89808190-Mindoro-biodiversity-conservation-foundation-inc-mbcfi-mindoro-biodiversity-conservation-program-thrusts.html

Graphidaceae (Ascomycota: Lecanoromycetes: Ostropales). *Fungal Diversity 52*: 107–121.

Hinds J.W, & Hinds P.L. (2007). The macrolichens of New England. New York, The New York Botanical Garden Press. https://www.nybg.org/content/uploads/2017/08/Macrolichens-E-release-2-8-08.pdf

Hodkinson, B.P. (2012) An evolving phylogenetically based taxonomy of lichens and allied fungi. Opuscula Philolichenum 11: 4–10. https://sweetgum.nybg.org/images3/479/367/OP11_p2.pdf.

Hosonuma N., Herold, M., De Sy, V., De Fries, R.S., Brockhaus, M., Verchot, L., Angelsen, A., Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environ Res Lett. 7*(4):044009.

Ilondu, E.M.. (2019). Occurrence and diversity of Lichens in Abraka and its environs, Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management*. 23. 947.

IPCC. (2007). Fourth assessment report (IPCC AR4). Geneva: Intergovernmental Panel on Climate Change. https://archive.ipcc.ch/pdf/presentations/valencia-2007-11/pachauri-17-november-2007.pdf

Johansson, P., H. Rydin, and G. Thor. (2007). Tree age relationships with epiphytic lichen diversity and lichen life history traits on ash in southern Sweden. *Ecoscience* 14 (1):81- 91 with lichenicolous fungi from Paleogene amber. Scientific Reports, 9, [10360].

Journal of Current Research in Biosciences and Plant Biology, 2(10). ISSN: 2349-8080

Kaasalainen, U., Kukwa, M., Rikkinen, J., & Schmidt, A. R. (2019). Crustose lichens with lichenicolous fungi from Paleogene amber. Scientific Reports, 9, [10360].

Käffer, M., Ganade, G. & Marcelli, M. (2009). Lichen diversity and composition in Araucaria forests and tree monocultures in southern

Kirika, P., Ndiritu,G., Mugambi, G., Newton,L., & Lumbsch, T. (2018). Diversity and Altitudinal Distribution of Understorey Corticolous Lichens in a Tropical Montane Forest in Kenya (East Africa). Cryptogam Biodiversity and Assessment.

Lagarteja, N. K., Fajardo, W. T., Park, C., & Hur, J. (2014). Diversity and adaptive features of Corticolous

Lichens in the Hundred Islands, Philippines. *Philippine Journal of Systematic Biology, 3*(1).

Lakatos, M., Rascher, U., & Budel, B. (2006). Functional characteristics of corticolous lichens in the understory of a tropical lowland rain forest. *New Phytologist*, 172:679-695.

Lücking, R. (2008) Foliicolous lichenized fungi. *Flora Neotropica Monograph* 103: 1–866.

Lücking, R. (2009). The taxonomy of the Genus Graphis sensu Staiger (Ascomycota: Ostropales: Graphidaceae). *The Lichenologist* **41** (4): 319-362.

Lucking, R., Dal-Forno, M., Sikaroodi, M., Gillevet, P.M., Bungartz, F., Moncada, B., Yánez-Ayabaca, A., Chaves, J.L., Coca, L.F.and Lawrey, J.D. (2014). A single macrolichen constitutes hundreds of unrecognized species.

Lücking, R., Plata, E.R., Chaves, J. L, Umana, L., & Sipman H.J.M. (2009). How Many Tropical Lichens are there… really?. Diversity of Lichenology. Thell, A., Seaward, M.R.D and Feuerer T. (eds.). *Bibliotheca Lichenologica, 100*: 399–418.

MacArthur RH. (1972). Geographical Ecology: Patterns in the Distribution of Species (Harper and Row, New York). https://press.princeton.edu/books/paperback/9780691023823/geographical-ecology.

Máguas,C., Pinho, P.,, Branquinho,C., & Bohr, B. & Lakatos, M. (2013). Carbon-Water-Nitrogen relationships between lichens and the atmosphere: Tools to understand metabolism and ecosystem change. MycoKeys. 6. 95-106.

Marmor-Ohtla, L., Tõrra, T., Leppik, Saag, L. & Randlane, T. (2011). Epiphytic lichen diversity in Estonian and Fennoscandian old coniferous forests. *Folia Cryptogamica Estonica.* 48. 31-43.

Maulion, A. F. (2015). Assessment of Corticolous Lichen Diversity in Romblon *State University, Main Campus* [Unpublished institutional research] Odiongan, Romblon.

Mbow, M., Skole, D., Dieng, M., Justice, C., Kwesha, D., Mane, L., El-Gamri, M., Von Vordzogbe, V., Virji, H. (2012). Challenges and prospects for REDD+ in Africa: desk review of REDD+ implementation in Africa. Copenhagen: GLP-IPO. GLP Report No. 5. https://start.org/wp-content/uploads/REDD_Report.pdf.

McDonald, L., Woudenberg, M.V., Dorin, B.,Adcock, A.M., McMullin, R.T. and Cottenie, K. (2017). The effects of bark quality on corticolous lichen community composition in urban parks of southern Ontario. Botany 95: 1141–1149 (2017).

Minang, PA., Duguma, LA., Bernard, F., Mertz, O., van Noordwijk, M. (2014). Prospects for agroforestry in REDD+ landscapes in Africa. *Curr Opin Environ Sustain. 6*:78–82. https://www.asb.cgiar.org/publication/prospects-agroforestry-redd-landscapes-africa

Nash, T.H. (ed.) (2008). Lichen Biology. Cambridge: Cambridge University Press. https://books.google.com.ph/books/about/Lichen_Biology.html?id=lPRtQgAACAAJ&redir_esc=y

Pachauri, R.K., Allen, M.R, Barros, V.R., Broome, J., Cramer, W., Christ, R., Dubash, N.K. (2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II. https://epic.awi.de/id/eprint/37530/.

Palharini, K. M. Z., Vitorino, L. C., Menino, G. C. de O., & Bessa, L. A. (2020). Edge Effects Reflect the Impact of the Agricultural Matrix on the Corticolous Lichens Found in Fragments of Cerrado Savanna in Central Brazil. *Sustainability*, *12*(17), 7149. MDPI AG.

Patel-Weynand, T., Bentrup, G., Schoeneberger, M., Haan Karel, T., & Nair, P.K.R. (n.d.). https://www.fs.fed.us/research/publications/gtr/gtr_wo96/GTR-WO-96-Chapter9.pdf

Rivas Plata, E., Lücking, R., & Lumbsch, H.T. (2012a) A new classification for the family

Rosabal, D., Burgaz, A. R., & Reyes, O. J. (2013). Substrate preferences and phorophyte specificity of corticolous lichens on five tree species of the montane rainforest of Gran Piedra, Santiago de Cuba. *The Bryologist*, *116*(2), 113–121.

Royal Forestry Society. (2015). Tree Age. https://www.rfs.org.uk/learning/forestry-knowledge-hub/tree-biology/tree-age/

Terborgh. J.W. (2015). Toward a trophic theory of species diversity.

Van der Werf, G.R., Morton, D.C., De Fries, R.S., Olivier, J.G.J., Kasibhatla, P. S., Jackson, R.B., Collatz, G.J., Randerson, J. T. (2009). CO2 emissions from forest loss. *Nat Geosci. 2*:737–738.

Verchot, L., van,Noordwijk, M., Kandji, S., Tomich, T., Ong, C., Abrecht, A., Mackensen, J., Bantilan, C., Anupama, KV., & Palm, C. (2007). Climate change: linking adaptation and mitigation through agroforestry. *Mitig Adapt Strat Global Change. 12*, 901–918.

Vidyasagar, A. (2016). *What are Lichens?* https://www.livescience.com/55008- lichens.html

Weatherley-Singh, J., & Gupta, A. (2015). Drivers of deforestation and REDD+ benefit-sharing: A meta-analysis of the (missing) link. *Environmental Science Policy, 54*, 97–105.

Wolf, J. (1993). Diversity Patterns and Biomass of Epiphytic Bryophytes and Lichens Along an Altitudinal Gradient in the Northern Andes. *Annals of the Missouri Botanical Garden, 80*. 928-960. 10.2307/2399938.