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Diversity and species composition of lichens across altitudinal range in the Batang Toru Forest, North Sumatra, Indonesia

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Abstract. *Pasaribu N, Atni OK, Siregar JP. 2023. Diversity and species composition of lichens across altitudinal range in the Batang Toru Forest, North Sumatra, Indonesia. Biodiversitas 24: 2171-2178.* West Block of Batang Toru Forest, located in North Tapanuli Regency, North Sumatra is one of the protection forest areas which has uniqueness and high biodiversity, one of them is the lichen. The information regarding the lichen species found in the West Block of Batang Toru Forest Research Station has never been reported. Its various types and distributions are unknown. This study aimed to observe lichen at the Batang Toru Forest Research Area, which was carried out from September 2021 to March 2022. The study was carried out with the exploration method by exploring along the track. From the results of the study, there was a total of 54 species of lichen consisting of 23 families and 38 genera. Based on the types of the thallus, it was found 23 species of lichen classified as foliose, 21 crustose, 4 fruticose, 3 squamulose, and 3 filamentous. The most common lichen family found at the study site was Lobariaceae, with a total of six species. The species collected in this study were mostly found on the bark substrate. This study reveals important information about the variety of lichen species in the West Block of Batang Toru Forest, highlighting the urgent need for further research and conservation efforts to protect this unique and diverse ecosystem.

Keywords: Batang Toru, diversity, inventory, lichen

INTRODUCTION

The West Block Batang Toru Forest Research Station area is a tropical forest in North Sumatra that lies at the biogeographical transition zone between the northern and southern parts of Lake Toba. This unique transitional condition gives the area high biodiversity and makes it an important area for the assemblage of lichen diversity. Lichens are a unique group of organisms that result from the mutualistic symbiosis between fungi from the Ascomycota or Basidiomycota division, known as mycobionts, and green algae or blue-green algae, known as photobionts. These two groups of organisms coexist closely, forming a single entity (Atala et al. 2015). In lichen symbiosis, the photobionts play a crucial role in providing energy through photosynthesis, while the mycobionts create a protective microhabitat for the photobionts and form the thallus shape. Mycobionts protect photobionts from environmental factors, such as UV rays and high temperatures (Spribille et al. 2016), and receive carbon supply in different forms depending on the type of algae they form a symbiosis with (Noetzel et al. 2018). Lichens have slow growth and long life, and they can grow in various habitats, including extreme environments (Beckett et al. 2013). They grow on diverse substrates and tend to grow uniformly where the substrate conditions are uniform.

Lichens are resilient organisms that thrive in various environments and their populations are shaped by factors such as humidity, temperature, air quality, and nutrient availability (Gauslaa 2014; Rubio-Salcedo et al. 2017; Singh et al. 2017; Geiser et al. 2021). Lichens have a wide range of uses, including dye production and medicinal applications, and exhibit pharmacological activities such as antibacterial, antifungal, antitumor, and antioxidant properties (Zedda and Rambold 2015; Kalra et al. 2020; Elkhateeb et al. 2021). In addition, lichens can serve as bioindicators of air quality, climate change, and regional biodiversity, with their use being more cost-effective and efficient than ambient indicator devices or machines (Kularatne and Freitas 2013). To gain an understanding of their ecosystem services and benefits to humans, a comprehensive investigation of the functional traits and potential uses of lichens is crucial. Such investigations require surveys of abundant or unique species assemblages in a given area.

Lichens are capable of growing in a wide range of habitats, from low-tide areas to mountain summits, and from arctic and desert to tropical regions (Seaward 1977). The diversity and distribution of lichen species are influenced by several geographical parameters, including latitudinal and altitudinal gradients, environmental variables, and microhabitats (Abas and Din 2021). However, the causes of high lichen biodiversity in tropical areas remain uncertain, despite more attention given to temperate and boreal habitats. Indonesia is a biodiverse country, but there is limited research on lichen diversity in the country, particularly in North Sumatra. Only a few studies, such as those conducted by Khairunnisa (16 species) in 2016 and Hutasuhut (19 species) in 2021, have been carried out on lichen diversity in this region. The lichen diversity in the West Block of the Batang Toru Forest Research Station is yet to be studied. Therefore, there is a need to conduct an investigation to obtain data on lichen inventory in this area, as it will provide insight into the functional traits of lichens and their ecosystem service, which could potentially be beneficial to humans.

MATERIALS AND METHODS

Study area

This study was conducted at the *Yayasan Ekosistem Lestari*-Sumatran Orangutan Conservation Program (YEL-SOCP) Research Station, North Tapanuli Regency, North Sumatra, Indonesia. The study area is located in the West Block of the Batang Toru Forest Research Station, which has a forest area of approximately 76,000 hectares and includes both lowland and highland forests with an altitude ranging from 669 to 1,875 m.a.s.l. The West Block of the Batang Toru Forest Area is located between 98°55'36" to 99°01'00" E and 1°40'07" to 1°43'0" N, and is characterized by a unique climate, topography, and vegetation. The study was conducted from September 2021 to March 2022, and lichen specimens were identified at the Plant Systematics Laboratory, Medanense Herbarium (MEDA), Universitas Sumatera Utara.

Data collection and specimen processing

During explorations, lichen specimens were surveyed from seven tracking lines with varying distances. These tracking lines are named A (3000 meters), B (3500 meters), C (4000 meters), H (2600 meters), G (3300 meters), JMK (2400 meters), and Cave (2600 meters), and were distributed across an altitude range of 750 to 1000 m above sea level. Observations and collections of lichens were carried out along the tracks. The samples were collected from the substrate using a knife; lichen on bark substrates was collected at a height of 1 m from the ground surface. Types of lichens found in photographs and important characters are recorded in detail using a tally sheet. The sample is stored in an envelope, then given a label and description for identification purposes. The lichen specimens obtained were replaced with paper envelopes and preserved by drying them to prevent damage, moisture, and mold. The dried specimens are stored in the Herbarium Medanense (MEDA), Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara.

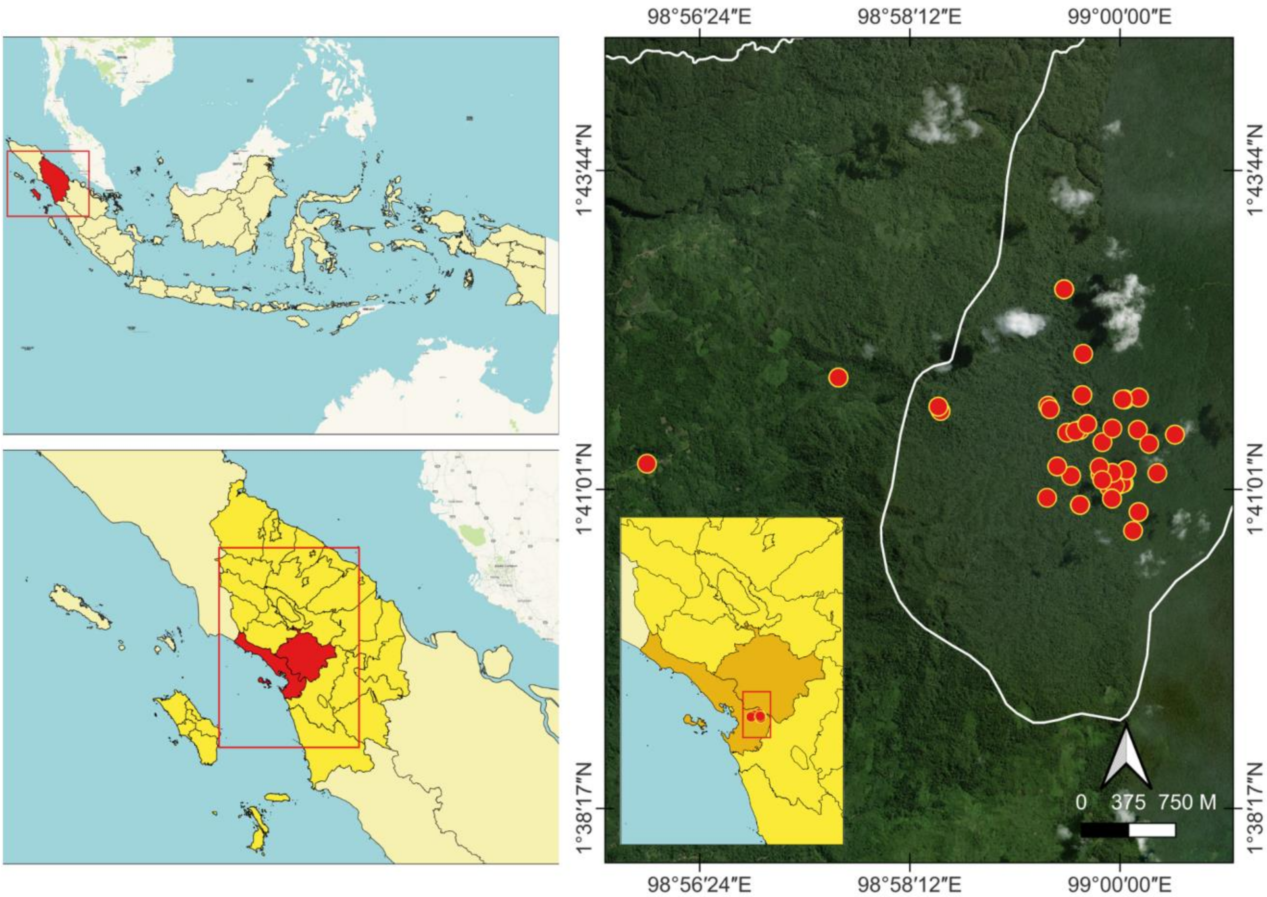

Figure 1. Map of lichen sampling point in Batang Toru Forest, North Sumatra, Indonesia

Lichen identification

Identification of lichens was conducted by: (i) Determine the growth form; foliose, squamulose, crustose or fructocose. These characters are important in separating genera. (ii) Checking the presence of soredia or isidia with a hand lens. These are by far the two most important characters used in identifying lichens at the species level and must be recognized without any doubt. The presence of cilia and the condition of the lower side should also be noted. (iii) Chemical test in lichen was used, i.e., color test and crystal test. The implementation of lichen identification is carried out by adjusting it to the identified lichen pictures, and assisted by using the identification key guide contained in the determination reference book as follows: Brodo (2016), Thomson (2019) and Muvidha (2020). A color test was made simply by applying a drop of reagent on the thallus surface or exposed medulla. If the test is positive, there will be a rapid color change, usually red or yellow; if it is negative nothing will happen. Three different reagents were used, i.e., calcium hypochlorite (bleaching powder, abbreviated C), potassium hydroxide (caustic lye abbreviated K or KOH), and KC. The thallus are cut crosswise and placed on the slide. Each reagent is dripped on the piece across the talus while observing the color change that occurs in the medulla below microscope. It is important to note that not all species of lichens will react to all spot tests, and multiple tests may be necessary to definitively identify a species. Additionally, spot tests can be subject to variation based on environmental conditions and the age of the lichen sample, so it is important to use a combination of morphological, chemical, and molecular methods for accurate lichen identification.

RESULTS AND DISCUSSION

Lichen diversity

We obtained 54 species of lichens consisting of 23 families and 38 genera, as depicted in Figure 1. The number of lichen species in this study is more than the number of lichen species reported by Khairunnisa (2016) in Telagah Forest, the Leuser Ecosystem Area, Langkat Regency, as many as 16 species of lichen with 10 family, and by Hutasuhut (2021) in the Sicikeh-sike Dairi Regency as many as 19 species of lichen with 7 family.

The difference in the number of lichen species obtained at the study sites was caused by study periods, sampling efforts and differences in the area of forest explored and various environmental factors that matched the lichen species habitat. This is in accordance with the opinion of Nascimbene and Marini (2015), the number of lichens that grow is also influenced by the altitude. The higher the sampling area, the more the number of lichens that grows. The West Block of Batang Toru Forest Research Station has environmental factors suitable for lichen growth, such as air humidity of around 33% to 95%, air temperature of 14°C to 31°C, and high rainfall ranging from 4,500 to 5,000 mm per year. According to Porada et al. (2016), lichens grow optimally in a humid environment with a humidity range of 40% to 69% and the optimal temperature for lichen growth is less than 40°C.

Lobariaceae is the most speciose family found in this study. This family belongs to the lichen folios group, with most species that have a specific thallus shape and are easy to recognize. According to Moncada et al. (2013), this family generates rhizomes that function to help attachment to the substrate and are a tool for absorbing food so that this family can grow well on various substrates. Lichens are scattered on various substrates. They live on bark, soil and rock substrates. As depicted in Table 1, of the 54 lichen species found in the study area, 49 species lived on bark substrates, including *Arthonia radiata, Bacidia schweinitzii, Coccocarpia erythroxyli, Lobaria pulmonaria, Pyrenula cruenta* and *Relicina eximbricata*, while 4 species lived on stone substrates namely *Cladonia acuminata, Lepraria albican, Lepraria alpina, Viridothelium virens* and *Cladonia rangiferina* was found in the soil substrate. The most abundant lichen substrate was found in the bark. According to Dittrich et al. (2014), the highest lichen diversity is found in old, large-branched trees and has slow growth. The physical condition of the bark, for example, roughness and contour, may directly influence the shape of the thallus it develops.

Lichen thallus

Lichens exhibit a diverse range of thallus morphologies, including foliose, crustose, fruticose, squamulose and filamentous forms. At our study site, we identified 23 species of lichen, comprising 21 crustose, 4 fruticose, 3 squamulose, 3 filamentous, and the most common type - foliose (Figure 2). The foliose thallus type, characterized by leaf-like lobes, is relatively sensitive to changes in environmental quality and hence, intolerant to unsuitable habitats (Balabanova 2021). Consequently, it is only found in specific ecological conditions, and often in areas with preserved ecosystems, such as the West Block of Batang Forest Research Station Toru.

Lichens display a variety of thallus morphologies, including crustose, foliose, fruticose, squamulose, and filamentous forms. Crustose thallus is shell-like and hard, resembling a brick that grows on tree trunks and dead wooden sticks, with a small scribble-like appearance. This type is difficult to remove without damaging the substrate, and commonly found lichens include *A. radiata, B. schweinitzii, Lecanora circumborealis, Lecidella elaeochroma,* and *V. virens.* Foliose thallus has a leaf-like shape, with an upper cortex layer protected by gelatin, resembling pseudoparenchymatous, and a lower algae layer covered by hyphae, which is often penetrated by haustoria fungi. The medulla, comprising hyphae woven into a broad prosenchyme, occupies the largest part of the thallus and lies beneath the algae layer. The lower cortex, if present, is located below the thallus and has a similar structure to the upper cortex but is thinner, often covered with rhizoidal hyphae or hairs that form the tomentum. This type of thallus is similar in structure to leaves, with an epidermal layer, algal layer, and medulla representing the mesophyll. Notable examples of foliose-type lichens include *Dictyonema thelephora, C. erythroxyli, Parmotrema perlatum,* and *R. eximbricata*.

Table 1. Lichen distribution at the west block research station of Batang Toru Forest, North Tapanuli Regency, North Sumatra, Indonesia

Species	Substrate	Reproduction	Thallus type	Chemical spot test		
				K	C	KC
Arthonia radiata (Pers.) Ach.	Wood	Perithecia	Crustose	+	-	+
Cryptothecia striata G. Thor	Wood	Soredia	Crustose	+	-	+
Pyxine cocoes (Sw.) Nyl.	Wood	Apothecia	Foliose	-	-	+
Chrysothrix chlorina (Ach.) J.R. Laundon	Wood	-	Crustose	+	-	+
Cladonia acuminata (Ach.) Norrl.	Rock	Isidia, Soredia	Squamulose	+	-	-
Cladonia rangiferina (L.) Weber ex F.H.Wigg	Soil	-	Fruticose	+	-	-
Coccocarpia erythroxyli (Spreng.) Swinscow & Krog	Wood	Apothecia	Foliose	+	+	-
Coccocarpia palmicola (Spreng.) Arv. & D.J. Galloway	Wood	Apothecia	Foliose	+	+	+
Coenogonium implexum Nyl.	Wood	Apothecia	Filamentous	+	-	-
Coenogonium linkii Ehrenb.	Wood	-	Filamentous	+	-	-
Coenogonium luteum (Dicks.) Kalb & Lücking	Wood	Apothecia	Crustose	+	-	+
Coenogonium sp.	Wood	-	Filamentous	+	-	-
Collema subflaccidum Degel.	Wood	-	Foliose	+	-	+
Lathagrium cristatum (L.) Otálora, P.M. Jørg. & Wedin	Wood	-	Foliose	+	+	+
Leptogium marginellum (Sw.) Gray	Wood	Apothecia	Foliose	+	-	-
Diorygma antillarum (Vain.) Nelsen, Lücking & Rivas Plata	Wood	Isidia	Crustose	+	+	+
Fissurina cypressi (Müll. Arg.) Lendemer	Wood	Lirellae	Crustose	+	-	+
Fissurina rufula (Mont.) Staiger	Wood	Lirellae	Crustose	+	+	+
Graphis scripta (L.) Ach.	Wood	Lirellae	Crustose	-	+	+
Haematomma persoonii (Fée) A. Massal.	Wood	Apothecia	Crustose	+	+	+
Cora glabrata (Spreng.) Fr.	Wood	-	Foliose	+	-	-
Dictyonema thelephora (Spreng.) Zahlbr.	Wood	Soredia	Foliose	+	-	-
Lecanora circumborealis Brodo & Vitik	Wood	Apothecia	Crustose	+	+	+
Lecidella elaeochroma (Ach.) M. Choisy	Wood	Apothecia	Crustose	+	+	+
Lobaria pulmonaria (L.) Hoffm.	Wood	Apothecia	Foliose	+	-	-
Sticta beauvoisii Delise	Wood	Soredia	Foliose	+	+	-
Sticta fuliginosa (Hoffm.) Ach.	Wood	Isidia, Soredia	Foliose	+	+	+
Sticta hypochroa Vain.	Wood	Soredia	Foliose	+	+	-
Sticta subcaperata (Nyl.) Nyl.	Wood	Apothecia	Foliose	+	-	-
Toensbergia leucococca (R. Sant.) Bendiksby & Timdal	Wood	-	Foliose	+	+	-
Hypocenomyce scalaris (Ach. ex Lilj.) M. Choisy	Wood	Apothecia	Squamulose	+	-	+
Pannaria conoplea (Ach.) Bory	Wood	-	Foliose	+	+	+
Pannaria rubiginosa (Thunb.) Delise	Wood	Apothecia	Foliose	+	-	+
Evernia prunastri (L.) Ach.	Wood	-	Fruticose	+	+	-
Parmotrema perlatum (Huds.) M. Choisy	Wood	Soredia	Foliose	+	-	+
Parmotrema tinctorum (Despr. ex Nyl.) Hale	Wood	-	Foliose	+	-	+
Relicina eximbricata (Gyelnik) Hale	Wood	Apothecia	Foliose	+	-	+
Usnea hirta (L.) Weber ex F.H. Wigg.	Wood	-	Fruticose	+	-	-
Heterodermia rugulosa (Kurok.) Trass	Wood	Apothecia, Isidia	Foliose	+	-	+
Polyblastidium hypoleucum (Ach.) Kalb	Wood	-	Foliose	+	+	+
Polyblastidium japonicum (M. Satô) Kalb	Wood	Soredia	Foliose	+	+	+
Phlyctis argena (Ach.) Flot.	Wood	-	Crustose	+	-	+
Pyrenula cruenta (Mont.) Vain.	Wood	Perithecia	Crustose	+	-	+
Pyrenula mamillana (Ach.) Trevis.	Wood	Perithecia	Crustose	+	+	+
Bacidia schweinitzii (E.Michener) A.Schneider	Wood	-	Crustose	+	+	-
Bacidia sp.	Wood	-	Crustose	+	+	+
Krogia borneensis Kistenich & Timdal	Wood	Apothecia	Squamulose	+	-	-
Lepraria alpina (B. de Lesd.) Tretiach & Baruffo	Rock	-	Crustose	+	+	+
Lepraria incana (L.) Ach.	Wood	-	Crustose	+	+	+
Lepraria lobificans Nyl.	Rock	-	Crustose	+	+	+
Stereocaulon ramulosum Raeusch.	Wood	Soredia	Fruticose	+	+	-
Mycoblastus sanguinarius (L.) Norman	Wood	Apothecia	Crustose	+	+	+
Viridothelium virens (Tuck. ex Michener) Lücking, M.P. Nelsen & Aptroot	Wood, Rock	-	Crustose	+	-	+
Flakea papillata O.E. Erikss.	Wood	Apothecia	Foliose	+	+	-

Note: K: KOH 10%, C: $Ca(OCI)_2$, KC: KOH 10% + $Ca(OCI)_2$

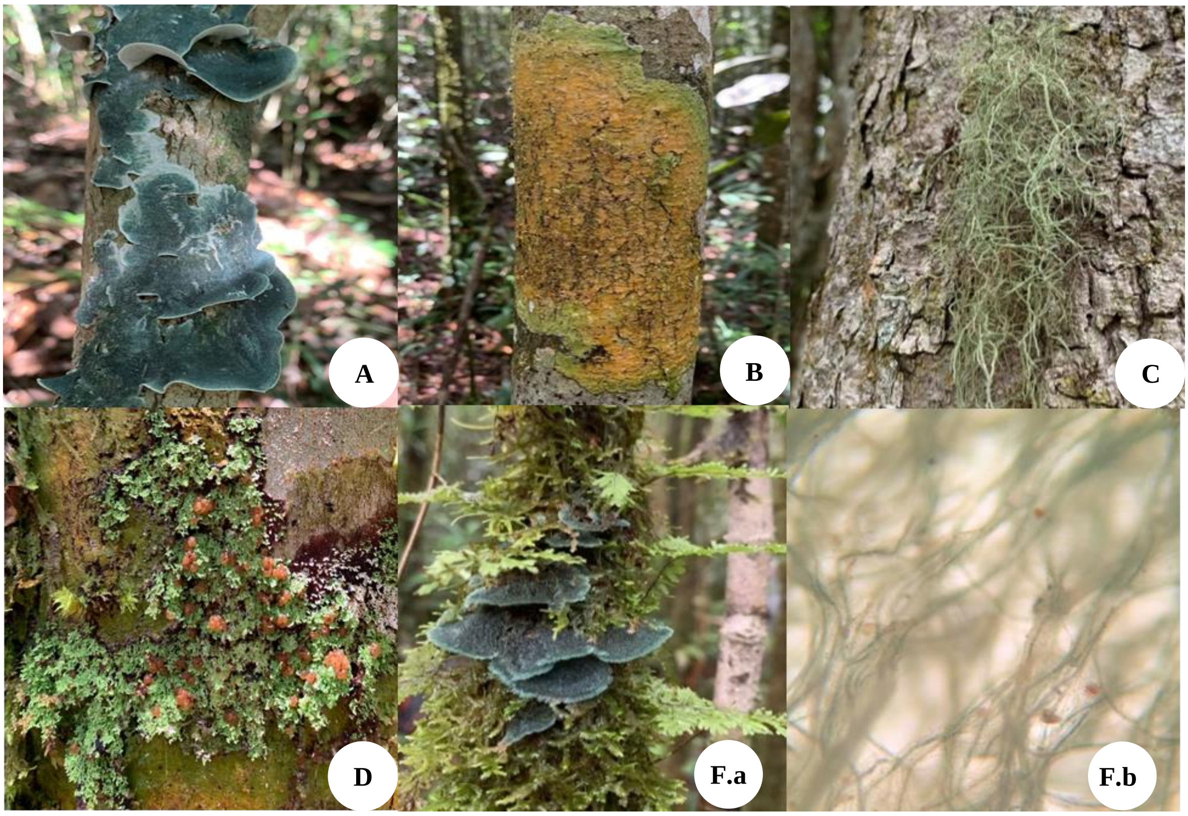

Figure 2. The shape of the lichen thalli: A. Foliose, *Dictyonema thelephora*; B Crustose, *Viridothelium virens*; C. Fruticose, *Cladonia chlorophaea*; D. Squamulose, *Krogia borneensis*; F. Filamentous, *Coenogonium* sp. a. External morphology of the thallus, b. Anatomy of the thallus under the microscope

Fruticose thallus has a cylindrical shape, with an upright and branched structure that resembles a skewed network rather than a horizontal layer. It grows attached to the substrate by one or more root-like rhizines and is commonly found hanging in the air or sticking to trees in the mountains. Some lichens with a fruticose thallus contain antibiotic and anti-cancer compounds. Examples of fruticose lichens include *C. rangiferina, Stereocaulon ramulosum, Usnea hirta,* and *Evernia prunastri*. Squamulose thallus looks like a scale-shaped balance with many small holes or squamules. This type of thallus resembles a crustose talus, with a raised rim above where it grows. Squamulose lichens include *Cladonia chlorophaea, Krogia borneensis,* and *Hypocenomyce scalaris*. Filamentous thallus has a hair-like or thin filamentous shape, resembling fibrous and unbranched strands. This type of thallus is based on the photobiont form, rather than the mycobiont form, and is commonly found in the *Coenogonium* family, including *Coenogonium implexum, Coenogonium linkii, Coenogonium luteum,* and *Coenogonium* sp.

Lichen reproductive structure

Lichen reproduction occurs through two distinct processes: asexual and sexual reproduction. Asexual reproduction happens when the lichen produces soredia and isidia on the surface of its thallus. Sexual reproduction involves the formation of specialized fungal bodies, such as apothecia, perithecia, and lirellae. In this study, the identified reproductive structures of lichens included apothecia, perithecia, lirellae, soredia, and isidia (Figure 3). Apothecia are cup-shaped structures that contain the hymenium, which is composed of an apical structure without paraphyses and an ascus that forms a thin layer extending to the inner surface of the cup. These structures are typically found in crustose lichens, with a diameter ranging from 0.5 to 3 mm. In larger foliose lichens, the diameter of apothecia may reach 10-20 mm (Roth et al. 2021). The identified lichens with apothecia in this study included *Flakea papillata, K. borneensis, Pyxine cocoes,* and *Sticta subcaperata*.

Perithecia, which have a small tube-like ostiolum, peri physes and sometimes paraphyses, are typically globose to flask-shaped and mostly immersed (Réblová et al. 2016). Among the lichens that possess perithecia are *A. radiata* and *P. cruenta*. Lirellae, on the other hand, is a modified apothecium that is elongated, curved, branched, and black-colored, and is often found in the family Graphidaceae. *Fissurina cypressi*, *Fissurina rufula*, and *Graphis scripta* are some of the lichens that exhibit lirellae (Lücking et al. 2013). Soredia, which are powdered forms that occur within nodule-like soralium structures, each give rise to a new thallus under favorable conditions. Soredium hyphae develop from hyphae branching out from the algae layer and encircling one or more algal cells (Zanetti et al. 2015).

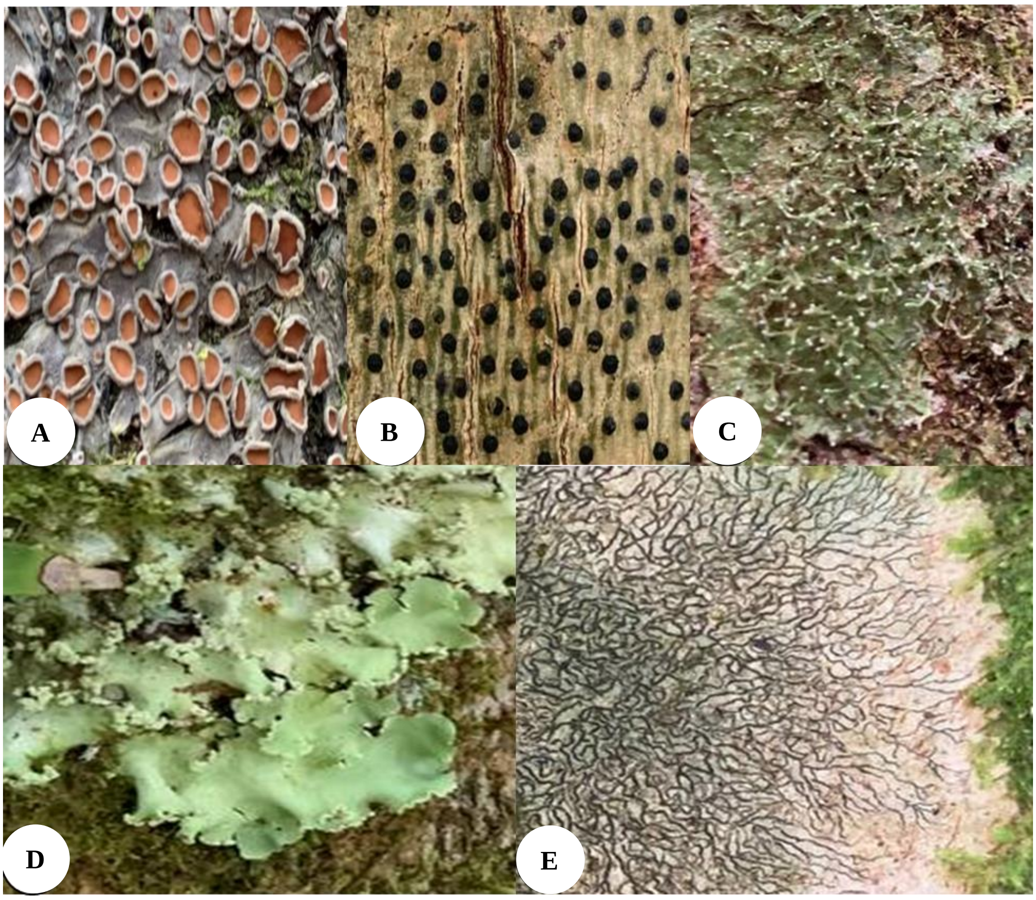

Figure 3. Lichen reproductive structures: A. Apothecia in *Sticta subcaperata*; B. Perithecia in *Pyrenula mamillana*; C. Isidia on *Diorygma antillarum*; D. Soredia on *Parmotrema perlatum*; E. Lirellae on *Fissurina rufula*

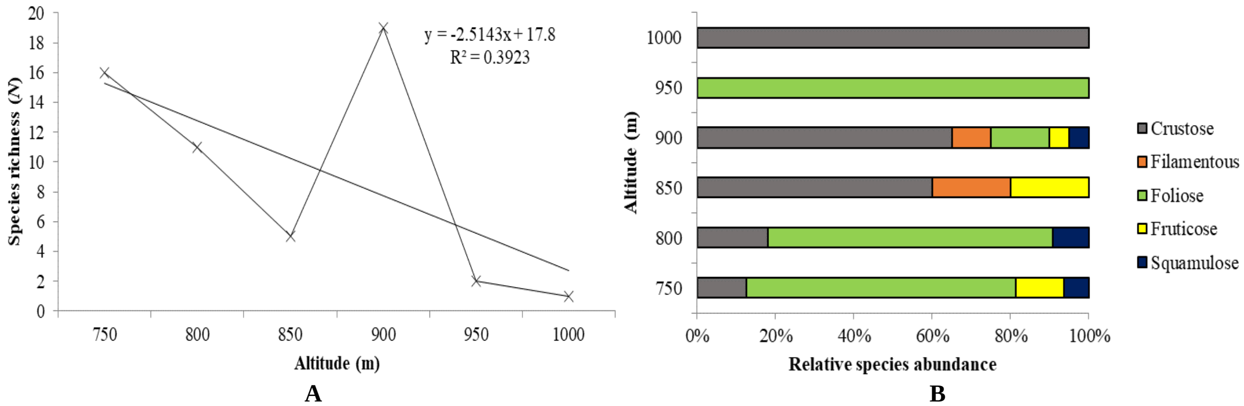

Figure 4. A. Total lichen species richness along elevation gradient; B. Percentage lichen growth form composition along elevation gradient recorded in Batang Toru Forest, North Tapanuli, North Sumatra, Indonesia

Lichens possessing soredia include *Crypthothecia striata* G. Thor, *D. thelephora, P. perlatum*, *Polyblastidium japonicum,* and *Sticta beauvoisii*. Isidia, which are easily broken outer corals that scatter as fragments on the surface of tree bark or other substrates, can become new lichens if they are dry and brittle and are separated from the thallus pieces. The pieces will then be transported by wind or rainwater and deposited in a new location, where they will develop into a new lichen (Ficko 2022). Examples of lichens with isidia include *Diorygma antillarum* and *Heterodermia rugulosa*.

Distribution of lichens along elevation gradient

The lichen community in Batang Toru is distributed based on altitudes and geographical areas as presented in Figure 4A. The community occupies the forest region within the range of 750-1000 m with 54 species. The highest species richness in the community was found at

900 m.a.s.l and declined at 1000 m.a.s.l with only one species. The relationship between altitude and lichen community was analyzed using a linear regression model with a moderate level of correlation (R^2 = 0.3923). The intermediate elevations can function as an intermediary or transitional zone, facilitating the coexistence and interaction of species from both lower and higher elevations. Such ecological conditions can promote higher species diversity.

Our finding was quite different from a study by Kumar et al. (2014) who stated that no significant relationship was found between the number of species and elevation. In addition, elevation, and climatic variables, e.g., precipitation, water humidity, and temperature may be different across altitudinal ranges and affect the species composition of the lichen community in the forest (Bässler et al. 2016). Numerous studies have documented various altitudinal patterns of lichen diversity and distribution, including a decrease or increase with increasing elevation, a hump-shaped distribution, and no trend at all (Baniya et al. 2010; Nascimbene and Marini 2015; Rai et al. 2015). Although the reasons behind these differences remain unknown, it is widely acknowledged that maximum species richness occurs under optimal environmental conditions. The relationship between species richness and altitude is believed to follow a similar pattern to that of latitudinal gradients. This pattern is characterized by a hump-shaped curve, which is attributed to the regional species pool. Environmental factors at high-altitudes may limit the availability of species, resulting in lower diversity in high-altitude communities. It is thought that high-altitude communities are just a subset of the larger regional species pool, and as the size of the species pool decreases with altitude, so does the local species richness (Pinokiyo et al. 2008). Furthermore, Figure 4B illustrates that the occurrence of different types of lichen thallus is dependent on the altitude of the area, with crustose and foliose thalli being more common across different altitudes, while the filamentous thallus is least represented. According to Shukla (2014), crustose thalli are the most efficient of all thallus types due to their minimal water requirements and ability to preserve water by clinging onto the substrate. Crustose lichens can persist over a broad range of altitudes, owing to their capacity to withstand extreme environmental conditions such as temperature fluctuations, drought, and exposure to high levels of UV radiation (Armstrong 2017). These lichens have a unique morphology in the form of a crust, which allows them to grow with minimal water and results in ease of growth. There are two types of crustose lichens, namely epilithic and endolithic, with epilithic types being attached through a multitude of fungal hyphae that form the base of the thallus, while endolithic types are fully embedded within the substrate (Froberg et al. 2011). Due to their simpler thallus structure compared to other lichen types, crustose lichens are more tolerant of air pollution (McCune 2000). Their dense structure provides them with protection against environmental stresses and herbivores, and they are capable of growing on various substrates, including rocks and soil, which allows them to occupy a diverse range of habitats. By using a combination of physiological and morphological mechanisms to adjust to severe environmental conditions, crustose thalli have flourished in a variety of habitats across altitudinal gradients. As a result of this adaptation, crustose lichens can thrive at altitudes above 1000 m where water availability is scarce. According to a recent study by Subbaiyan et al. (2023) conducted in Eastern Ghats, India, the highest diversity of lichens belonging to the crustose-typed parmelioid group was observed in saxicolous habitats based on the substrate they grow on. In contrast, the foliose thallus type has a leaf-like structure with lobes, and Sujetovienė (2017) suggests that this thallus type is relatively intolerant to unfavorable habitats, and is only found in specific environmental conditions. Because of its sensitivity to changes in environmental quality, the foliose thallus type is typically observed in habitats that preserve their natural ecosystems, such as the Batang Toru Forest. Therefore, our study shows that in higher elevations, the diversity of crustose lichens is higher than that of foliose lichens.

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