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Biodiversity of epiphytic lichen at the bodogol nature conservation education center, sukabumi, west java

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ABSTRACT

The Bodogol Education and Nature Conservation Center (PPKA) area is a representative area for lowland mountain tropical forest ecosystems on the island of Java so that the biodiversity in this area is quite high. The purpose of this study was to determine the diversity of lichens found in the Rasamala and Cikaweni lines of PPKA Bodogol, Sukabumi, West Java. Biodiversity research is important because of the presence of lichens as part of biodiversity that is beneficial to the ecosystem. The research method used is descriptive with exploratory techniques. Determination of trees that contain lichens is done by using purposive sampling technique. The results showed that in both pathways, lichens with crustose talus type dominated. On the Rasamala Line, 7 types of lichens were found, while on the Cikaweni Line, 5 types of lichens were found. The species diversity (H') of lichens in the Rasamala pathway was 1.51 while in the Cikaweni route it was 1.18. So based on the Shannon-Wienner formula, the biodiversity in the Rasamala and Cikaweni trails is in the medium category.

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INTRODUCTION

Data from Herbarium Bogoriense Bogor records that lichen biodiversity in Indonesia is about 40,000 species (Suwarso, 1995). The high lichen biodiversity in tropical areas is due to diverse and supporting environmental factors (Fastanti *et al.,* 2020). Opportunities for lichen study are open since only a few researchers focus on lichen study (Ramadhanti *et al.,* 2021). The need for the latest information collection on lichen diversity continues, especially in conservation areas.

The Bodogol Nature Conservation Education Center (PPKA) is a representative of an ecosystem of tropical rainforest area of lowland mountains on Java Island; hence, it has high

biodiversity (Alandana *et al.*, 2015). Bodogol forest has a heterogenous forest that supports the life of various flora, fauna, and microorganism, including lichen. Lichen is a symbiotic association between photosynthetic macroorganisms, namely algae from the green algae group (Chlorophyceae) or Cyanobacteria and fungus from Ascomycetes and Basidiomycetes groups and is united by fungal hyphae mass (Campbell *et al.*, 2012).

The selection of Rasamala and Cikaweni routes in Bodogol areas is due to both routes having a habitat condition that support the growth of lichen. Rasamala route has a habitat condition dominated by rocks and muddy ground with loose canopy cover (Deslina *et al.*, 2021), a temperature of 24.40°C, and a humidity of 85% (Yuniar *et al.*, 2014). The Cikaweni route has a more open forest floor, fewer rotting twigs and branches, and the sun could penetrate the forest floor around 25-35% (Fahri *et al.*, 2015). It has a humidity of 76% and a temperature of 22.99°C (Yuniar *et al.*, 2014). A study by Murningsih *et al.* (2016) supports the statement by indicating that light intensity affects lichen growth since it is needed for photosynthesis. An optimum temperature for lichen growth is under 40° C and a temperature above 45°C will damage lichen's chlorophyll and disturb the photosynthesis process. Humidity is also a key factor for lichen growth since it can live in a moist habitat (85%); however, humidity above 85% can reduce photosynthesis effectiveness.

Studies on lichen diversity in PPKA Bodogol West Java are limited. Several reported studies on lichen in the Java area include those in the Geopark area Cileteuh Sukabumi, West Java (Permatasari *et al.*, 2016), Kamojang, West Java (Kusmoro *et al.*, 2018), Great Forest Park, East Java (Jannah *et al.*, 2019), Jatinangor, West Java (Kusmoro *et al.*, 2019), and Mount Halimun Salak National Park, West Java (Fastanti *et al.*, 2020). However, only a small number of studies on lichen biodiversity are reported in the area of Mount Gede Pangrango National Park, especially in PPKA Bodogol. Therefore, the current research focuses on providing new information regarding lichen diversity in the Rasamala and Cikaweni routes in PPKA Bodogol.

Lichen plays a significant role in the environment as a pioneer organism in an extreme environment and a bioindicator of environmental change. Lichen can live in extreme environmental conditions since it requires minimum living conditions and is resistant to low water conditions for a long period. Lichen is prone to pollution thus it can be a bioindicator of environmental change (Rindita *et al.*, 2015). Based on the aforementioned, it is important to conduct a study on lichen biodiversity in Rasamala and Cikaweni routes in PPKA Bodogol, Sukabumi West Java due to its existence as part of biodiversity and its benefits for the ecosystem.

The study aims to identify lichen biodiversity in Rasamala and Cikaweni routes in PPKA Bodogol, Sukabumi West Java and it is expected to become a reference for lichen species in the location.

RESEARCH METHODS

Research Design

The research employed a descriptive method with an exploration technique, which was observing lichen samples by exploring Rasamala and Cikaweni hiking trails. Selection of the tree samples that contain lichen used purposive sampling by tracing the routes. The research was conducted on June 19-22, 2021 at the area of the Bodogol Nature Conservation Education Center (PPKA) located on the slopes of Mount Gede Pangrango Sukabumi West Jawa, particularly in Rasamala and Cikaweni routes.

Population and Samples

The research population included all epiphytic lichens on the trees along the Rasamala and Cikaweni routes at PPKA Bodogol. The tree selection was conducted by following the routes using a purposive sampling method, which was by taking a chest-high plots in tree parts near the routes.

The chest-high plots were selected since it was impossible to reach the whole sides of the high trees or those near the cliff. The minimum sample observed was epiphytic lichen species on 30 trees in each route.

Instruments

Tools used in the research consisted of Google Maps, a thermometer, a hygrometer, a GLAMA app (*Gap Light Analysis Mobile App*), magnifying glass, clear plastic size 10 cm x 10 cm (Figure. 1), stationary, field books, and camera. Materials needed for the research included lichens, an identification book, and a lichen field guide.

Figure 1. A plot of Clear Plastic size 10 cm X 10 cm

Procedures

Steps in the research comprised determining the observation location on the Rasamala and Cikaweni routes, observing lichens found and writing down their characteristics and number of individuals, and documenting them in color images. The next step was data collection on lichens found along the routes. The lichen data were analyzed based on their characters and identified data of environmental parameters on both routes. Further, lichen species were identified using a field guide and carried out data processing (Figure 2).

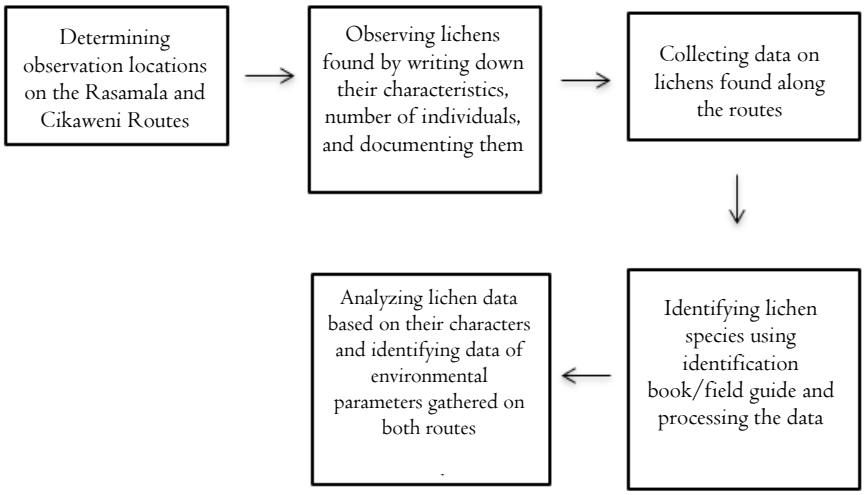

Figure 2. The procedure of lichen biodiversity research at the PPKA Bodogol.

Data Analysis

The data were analyzed in a quantitative descriptive manner. Damayanti (2006) stated that sample data obtained were calculated for their relative dominance (DR), absolute frequency (FM),

relative frequency (FR), Importance Value Index (INP), and species diversity (H'). Diversity is categorized into three types, low, moderate, and high as indicated in Table 1.

$$DR = \frac{absolute\ domunance\ of\ species\ i}{total\ frequency\ of\ species\ i}$$

$$FM = \frac{number\ of\ subplot\ where\ a\ species\ found}{Number\ of\ all\ observation\ subplot}$$

$$FR = \frac{absolute\ frequency\ of\ species\ i}{Total\ frequency\ species\ i}\ x\ 100\%$$

$$INP = FR + DR$$

Next, the calculation of species diversity (H') followed Shannon – Wienner:

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

$$H' = -\sum_{i=1}^{n} \left[\frac{n_i}{N} \ln \frac{n_i}{N} \right]$$

Where:
Pi = Comparison of total individuals of a species to total species
n = Total species
ni = Total individual per species i (i= 1,2,3,...n)
N = Total individual species found
ln = Natural logarithm

Table 1. Classification of Shannon – Wiener diversity index score

Shannon – Wiener index score	Category
<1	Low diversity, low distribution of each species individuals, and low community stability.
1-3	Moderate diversity, moderate distribution of the number of individuals of each species, and moderate community stability.
>3	High diversity, high distribution of the number of individuals of each species, and high community stability.

RESULTS

Tracing on the Rasamala route found lichen from 7 genera in 30 plots installed along the route. Lichen species found included *Lepraria* sp., *Hafellia* sp., *Cryptothecia* sp., *Parmelia* sp. *Graphis* sp. *Dirinaria* sp., and *Cladonia* sp. (Table 2).

Table 2. Lichen Species on Rasamala Route

Lichen Species	Thallus Type	Substrate Tree Species	Number of Plot
Lepraria sp.	Crustose	*Syzygium polyanthum* *Ficus fistulosa* *Cyathea* sp.	8
Hafellia sp.	Crustose	*Syzygium polyanthum*	1

Parmelia sp.	Crustose	*Syzygium polyanthum* *Altingia excelsa*	4
Cryptothecia sp.	Foliose	*Ficus fistulosa* *Dendrocnide stimulans* *Altingia excelsa* *Mangifera ochrata*	12
Graphis sp.	Crustose	*Altingia excelsa*	2
Dirinaria sp.	Crustose	*Cyathea* sp.	2
Cladonia sp.	Squamulose	*Castanopsis argentea*	1
	Total		30

Tracing in the Cikaweni route found lichen from 5 species in 30 plots installed along the route. The dominant lichen found was *Lepraria* sp., which was found in 18 plots. *Parmelia* sp. was dominant in 4 plots and followed by *Graphis* sp. and *Cryprolechia* sp. each dominant in 3 plots and *Cryptothecia* sp. that only dominant in 2 plots (Table 3).

Table 3. Lichen Species in the Cikaweni Route

Lichen Species	Thallus Type	Substrate Tree Species	Number of Plot
Lepraria sp.	Crustose	*Schima wallichii* *Pinus merkusii* *Calliandra sp.*	8
Cryptothecia sp.	Crustose	*Pinus merkusii* *Ficus ribes*	3
Graphis sp.	Crustose	*Pinus merkusii* *Maesopsos eminii*	2
Parmelia sp.	Foliose	*Pinus merkusii*	4
Cryprolechia sp.	Crustose	*Maesopsos eminii* *Calliandra sp.*	2
	Total		30

Table 4. The Values of Relative Dominance (DR), Absolute Frequency (FM), Relative Frequency (FR), Importance Value Index (INP), and Species Diversity (Ĥ) of Lichen Species in the Rasamala Route in PPKA Bodogol

No.	Lichen Species	DR (%)	FM	FR (%)	INP (%)	Ĥ
1.	*Lepraria* sp.	26,67	0,29	29,9	56,57	0.35
2.	*Hafellia* sp.	3,33	0,03	3,10	6,43	0,11
3.	*Parmelia* sp.	13,33	0,11	11,34	24,67	0,26
4.	*Cryptothecia* sp.	40	0,42	41,23	81,23	0,36
5.	*Graphis* sp.	6,67	0,08	7,21	13,88	0,16
6.	*Dirinaria* sp.	6,67	0,04	4,12	10,79	0,16
7.	*Cladonia* sp.	3,33	0,03	3,10	6,43	0,11
	Total	100	1,00	100	200	**1,51**

The species diversity (H') in the Rasamala route was 1.51 (Table 4), whereas in the Cikaweni route was 1.18 (Table 5).

Table 5. The Values of Relative Dominance (DR), Absolute Frequency (FM), Relative Frequency (FR), Importance Value Index (INP), and Species Diversity (Ĥ) of Lichen Species in the Cikaweni Route in PPKA Bodogol

No.	Lichen Species	DR (%)	FM	FR (%)	INP (%)	Ĥ
1	*Lepraria* sp.	60	0,59	59	119	0,3
2	*Cryptothecia* sp.	10	0,10	10	20	0,23
3	*Graphis* sp.	6,67	0,07	7	13,67	0,16
4	*Parmelia* sp.	13,33	0,11	11	24,33	0,26
5	*Cryptolechia* sp.	10	0,13	13	23	0,23
	Total	100	1,00	100	200	**1,18**

DISCUSSION

Lichen from *Cryptothecia* sp. had the highest distribution in 12 out of 30 plots installed. The species are mostly found in tree substrate that has rough and cracked bark, such as *Altingia excelsa* and *Ficus fistulosa*. Similarly, Ernilasari (2014) states that *Cryptothecia* sp. is a lichen that has a wide distribution in tropical areas and can live on a rough or smooth surface of tree bark (Figure 3) that is tolerant to the air quality of the environment. Moreover, Handoko (2015) opines that *Cryptothecia* sp. is a common species of crustose due to its morphology and character that is resistant to drought or lack of water. The body of *Cryptothecia* sp sticks to the thin bark thus minimizing water usage since the bark tissue fulfills its fewer water needs (Figure 3b).

The least found lichen species in the Rasamala route was from *Hafellia* genus. This lichen is cosmopolitan or easily found due to its high spread (Galloway & Morberg, 2005); however, the current research only found a few of this species. This might be related to the number of colonies of this species not dominant in the observation location. Several studies suggest that the number of lichen is decreasing due to extreme environmental conditions and human activity disorders (Galloway & Morberg, 2005).

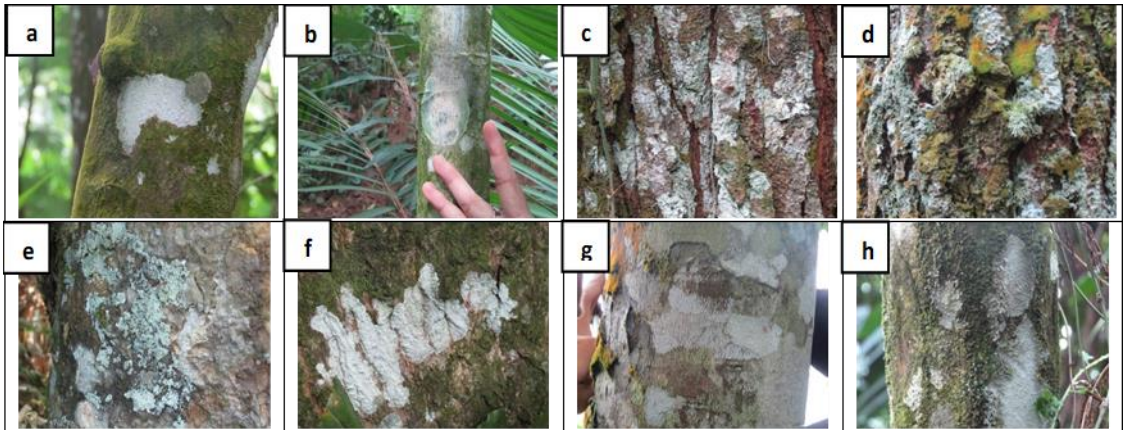

Figure 3. Lichen Morphology in Rasamala and Cikaweni Routes: (a) *Lepraria* sp. (b) *Cryptothecia* sp. (c) *Graphis* sp. (d) *Parmelia* sp. (e) *Cladonia* sp. (f) *Cryprolechia* sp. (g) *Hafellia* sp. (h) *Dirinaria* sp.

Lepraria sp. was dominant in the Cikaweni route since it is a cosmopolitan and tolerant species. Fiedaos et al (2017) state that *Lepraria* sp. is a tolerant lichen since it can be found in all

observation locations both in an area with clean and polluted air. On the other hand, lichen from Graphis sp. was hardly found in the route. (Figure 3c).

Data presentation in Table 1 and Table 2 indicate that both locations had differences and similarities in terms of lichen vegetation. The two locations had 4 similar species of lichen vegetation and 4 different species of lichen vegetation. The similar species was *Parmelia* sp (Figure 3d). The species is a lichen with an excessive distribution due to its high adaptation to abiotic factors such as light intensity, humidity, and temperature (Hadiyati, Setyawati, & Mukarlina, 2013). It is tolerant to pollutants, such as sulfur; thus, it has a wide life span.

Figure 4. General Condition in Rasamala and Cikaweni Routes: (A) Rasamala Route. (B) Cikaweni Route

In both routes, lichen of crustose type was dominant compared to foliose and squamulose since this type is in the form of crust and tends to stick on the stem thus it requires less water. This illustrates that crustose is easy to grow due to lichen growth that is affected by the host plant and plant age (Jumaidi, 2012). Istam (2007) in Asih (2013) expresses that some lichen species can adapt because of their morphology. The crust shape of the crustose and its lower parts that stick evenly to the substrate is influenced by the humidity factor and sufficient water availability; hence, the need for water for all parts of the thallus is met. In the current research, squamulose was only found in the Rasamala route with its substrate, which is *Castanopsis argentea.*

The species diversity (H') in the Rasamala route was 1.51 (Table 4), whereas in the Cikaweni route was 1.18 (Table 5). The Shannon – Wienner formula asserts that if the value of species diversity is $H' = 1 \leq H' \leq 3$, then the species diversity is moderate. Therefore, the lichen diversity in Rasamala and Cikaweni routes is moderate. Differences in the lichen species diversity in both routes were due to other factors. Bua (2013) states that environmental factors can affect a species' diversity including lichen growth. The factors are temperature, substrate plant species, humidity, light intensity, and topography.

The Rasamala route is located at an altitude of 750-822 meters above sea level and the Cikaweni route is at 757-822 meters above sea level. The Rasamala route had an average canopy cover index of 63.55%, whereas the Cikaweni route was only 59.45%. The canopy measurement used the GLAMA app (*Gap Light Analysis Mobile App*). Canopy cover influences diversity since lichen needs light for photosynthesis (Soedaryanto, 1992). The average temperature in Rasamala and Cikaweni routes was 23.45°C and 24.49°C, respectively. Lichens have a good life range or temperature tolerance thus they can live at a low or high temperatures. The optimum temperature for lichen growth is below 40°C and a temperature above 45°C can harm lichen chlorophyll which will disturb the photosynthesis activities. The average humidity in Rasamala and Cikaweni routes was respectively 45,71% and 43,45%. According to Noer (2004), lichens prefer habitats with humidity from 40% to 69%. Therefore, the Rasamala route has more lichen species. However, air conditions in the Rasamala route are polluted because it is often crossed by vehicles (Figure 4a). The Cikaweni route, on the other hand, still has pine stands with a wide distribution (Figure 4b).

This is a factor for the existence of air pollution-tolerant lichen species, such as *Cryptothecia* sp., *Parmelia* sp., and *Lepraria* sp.

Obstacles in completing the article on lichen diversity research in Rasamala and Cikaweni routes, PPKA Bodogol include the difficulties in collecting data due to the slippery route during rainy days and the far distance location to obtain data that could represent the routes. The collection of lichen plots was conducted once for each tree. Moreover, trees that contain lichen were often located on the edge of the cliff so the collection was only conducted on the tree sides near the road since it was difficult to reach all sides of the tree at chest level.

CONCLUSION

The research found 7 lichen species in the Rasamala route, namely *Lepraria* sp., *Hafellia* sp., *Cryptothecia* sp., *Parmelia* sp. *Graphis* sp. *Dirinaria* sp., and *Cladonia* sp., whereas in the Cikaweni route the species found include *Lepraria* sp., *Parmelia* sp., *Graphis* sp., *Cryprolechia* sp., and *Cryptothecia* sp. The lichen species diversity (H') in the Rasamala route was 1.51 and 1.18 in the Cikaweni route. Lichen diversity in both routes was in the moderate category. Differences in the lichen species diversity in both routes were due to the effect of temperature, humidity, light intensity, and topography. The research implication is that it provides new information on lichen diversity and differences in Cikaweni and Rasamala routes as an effort of lichen conservation.

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