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Species Diversity and Distribution Area of Lichen in Baturraden Botanical Garden, Banyumas

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ABSTRACT

Lichen is a symbiotic organism between fungi and algae which is used as a bioindicator of air pollution. This study aims to determine the diversity of species and distribution areas of lichen in Baturraden Botanical Garden, Banyumas Regency by using purposive random sampling method. Sampling was carried out at three stations, namely flora of Java forest (Javanese mountain plants), resin tree forest (damar forest), and natural forest. Based on the results of the research at the three observation stations, 10 species of lichen were found. The lichens found belonged to 8 families including *Cryptothecia striata* (Family *Arthoniaceae*), *Dirinaria picta* (Family *Caliciaceae*), *Graphis scripta* and *Diorygma poitaei* (Family *Graphidaceae*), *Parmotrema austrosinense* and *Parmotrema perlatum* (Family *Parmeliaceae*), *Psilolechia lucida* (Family *Psilolechiaceae*), *Lepraria caeosioalba* (Family *Stereocaulaceae*), *Normandina pulchella* (Family Verrucariaceae), *Opegrapha atra* (Family *Opegraphaceae*). The thallus types of lichen found were *foliose*, *crustose*, and *squamulose* species. The average value of the species diversity index from the three stations is H' = 1.493 in the moderate abundance category. The distribution of lichens in Baturraden Botanical Garden is influenced by climatic factors (light intensity, air temperature, humidity), topographic factors (altitude) and environmental conditions.

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1. Introduction

Lichen is a symbiotic organism which is highly advantageous for the environment. The symbiosis is between fungi (mikobiont) from the *Ascomycetes* and *Basidiomycetes* group and algae (fikobiont) from the *Cyanobacteria* or *Chlorophyceae* group. Algae are nutrient-contributing organisms for the life of lichens, while fungi serve to provide a supply of water and minerals needed by the algae[9]. Lichen is one of the organisms used as a bioindicator of air pollution because it easily absorbs chemicals in the air and rainwater[2]. Bioindicators are organisms whose presence can be used to detect, identify and qualify environmental pollution. The response of bioindicators to pollutants is often reflected in their cumulative impact on the function and diversity of the surrounding environment compared to monitoring instruments[10]. *Corticolous lichen* (epiphyte lichen) is an important component of forest ecosystems that is very sensitive to environmental

changes caused by air pollution and climate changes. Distribution and diversity analysis of corticolous lichen communities can be used practically in environmental quality analysis[18].

Based on the results of research conducted by Mafaza et al.[7] regarding the diversity of lichen species in Semarang City, 18 lichen species were found, of which 13 species have been identified and 5 species have not. There are about 40,000 species of lichen in Indonesia[2]. However, the reality is that in biology books only a few species have been identified. In addition, exploration of lichen has not been done much so that the potential for researching lichen is broadly open.

Based on observations, Baturraden Botanical Garden is a conservation area for various plant species to form and develop new habitats. Previous research on the potential of lichens in Baturraden Botanical Garden has never been made. As such, this research is important to determine the diversity of species and distribution areas of lichens. The purpose of this study was to find out the diversity of species and distribution areas of lichens in Baturraden Botanical Garden, Banyumas Regency.

2. Method

2.1. Tools and Materials

The tools used in this research were stationery, measuring tape, raffia rope, scissors, pegs, magnifying lens, digital camera, lux meter, thermometer, hygrometer, and altimeter. The material used in this study was lichen found at the sampling site.

2.2. Field Observations

Field observations were carried out to identify the conditions of the research location that would be used. Field observations also served to determine the sampling techniques and methods for the research.

2.3. Sampling

Sampling was determined based on the type of location and the presence of lichen on the host tree which could represent the Baturraden Botanical Garden. Lichen data collection was carried out at three locations or observation stations from five selected stations, namely Flora of Java forest (Javanese mountain plants), resin tree (damar) forest, and natural forest by purposive random sampling, namely choosing deliberately but randomly in determining the locations (research stations) which were considered to represent the lichen communities[9].

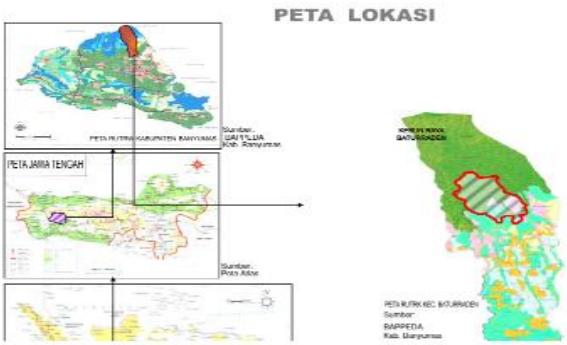

Fig. 1. Research Site Map of Baturraden Botanical Garden[8]

Lichen sampling at each observation station was carried out on six plots measuring 10 × 10 meters which represented the area of each station with a distance between plots of 10 meters. Three (3) host trees were taken from each plot. Sampling of lichen in each host tree was carried out on the surface of the bark of the tree located at the height of 50 cm - 150 cm from the ground surface.

Furthermore, records were made on the types of lichens, then documented using a digital camera to facilitate identification.

2.4. Identification Process

Lichen identification was done by examining the morphological characteristics of each of the samples obtained from the research area, namely shape and color of the lichen thallus based on references from the lichen web portals and supporting journals. Upon identification, the samples obtained from the research area were recorded in the observation table based on the sampling point and were not proceeded to the herbarium specimen making process.

The host trees used as a substrate for lichen growth were documented for the identification process by examining the morphology of the stems and leaves based on literature reference. In addition, there were host trees that had been recorded in the inventory of the administrator of Baturraden Botanical Garden, hence further identification was not required.

2.5. Data Analysis

Diversity Index

According to Fachrul (2007), the diversity of species in a community can be identified from the diversity index. According to Odum (1971) the species diversity index based on the Shannon-Wiener formula is as follows.

$$H' = -\sum (ni/N) \log (ni/N)$$

Where:
H' = Shannon-Wiener diversity index
N = Total Number of individuals of all species
ni = Number of individuals of a certain species i
Pi = Probability of interest for each species (ni/N)
Ln = Natural logarithm
The value of the species diversity index according to Shannon-Wiener is defined as follows.

H' ≥ 3 = species diversity in transect is high
H' 1 ≤ H' ≤ 3 = species diversity in transect is medium
H ≤ 1 = species diversity in transect is low

Dominance Index

The dominance index was calculated using the Simpson index formula as follows.

$C = \sum Pi^2$ where $Pi = ni/N$

Description:
C = Simpson dominance index
ni = number of individuals of a species
N = number of individuals of all species

The criteria used to interpret the dominance of plant species is that the closer to zero a value means the lower the index or dominance of one plant species, while the closer to one a value means the greater the index and the tendency of dominance of several plant species[15].

Evenness Index

The evenness was calculated using the Evenness Index formula.

E = H' / Ln S

Description:
H' = Shannon-Wiener Index
S = Number of Species
E = Evenness Index

Ln = Natural Logarithm

Evenness Index Categories
$E \geq 0,5$ = Even criteria
$0,21 \leq E \leq 0,5$ = Sufficiently even criteria
$E \leq 0,20$ = Uneven criteria

2.6. Analysis of Distribution Area Characteristics

The analysis of the distribution area characteristics was carried out using descriptive data analysis based on the collected data, namely data on environmental factors (climatic and topographic factors).

3. Results and Discussion

Based on the results of research conducted at the Baturraden Botanical Garden in Banyumas Regency regarding the diversity of lichen species, 10 species of lichens belonging to 8 families and 6 species of host trees used as substrates for lichen growth were found. The lichen species found in the research area are included in the type of lichen that attaches (epiphytes) to the bark of the host tree (corticolous) and are included in the types of crustose, foliose, squamulose thallus. The data of this study are presented in Table 1 and Figure 2.

Table 1. Species of lichens and host trees found at Baturraden Botanic Garden

No	Family	Species	Host Tree
	Arthoniaceae	*Cryptothecia striata*	*Cinnamomun sintoc*
			Eugenia uniflora
			Agathis dammara
	Caliciaceae	*Dirinaria picta*	*Cinnamomun sintoc*
			Litsea monopetala
	Graphidaceae	*Graphis scripta*	*Agathis dammara*
			Litsea monopetala
			Castanopsis argentea
		Diorygma poitaei	*Litsea monopetala*
	Parmeliaceae	*Parmotrema austrosinense*	*Calliandra calothyrsus*
			Castanopsis argentea
		Parmotrema perlantum	*Agathis dammara*
			Calliandra calothyrsus
	Psilolechiaceae	*Psilolechia lucida*	*Agathis dammara*
	Stereocaulaceae	*Lepraria caesioalba*	*Agathis dammara*
	Verrucariaceae	*Normandina pulchella*	*Agathis dammara*
	Opegraphaceae	*Opegrapha atra*	*Agathis dammara*

Fig. 2.*Cryptothecia striata*

Fig. 3.*Diorygma poitaei*

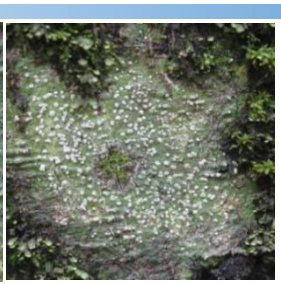

Fig. 4.*Dirinaria picta*

Fig. 5.*Graphis scripta*

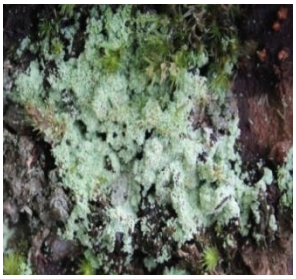

Fig. 6.*Lepraria caesioalba*

Fig. 7.*Normandina pulchella*

Fig. 8.*Opegrapha atra*

Fig. 9.*Parmotrema perlatum*

Fig. 10. *Psilolechia lucida*

Fig. 11. *Parmotrema austrosinense*

Based on the results of the study, the 10 lichen species were grouped into 3 groups of thallus types. The type of crustose thallus (whose structure looks like a layer of crust that is tightly attached to the substrate with varying colors) was found in 7 lichen species namely *Graphis scripta*, *Lepraria caeosioalba*, *Cryptothecia striata*, *Psilolechia lucida*, *Diorygma poitaei*, *Opegrapha atra* and *Dirinaria picta*. The foliose thallus type (whose structure is in the form of sheets like leaves with green to grayish green colors) was found in 2 lichen species namely *Parmotrema perlantum* and *Parmotrema austrosinense*[9]. The squamulose thallus type (thallus structure with lobes and overlapping each other) was found in 1 lichen species of *Normandina pulchella*. The results showed that the crustose thallus type was more commonly found than other types of thallus. The crustose thallus type is the most resistant thallus type compared to other thallus types. This is because lichens with crustose thallus morphology are protected from potential water loss by sticking to their substrates, considering that this type has the characteristic of tightly attaching to the substrate and has the homoiomerous tissue type, in which phycobionts (algae) are located around the hyphae[13].

Furthermore, with regard to the host trees used as substrates for lichen growth in the research area, 6 species of host trees were found. The *Agathis dammara* species was the tree species found in all research stations and was the one with most lichen species grown. The trees most commonly found as host trees generally had rough, cracked bark, with many grooves allowing water to flow from the canopy carrying humus and litter, and fog was more easily bound and collected. In addition, this is due to the bark of trees with soft fiber texture that is easy to penetrate by the roots of epiphytic plants[17].

Furthermore, the analysis of the diversity of lichen species in the research site can be made by calculating the diversity index from the Shannon-Wiener index formula (H'), where Evenness index (E) is used to see the evenness distribution of lichen in the research site, Simpson dominance index (C) is used to obtain information on the species of plants that dominate a community[15] which is presented in Table 2 below.

Table 2. Diversity index values of lichen species at three observation stations in Baturraden Botanical Garden

Type of index	Average
Shannon-Wiener Species Diversity (H')	1,493
Evenness (E)	0,116
Simpson Dominance (C)	0,272

Based on Table 2, it is known that the lichen diversity index at the three stations in the research area had an average value of H' = 1.493 where according to Shannon-Wiener this would be interpreted that the lichen diversity index in the research site in the Baturraden Botanical Garden was moderate because it was in the category $1 \leq H' \leq 3$. The diversity of lichen species found in the research area was moderate, this was due to the significant difference in the number of individuals in the lichen species found in the observation plot[6]. In addition, the forest in the research site was in the climax and stable condition so that it tended to have a moderate diversity index value due to the rare occurrence of disturbances, both by nature and humans[5].

Based on Table 2, the evenness index of lichen species in the research area showed an average value of E = 0.116 with uneven criteria. This was due to the high density of the lichen species of *Cryptothecia striata* at each research station so that it caused the low evenness value in the research area. The inequality in the proportion of density among individuals is caused by the dominance of certain species[16].

Based on Table 2, it was found that the Simpson dominance index (C) of lichen species in all research areas had an average value of C = 0.272 where, according to Setiawan[15], the criteria used to interpret the dominance of plant species is that the closer a value to zero means that the index is lower or there is dominance by one plant species. The species were *Cryptothecia striata* with the highest number and *Opegrapha atra* with the least number. This shows that *Cryptothecia striata* dominated the research area in Baturraden Botanical Garden because species diversity was influenced by the distribution of individuals within each species. In addition, the existing environmental factors were suitable for the habitat of *Cryptothecia striata*, and vice versa[6]. Furthermore, the abundance of a lichen species can be used as an indicator of lichen tolerance and sensitivity to air pollution[19].

3.2. Research Environmental Conditions

Roziaty[14] states that there are several factors that can help the process of lichen distribution in an environment. Vegetative propagation is an efficient way to help it spread. This is also supported by the nature of lichen which has resistance to extreme temperatures and humidity. Lichen growth in the research areas at Baturraden Botanical Garden was influenced by several environmental factors, including climatic factors such as light intensity, humidity, air temperature and topographic factors such as altitude as presented in Table 3.

Table 3. Environmental factors affecting the growth of lichen at Baturraden Botanical Garden in Banyumas.

No	Environmental Factors	Station			Value Range
		I	II	III	
	Light intensity (lux)	394,7	348	215,4	319,3
	Air temperature (ºC)	25	24	23,3	24,1
	Humidity (%)	73,7	76	79	76,2
	Altitude (masl)	666,5	827	1090,4	861,3

[a.] Description:
[b.] Station I : Flora of Java forest (Java mountain vegetation)
[c.] Station II : Resin (Damar) Forest
[d.] Station III : Natural

The lichen found came from different tree bark substrates, with the difference in the tree species as well as the bark textures. The type of substrate greatly determines the type of growing lichen, such as the smoothness of the substrate, the height, and the position of the substrate[7]. Lichens are very dependent on their ability to adapt in finding a place to live or the substrate, in order that they can survive even though the environment is not suitable. Another factor that determines the type and quality of lichen growth is the salt content in the form of water vapor[12].

Table 4. Data of number of lichen individuals at each of the stations at Baturraden Botanical Garden in Banyumas Regency

Station	Number of Individuals
Flora of Java forest (Java mountain vegetation)	224
Resin (Damar) forest	157
Natural forest	29

More lichen species were found at station I than at stations II and III (Table 4). Based on the research at station I (Flora of Java forest), this was due to the following conditions: the air temperature was 25ºC, light intensity was 394.7 lux, humidity was 73.7% and altitude was 666.5 masl. In addition, there were several types of trees that were used as substrates for lichen to grow, there was sufficient light intensity to support lichen growth and the vegetation was not dense. Such a condition is supported by the opinion of Jannah et al.[4] that light is the main factor that determines lichen growth, because photosynthesis that occurs in algae (photobiont) in lichen thallus will occur optimally in areas with sufficient light intensity.

At station II of the damar forest, fewer lichen species were found compared to the ones at station I of the Flora of Java forest (Table 4). Based on the research, the air temperature was 24ºC, light intensity was 348 lux, humidity was 76%, and altitude was 827 masl. In addition, this was because the vegetation at station II (damar forest) was dominated by damar trees only. This shows that homogeneous habitats have less diversity than heterogeneous habitats[1]. Besides, station II was located close to the tourist location of "Pancuran Tujuh" so that there were a lot of vehicle traffic and visitor activities at the tourist attraction.

At station III, fewer lichen species were found compared to the ones at station II damar forest (Table 4). Based on the research, it was found that the air temperature was 23.3ºC, light intensity was 215.4 lux, humidity was 79%, and altitude was 1090.4 meters above sea level. In addition, this was because station III (natural forest) had the forest characteristics of large diameter trees, dense tree vegetation, lack of light intensity to supply lichen growth so that it inhibited lichen growth on tree bark substrates, as well as high topography. Such a condition is supported by the statement of Murningsih & Mafazaa[9] that areas with low light intensity and are shaded would present less number of lichens. Jannah et al.[4] state that areas with an altitude of ≥ 1500 masl have fewer lichen species than areas with an altitude of 1200 masl. Higher areas have large trees so that the area is

shaded. These conditions do not support the growth of lichens which require sufficient amounts of light for photosynthesis.

Furthermore, temperature is also an important factor for plants because temperature determines the rate of chemical reactions and activities in life processes. Temperature is also a climatic factor that supports the existence of a vegetation because temperature affects metabolic processes[11]. The optimal temperature for lichen growth is below 40ºC, while temperatures above 45ºC can damage lichen chlorophyll and may disrupt photosynthetic activity[9]. In addition, the difference in the canopy of the plants that became the sampling location contributed to the differences in environmental conditions at the research sites. The canopy densities at stations 1 and 2 tended to be more open than the canopy density at station 3, so this had an impact on high light intensity, high temperature, and low humidity[3].

4. Conclusion

Based on the results and discussion on the species diversity and the distribution area of lichens in Baturraden Botanical Garden, Banyumas Regency, it can be concluded that the diversity of lichen species in the study area was found to be as many as 10 lichen species belonging to 8 families with an average value of the Shannon-Wiener H' diversity index. = 1,493 with moderate abundance category and that the characteristics of the lichen distribution area in the study area were influenced by environmental factors including climatic factors (air temperature, humidity, light intensity), topographic factors (altitude) and environmental conditions which were the factors for lichen growth.

From this research it is suggested that there be a need for further research on the diversity of edible lichen species in Baturraden Botanical Garden, Banyumas Regency, Central Java.

REFERENCES

[1] Adhitya, F., Ariyanti, N. S., & Djuita, N. R. (2014). Keanekaragaman lumut epifit pada gymnospermae di Kebun Raya Bogor. *Floribunda*, *4*(8), 212–217. https://www.ptti.or.id.

[2] Andrea, E. S., Zuhri, R., & Marlina, L. (2018). *Identifikasi jenis lichen di kawasan objek wisata Teluk Wang Sakti*. *1*(2), 7–14. http://journal.stkipypmbangko.ac.id/index.php/biocolony/article/view/103.

[3] Fandani, S. T., Sulistiyowati, H., & Setiawan, R. (2019). Tingkat pencemaran udara di Desa Silo dan Pace, Kecamatan Silo, Kabupaten Jember dengan menggunakan lichen sebagai bioindikator. *Berkala Sainstek*, *7*(2), 39–42. https://doi.org/10.19184/bst.v7i2.6861.

[4] Jannah, M., Habibi, M., & Madihah, A. (2017). *Studi keanekaragaman lichen di hutan daerah Malang Propinsi Jawa Timur sebagai langkah awal pemanfaatan lichen di Indonesia*. *03*(02), 9–14. http://www.ejournal.unmabanten.ac.id

[5] Kuswantoro, F., Lugrayasa, I. N., & Sujarwo, W. (2018). Studi ekologi kuantitatif hutan pilan sebagai dasar pengembangan Kebun Raya Gianyar. *Jurnal Ilmu Kehutanan*, *12*(2), 184–195. https://doi.org/10.22146/jik.40147

[6] Lusiana, Jamhari, M., & Tangge, L. (2018). *Keanekaragaman jenis lichen di perkebunan kakao Desa Sejahtera Kecamatan Palolo Kabupaten Sigi dan pemanfaatannya sebagai sumber belajar*. *6*(1), 185–190. https://jurnal.fkip.untad.ac.id

[7] Mafaza, H., Murningsih, M., & Jumari, J. (2019). Keanekaragaman jenis lichen di Kota Semarang. *Life Science*, *8*(1), 10–16. https://doi.org/10.15294/lifesci.v8i1.29985

[8] Mandiriati, H., Marsono, D., Poedjirahajoe, E., & Sadono, R. (2016). Konservasi keanekaragaman jenis tumbuhan jawa di Kebun Raya Baturraden di kawasan bekas hutan produksi terbatas. *Jurnal Ilmu Lingkungan*, *14*(1), 33. https://doi.org/10.14710/jil.14.1.33-38

[9] Murningsih, M., & Mafazaa, H. (2016). Jenis-jenis lichen di Kampus Undip Semarang. *Bioma : Berkala Ilmiah Biologi*, *18*(2), 20. https://doi.org/10.14710/bioma.18.2.20-29

[10] Nailufa, L. E., Laelasari, I., Fitriani, M., & Paramadina, A. (2021). Morfologi tipe thalus lichen sebagai bioindikator pencemaran udara di Kudus. *Bioma*, *3*(1), 36–42. https://ojs.unsulbar.ac.id

[11] Nursal, S., & Sirait, I. N. (2013). Karakteristik komposisi dan stratifikasi vegetasi strata pohon komunitas riparian di kawasan hutan wisata Rimbo Tujuh Danau Kabupaten Kampar Provinsi Riau. *Jurnal Biogenesis*, *9*(2), 40–46. http://ejournal.unri.ac.id/index.php/JPSB/article/view/1897

[12] Pratama, A., & Trianto, M. (2020). Keanekaragaman lichen di hutan mangrove Desa Tomoli Kabupaten Parigi Moutong. *Jurnal Pendidikan Biologi*, *5*(3), 140–150. https://doi.org/https://DOI 10.32938/jbe.v5i3.730

[13] Rasyidah. (2018). Kelimpahan lumut kerak (lichens) sebagai bioindikator kualitas udara di kawasan perkotaan Kota Medan. *Klorofil*, *1*(2), 88–92. http://jurnal.uinsu.ac.id/index.php/klorofil/article/view/1601/1288

[14] Roziaty, E. (2016). Review : Kajian lichen : Morfologi, habitat dan bioindikator kualitas udara ambien akibat polusi kendaraan bermotor. *Bioeksperimen: Jurnal Penelitian Biologi*, *2*(1), 54. https://doi.org/10.23917/bioeksperimen.v2i1.1632

[15] Setiawan, H. (2016). Analisis vegetasi kawasan hutan adat lindu untuk penilaian kesehatan hutan daerah penyangga. *Prosiding Seminar Nasional from Basic Science to Comprehensive Education*, 47–53. https://doi.org/https://doi.org/10.24252/psb.v2i1.3655

[16] Sudrajat, W., Setyawati, T. R., & Mukarlina. (2013). Keanekaragaman lichen corticolous pada tiga jalur hijau di Kabupaten Kubu Raya. *Protobiont*, *2*(2), 75–79. https://jurnal.untan.ac.id

[17] Sujalu, A. P. (2017). Identifikasi pohon inang epifit di hutan dipterocarpaceae dataran rendah klimaks Kabupaten Malinau. *ULIN: Jurnal Hutan Tropis*, *1*(2), 196–201. https://doi.org/10.32522/u-jht.v1i2.1014

[18] Susilawati, P. R. (2017). Fruticose dan foliose lichen di Bukit Bibi, Taman Nasional Gunung Merapi. *Jurnal Penelitian*, *21*(1), 12–21. https://e-journal.usd.ac.id/index.php/JP/article/view/879/695

[19] Will-Wolf, S., Jovan, S., Neitlich, P., Peck, J. E., & Rosentreter, R. (2015). Lichen-based indices to quantify responses to climate and air pollution across northeastern U.S.A. *Bryologist*, *118*(1), 59–82. https://doi.org/10.1639/0007-2745-118.1.059