JPBIO (Jurnal Pendidikan Biologi)
Vol. 6, No. 2, November 2021, 220 – 230 //e-ISSN 2540-802X
http://jurnal.stkippersada.ac.id/jurnal/index.php/JBIO/index

Mosses at the bodogol natural conservation education center: species, diversity index, and evenness index

Rizhal Hendi Ristanto*, Hany Qisthina Syahira, Alma Tasya Yuanisa, Aisha Amalia, Riezka Lianita, Ariella Azzahra, Diana Vivanti Sigit

Biology Education, Faculty of Mathematics and Natural Science, Universitas Negeri Jakarta

* Corresponding author: rizhalhendi@unj.ac.id

Article Info

Article History:
Received 01 July 2021
Revised 19 September 2021
Accepted 01 October 2021
Published 30 November 2021

Keywords:
Diversity
Mosses
PPKA Bodogol

ABSTRACT

Mosses or Bryophytes are a group of cryptogamous plants or lower plants. Moss can be found in various places that have high humidity by attaching to various substrates, such as soil, rocks and tree bark. PPKA Bodogol is a potential area that protects endemic flora and fauna on the island of Java that has excellent humidity and air for moss growth and supports moss diversity. This study aims to determine the diversity of mosses and their relationship to environmental factors in the PPKA Bodogol. Data collection in this study was carried out at the PPKA Bodogol on 3 routes, namely Cikaweni, Rasamala and Kanopi. This research uses a purposive sampling method with a cover square technique. The results showed that the total number of moss species identified were 21 species. Then it was also known that the highest level of diversity was found on the Rasamala route with a diversity index of 3.03. In the Cikaweni route, was in moderate category, namely 1,967. The lowest diversity index, however, was in the canopy path with a medium category, namely 1.216. Environmental factors such as humidity, temperature, light intensity, and altitude also had an influence on the level of moss diversity of the three routes.

Citation: Ristanto, R.H., Syahira, H.Q., Yuanisa, A.T., Amalia, A., Lianita, R., Azzahra, A., & Sigit, D.V. (2021). Mosses at the bodogol natural conservation education center: species, diversity index, and evenness index. *JPBIO (Jurnal Pendidikan Biologi), 6*(2), 220-230. DOI: https://doi.org/10.31932/jpbio.v6i2.1308

INTRODUCTION

Various factors influence the distribution pattern of moss diversity, among others ecological and geographical conditions (Maul, Wei, Nebel, Luebert, Quandt, & Kessler, 2020). The diversity of mosses that grow in an area can indicate growth suitability and illustrate the conditions of an ecology system in its surrounding. Mosses in the perspective of ecology can be used as a

bioindicator of environmental quality including air pollution (Kristiyanto, Sitanggang, & Azzahro, 2018).

Indications that influence moss species diversity and abundance are altitude and topography (Endang, Jumiati, & Dyah, 2020). Altitude is related to humidity, light intensity, temperature, and rainfall. According to Putra, Ambarwati, Mubyarsih, & Alesti (2015), altitude causes differences in the chlorophyll content in mosses; the highest the altitude, the lower the chlorophyll content in the mosses.

Moss is a plant with high sensitivity towards environmental changes. Factors of moss species diversity and abundance include microclimate, namely temperature, humidity, light intensity, and air (Putrika, Nisyawati, & Ariyanti, 2017). The moss diversity can be determined according to the conditions of a moist substrate and optimum light intensity. Moreover, Satiyem (2012) opines that moss growth is also influenced by humidity, altitude, air temperature, and pH. These factors are mutually connected and could affect physiological processes occurred in the plant. Moss is a very selective plant towards the conditions of its environmental climate. Microclimate conditions are included in the aspects that influence moss plants in their growth and development processes (Lestiani, Lestari, Rizkia, Pratiwi, Azrai, & Rini, 2021).

Moss is a low-level plant group that lives on land. It generally grows by attaching its substrates, such as trees, moist soil, rocks, and barks (Windadri & Susan, 2013). Differences in the tolerance towards environmental factors of each moss species will affect its adaptation level, species composition, and distribution (Windadri & Susan, 2013; Mulyani, Perwati, & Murningsi, 2015).

Several studies, such as research by Putrika (2012) and by Endang *et al.* (2020), have identified moss diversity that is varied depending on its taxonomy groups and geographical areas. Putrika (2012) discloses that light intensity affects moss diversity. Endang *et al.* (2020), on the other hand, states that temperature and humidity also influence moss diversity. These studies have not revealed the link between various factors influencing moss diversity (Satiyem, 2012). A conservation site is required to preserve moss diversity and benefits.

The Bodogol Natural Conservation Education Center (PPKA) is known as a research and education center located in the Sukabumi region. The main function of the center is to protect the flora and fauna of the Java Island endemic. The PPKA Bodogol forest area is a potential area in Indonesia to represent the richness of the archipelago plants including mosses. It has a heterogeneous forest that supports the life of its flora and fauna. The heterogeneous forest of the PPKA Bodogol has an excellent physical condition and several habitat types that are suitable to become a conservation site for plant diversity, among others various moss types.

Due to the importance of factors influencing moss diversity, the current study aims to expose species, diversity index, and evenness index in the PPKA Bodogol by considering various factors, namely altitude, humidity, temperature, and light intensity. It is expected that the research results become one of the data sources that discuss moss diversity in the PPKA Bodogol and can be used as a basis for moss diversity conservation. Additionally, the research results can become a reference and add supporting data for future moss diversity-related studies.

RESEARCH METHODS

Research Design

The research was carried out at the Bodogol Natural Conservation Education Center (PPKA), Sukabumi, West Java on June 19-22, 2021. The research method was an explorative survey method, namely by collecting and exploring information on the determined population and sample through exploration of the research environment (Adiyanta, 2019).

Population and Samples

The sample was taken using a purposive sampling technique, i.e. sampling with a certain consideration, such as the number of mosses in each plot and factors influencing diversity, namely altitude, humidity, temperature, and light intensity. The research sampling technique used a square-shaped square with $1m^2$ of size and divided by adding 4 horizontal and vertical lines that resulted in a size of 20x20 cm. The exploration routes in the PPKA Bodogol research consisted of Cikaweni, Rasamala, and Kanopi routes. The three routes were chosen based on altitude and humidity that supported moss diversity. Plots were prepared in total 27 plots with 14 plots in the Rasamala route, 10 plots in the Cikaweni route, and 3 plots in the Kanopi route.

Instruments

The research employed the following tools: The Global Positioning System (GPS), compass, altimeter (to measure altitude), lux meter (to measure light intensity), hygrometer (to measure humidity), knives, plastic ropes, cotton ropes, gauge, digital camera, microlens, hand lens, stationary, moss identification book, and data tabulation. The data tabulation consisted of data recording on the number of plots, moss species name, coordinates, moss substrates, and environmental factors of the moss growth, such as temperature, altitude, humidity, and light intensity.

Procedures

The data collection was conducted in the areas of PPKA Bodogol, Sukabumi, West Java. Next, moss species searching took place in the 3 routes, namely Cikaweni, Rasamala, and Kanopi. The Cikaweni route used 10 plots with purposive sampling. Plots were created in each route with a size of 1 m^2 and divided by size of 20x20cm. The plot placement was carried out using the following consideration: the presence of moss species and the number of moss in the plot placement locations. Once the plot placement was completed, morphology identification and determination of moss species found were conducted. The moss species identified in the plots were calculated using a cover square technique. The moss species in the plots were documented using a digital camera and microlens to obtain a more clear species picture. The measurement procedure for environmental factors such as altitude was conducted using an altimeter, whereas a hygrometer was used to measure humidity. Additionally. The temperature was measured using a thermometer and a luxmeter was employed for measuring light intensity.

Data Analysis

The research data analysis employed a qualitative descriptive method by considering the shape of moss morphology and a quantitative method by calculating moss species diversity using Shannon-Wiener (H') Index. The Shannon-Wiener formula on diversity index (H') has several provisions.

Table 1. Provisions of diversity index (H')

Diversity Index Value	Category
H'> 3	High
1<H'<3	Moderate
H'<1	Low

RESULTS

The exploration and observation found two moss classes, namely Bryopsida and Hepaticopsida with 9 species identified. The identified species in the Cikaweni route are presented

in Table 1. The environmental factors in the Cikaweni route consisted of a temperature of 20.2-27.6°C, humidity of 32.2-51.1%, light intensity of 234-1143 lux, and altitude of 823-869 m asl.

Table 2. Spesies found in the Cikaweni Route

Cikaweni Route				
No.	Family	Spesies	Total	Substrate
1	Sphagnaceae	*Sphagnum sp.*	40	Tree
2		*Sphagnum fimbriatum*	11	Rocks
3	Fissidentaceae	*Fissidens* sp.	13	Tree
4	Polytrichaceae	*Polytrichum sp.*	15	Rocks
5	Hypnaceae	*Taxiphyllum* sp.	21	Tree
6	Lophocoliaceae	*Lophocolea bidentata*	17	Soil
7	Meteoriaceae	*Barbella horridula*	9	Tree
8	Pottiaceae	*Tortella tortuosa*	27	Tree
		Total	153	-

The next route was the Rasamala route. There were 14 plots in the route and 3 moss classes were found, namely Bryopsida, Hepaticopsida, and Anthocerotopsida. Moreover, 13 moss species were identified. The identified species in the Rasamala route were presented in Table 2. The environmental factors in the route comprised a temperature of 17.9-27.4°C, humidity of 31.5-50.7%, light intensity of 333-3565 lux, and altitude of 812-836 masl.

Table 3. Species found in the Rasamala Route

Rasamala Route				
No.	Family	Species	Total	Substrate
1	Sphagnaceae	*Sphagnum sp.*	12	Tree
2	Lophocoliaceae	*Lophocolea bidentata*	47	Rocks and soil
3	Dumortiaceae	*Dumortiera hirsuta*	18	Rocks
4	Neckeraceae	*Neckropsis undulata*	21	Rocks
5	Dicranaceae	*Dichodontium* sp.	14	Rocks
6		*Dicranum scoparium*	15	Tree
7	Hypnaceae	*Ectropothecium* sp.	15	Soil
8		*Hypnum cupressiforme*	29	Rocks
9	Anthorecotaceae	*Phaeoceros laevis*	3	Rocks
10	Pallaviciniaceae	*Symphyogyna brasiliensis*	15	Soil
11	Brachytheciaceae	*Brachythecium rutabulum*	14	Soil
12	Amblystegiaceae	*Platdictya confervoide*	5	Rocks
13	Pottiaceae	*Hyophila involuta*	5	Rocks
		Total	213	

The next route was the Kanopi route that had 3 plots and 2 moss classes were found, namely Bryopsida and Hepaticopsida with 4 species identified. The identified species in the Kanopi route could be seen in Table 3. The environmental factors in the Kanopi route included temperature of 21.2-24.0°C, humidity of 32.8-51.2%, light intensity of 354-2871 lux, and altitude of 834-853 masl.

Tabel 4. Species found in the Kanopi Route

Kanopi Route				
No.	Family	Species	Total	Substrate
1	Dumortiaceae	*Dumortiera hirsuta*	18	Rocks and Soil
2	Marchantiaceae	*Marchantia sp.*	17	Rocks
3	Fissidentaceae	*Fissidens* sp.	2	Rocks and Soil
4	Pallaviciniaceae	*Symphyogyna brasiliensis*	14	Soil
		Total	51	

Table 4 discusses the calculation results of diversity index (H'), species richness, and evenness index (E) of mosses found in the Cikaweni, Rasamala, and Kanopi routes. The diversity index was calculated using the Shannon-Wiener formula.

Table 5. Diversity (H'), Evenness, Species Richness, and Evenness Index (E) in Cikaweni, Rasamala, and Kanopi Routes

Route	Species	Total	Diversity Index (H')	Species Richness	Evenness Index (E)
Cikaweni	*Sphagnum sp.*	40	1.967	8	0.646
	Sphagnum fimbriatum	11			
	Fissidens sp.	13			
	Polytrichum sp.	15			
	Taxiphyllum sp.	21			
	Lophocolea bidentata	17			
	Barbella horridula	9			
	Tortella tortuosa	27			
	Total	153			
Rasamala	*Sphagnum sp.*	12	3.003	13	0.986
	Lophocolea bidentata	47			
	Dumortiera hirsuta	18			
	Neckropsis undulata	21			
	Dichodontium sp.	14			
	Dicranum scoparium	15			
	Ectropothecium sp.	15			
	Hypnum cupressiforme	29			
	Phaeoceros laevis	3			
	Symphyogyna brasiliensis	15			
	Brachythecium rutabulum	14			
	Platdictya confervoide	5			
	Hyophila involuta	5			
	Total	213			
Kanopi	*Dumortiera hirsuta*	18	1.216	4	0.399
	Marchantia sp.	17			
	Fissidens sp.	2			
	Symphyogyna brasiliensis	14			
	Total	51			

Table 4 shows that the diversity level of moss species in the Cikaweni and Kanopi routes was moderate with an index value of 1.967 and 1.216, respectively, whereas it was high in the Rasamala route with an index value of 3.003.

Figure 1. Moss species in the PPKA Bodogol. (a) *Sphagnum* sp., (b) *Lophocolea bidentata,* (c) *Dumortiera hirsuta,* (d) *Neckropsis undulata,* (e) *Dichodontium* sp., (f) *Marchantia* sp., (g) *Platdictya confervoide,* (h) *Ectropothecium* sp., (i) *Fissidens* sp., (j) *Polytrichum* sp., (k) *Taxiphyllum* sp., (l) *Sphagnum fimbriatum,* (m) *Barbella horridula,* (n) *Tortella tortuosa,* (o) *Hypnumcupressiforme,* (p) *Barbula unguiculata,* (q) *Phaeoceros laevis,* (r) *Symphyogyna brasiliensis,* (s) *Brachythecium rutabulum,* (t) *Dicranum scoparium,* (u) *Hyophila involuta.*

DISCUSSION

Morphology of Mosses Found

The number of moss species identified in the Bodogol PPKA consisted of 21 species as illustrated in Figure 1. (a) *Sphagnum* sp. moss was found in the Cikaweni and Rasamala routes on

tree substrates. The species has characteristics of pale green color and a pointed phylloid surrounding the cauloid. The moss was found in the sporophyte phase with golden yellow seta and calyptra. (b) *Lophocolea bidentata* moss was found in the Cikaweni and Rasamala routes with rocks and soil substrates. This moss has characteristics of dark green color with a smooth and shiny phylloid surface. The moss is included in the leafy-liverwort with a gametophyte phase. (c) *Dumortiera hirsuta* moss was found in the Rasamala and Kanopi routes with rocks and soil substrates. The mass shape is dichotomous thallus with a dark green color without spots. The thallus form lobes with a smooth and shiny surface. The moss was found in the sporophyte phase with spores are located at the end of the phylloid. (d) *Neckropsis undulata* moss was only found in the Rasamala route with rocks substrate. The moss has a glossy green phylloid with a grain shape. The phylloid is pinnately attached to the cauloid. The cauloid is black and branched. The moss was found in the gametophyte phase. (e) *Dichodontium* sp. moss was only found in the Rasamala route with rocks substrates. The mosses grow acrocarp or upright and have no branches. Its phylloid is like a thin ribbon with a pointed end. The moss was found in the gametophyte phase. (f) *Marchantia* sp. moss was found in the Kanopi route with rocks substrates. The moss was found in the sporophyte phase with spores at the tip of the thallus. The moss characteristics include dark green in color and have spots on its thallus. Midrib was seen on its thallus that is curved inward. The thallus is lobed to form a heart and is dichotomous.

Next, (g) *Platdictya confervoide* moss was found in the Rasamala route with rocks substrates. The moss was found in the gametophyte phase. Phylloid in this moss has a thread-like shape that is very small and upright. The phylloid are lanceolate or ovate-lanceolate and no cauloid was seen. Rhizoid in the moss has a fine and slightly rough texture. (h) *Ectropothecium* sp. was found in the Rasamala route with soil substrates. The moss has a light to dark green pinnate phylloid with a tapered phylloid tip. The moss was found in the gametophyte phase. (i) *Fissidens* sp. was found in the Cikaweni and Kanopi routes with rocks and soil substrates. The moss is generally found to grow along with *Dumortiera hirsuta* species. The moss has characteristics of a light green color, its phylloid is fingered with a pointed phylloid tip, and was found in the gametophyte phase. (j) *Polytrichum* sp. was only found in the Cikaweni route with rocks substrates. The moss was found in the gametophyte phase. It has a grass-like shape and looks stacked phylloid. The phylloid has a long size with a slightly pointed tip and is green. (k) *Taxiphyllum* sp. was found in the Cikaweni route with tree substrates. The species has characteristics of orange color with a fluff-like phylloid. The moss was found in the gametophyte phase.

Next, (l) *Sphagnum fimbriatum* moss was only found in the Cikaweni route with rocks substrates. The phylloid in this moss is sharp and green. The phylloid has a spiral shape that surrounds the cauloid. The moss was identified in the gametophyte phase. (m) *Barbella horridula* moss was only found in the Cikaweni route with tree substrates. The phylloid in the moss surrounds the cauloid and is green to dark green. The moss was found in the gametophyte phase. (n) *Tortella tortuosa* moss was found in the Cikaweni route with tree substrates. The phylloid in the moss appears to be colonized that almost fills the substrates. The phylloid has a star shape. The moss was found in the gametophyte phase. (o) *Hypnumcupressiforme* moss was found in the Rasamala with rocks substrates. The moss grows pleurocarpus or creeps on rocks. Its cauloid is branched and covered with piled phylloid. The phylloid tip is pointed and shiny green. The moss was found in the gametophyte phase. (p) *Barbula unguiculata* was only found in the Rasamala route with tree substrates. Its phylloid are like cushions or clumps with a dark green to pale yellow color. It has an alternating phylloid arrangement; thus, it looks like a pile. The moss was found in the gametophyte phase.

Further, (q) *Phaeoceros laevis* moss was only found in the Rasamala route with rocks substrates. Its thallus is similar to leafy liverwort. The thallus has a smooth surface. The moss was found in a very moist location. Its thallus is dark green and has a horn-like capsule with a size of 1-1.5 cm. (r) *Symphyogyna brasiliensis* moss was found in the Rasamala and Kanopi routes with soil substrates. The moss is included in the leafy-liverwort. It is light green in color with a surface that looks runny and smooth. In its thallus, a dark green midrib is observed. It grows creeping on the substrates. It was found in the gametophyte phase. (s) *Brachythecium rutabulum* moss was only found in the Rasamala route with soil substrates. The phylloid shape is oval with a pointed tip. The cauloid grows pleurocarp with dense and light green phylloid. The moss was found in the gametophyte phase. (t) *Dicranum scoparium* moss was found in the Rasamala route with tree substrates. The moss has a coarse texture and looks like a woolen thread. Its phylloid shape is like an elongated spear with dark green color. The cauloid is not visible. The moss was found in the gametophyte phase. (u) *Hyophila involuta* moss was found in the Rasamala route with rocks substrates. The moss has a pointed phylloid and is seen to be surrounding the cauloid. It was found in the gametophyte phase.

DISCUSSION

Moss Diversity

Based on Table 4, the moss diversity in the Cikaweni route was moderate with an index value of 1.967. The moss diversity in the Rasamala route was high with an index value of 3.003. The moss diversity index in the Kanopi route was moderate with an index value of 1.216. The species with the largest number of individuals in the plots in the Rasamala route was *Lophocolea bidentata*. Species with the lowest number of individuals in the plots in the Kanopi route was *Fissidens* sp.. The calculation of species evenness level used Evenness Index (E) with a provision that the higher the index value, the higher the relative evenness. Based on data obtained, the highest evenness level of the moss types was in the Rasamala route with E=0,986, whereas the lowest evenness level of the moss types was in the Kanopi route with E=0,399.

Relationship between Substrates and Mosses

Moss diversity is influenced by substrate existence. Moist substrate conditions could help mosses in their development to produce new individuals. Types of mosses identified in the research routes (Rasamala, Cikawen, and Kanopi) were found in different substrates, namely soil, rocks, and tree.

The Rasamala route had moss diversity that was mostly found on rocks substrate, which was 8 families, namely Lophocoliaceae, Dumortiaceae, Neckeraceae, Dicranaceae, Hypnaceae, Anthorecotaceae, Amblystegiaceae, and Pottiaceae. This suggests that rocks have sufficient water content for moss growth (Riani, 2017). This was due to a fairly open canopy cover that allows moss to perform photosynthesis since it has sufficient light. Rocks that have a rough surface can accommodate water in their basin that make them wet; therefore, moss spores could fall with support from adequate sunlight intensity to make the moss grow and develop.

The Cikaweni route had moss diversity that was mostly found on tree substrate. There were 5 families, namely Sphagnaceae, Fissidentaceae, Hypnaceae, Meteoriaceae, and Pottiaceae. This indicates that mosses found on the tree have light intensity and humidity that are enough in supporting their growth. Types of trees covered with moss mostly have rough tree bark. Rough tree bark is able to store and absorb rainwater that can be absorbed by the mosses (Saputra, 2013). In the Kanopi route, moss diversity was mostly found on rocks and soil substrates that consisted of 4 families, namely Dumortiaceae, Marchantiaceae, Fissidentaceae, and Pallaviciniaceae. The moss diversity mostly identified in this route was in the Hepaticopsida class. This suggests that the route

has the highest humidity compared to other routes. Air humidity has a significant effect on moss growth since it can support the photosynthesis process.

Based on its substrate, mosses in the Cikaweni route were mostly found on tree bark. Mosses that grow on tree bark cause light intensity and humidity in the location where the mosses are found are sufficient in supporting their growth. This is related to the moss growing locations that are not exposed to direct sunlight (Lestiani, et al, 2021).

Relationship between Environmental Factors and Mosses

The environmental factors in the Cikaweni route consisted of and an average temperature of 23.9°C, average humidity of 41.7%, an average light intensity of 689 lux, and an average altitude of 846 masl. Mosses that dominantly grow in this route come from the Sphagnaceae family with species of *Sphagnum* sp. and *Sphagnum fimbriatum*. The data collection in this route was carried out in the afternoon thus the detected temperature was fairly high with low humidity. Lukitasari Lukitasari (2018) stated that the Sphagnaceae family, especially *Sphagnum* sp., has the ability to store more water used by mosses to retain moisture.

The environmental factors in the Rasamala route included and average temperature of 22.7°C, average humidity of 41.1%, average light intensity of1949 lux, and average altitude of 824 masl. Mosses that dominantly grow in this route come from Lophocoliaceae family with species of *Lophocolea bidentata*. The PPKA Bodogol is a tropical rainforest and according to research (Aristria, Parwati, & Wiryani, 2014), leafy-liverwort, such as Jungermanniidae and Lophocoliaceae, thrives in this tropical forest area.

The environmental factors in this route are the beautiful mountain environment and the authenticity of the forest is still maintained. However, due to many vehicles passing by the route, it has more air pollution compared to other routes in the PPKA Bodogol. *Lophocolea bidentata* had a richness that dominated this route since it is able to survive in this kind of environment. according to Lukitasari (2018), the Plagiochila family has a similar morphology to *Lophocolea bidentata*, namely it has an oil body that serves to protect cells from drought. Additionally, mosses found in this route had incomplete morphology because they were stepped on or damaged. This indicates that mosses could absorb pollutants through their phylloid surface and are accumulated in the cells; therefore, the moss morphology is imperfect as in other routes that have their air maintained (Lukitasari, 2018).

Leaf mosses were mostly found in the Rasamala route and the liverworts found were dominated by leafy liverworts. This can be linked to the fairly open canopy cover; thus, the route has a sufficient light requirement that allows mosses to perform photosynthesis. Thallus liverwort was seldom to be found in the route as its existence is indicated by dense canopy cover to support high-humidity environmental conditions.

The environmental factors in the Kanopi route consisted of an average temperature of 22.6°C, average humidity of 42%, an average light intensity of 1613 lux, and an average altitude of 844 masl. Mosses mostly identified in this route came from Dumortiaceae with its species of *Dumortiera hirsuta*. The species was found in a large number, had a complete morphology, and a wide range of species. The richness of the moss species was due to the Kanopi route that is far from air pollution. This is consistent with Susilo, Huda, & Amrul (2020), stating that moss body size can be influenced by pollution. The more the air is contaminated by pollution, the moss body structure will decrease.

The Kanopi route has the highest humidity compared to other routes. This is one of the factors for high diversity in the Hepaticopsida class. Air humidity has a significant effect on growth since it is directly related to the photosynthesis process. The photosynthesis rate will increase with an increase in air humidity in the environment or microclimate. Therefore, it can be concluded that

light intensity affects moss growth. If the moss growth decreases likewise the moss abundance, and vice versa (Maharani, Pujiastuti, & Murdiyah, 2017).

The Kanopi route area is mostly covered by a dense canopy. During the observation, the weather was clear and supported the amount of light intensity in the route. Light intensity is also influenced by the percentage of canopy cover in the area. A dense canopy cover affects the light intensity received by the moss plant underneath; hence, it influences humidity and temperature under the canopy (Marhento & Zainab, 2020).

The altitude in each route was in the range of 812-869 masl. This indicates that the research was only conducted at relative altitudes or at an altitude that had a short interval. In research by Satiyem (2012) and Putra *et al.* (2015), moss data collection was conducted with pre-determined altitude limits. According to research by Satiyem (2012), moss diversity at the altitude of 1000 masl, 1200 masl, and 1400 masl were 0.8, 0.6, and 0.4, respectively. This suggests that the higher the altitude, the less moss diversity. This is due to the environmental factors at larger altitude numbers resulting in lower humidity, whereas light intensity and temperature will be higher. As a consequence, moss diversity will be lower due to moss sensitivity towards environmental factors.

CONCLUSION

Based on the observation conducted in three routes in the PPKA Bodogol, namely Cikaweni, Rasamala, and Kanopi routes, 21 moss species were found that consisted of Sphagnum sp., Sphagnum fimbriatum, Fissidens sp., Polytrichum sp., Taxiphyllum sp., Lophocolea bidentata, Barbella horridula, Tortella tortuosa, Dumortiera hirsuta, Neckropsis undulata, Dichodontium sp., Dicranum scoparium, Ectropothecium sp., Hypnum cupressiforme, Phaeoceros laevis, Symphyogyna brasiliensis, Brachythecium rutabulum, Platdictya confervoide, Hyophila involuta, and Marchantia sp.. Eight moss species from 7 families were found in the Cikaweni route with a moderate diversity index, which was 1.967. 13 species from 11 families were identified in the Rasamala route with a high diversity index, which was 3.003. In the Kanopi route, 4 moss species from 4 families were found with a moderate diversity index of 1.216. Moss diversity was influenced by environmental factors that consisted of temperature, light intensity, and humidity. These factors affected moss growth, distribution, and evenness in an environment.

ACKNOWLEDGMENT

The authors are sincerely grateful to the Ministry of Education, Culture, Research, and Technology, Indonesia that has provided research fund assistance through a competitive research grant with contract 22/E4.1/DSD/LPPM/2021. Thanks are also conveyed to the rangers and officers of the Bodogol Nature Conservation Education Center (PPKAB) National Park Gunung Gede Pangrango, Indonesia, who has given permission and helped this study.

REFERENCES

Adiyanta, F. S. (2019). Hukum dan Studi Penelitian Empiris: Penggunaan Metode Survey sebagai Instrumen Penelitian Hukum Empiris. *Administrative Law and Governance Journal, 2*(4), 697-709. Retrieved from https://doi.org/10.14710/alj.v2i4.697-709

Aristria, D., Parwati, L.K., & Wiryani, E. (2014). Keanekaragaman Marchantiophyta Epifit Zona Montana di Kawasan Gunung Ungaran, Jawa Tengah. *Jurnal BIOMA, 16*(1), 26-32. Retrieved from https://doi.org/10.14710/bioma.16.1.26-32

Endang, T., Jumiati., & Dyah, P. (2020). Inventarisasi Jenis-Jenis Lumut (Bryophyta) di Daerah Aliran Sungai KaburaBurana Kecamatan Batauga Kabupaten Buton Selatan. *Jurnal Biologi Tropis, 20*(2), 161-172. Retrieved from http://dx.doi.org/10.29303/jbt.v20i2.1807

Kristiyanto., Sitanggang, N.D.H., & Azzahro, S.F. (2018). Keanekaragaman dan Peran Ekologi Lumut (Bryophyta) di Area Arboretum Wanawisata Pramuka Cibubur. *Prosiding Seminar Nasional Biologi 2018: Pengembangan Potensi Sumberdaya Hayati Lokal untuk Mendukung Pemanfaatan Megabidiversitas*. Mei 2018, Semarang, Jawa Tengah, Indonesia. Hal. 176-181. Retrieved from https://www.researchgate.net/publication/329670113

Lestiani, A., Lestari, R.S.D., Rizkia, R.A., Pratiwi, A.M., Azrai, A.P., & Rini, D.S. (2021). Survei keberagaman lumut dan pohon inang di kawasan Kebun Raya Bogor. *Proceeding on Biology Education, 4*(1), 51-62. Retrieved from https://doi.org/10.21009/pbe.4-1.5

Lukitasari, M. (2018). *Mengenal Tumbuhan Lumut (Bryophyta) Deskripsi, Klasifikasi, Potensi, dan Cara Mempelajarinya.* Magetan: CV.EA Media Grafika

Maharani, A., Pujiastuti., & Murdiyah, S. (2017). Biodiversity of Division Bryophyta (True Moss) in Kapas Biru Waterfall Pronojiwo Lumajang. *Bioedukasi 15*(2), 31-37. Retrieved from https://doi.org/10.19184/bioedu.v15i2.6936

Marhento, G. & Zaenab, C. (2020). Biodiversitas Lumut Epifit di Gunung Kendeng Dalam Kawasan Taman Nasional Gunung Halimun Salak Jawa Barat. *Prosiding Seminar Nasional Perhimpunan Masyarakat Etnobiologi Indonesia, 4*(1). Retrieved from https://jte.pmei.or.id/index.php/jte/issue/view/9

Maul, K., Wei, Y-M., Nebel, M., Luebert, F., Ho, B-C., Quandt, D., & Kessler, M. (2020). Different Predictors Shape the Diversity Patterns of Epiphytic and Non-Epiphytic Liverworts in Montane Forest of Uganda. *Front. Plant Sci., 11*, 765. Retrieved from https://doi.org/10.3389/fpls.2020.00765

Mulyani, E., Perwati, L.K. & Murningsi. (2015). Lumut Daun Epifit di Zona Tropik Kawasan Gunung Ungaran, Jawa Tengah. *Jurnal Bioma, 16*(2), 76-82. Retrieved from https://www.readcube.com/articles/10.14710/bioma.16.2.76-82

Putra, H.F., Ambarwati, D.S., Mubyarsih N., & Alesti T. (2015). Karakteristik Fisiologis Lumut pada Beberapa Ketinggian di Kawasan Gunung Tangkuban Perahu. *Jurnal Sumberdaya Hayati, 1*(2), 60-63. Retrieved from http://biologi.ipb.ac.id/jurnal/index.php/jsdhayati

Putrika, A. (2012). Komunitas Lumut Epifit di Kampus Universitas Indonesia Depok. *Tesis*. Universitas Indonesia.

Putrika, A., Nisyawati., & Ariyanti, S.N. (2017). Keragaman lumut epifit di hutan kota dan tepi jalan utama Kampus Universitas Indonesia. *Jurnal Bio-site, 3*(1), 25-38. Retrieved from https://online-journal.unja.ac.id/BST/article/view/4413

Riani, L. (2017). Inventarisasi Jenis Lumut (Bryophyta) di Kawasan Hutan Air Terjun Bukit Maras Desa Dalil Bangka. Skripsi. Bangka Belitung: Fakultas Pertanian, Perikanan dan Biologi, Universitas Bangka Belitung.

Satiyem. (2012). Keanekaragaman Tumbuhan Lumut (Bryophyta) pada Berbagai Ketinggian Hubungannya dengan Kondisi Lingkungan di Wilayah Lereng Selatan Merapi Pasca Erupsi. *Skripsi*. Universitas Negeri Yogyakarta. Yogyakarta. Retrieved from https://eprints.uny.ac.id/8179/

Saputra, A. (2013). Identifikasi Lichen di Kebun Raya Bukit Sari Kabupaten Tebo Provinsi Jambi. *Skripsi*. Jambi: FKIP Universitas Negeri Jambi.

Susilo, F., Huda, M.K., & Amrul, H.M.Z.N. (2020). Malesia Bryophytes Diversity. *Budapest International Research in Exact Sciences (BirEx) Journal, 2*(1), 106-112. Retrieved from https://doi.org/10.33258/birex.v2i1.803

Windadri, F.I. & Susan, D. (2013). Keanekaragaman Jenis Lumut di Kepulauan Raja Ampat, Papua Barat. *Jurnal Buletin Kebun Raya, 16*(2), 75-84. Retrieved from https://dx.doi.org/10.14203/bkr.v16i2.31