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## RESEARCH ARTICLE

# Diversity of Sporous Plants (*Bryophyta* and *Pteridophyta*) and Lichens in the Pananjung Pangandaran Nature Reserve Area, West Java

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## ABSTRACT

The study aims to determine the diversity of terrestrial fern species (pteridophyta) and mosses (bryophyta) in the Pananjung Pangandaran Nature Reserve, West Java. The method used in this study is a qualitative description of the design of the transmission belt. Collected samples were conducted with a purposive sampling method. A lengthy transect line extends approximately 110 meters and comprises up to six quadrants, each measuring 10 by 10 meters. The research identified eight types of terrestrial fern, including two in three orders and six families; seven species have been identified with a total of 437 individuals in the form of moss plants and 235 individuals from nine species of lichens belonging to five families of Arthoniaceae, Collemataceae, Bacidiaceae, Graphidaceae and Leprariaceae. The calculation of the results using the Shannon-Wiener index ( $H'$ ) index diversity type indicates that the terrestrial fern  $H' = 1.929$  falls under the category medium. The highest Importance Value Index (INP) is *Acystopteris tenuisecta* with 80.148%, whereas the lowest is *Pteris vittata* L. at 13.614 %. The Diversity Index ( $H'$ ) of moss plants is 1.1041, classified as medium criteria. The diversity of lichens with a value of  $H' = 1.92$ . The most common lichen species, *Bacidia* sp, became the dominant species in the study area, with as many as 64 individuals exhibiting an Important Value Index (INP) of 44.475%. It shows that terrestrial ferns, moss plants and lichens are in the moderate category, so they are quite safe in carrying out their vital functions to maintain soil density.

**Keywords:** Diversity index, ferns, important value index, lichens, Pananjung nature reserve

## Introduction

Indonesia is one of the countries with the largest tropical forests in the world. For this reason, the Indonesian government has created a number of nature reserves as a conservation effort to maintain the existence and diversity of endemic flora and fauna in an area. According to the Director General of Forest Protection and Nature Conservation (PHKA) of the Ministry of Environment and Forestry, Indonesia has more than 100 nature reserves.<sup>1</sup> The nature reserve area is usually divided into two areas like a fist, namely the western area, which functions as a tourist

forest, and the eastern area, which is an area that is relatively closed to tourists.<sup>2</sup> One of the nature reserves is in Pangandaran district, which is famous for its beautiful beaches. The Pangandaran Nature Reserve area is a rainforest ecosystem located in the southern coastal area of West Java with an area of 497 Ha.<sup>3</sup> This area has a sloping and hilly surface with a 0–75 meters height above sea level. The Pananjung nature reserve is unique because it is a peninsula surrounded by beaches on the west and east, slightly separated from the mainland of Pangandaran Regency.<sup>4</sup> These unique geographical conditions cause several endemic lowland flora and fauna, which

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are influenced by the coastal environment.<sup>5</sup> Coastal ecosystems, lowland forest ecosystems and plantation forest ecosystems are all within the Pananjung Pangandaran Nature Reserve area.<sup>6</sup>

Indonesia, which has more than 100 nature reserves, including the Pananjung nature reserve, can be sure to have a very rich diversity of flora and fauna, including groups of spore plants such as ferns, mosses and lichens. This is proven based on research that Indonesia has approximately 1,300 species of ferns (pteridophytes).<sup>7</sup> The fern group is a combination of cormophytes and thallus plants with spores, so they are often referred to as “spore-bearing Cormophytes”.<sup>8</sup> Ferns containing spore-bearing Cormophytes can live in various environments, including terrestrial, aquatic, and epiphytic. Ferns have several functions, including forming humus, protecting the soil from erosion, maintaining soil moisture, pioneering plants in the early stages of forest ecosystem succession, and being ornamental plants. The existence and diversity of ferns, which play a role in preventing erosion, are now threatened with extinction due to various human activities in exploiting forests, such as forest burning, clearing land for agriculture and plantations, excessive logging, and housing construction. To respond to the threat of extinction of ferns, various conservation methods have been carried out, including ex situ methods for preserving spores, gametophytes and ferns, or through a combination of ex situ and in situ methods. Even for several species that are already threatened with extinction, in vitro conservation methods are recommended.<sup>9</sup>

Moss plants (bryophytes) also grow abundantly in tropical areas with humid conditions, such as Indonesia.<sup>10</sup> This is proven that Indonesia also has a diversity of 1500 types of moss plants from a total of 1800 types of moss plants spread throughout the world.<sup>11</sup> *Bryophyta*, which means plants that live in damp areas, comes from the words *bryon*, which means moss and *python*, which means moist or wet.<sup>12</sup> Mosses are a group of lower plants that grow widely on land. This small moss sticks to surfaces such as rocks, trees, wood, and soil. Moss plants (bryophyta) are divided into three classes, namely liverworts (Hepaticopsida), leaf mosses (Anthocerotopsida), and leaf mosses (Bryopsida). Moss plants are good water absorbers, so they can prevent flooding and maintain soil density so that it does not experience erosion easily. Considering the important function of mosses in preventing erosion, a moss conservation method has been recommended using land with low intensity and high structural heterogeneity.<sup>13</sup>

Indonesia also has a diversity of 17000 types of lichens from a total of 100000 types of lichens spread throughout the world.<sup>14</sup> Lichens (*Lichenes*) re-

sult from a symbiosis of blue-green algae with fungi. Blue-green algae, often known as *Cyanobacteria*, is a photosynthetic organism with many photosynthetic cells held together by collections of fungal hyphae forming a lichen. Lichens of various shapes can be found on surfaces such as rocks, trees, rotting logs, and roofs.<sup>15</sup> Lichens usually live attached and can survive and thrive in arid environments. Lichens are considered pioneer plants, along with blue algae. Lichens reproduce by breaking the thallus or soredium into small pieces that can grow larger. When the developing fungal spores enter a symbiosis with the right algae, lichens form. If the conditions are not right, algae and fungi will breed, respectively.<sup>16</sup> Lichens are plants that function as indicators of air pollution. Lichens are usually preserved naturally in their habitat through forest management as protected conservation areas.<sup>17</sup>

Ferns, mosses and lichens were also detected in the Pananjung nature reserve. The Pananjung Nature Reserve area, with a land area of 530 hectares and most of it having sloping topography ranging from 2-3 meters above sea level, has been declared as one of the supporters of Pangandaran beach tourism, which is known to be beautiful by the people of West Java.<sup>18</sup> This could become a problem in the future because most residents still view nature reserves as tourist attractions rather than as areas for research and conservation of animals and plants. The number of tourist visits that are not limited to high intensity and interactions that do not care about the preservation of flora and fauna can cause damage to the ecosystem and biodiversity in the Pangandaran Nature Reserve area.<sup>19</sup> On the other hand, data and information about the biodiversity of flora and fauna, especially ferns, mosses, and lichens in the Pangandaran Nature Reserve Area, still need to be provided.<sup>7</sup> Therefore, our research aims to identify the diversity of spore plants, especially ferns (pteridophytes), mosses (bryophytes), and lichens in the Pangandaran Nature Reserve Area, because their function is considered vital to maintain soil density to prevent erosion and an indicator of air pollution, which can have an impact bad for the tourist area in Pangandaran.

## Materials and methods

### Materials

The research sampling location was in June 2022 in the Cirengganis block of the Pananjung Pangandaran Nature Reserve, West Java. This research uses qualitative and descriptive methods. The used research design is “Belt Transect”. The length of the transect line used is around 110 meters; every 10 meters, there is

a plot measuring 10 × 10 meters. Six plots were included in this research. To determine the abundance of ferns, mosses and lichens in each plot, observation subplots were made of mica plastic measuring 25 × 25 cm. Research was carried out on ferns, mosses, and lichens on soil, rocks, and trees up to a height of 2 meters on trees with a diameter of more than 10 cm. Sampling was carried out by roaming with a purposive sampling technique. The tools used in this research were a rolling tape measure, transect rope, plastic mica plots, camera, knife, and observation sheet. Tools for measuring environmental factors are lux meters, soil testers, thermometers and hygrometers.

### Methods

Two types of data used to obtain research: main data and supporting data. The main source of information is several types of ferns, mosses, and lichens found in the Pananjung Pangandaran Nature Reserve, West Java, in the Cirengganis block. Supporting data consists of data measuring climatic factors at the research location, such as air humidity, soil moisture, soil pH, air temperature, soil temperature and light intensity.

After obtaining the data, calculations were then carried out adapted from<sup>20</sup> to obtain the results of the Shannon-Wiener Diversity Index (H'), Relative Density Value (KR), Relative Frequency Value (FR), Relative Dominance Value (DR), and Important Value Index (INP) with the following formula:

relative density (KR)

$$= \frac{\text{absolute density of a species}}{\text{the sum of the densities of all species}} \times 100\%$$

relative frequency (FR)

$$= \frac{\text{absolute frequency of a species}}{\text{the sum of the frequency of all species}} \times 100\%$$

relative domination (DR)

$$= \frac{\text{absolute domination of a species}}{\text{the sum of the domination of all species}} \times 100\%$$

important value index (INP) = relative density (%)

+ relative frequency (%) + relative domination (%)

diversity index (H') =  $-\sum p_i \ln p_i$

The results obtained can be classified into three categories, namely:

- If  $H' < 1$ , then the diversity index is categorized as low.
- If  $H' 1 < H' < 3$ , then the diversity index is categorized as medium.
- If  $H' > 3$ , then the diversity index is categorized as high.

### Results and discussion

Based on observations made at the Pananjung Pangandaran Nature Reserve, ferns, mosses and lichens have been identified, as shown in the Table 1 below:

**Table 1.** Diversity index data (H') of terrestrial ferns.

No.	Species	Amount	Pi	ln Pi	H'
1.	<i>Asplenium nidus L.</i>	3	0.070	2,663	0.186
2.	<i>Drynaria sparsisora</i>	4	0.093	2,375	0.221
3.	<i>Lygodium circinnatum</i>	8	0.186	1,682	0.313
4.	<i>Acystopteris tenuisecta</i>	12	0.279	1,276	0.356
5.	<i>Nephrolepis cordofolia</i>	5	0.116	2,152	0.250
6.	<i>Pteris vittata L.</i>	2	0.047	3,068	0.143
7.	<i>Acrostichum aureum</i>	6	0.140	1,969	0.275
8.	<i>Selaginella sp.</i>	3	0.070	2,663	0.186
Amount		43	1,000	17,847	1,929

In Table 1, it can be seen that there are eight species and 43 individuals found in the Cirengganis Block, Pananjung Pangandaran Nature Reserve Area, West Java. With the calculation results of the Shannon-Wiener species diversity index value, namely  $H' = 1.929$ . The terms of the value of the Shannon-Wiener species diversity index, that is, if  $1 \leq H' \leq 3$ , then the diversity is classified as moderate in terms of the distribution of the number of individuals of each species and the stability of the community. This shows that the diversity of terrestrial ferns (pteridophytes) in the Cirengganis Block in the Pananjung Pangandaran Nature Reserve Area, West Java, is included in the medium category.

A plant type that has a large amount of important value indicates a high level of dominance, whereas if a plant type has a small important value, it indicates a low level of dominance.<sup>21</sup> In Table 2, the calculation results show that the *Acystopteris tenuisecta* fern has the highest number of individual species, followed by the *Lygodium circinnatum* type, shown by the relative density (KR) value of 27.907% and 18.605%. Meanwhile, the fern type *Pteris vittata L.* has a very small number of individuals, as indicated by the relative density (KR) value of 4.651%. This shows that a high density value will be able to develop and live well because it has a large area.<sup>22</sup> Likewise, the distribution of nail types that have a fairly wide distribution level

**Table 2.** Importance value index (INP) of terrestrial ferns.

No.	Species	KR (%)	FR (%)	DR (%)	INP (%)
1.	<i>Asplenium nidus L.</i>	6.977	6.552	15.385	28.883
2.	<i>Drynaria sparsisora</i>	9.302	8.696	7.692	25.690
3.	<i>Lygodium circinnatum</i>	18.605	17.391	12.308	48.304
4.	<i>Acystopteris tenuisecta</i>	27.907	26.087	26.154	80.148
5.	<i>Nephrolepis cordofolia</i>	11.628	17.391	7.692	36.712
6.	<i>Pteris vittata L.</i>	4.651	4.348	4.615	13.614
7.	<i>Acrostichum aureum</i>	13.953	13.043	21.538	48.535
8.	<i>Selaginella sp.</i>	6.977	6.522	4.615	18.114
Amount		100	100	100	300

is shown to have a relative frequency value (FR) of 26.087%, while those whose distribution is limited is indicated by a relative frequency value (FR) of 4.348%. This shows that the more quadrants found, the higher the frequency value its presence is increasingly high.<sup>22</sup>

The highest relative dominance (DR), namely 26.154%, is shown by the important value index (INP), namely 80.148% and the lowest relative dominance (DR), namely 4.615%, is shown by the important value index (INP), namely 13.614%. This shows that species dominance in a community can be exercised over one species, several species, or even over many species.<sup>23</sup> If the INP is greater for a species, the greater the role of the species in a community. INP that is evenly distributed in the number of species is an indicator of increasingly high biodiversity in an ecosystem.<sup>24</sup> The environmental conditions in each quadrant are different; the quadrant, where many fern species are found, is at a distance of 90 meters from the beach. The middle area of the forest is humid, not exposed to direct sunlight and protected by shade. Some are found close to rocks; the air temperature is quite cold and the soil conditions are moist. The habitat factors can influence the structure and composition of vegetation. This shows that abiotic environmental conditions influence plant habitat.<sup>25</sup>

Air temperature is a factor that regulates the distribution of vegetation.<sup>26</sup> Vegetation on earth will be affected by temperature differences, so that various types of ferns will also be affected. In general, ferns are land plants that are often found in areas that are quite sheltered or damp. Ferns generally grow at air temperatures ranging between 21–27°C and they are usually found under dense canopy trees with low temperatures.<sup>27</sup> Based on this, the air temperature measured in the study area still supports the growth of ferns, ranging from 26 to 27.3°C and the conditions in the quadrant studied are under a canopy tree.

Soil temperature also has an important role in fern growth because soil is the main medium, especially for vegetation growth. In tropical areas, the optimum soil temperature for ferns ranges between

22–37°C. The soil temperature measured in the research study area still supports fern growth, namely 27–29°C.<sup>9</sup> Apart from that, air humidity also affects nail growth. The ideal soil condition for fern growth is between 50% - 80%, this is in accordance with the soil moisture condition at the observation location, namely 80%, which supports optimal fern growth in the area.<sup>28</sup> Decreasing temperature will lead to an increase in air humidity.<sup>29</sup>

Many ferns grow on moderately acidic to alkaline substrates, namely soil pH between 5–8.<sup>9</sup> A soil pH of 5.5–6.5 is suitable for the growth of fern.<sup>30</sup> Acidic if the pH is less than 7, the soil pH conditions in the research area still support the growth of fern. This is in accordance with the soil pH in each quadrant condition, namely slightly acidic.<sup>30</sup>

The fewest species found were *Pteris vittata L.*, numbering 2 individuals with a value of  $H' = 0.143$ , a dominance value, namely an INP figure of 13.614%, which means that this species has very little diversity and has a small role in the fern community in the Pananjung Nature Reserve Area Pangandaran.<sup>9</sup> This plant grows in open ground in lowlands and mountains, and frequently grows on walls and old buildings.<sup>31</sup> The range of light intensity in open areas is 39,500 – 87,000 lux with an average of 53,000 lux.<sup>32</sup> Meanwhile, in the environmental conditions of this study area, the light intensity is 1,531 lux, filled with tall trees and broad-leaved undergrowth so that growth is less than optimal. Apart from that, soil pH also influences. The results of soil pH measurements show that areas with a pH that is close to neutral conditions allow more types of plants to grow.<sup>33</sup> The small role of this plant means that it is less suitable for the existing habitat in the study area. Therefore, this species finds it difficult to adapt to the unsupportive environment in which it grows, so its distribution is not widespread; it is only found in a few and very low locations.

Judging from the results of research in the Sicike-cike Nature Tourism Park with an altitude of 1,410–1,433 meters above sea level, a total of 20 types of ferns were found, and the diversity index value for terrestrial and epiphytic ferns was classified as moderate.<sup>34</sup> The data measured are air temperature, air humidity, target depth and soil pH, soil temperature, light intensity, and height. In the Pananjung Pangandaran Nature Reserve Area, the research location is in the Cirengganis Block with a location height of 0–45 meters above sea level. Eight types of ferns were found supported by abiotic factors that were measured, namely light intensity, air temperature, air humidity, soil temperature, humidity and soil pH. When compared with the types of terrestrial ferns found in the Sicike-cike Tourism Park, the location

**Table 3.** Diversity index data (H') of mosses plants.

No.	Family	Species	$\Sigma$	H'
1.	Polytrichaceae	<i>Pogonatum contortum</i> (Brid.) Lesq.	74	0,296
2.		<i>Atrichum undulatum</i> (Hedw.) P.Beauv	50	0,244
3.	Hypnaceae	<i>Hypnum cupressiforme</i>	3	0,033
4.	Thuidiaceae	<i>Thuidium glaucinoides</i>	3	0,033
5.	Leujeneaceae	<i>Archilejeunea planiuscula</i> (Mitt.) Steph.	289	0,286
6.	Leujeneaceae	<i>Lophojeunea acutifolia</i> Mizzut & Piippo.	15	0,113
7.	Leujeneaceae	<i>Leujenea</i> sp.	3	0,033

**Table 4.** Importance value index (INP) of mosses plants.

No.	Family	Species	KR%	FR%	INP%
1.	Polytrichaceae	<i>Pogonatum contortum</i> (Brid.) Lesq.	16,934	20,000	36,934
2.		<i>Atrichum undulatum</i> (Hedw.) P.Beauv	11,442	13,333	24,775
3.	Hypnaceae	<i>Hypnum cupressiforme</i>	0,686	6,667	7,353
4.	Thuidiaceae	<i>Thuidium glaucinoides</i>	0,686	6,667	7,353
5.	Leujeneaceae	<i>Archilejeunea planiuscula</i> (Mitt.) Steph.	66,133	33,333	99,466
6.		<i>Lophojeunea acutifolia</i> Mizzut & Piippo.	3,432	13,333	16,766
7.		<i>Leujenea</i> sp.	0,686	6,667	7,353
Amount			100	100	200

shows a greater diversity of types. This is likely influenced by abiotic factors, namely the altitude of the location.

Judging from the results of research by Yusuf Ibrahim, there are the low category types of ferns in Mount Masigit Kareumbi Buru Park, Bandung Regency, which are classified as moderate.<sup>35</sup> This is supported by environmental parameter measurement data, namely light intensity, air humidity, air temperature, soil moisture, and soil pH. One of the factors influencing the number of species found is the soil pH of 6-7, which is neutral. Meanwhile, the soil pH in the Pananjung Pangandaran Nature Reserve Area in the Cirengganis Block has a soil pH of 5-6, which is slightly acidic. The results of soil pH measurements show that areas with a pH that is close to neutral conditions allow more plant species to grow.<sup>33</sup> Based on comparison results in several other research locations, it shows that what really influences the presence of fern in nature is the height factor. This shows that elevation and soil pH influence the presence of ferns.

Table 3 shows that the diversity index of bryophyte mosses in the Pananjung Pangandaran nature reserve has a final value of  $H'=1.1041$ , indicating moderate group diversity.

Based on Table 4 above, the highest important index: Relative Density (KR) value is in the *Archilejeunea planiuscula* (Mitt.) Steph species. The number 66.133% of the data shows that moss has the highest abundance compared to other species, because 289 individuals were found. For relatively low KR, it is at moss *Hypnum cupressiforme*, *Thuidium glaucinoides*, and *Leujenea* sp with a total of 0.686%. The data states

that this moss has the lowest abundance, with each having 3 individuals. The most widely distributed Relative Frequency (FR) is in the species *Archilejeunea planiuscula* (Mitt.) Steph, with a total of 33.333% of this species found in 5 plots. Meanwhile, the lowest spread is at species *Hypnum cupressiforme*, *Thuidium glaucinoides*, and *Leujenea* sp, with a total of 6.667% found in only one plot. Important Value Index, INP, which shows the highest amount of moss control is in the species *Archilejeunea planiuscula* (Mitt.) Steph with a total of 99.466%. This number is the highest figure compared to other species.

The results of the observations that have been made are two classes, namely Bryopsida and Hepaticopsida, which belong to 2 classes: 4 nations, 4 tribes, 7 genera and 7 species. There are 2 species in the Polytrichaceae tribe, 1 species in the Hypnaceae tribe, 1 species in the Thuidiaceae tribe, and 3 species in the Leujeneaceae tribe. There are 7 species of them: *Pogonatum contortum* (Brid.) Lesq, *Atrichum undulatum* (Hedw.) P. Beauv., *Hypnum cupressiforme*, *Thuidium glaucinoides*, *Archilejeunea planiuscula* (Mitt.) Steph., *Lophojeunea acutifolia* Mizzut and Piippo., *Leujenea* sp.

In research conducted in the Pananjung Pangandaran Nature Reserve, more *Lejeuneaceae* tribes were found compared to other tribes. This proves that the *Lejeuneaceae* family is the type of moss most commonly found in lowland protected areas.<sup>36</sup> *Lejeuneaceae* can grow in various environmental conditions; for example, it can grow in open or closed environments. It can also live on the outskirts of cities, plantations and forests.<sup>37</sup> Apart from that, the *Lejeuneaceae* family can grow in humid tropical rain

but can also be found in open places and disturbed areas such as gardens.

Based on the criteria from Shannon Wiener, it is stated that the diversity of mosses in the Pananjung Pangandaran Nature Reserve is classified as moderate, namely  $H' = 1.1041$ . The diversity and abundance of moss depends on environmental conditions and the altitude at which the moss lives.<sup>38</sup>

The presence of moss at the research location is of course influenced by abiotic factors consisting of light intensity, air temperature, air humidity, soil temperature, soil moisture and soil pH. Based on the results of measurements carried out at the research location, it is clear that light intensity can be influenced by the density of the tree canopy. The density of the tree canopy can cause humidity and temperature under the tree to be influenced by the low intensity of light entering through the ground surface.<sup>11</sup> The light intensity obtained at the research location is between 11, 110 – 1,289. Suggesting that moss can grow well at optimal/good light intensity of 10,000 lux or 795 Cd to help moss in the photosynthesis process.<sup>32</sup> Therefore, the light intensity of 11,110-1,289 received by moss plants can be well received. The air temperature obtained at the research location is 26-27.3°C. The air temperature there supports the survival of moss. The moss plants will be optimal at an air temperature of 10-30°C and moss is also tolerant at temperatures of 40°-50°C.<sup>39</sup>

The air humidity obtained at the research location supports the survival of moss as it is found to be 92-92.5%. Because moss can live and grow well at air humidity of around 70-90%. If the growth of the moss is below the specified standards, the development and growth of the moss will be hampered and the productivity of the moss will be reduced.<sup>11</sup> Therefore, humidity at the research location supports the survival of the moss.

Soil moisture obtained at the research location supports the survival of moss because it is found to be 80%. Soil moisture can affect species, and optimal humidity in the soil is around 70-98% suitable for moss growth.<sup>40</sup> Therefore, the results obtained at the location support the survival of mosses. The soil pH obtained at the research location supports the survival of moss because the pH is 5.3 - 6.4.<sup>41</sup> This shows that moss can live well at that soil pH.

If you look at the results of research conducted in the Pucok Krueng Raba River area, Lhoknga District, Aceh Besar Regency (lowland), it is clear that the diversity in the area is classified as moderate with a diversity index value of 2,249. with the discovery of 16 types of mosses.<sup>42</sup> The diversity of moss types can be influenced by several environmental factors, such as abiotic, light intensity, temperature, air humidity, and soil pH, or abiotic factors such as vegetation. The

**Table 5.** Diversity index data ( $H'$ ) of lichenes.

No.	Family	Species	$\Sigma$	$H'$
1.	Arthoniaceae	<i>Cryptothecia striata</i>	49	0,327
2.	Collemaaceae	<i>Collema subflaccidum</i>	8	0,115
3.	Bacidiaceae	<i>Bacidia sp</i>	64	0,354
		<i>Bacidia schweinitzii</i>	41	0,305
4.	Graphidaceae	<i>Dyplolabia afzelii</i>	5	0,082
		<i>Graphis scripta</i>	10	0,134
		<i>Graphis sp</i>	13	0,160
		<i>Diorygma poitaei</i>	30	0,263
5.	Leprariaceae	<i>Lepraria sp</i>	15	0,176
	Amount	235	1,92	

results of research conducted in the Kawasan Hutan Desa Taupe, Kecamatan Mamasa, Kabupaten Mamasa, and Sulawesi Barat show that diversity at the research location is classified as moderate with a diversity index value of 4,402.<sup>43</sup> With the discovery of 17 species, the diversity of moss types is due to environmental conditions, both abiotic and biotic factors.

Based on Table 5, it shows that in the Pananjung Pangandaran Nature Reserve area, West Java, in the Cirengganis block, 235 individuals of lichens were found to have diversity with a value of  $H' = 1.92$  which is classified as moderate according to the Shannon-Wiener formula.

Based on Table 6, the highest INP is in the *Bacidia sp* species, which has a value of 44.475%, derived from the total relative density and relative frequency. The number of individuals and occurrences found from all plots of this species was higher. The lowest INP value is *Collema subflaccidum*, with a value of 6.853%.

Based on research conducted in the Pananjung Pangandaran Nature Reserve area, West Java, there were 235 individuals from 9 species of lichens belonging to 5 families, namely the families *Arthoniaceae*, *Collemaaceae*, *Bacidiaceae*, *Graphidaceae*, and *Leprariaceae*. There are two types of lichens found throughout the research location, namely crustose (the thallus structure is tightly attached to the substrate like a crust) and foliose (the thallus structure is in the form of thin sheets like leaves). The lichens that were mostly found in this study were those with Crustose type talus consisting of 8 species, namely *Cryptothecia striata*, *Bacidia sp*, *Bacidia schweinitzii*, *Dyplolabia afzelii*, *Graphis scripta*, *Graphis sp*, *Diorygma poitaei*, *Lepraria sp* and Foliose type talus were found only 1, namely *Collema subflaccidum*.

*Bacidia sp* is a species of lichen that is often found in the research location with a total of 64 individuals. This lichen is found in almost every plot, found in plot 1, plot 2, plot 3, plot 4 and plot 6. This species of lichen is included in the Crustose type of thallus, adhering firmly to its substrate, typically seen on tree bark. This is supported by research which states that the type of lichen thallus that is most commonly

**Table 6.** Importance value index (INP) of lichenes.

No.	Family	Species	KR%	FR%	INP
1.	Arthoniaceae	<i>Cryptothecia striata</i>	20,8511	17,2414	38,092
2.	Collemaataceae	<i>Collema subflaccidum</i>	3,4043	3,4483	6,853
3.	Bacidiaceae	<i>Bacidia sp</i>	27,2340	17,2414	44,475
		<i>Bacidia schweinitzii</i>	17,4468	13,7931	31,240
4.	Graphidaceae	<i>Dyplolabia afzelii</i>	2,1277	6,8966	9,024
		<i>Graphis scripta</i>	4,2553	6,8966	11,152
		<i>Graphis sp</i>	5,5319	10,3448	15,877
		<i>Diorygma poitaei</i>	12,7660	13,7931	26,559
5.	Leprariaceae	<i>Lepraria sp</i>	6,3830	10,3448	16,728
	Amount	100	100	200	

found is crustose because this type of lichen is like a sticky crust closely attached to trees, which indicates that this type of talus type needs little water, is easy to grow and is tolerant of polluted air, so the crustose type is often found at the observation location.<sup>44</sup> A species that is rarely found is *Collema subflaccidum* with 8 individuals. This lichen was found only in plot 1 and is a foliose thallus type.

Of all the research locations, no types of lichens were found on rocks or soil but were only found on tree bark. This is because almost all of the most common types of lichens are the crustose thallus type, which usually sticks to tree bark. The crustose thallus growth form of lichens is widespread throughout Indonesia.<sup>14</sup> Because this type attaches to tree trunks and is shaped like a crust, it requires little water and gives the impression of being painted on the substrate.

The diversity of lichens found in the Pananjung Pangandaran Nature Reserve area, West Java, in the Cirengganis block is classified as moderate with a value of  $H' = 1.92$ . The most commonly found lichen species, *Bacidia sp*, is the species that dominates the research location, with 64 individuals with an Importance Value Index of 44.475%. This shows that the environmental conditions at the research location are still supportive, because environmental factors greatly influence the high and low diversity of lichens. Supported by research that states that the large number of lichen plant species is due to supportive environmental factors in the area, so that lichen plants can grow and live well.<sup>42,45</sup>

The diversity of lichen plants at the research location is classified as moderate.<sup>46</sup> This is due to the lack of trees, as there is no host or substrate where the lichen plants can attach to live. In research, also conducted in a lowland forest area, obtained data on lichen was not very diverse. According to Timdal (2016) the number of colonies and diversity of lichens can vary depending on the altitude of an area, so the higher the location or sampling, the greater the population and diversity of lichens.<sup>47</sup>

Research conducted by<sup>46</sup> found 57 lichen species from 23 families and 38 genera were found. Based on their thallus types, 26 lichen species were identified as crustose, 17 as foliose, 6 as squamulose, 5 as fruticose, and 3 as filamentous. The number of individuals found in the research was 1,635 individuals. The diversity of lichens in the Abdul Latief Sinjai Borong Forest Park Area is classified as moderate with an  $H'$  value of 2.77 according to the Shannon-Weiner diversity index. Research conducted by<sup>47</sup> at all research locations found 24 species of lichens, consisting of 15 families with a total of 1,545 individual species. The lichen diversity index in this study is  $H' 2.8448$ , which means the diversity is classified as moderate according to the calculation category of the Shannon-Wiener formula.

Based on research that has been carried out, having the same diversity is classified as moderate but has a different number of individuals and species. If you look at Nuryani and Fithri's research, it was found that the number of species was greater than in research in the Pananjung Pangandaran Nature Reserve area, West Java. In Nuryani's research, 27 species were found and in Fithri's research, 24 species were found. In this study, 9 species were found. This means that the height, temperature, humidity and light intensity of an area indicate that the growth and spread of lichens is influenced by these environmental factors. Nuryani's research location was carried out in the Abdul Latief Sinjai Grand Forest Park area, the topography of which is gentle, hilly and mountainous, while Fithri's research location was in Brayeun, which is one of the mountains located in Leupung District, Aceh Besar, where more lichen species were found.

## Conclusion

The diversity in the Cirengganis Block in the Pananjung Pangandaran Nature Reserve Area, West Java, is terrestrial ferns in the medium category, with eight types of terrestrial ferns included in the six highest

families, *Acystopteris tenuisecta* and *Pteris vittata* L. caused by altitude and soil pH; moss plants in the medium category with seven moss species, including *Pogonatum contortum* (Brid.) Lesq, *Atrichum undatum* (Hedw.) P. Beauv., *Hypnum cupressiforme*, *Thuidium glaucinoides*, *Archilejeunea planiuscula* (Mitt.) Steph, *Lophojeunea acutifolia* Mizzut & Piippo, *Lejeunea* sp. with the highest number is the *Archilejeunea planiuscula* species because it is supported by several factors such as light intensity, altitude, humidity, temperature and soil pH; lichens in the medium category, with 235 individuals found from 9 species of lichens belonging to 5 families, *Arthoniaceae*, *Collemataceae*, *Bacidiaceae*, *Graphidaceae* and *Leprariaceae*. There are two types of lichens throughout the research location: *crustose* and *foliose*. The types of talus that were mostly found in this study were *Crustose talus* types consisting of *Cryptothecia striata*, *Bacidia* sp, *Bacidia schweinitzii*, *Dyplolabia afzelii*, *Graphis scripta*, *Graphis* sp, *Diorygma poitaei*, *Lepraria* sp and the least frequently found *Foliose talus* type was *Collema subflaccidum*. The most common lichen species found was *Bacidia* sp, with 64 individuals.

Future research on diversity can be carried out using a genetic approach to obtain certain nucleic acid sequences or functional amino acid sequences to be used as barcode genes, which can be used for various further research, especially phylogenetic studies.

### Authors' declaration

- Conflicts of Interest: None.
- We hereby confirm that all Tables in the manuscript are ours.
- No human studies are present in the manuscript
- No animal studies are present in the manuscript
- Ethical Clearance: The project was approved by the local ethical committee at Universitas Pasundan, Bandung, Indonesia.

### Authors' contribution statement

Conceptualization, Y. I.; Methodology, Y. I. and G.; Formal Analysis, I. S. K.; Resources, Y.I. and E. K.; Writing – Original Draft Preparation, Y. I., G., E. K., and I. S. K.; Writing – Review & Editing, Y.I. and I. S. K..

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# تنوع النباتات البوغية (الحزازيات والسرخسيات) والأشنات في محمية بانانجونج باندانجان الغربية، جاوة الغربية

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## الخلاصة

لا يخلو القطاع السياحي في باندانجان أبداً من الزوار، مما يجعل من الصعب نسبياً على المديرين مراقبة وضبط أنشطة الزوار، والتي قد يكون لها تأثير سلبي على وجود وتنوع النباتات والحيوانات مثل الحزازيات والسرخسيات والأشنات في منطقة بانانجونج باندانجان المحمية. تحافظ منطقة محمية بانانجونج عمداً على الأشنات والعديد من النباتات البوغية، وخاصة الحزازيات والسرخسيات، لأنها يمكن أن تُستخدم للحفاظ على كثافة التربة وبالتالي منع التآكل، والذي قد يعرض سلامة السكان المحليين للخطر ويؤثر سلباً على القطاعين الاقتصادي والسياحي في مقاطعة باندانجان. لهذا السبب، تهدف دراستنا إلى تحديد تنوع أنواع السرخس الأرضي (السرخسيات) والطحالب (الحزازيات) في محمية بانانجونج باندانجان الطبيعية، جاوة الغربية. المنهجية المستخدمة في هذه الدراسة هي الوصف النوعي لتصميم حزام النقل. تم جمع العينات باستخدام طريقة أخذ العينات الهادفة. تم استخدام خط مسح طولي بطول 110 متر تقريباً؛ يحتوي المسح الطولي على ست مربعات، مقياس كل منها 10×10 متر. بناءً على نتائج البحث، تم العثور على 8 أنواع من السرخس الأرضي، بما في ذلك نوعان في 3 رتب و 6 عائلات؛ تم تحديد 7 أنواع بإجمالي 437 فرداً من نباتات الطحالب و 235 فرداً من 9 أنواع من الأشنات تنتمي إلى 5 عائلات هي Arthoniaceae و Collemataceae و Bacidiaceae و Graphidaceae و Leprariaceae. استناداً إلى حساب النتائج باستخدام مؤشر شانون-وينر (H') لتنوع الأنواع، يبلغ مؤشر تنوع السرخس الأرضي  $H' = 1.929$  وينتمي إلى الفئة المتوسطة. أعلى مؤشر قيمة أهمية (INP) هو *Acystopteris tenuisecta* بنسبة 80.148%، بينما أدنى مؤشر قيمة أهمية (INP) هو *Pteris vittata* L بنسبة 13.614%. مؤشر التنوع (H') لنباتات الطحالب هو 1.1041، مصنف ضمن المعايير المتوسطة. كان مؤشر القيمة المهمة (INP) للطحالب في موقع الدراسة الأعلى، وهو *Archilejeunea planiuscula* (Mitt.) Steph بقيمة 99.466. يُصنف تنوع الأشنات على أنه متوسط، بقيمة  $H' = 1.92$ . أصبح نوع الأشنات الأكثر شيوعاً، *Bacidia* sp، النوع السائد في منطقة الدراسة، بعدد 64 فرداً مع مؤشر قيمة مهم (INP) يبلغ 44.475%. استناداً إلى مؤشر التنوع (H')، يظهر أن السرخسيات الأرضية ونباتات الطحالب والأشنات في الفئة المتوسطة، لذا فهي آمنة إلى حد ما في أداء وظائفها الحيوية للحفاظ على كثافة التربة لتجنب كوارث التآكل. يمكن للبحوث المستقبلية استخدام نهج جيني للحصول على تسلسلات حمض نووي معينة تعمل كباركود جيني لكل نوع بحيث يمكن إجراء الدراسات البحثية وجهود الحفظ المختلفة بشكل علمي.

**الكلمات المفتاحية:** محمية بانانجونج الطبيعية، مؤشر التنوع، مؤشر القيمة المهمة، السرخسيات، الطحالب، الأشنات.