ARTICLE CORRESPONDENCE

1. **Submitted to the journal "Biogenesis : Jurnal Ilmiah Biologi" (20-02-2023)**
2. **Technical Revision (20-3-2023)**
3. **Requested Technical Revision (22-3-2023)**
4. **Review Results (16,24,28-5-2023)**
5. **Reminder Manuscript Revisions (8-10-2023)**
6. **Revision Manuscript (27-9-2023)**
7. **Paper accepted for publication (31-7-2023)**
   - Final paper
8. **Paper published (31-7-2023)**

1.Submitted to the journal “Biogenesis : Jurnal Ilmiah Biologi” (20-02-2024)

https://journal.uin-alauddin.ac.id/index.php/biogenesis/authorDashboard/submission/36221

Import favorites | Sistem Informasi Ke... | Sistem Informasi Ak... | Simbelmawa - Prog... | PPK KEMDIKBUD | 30e0814d-307e-45c... | metodologi-peneliti...

Biogenesis: Jurnal Ilmiah Biologi | Tasks 0 | English | View Site | mariaulfah520

Submission Library | View Metadata

Submissions

Types of diversity and ecological functions of pteridophytes in the Lawe Secepit Waterfall Kendal

Maria Ulfah, Luhur Pujo Santoso, Ricky Alamsyah, Sulis Setya...

Submission | Review | Copyediting | Production

Submission Files Search

108035-1	mariaulfah520, Biogenesis_ Maria Ulfah.docx	February 20, 2023	Article Text
	Edit		
110668-1	deviarmita, 36221-Article Text-110630-1-18-20230402.docx	April 3, 2023	Article Text

Download All Files

2. Technical Revision (20-3-2023)

mariaulfah upgris <mariaulfah@upgris.ac.id>

[bio] New notification from Biogenesis: Jurnal Ilmiah Biologi

1 pesan

Devi Armita <journal@uin-alauddin.ac.id> 20 Maret 2023 pukul 09.05
Balas Ke: Isna Rasdianah Aziz <biogenesis@uin-alauddin.ac.id>
Kepada: Maria Ulfah <mariaulfah@upgris.ac.id>

You have a new notification from Biogenesis: Jurnal Ilmiah Biologi:

You have been added to a discussion titled "Technical Revision" regarding the submission "Types of Diversity and Ecological Functions of Pteridophyte in The Lawe Secepit Waterfall Kendal Indonesia".

Link: https://journal.uin-alauddin.ac.id/index.php/biogenesis/authorDashboard/submission/36221

Isna Rasdianah Aziz

_____ Biogenesis: Jurnal Ilmiah Biologi http://journal.uin-alauddin.ac.id/index.php/biogenesis

3.Requested Technical Revision (22-3-2023)

mariaulfah upgris <mariaulfah@upgris.ac.id>

TECHNICAL REVISION

1 pesan

Biogenesis Jurnal Ilmiah Biologi <biogenesis@uin-alauddin.ac.id> 22 Maret 2023 pukul 12.07
Kepada: mariaulfah@upgris.ac.id, luhurpujo.s27@gmail.com, rickyalamsyah05@gmail.com, sulistyan24@gmail.com, sa6529526@gmail.com

Dear Authors,
Maria Ulfah, Luhur Pujo Santoso, Ricky Alamsyah, Sulis Setyaningrum, Septiana Kurniawati

Regarding the manuscript entitled "Types of Diversity and Ecological Functions of Pteridophyte in The Lawe Secepit Waterfall Kendal Indonesia" which has been submitted to our journal Biogenesis: Jurnal Ilmiah Biologi (SINTA 2), the editorial team has requested technical revision of your manuscript through pre-discussion in web OJS. We're hoping the author can finish the revision by ***March 31, 2023.***

We, therefore, convey. Thank you for your cooperation

Best Regards,
Isna Rasdianah Aziz
Editor in Chief Biogenesis: Jurnal Ilmiah Biologi SINTA 2
Department of Biology, Faculty of Science and Technology
Universitas Islam Negeri Alauddin Makassar
South Sulawesi, Indonesia. 92113
Ph./WA/Telegram: +6285242001984
SCOPUS ID: 57203528937
E-mail: isna-rasdianah@uin-alauddin.ac.id

4. Review Results (16,24,28-5-2023)

Reviewer's Attachments

Search

113119-1	, review - 36221-Article Text-110669-1-4-20230403.docx	May 16, 2023
113788-1	, Review_36221-Article Text-110669-1-4-20230403.docx	May 24, 2023
114172-1	, 36221-Article Text-110669-1-4-20230403.docx	May 28, 2023

pISSN 2302-1616, eISSN 2580-2909
Vol x, No. x, 20xx, pp x
Available online http://journal.uin-alauddin.ac.id/index.php/biogenesis
DOI xxxxx

Types of diversity and ecological functions of Pteridophyte in the Lawe Secepit Waterfall Kendal Indonesia

ABSTRACT. Lawe Secepit Waterfall Limbangan Kendal has an environmental condition that is still very natural because there is no further management from the local government. This area has the potential as a habitat for various Pteridophyte species, both epiphytic and terrestrial. This study aims to determine the diversity of species and ecological functions of Pteridophyte in the area of Lawe Secepit Waterfall Limbangan Kendal. This research was conducted through field research activities with the method of observation and literature study. Data collection was carried out by making four research stations with a size of 5m x 5m at each station with a distance between stations of ± 10 m. The results showed that there were 17 types of Pteridophyte consisting of 3 orders, 10 families and 15 genera. The diversity of Pteridophyte species in the Lawe Secepit Waterfall Limbangan Kendal area is included in the medium category with a species diversity index value of 2.48. Pteridophyte play a role as producers in the food chain, forming soil nutrients, regulating water systems, and preventing erosion. Environmental conditions have an influence on the diversity of Pteridophyte in the area.

Keywords: ecological function; Lawe Secepit Waterfall; Pteridophyte; species diversity; water management

INTRODUCTION

Indonesia is one of the countries with a very abundant level of biodiversity, both flora and fauna (Sari & Mukti, 2019). Such biodiversity includes plants and animals which is spread throughout the territory of Indonesia. Indonesia ranks fourth the world for plant species diversity, which has approximately 38,000 species. The diversity of these plant species is depicted in the forests that spread throughout Indonesia (Hidayat, *et al*., 2018). A total of 515 species of this plant were found in Java Island (Wahyuningsih *et al*., 2016). Pteridophyta being one type of flora that has high diversity and large distribution (A'tourrohman *et al*., 2020). This makes biodiversity in Indonesia to be predicted as a long-term asset that needs to be studied, studied, and researched continuously for the welfare of the country in the future. Biodiversity is a term used to describe the diversity of living things found in an area. The abundance of biodiversity in Indonesia is caused by the location of Indonesia which is in the tropics with a geological location at the confluence of three large tectonic plates (the Indo-Australian plate, the Eurasian plate, and the Pacific plate), as well as its geographical location which is right on the equator with a geographical location. islands that are separated and far from each other so that it can cause speciation and produce very abundant genetic variation, both in plants and animals. Pteridophytes are vascular plants without seeds currently with about 12,000 known species. They are from two phylogenetically distinct groups: the *lycophytes* (less than 1500 species) and the ferns (some 10,500 species) (PPG I, 2016).

They are widely distributed, from the tundra to tropical forests, being more diverse in the equatorial region. Although lycophytes and ferns reach high frequency and abundance in humid forests, they also occur in dry environments, where some genera can be quite species rich (Moran, 2008). Locally *pteridophytes* are not randomly distributed, as their presence or absence reflects microhabitat characteristics, such as soil texture and fertility, atmospheric temperature and humidity, precipitation, and light intensity (Nóbrega *et al*., 2011; Patil *et al*., 2016). *Pteridophyte* is a group of plants that can be found in almost every region in Indonesia. *Pteridophyte* always grow a lot near waterfalls. Species of *Pteridophyte* grow abundantly in mountainous areas compared to the lowlands (Kessler, 2010). *Pteridophyte* are grouped into cryptogamae that prefer to grow in moist areas; therefore about 65% are found in tropical rainforest areas (Hietz, 2010). Waterfalls are open spaces in forests and give epiphytic plants the opportunity to settle terrestrially in rocks (Van Stenis, 2006). In the Dholo Waterfall, Kediri East Jawa Indonesia found 22 species of Pteridophyte from 18 genera, 13 families *Pteridophyte* (Rizky, 2016). *Pteridophyte* that can be found in the world reach 10,000 species (Suraida, Susanti, and Amriyanto., 2013), while Pteridophyte that can be found in Indonesia reach 3,000 species (Apriyanti *et al*., 2017). The presence *Pteridophyte* in an area can be used as an

Commented [AL1]: - What is known about the topic: 1) Up-to-date studies à 35 – 50% literatures are 5 y.o. ; 2) Cite broadly worldwide studies

- Clearly describe the problem
- Specific aims, Based on the problem

Commented [AL2R1]: for paragraph 2, the paragraph describes Pteridophyte, but the sentence order is not correct. sentences should be arranged systematically and show the relationship between sentences. So in one paragraph, one main topic is enough, but in paragraph 2 there are still many main sentences. For example: it can be discussed in main sentences describing pteridophytes based on morphological characters, then systematically, then their habitat, arranged into 1 topic of discussion with 1 main sentence.

the results of other studies should be separated by a description of the Pteridophyte.

Commented [AL3R1]: it is necessary to have a literacy study from other research in the same field, then compare it with the research objectives to be carried out, so that the research gaps can be seen and the novelty of this research can be seen.

Commented [AL4R1]: the fundamental problem why it is necessary to research biodiversity and ecological functions is not yet clear.

Commented [AL5R1]: what is the next goal after knowing the diversity and ecological functions of the waterfall? does it lead to a pattern of conservation or ecotourism, is it just information.

indicator of environmental conditions in the area. The presence of *Pteridophyte* in an area can indicate whether the area can support the life of an organism or not, because it has interaction and dependence with its environment. Diversity *Pteridophyte* can be used as supporting data in decision makers related to environmental management, development, and conservation (Imaniar, 2017). This is the reason why the existence of *Pteridophyte* needs to be maintained.

The existence of *Pteridophyte* is one of the components of the ecosystem that can indicate whether the environment can support the life of the organism or not because it has a reciprocal relationship and interdependence with the environment (Wahyuna, 2014). In general, *pteridophyte* plants grow in sheltered and moist places (Dayat, 2020). The waterfall area can be one of the habitats of *Pteridophyte* because it has a relatively good bioecology, so it can support the life of *Pteridophyte*. Lawe Secepit Waterfall located in the village of Ngesrepbalong Limbangan Kendal. Lawe Secepit Waterfall can be accessed by walking for 20 minutes from the parking location. Lawe Secepit Waterfall has a waterfall as high as 20 meters with a water discharge that is not too heavy. The environmental condition of Lawe Secepit Waterfall is still very natural because there is no further management in the area of Lawe Secepit Waterfall so that access to the location is quite difficult and has the effect of not too many visitors touching the area. The area of Lawe Secepit Waterfall has the potential as a habitat for various *Pteridophyte*, but until now there has been no research on the diversity of Pteridophyte in the area. The research aimed are to document the pteridophyte species with ecological function and to evaluate the ecological knowledge of the local inhabitants of Lawe Secepit Waterfall regarding the pteridophytes. We provide a conceptual synthesis of the rapidly expanding field of *Pteridophyte* ecology in order to establish a framework for future research and to encourage interdisciplinary approaches to studies of *Pteridophyte*.

MATERIALS AND METHODS

Study site. This research was conducted along the Lawe Secepit Waterfall area in Ngesrepbalong Limbangan Kendal Central Jawa.

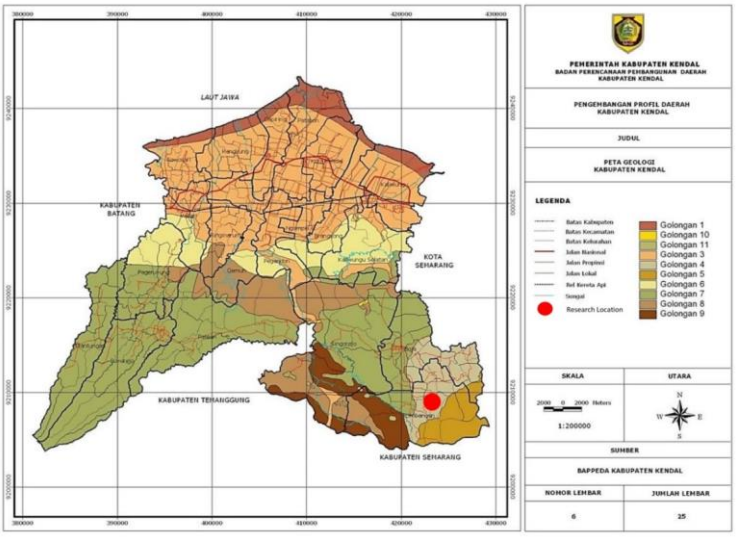


Fig. 1. Research Location (Source : BAPPEDA Kendal Central Java, 2010)

Commented [AL6]: please provide a description of the research location, for example latitude, altitude, temperature and humidity, ect

Commented [AL7]: the quality of this image is low, please replace it with a high resolution and clear

This research was conducted in August-December 2022. Field exploration research and literature review were used in this study (Darwin *et al*., 2021). The research activity uses a descriptive quantitative method with the sampling method using the quadratic method (Harjosuwarno, 1990). The sampling technique used purposive sampling (Asrianny *et al*., 2010). The sampling step was carried out at four sites (Fig.2). The population in this study is the entire pteridophyte vegetation in the Lawe Secepit Waterfall area in Ngesrepbalong Limbangan Kendal Central Java. While the research sample is pteridophyte plants contained in sample plots measuring 5x5 meter. Plant sampling is divided into three parts at each site,

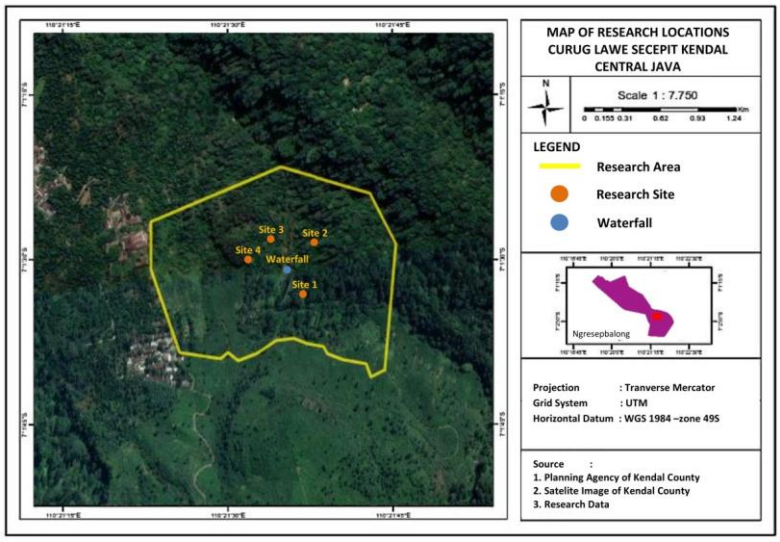


Fig. 2. Research Site (Source : Primary Data, 2023)

The tools and materials used are stationery, camera, 5x5 meter plot, hygrometer, soil tester, lux meter, plastic bag, cutter, identification book, 70% alcohol, sack and paper. The steps of this research are field surveys, sampling, species identification, herbarium preparation, and report preparation. Pteridophytes found in each plot were recorded with the names given by taxonomists, counted the number of species, and captured. Then, samples of plants of unknown species were taken, ~~put in the plastic~~, ~~and preserved using 70% alcohol~~. For identification purposes, all parts of plants are taken. The determination of Pteridophyta species was carried out by the method of comparing the morphological features of the identified Pteridophyta plants. The instrument used in this stage was the Pteridophyta plant observation sheet. Sample identification was conducted at the Biology Education Laboratory Universitas PGRI Semarang to determine the type of pteridophyta using an identification book, A Textbook of Botany by Shital P. Misra S. N. Pandey, 2009 and Ferns : British and Exotic by Edward Joseph Lowe, 2015.

Data analysis. Data analysis was conducted qualitatively and quantitatively. Descriptive qualitative data analysis is presented in a table containing the names of order, family, genus and species. The morphological data from the pteridophytes were analyzed through a qualitative approach viewed from environmental aspects (temperature, air humidity, soil moisture, light intensity, and soil pH). Quantitative analysis about diversity index of Pteridophyte can be calculated using the formula by Shannon-Weiner (Zar, 2010; Handayani, 2012). Points of the Species Diversity Index, according to Shannon Wiener based on the following the value of $H' > 3,00$ indicates that the species diversity on a transect is high. The value of $1,00 \leq H' \leq 3,00$ indicates that the species diversity on a transect is

Commented [AL8]: Literature review for what?

Commented [AL9]: The sampling technique used purposive sampling, please explain the reasons for using purposive sampling

Commented [AL10]: research time should be separated from the method, accompanied by season information

Commented [AL11]: can 3 sites or 4 sites represent the entire Lawe Secepit Waterfall area?

Commented [AL12R11]: consider this because to mention the Lawe Secepit Waterfall area, the sample must be representative

Commented [AL13]: what if find the species that the researcher don't know the name yet?

Commented [AL14]: Put some samples for identification

Commented [AL15]: For identification purposes, all parts of plants are taken and preserved using 70% alcohol

Formatted: Strikethrough

Commented [AL16]: Identification Method:
1.Using the identification key
2.Create a Description
3.Comparing with Specimen
4.Comparing Images (Books / Online Media)
5.Expert Assistance Determination

of moderate diversity. The value of H' < 1.00 indicates that the species diversity on a transect is small or low. In addition to identify the diversity of Pteridophyte, this study also aims to determine the ecological function of Pteridophyte. The results of the diversity found and ecological functions were analyzed by descriptive analysis.

note

RESULTS AND DISCUSSION

Environmental conditions. Environmental conditions in the area of Lawe Secepit Waterfall Limbangan Kendal are very supportive for the growth of *Pteridophyte*. Data of environmental conditions at each research site can be seen in Table 1.

Table 1. Environmental conditions

Site	Temperature (ºC)	Air Humidity (%)	Soil Moisture (%)	SoilpH	Light Intensity (lux)
I	24	91	60	6.5	3250
II	26	78	30	6.5	2280
III	25	90	70	6.2	1470
IV	26	90	70	5.9	1270

The development of *Pteridophyte* is strongly influenced by the surrounding environmental conditions. Abiotic factors that affect *Pteridophyte* are climate (air temperature, air humidity, light intensity), soil and other environmental physical conditions (Katili, 2013). Each type of plant has a minimum, maximum, and optimum condition for existing environmental factors as well as survival against various environmental conditions (Windari & Murningsih, 2021). Based on the data obtained, environmental conditions in the Lawe Secepit Waterfall Limbangan Kendal area have the potential for the growth of various types of *Pteridophyte*.

Lawe Secepit Waterfall Limbangan Kendal has a temperature in the range of 24ºC – 26ºC, where the temperature is suitable for *Pteridophyte*, so that *Pteridophyte* will grow and develop optimally and in the end their distribution will increase. *Pteridophyte* that grow in the tropics generally require a temperature range of 21 – 27°C for growth (Lestari, 2019). *Pteridophyta* generally lives in humid environments with temperatures ranging from 21–27ºC at varying altitudes and habitats in aquatic, terrestrial, and epiphytic areas (Nabila *et al*., 2021).

Generally, *Pteridophyte* live in shady places with high humidity levels. Humidity level of 30% is the lowest percentage that can be tolerated for nail growth (Imaniar, 2017). Air humidity in Lawe Secepit Waterfall ranges from 78 - 91%, so it is still within the tolerance range for its growth. Light intensity ranging from 200-600 fc is suitable for the growth of *Pteridophyte* (Lestari, 2018). Ecosystems are affected by sunlight because the sun determines the temperature at that place. In addition, the process of photosynthesis in plants also requires sunlight. *Pteridophyte* need a minimum amount of light to be able to obtain energy for growth and development.

An acidic pH between 5.5 – 6.5 is a suitable soil pH for *Pteridophyte*, but a more alkaline pH ranging from 7-8 is needed *Pteridophyte* to grow in rocky areas (Siska, 2019). *Pteridophyte* prefer acidic pH, except in some members. Growth *Pteridophyte* is influenced by pH because it affects the absorption of nutrients.

Species diversity. Species diversity is one of the more frequently measured quantities in ecology, yet how to measure it is complex, and sometimes contentious (Chao *et al*., 2020). The individual number of *Pteridophyte* found in the whole plot location in the Lawe Secepit Waterfall Limbangan Kendal was 545 individuals from 3 order, 17 species, 15 genera, and 10 families. The most abundant species was *Marsilea crenata*.

Commented [AL17]: What?

Commented [AL18]: why are ecological functions not observed directly?

Commented [AL19]: how to analyze environmental parameters?
better added using PCA analysis

Commented [AL20]: Every tables and images should be separated with explanation. Images in same classification should be group (editable), use text box to write the code.
Discussions are presented clearly and informative. Data discussed by comparing the data obtained with the previous data, clarifying arguments against the results obtained in accordance with the research objectives, and explaining the similarities and differences as well as demonstrate the uniqueness of the invention.

Commented [AL21]: I think it's better to present data on diversity and ecological function first, then environmental conditions

Fig. 1. *Pteridophyte* found in Lawe Secepit Waterfall Limbangan Kendal A. *Marsilea crenata* B. *Pteris biaurita* L C. *Selaginella intermedia* D. *Pyrrosia angustata* E. *Christella parasitica* (L.) H.Lev F. *Adiantum capillus veneris* G. *Doryopteris concolor* H. *Phymatosorus scolopendria* I. *Pityrogramma calomelanos* J. *Cystopteris fragilis* K. *Orthiopteris saccolama* L. *Nephrolepis biserrata* M. *Tectaria heracleifolia* N. *Phymatodes nigrescens* O. *Sphenomeris chinesis* P. *Selaginella plana* Q. *Pyrossia lanceolata.*

The diversity of *Pteridophyte* found in the area of Lawe Secepit Waterfall Limbangan Kendal is indicated in Table 2.

Table 2. Diversity of *Pteridophyte* found in Lawe Secepit Waterfall Limbangan Kendal.

Order	Family	Genus	Species
Marsileales	Marsileaceae	Marsilea	*Marsilea crenata*
Selaginellales	Selaginellaceae	Selaginella	*Selaginella intermedia*
			Selaginella plana
Polypodiales	Polypodiaceae	Pyrrosia	*Pyrrosia angustata*
			Pyrossia lanceolata (L.) Farw.
		Phymatodes	*Phymatodes nigrescens*
		Phymatosorus	*Phymatosorus scolopendria*
	Tectariaceae	Tectaria	*Tectaria heracleifolia*
	Nephrolepidaceae	Nephrolepis	*Nephrolepis biserrata*

Commented [AL22]: Species name must be written in full

Commented [AL23]: Like This

Dennstaedtiaceae	Orthioptheris	*Orthioptheris saccolama*
Pteridaceae	Doryopteris	*Doryopteris concolor*
	Pteris	*Pteris biaurita* L.
	Adiantum	*Adiantum capillus veneris*
	Pityrogramma	*Pityrogramma calomelanos*
Cystopteridaceae	Cystopteris	*Cystopteris fragilis*
Lindsaeaceae	Sphenomeris	*Sphenomeris chinesis*
Thelypteridaceae	Christella	*Christella parasitica* (L.) H.Lev

Species diversity index. The species diversity index *Pteridophyte* found in the Lawe Secepit Waterfall Limbangan Kendal area was analyzed using the Shannon-Whiner formula and the results obtained can be seen in Table 3.

Table 3. Diversity index of *Pteridophyte*

Species	Sites				∑	H'
	1	2	3	4		
Marsilea crenata	-	72	-	55	127	0,339
Pteris biaurita L.	31	7	12	23	73	0,268
Selaginella intermedia	31	17	-	-	48	0,213
Pyrrosia angustata	-	-	32	7	39	0,187
Christella parasitica (L.) H.Lev	24	-	-	14	38	0,184
Adiantum capillus veneris	36	-	-	-	36	0,179
Doryopteris concolor	-	-	31	-	31	0,161
Phymatosorus scolopendria	-	-	27	-	27	0,147
Pityrogramma calomelanos	-	9	16	-	25	0,139
Cystopteris fragilis	-	-	-	22	22	0,128
Orthioptheris saccolama	19	-	-	-	19	0,114
Nephrolepis biserrata	17	-	-	-	17	0,107
Tectaria heracleifolia	-	13	-	-	13	0,086
Phymatodes nigrescens	8	3	-	-	11	0,078
Sphenomeris chinesis	-	-	-	9	9	0,066
Selaginella plana	5	-	-	-	5	0,042
Pyrossia lanceolata.	5	-	-	-	5	0,042
TOTAL					545	2,48

Based on the results of research *Pteridophyte* in the Lawe Secepit Waterfall Limbangan Kendal, the results of the calculation of the diversity index are 2.48. Based on the Shannon-Weiner law, the diversity index value is included in the moderate criteria. Diversity can be used as a parameter to measure community stability. The higher the diversity index value, the more stable the community will be. This shows that the *Pteridophyte* community in the Lawe Secepit Waterfall Limbangan Kendal is relatively stable.

Ecological functions. The *Pteridophyte* have a role both ecologically and economically. Ecologically, the existence of *Pteridophyte* acts as a producer in a food chain and components in the nitrogen cycle. Meanwhile economically, *Pteridophyte* has the potential for trade commodities because of its role as an ornamental plant, medicinal plants, vegetables, and as a protector of seedlings (Vijayakanth & Sathis, 2016; Zhang Xianchun *et al*., 2016). The role of *Pteridophyta* for humans as a source of germplasm, including for consumption needs, raw materials for traditional medicine, ornamental plants, handicrafts, and fertilizers for soil improvement (Ciawi *et al*., 2022). *Pteridophyte* as part of biodiversity which has quite important ecological functions. In general, *Pteridophyte* have ecological functions as litter mixers for the formation of soil nutrients, as producers in the food chain, and habitats for several other organisms, as well as acting as ground cover so that they can regulate water systems. Vegetation has a role which is very important in forest communities and serves as a buffer life, both in preventing erosion, and maintaining the stability of the global climate (Hidayati, 2010). For humans, *Pteridophyte* have been a lot used among others as an ornamental plant, vegetables and medicinal materials (Zelnik *et al*., 2021). But not in a way directly, the presence of

Commented [AL24]: a rarefaction curve can be added to show that the yielded diversity index has sufficiently represented the sampling efforts towards the study area. you can analyze using PAST Program

Commented [AL25R24]: the discussion should be further expanded, and linked to environmental factors. analysis using Principal component analysis (PCA).

spike plants also providing benefits in maintaining forest ecosystems, among others, in the formation of soil, soil security against erosion, as well as helps the weathering process of forest litter (Arini & Julianus, 2012). *Pteridophyta* for the environment has an ecological role, such as covering soil, protecting the soil from erosion, mixing litter for soil nutrient formation, and acting as producers in the food chain. Ecological function of each species of *Pteridophyte* found can be seen in Table 4.

Table 4. Ecological function of *Pteridophyte* found in Lawe Secepit Waterfall Kendal

Species	Functional Roles
Marsilea crenata	Contributing organic matter to the soil, improving soil physical properties, and increasing soil microbial activity.
Pteris biaurita L.	As a hyperaccumulator of heavy metals because it has phytokelanin compounds that function to bind heavy metals arsenic and mercury.
Selaginella intermedia	Fertilize soil, control water system, as ground cover vegetation, and maintain soil moisture.
Pyrrosia angustata	As a habitat for insects, retaining water and moisture.
Christella parasitica (L.) H.Lev	As a producer of the food chain, regulate water management, cover soil, and prevent erosion.
Adiantum capillus veneris	Retaining surface runoff (*run off*) by inhibiting and holding rainwater continuously.
Doryopteris concolor	Source of food for other organisms and produce soil nutrient-forming litter.
Phymatosorus scolopendria	Bioindicator of humidity.
Pityrogramma calomelanos	As a food chain producer and natural photoremediation for arsenic contaminated soil.
Cystopteris fragilis	Helps weathering forest litter, prevents erosion, maintains water use in the soil and regulates water management.
Orthioptheris saccolama	As a cover vegetation, mixing of litter for the formation of soil nutrients, and producers in the food chain.
Nephrolepis biserrata	Cleans the air of toxic pollutants, and can maintain soil moisture and temperature.
Tectaria heracleifolia	Helps the weathering process of dry leaf litter, as a ground cover, and prevents erosion,
Phymatodes nigrescens	Fertilizes the soil because it acts as a source of nutrients and natural fertilizer
Sphenomeris chinesis	Prevents erosion and maintains water use in the soil.
Selaginella plana	An antidote to poisonous snakes, traditional medicine.
Pyrossia lanceolata.	Habibat for insects.

Note

CONCLUSION

Based on the results of research conducted in the Lawe Secepit Waterfall Limbangan Kendal, 545 individuals from 3 order, 15 genera, 10 families and 17 species of Pteridophyte with a species diversity index value of 2.48 that was included in the medium category (index value 1.00-3.00), analyzed using the Shannon-Whiner formula. *Pteridophyte* have ecological functions as litter mixers for the formation of soil nutrients, as producers in the food chain, bioindicator of humidity and habitats for several other organisms, as well as acting as ground cover so that they can regulate water systems.

ACKNOWLEDGEMENTS

Authors thankfully acknowledge the financial assistance provided by UPGRIS Research Programme SK No.20.a/MAWA/UPGRIS/II/2022 for providing the infrastructural facility and consistent encouragement during the course of studies.

REFERENCES

Commented [AL26]: Discussion:
- Summarize what you did
  - •Reintroduced the topic
  - •Restate the problem
  - •Summarize key findings
- Interpret the findings
  - •Similarities and differences
  - •Unexpected/negative results
  - •Limitations
  - •Importance to the field

Commented [AL27R26]: please add a discussion with those components!

Commented [AL28]: Conclusion:
- Main conclusion: The solution of the problem
- Key findings: 1-2 most important findings
- Implications: Contribution to the field
- Future direction: How to build on the study

Commented [AL29R28]: Conclusion
A conclusion is not merely a summary of your research result or a re-statement of your research problem but a synthesis of key points, an answer to the research objective. Only in one paragraph, without numbering and bullets. Suggestion should be based on the research findings and refer for the future research.

Commented [AL30]: References
1. The author's name should be clear. If the author's name consists of more than one word, then used the last name, first name and middle name should be abbreviated. E.g: Taufik Ahmad Wahyudi written Wahyudi TA.
2. If there are more than two authors then all the author's name is listed (not abbreviated by et or et al). Format: For one author should be written name of the author, year of publication. For two authors should be written name of first author, name of the second authors, year of publication. For more than two auhtors should be written name of the first author, name of the second author, name of the third author, and so on, year of publication.
3. Name of journals should be not abbreviated.
4. The journal-title uses the original language, not translate to English.
5. Adapted reference minimal last 10 years, except in taxonomy study.
6. Adapted reference is 90% scientific journals with doi number.
7. Adapted reference is minimal 30 scientific journal with doi number, except in taxonomy study.

Commented [AL31R30]: please use citation software, eg: EndNOTE, Zotero, Mendeley, etc

Commented [AL32R30]: please cite an article published in the biogenesis journal

A'tourrohman, M. et al. (2020). Keanekaragaman Jenis Paku-Pakuan (*Pteridophyte*) dan Kajian Potensi Pemanfaatannya di Cagar Alam Ulolanang Kecubung. *Jurnal Bioeduscience*, 4(1), 73-8. http://dx.doi.org/10.29405/j.bes/4173-814991

Apriyanti, N., Santri, D. J., & Madang, K. (2017). Identifikasi Tumbuhan Paku (Pteridophyta) dan Kekerabatannya di Kawasan Wisata Air Terjun Curup Tenang Bedegung Kecamatan Tanjung Agung Kabupaten Muara Enim. *Jurnal Pembelajaran Biologi*, *4*(2), 113-125. https://doi.org/10.36706/fpbio.v4i2.7117

Arini, D.I.D dan Julianus, K. (2012). Keragaman Jenis Tumbuhan Paku (Pteridophyta) di Cagar Alam Gunung Ambang Sulawesi Utara. *Jurnal Tumbuhan Paku*. 2(1), 1-24.

Asrianny, ., Marian, ., & Oka, N. P. (2010). Keanekaragaman Dan Kelimpahan Jenis Liana (Tumbuhan Memanjat) Pada Hutan Alam di Hutan Pendidikan Universitas Hasanuddin . *Perennial*, *5*(1), 23-30. https://doi.org/10.24259/perennial.v5i1.186

Chao A, Kubota Y,Zelený D, et al. Quantifying sample completenessand comparing diversities among assemblages. *Ecological Research*. 2020;35:292–314. https://doi.org/10.1111/1440-1703.12102

Ciawi, Y., Salain, I. M. A. K., & Sutapa, A. A. G. (2022). The potency of fern stem as the carbon material for clay-based ceramic filter. *IOP Conference Series: Earth and Environmental Science*, 999(1), 012020. https://doi.org/10.1088/1755- 1315/999/1/012020

Darwin, M., Mamondol, M. R., Sormin, S. A., Nurhayati, Y., Tambunan, H., Sylvia, D., Adnyana, I. M. D. M., Prasetiyo, B., Vianitati, P., & Gebang, A. A. (2021). *Quantitative approach research method (T. S. Tambunan, Ed.; 1st ed.)*. CV Media Sains Indonesia.

Dayat, E. (2020). *Studi floristik tumbuhan paku (Pteridophyta) di hutan lindung gunung dempo Sumatera Selatan*. Institut Pertanian Bogor.

Harjosuwarno, S. (1990). *Dasar-dasar Ekologi Tumbuhan*. Fakultas Biologi UGM : Yogyakarta.

Handayani, Trikinasih, & Sugiarti, P. (2012). Keanekaragaman Jenis Tumbuhan Paku Di Kawasan Gunung Api Purba Nglanggeran Sebagai Sumber Belajar Biologi SMA Kelas X Materi Keanekaragaman Hayati. *Seminar Nasional Kedua Pendidikan Berkemajuan dan Menggembirakan*, 683–692. https://publikasiilmiah.ums.ac.id/handle/11617/9556

Hietz, P. (2010). *Fern adaptations to xeric environments. In Fern Ecology*. Cambridge: Cambridge University Press.

Hidayat, M., Laiyanah, L., Silvia, N., Putri, Y. A., & Marhamah, N. (2018). Analisis Vegetasi Tumbuhan Menggunakan Metode Transek Garis (Line Transek) di Hutan Seulawah Agam Desa Pulo Kemukiman Lamteuba Kabupaten Aceh Besar. *Proceedings of Biotik*, 4 (1), 85-91. http://dx.doi.org/10.22373/pbio.v5i1.2198

Hidayati, N. & Retnowati, D. (2010). *Kamus Lengkap Biologi*. Dwimedia Comp.

Imaniar, R., Pujiastuti & Murdiyah, S. (2017). Identifikasi Keanekaragaman Tumbuhan Paku Di Kawasan Air Terjun Kapas Biru Kecamatan Pronojiwo Kabupaten Lumajang Serta Pemanfaatannya Sebagai Booklet. *Jurnal Pendidikan Biologi*, 6(3), 341. https://doi.org/10.24114/jpb.v6i3.7901

Katili, A.S. (2013). Deskripsi Pola Penyebaran Dan Faktor Bioekologis Tumbuhan Paku (Pteridophyta) Di Kawasan Cagar alam Gunung Ambang Sub Kawasan Kabupaten Bolaang Mongondow Timur. *Sainstek*, **7**(2).

Kessler, M. LR, Walker & JM, Sharpe (2010). *Biogeography of Ferns. In Fern Ecology*. New York : Cambridge University Press. https://doi.org/10.1017/CBO9780511844898.003

Kurniawati, E., Wisanti, & Fida, R. (2016). Keanekaragaman Pteridophyte di Kawasan Hutan Wisata Air Terjun Girimanik Kabupaten Wonogiri. *LenteraBio*, 5(1), 74-78.

Lestari, I., Murningsih & Utami, S. (2019). Keanekaragaman Jenis Tumbuhan Paku Epifit di Hutan Petungkriyono Kabupaten Pekalongan, Jawa Tengah. *NICHE Journal of Tropical Biology*, 2(2), 15. https://doi.org/10.14710/niche.2.2.14-21

Lestari, S. (2018). *Identifikasi Tumbuhan Paku Sejati (Filicinae) Epifit di Gunung Pesagi Kabupaten Lampung Barat*. Lampung: Universitas Islam Negeri Raden Intan.

Lowe, E.J. (2015). *Ferns : British and Exotic. 8th Edition*. Arkose Press. United States of America.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook (3rd ed.)*. Thousand Oaks, CA: Sage.

Moran, R.C. (2016). *Neotropical genera of ferns and lycophytes: a guide for students*. New York : New York Botanical Garden.

Nabila, F., Sulistyowati, D., Isolina, I., Yani, R., Sigit, D. V., & Miarsyah, M. (2021). Diversity of types of pteridophyte epiphytes and spermatophyte epiphytes in the Bogor Botanical Gardens. *Proceeding of Biology Education*, 4(1), 36– 50. https://doi.org/10.21009/pbe.4-1.4

Nóbrega, G.A., Eisenlohr, P. V., Paciencia, M.L.B., Prado, J. & Aidar, M.P.M. (2011). A composição florística e a diversidade de pteridófitas diferem entre a floresta de restinga e a floresta ombrófila densa das terras baixas do Núcleo Picinguaba/PESM, *Biota Neotropica*, 11(2), 153-164. https://doi.org/10.1590/S1676-06032011000200015

Patil, S., Lavate, R., Rawat, V. & Dongare, M. (2016). Diversity and distribution of pteridophytes from Satara District, Maharashtra (India). *Plant Science Today*, 3(2), 149-156. https://doi.org/10.14719/pst.2016.3.2.216

PPG I. (2016). A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution*, 54, 563-603. https://doi.org/10.1111/jse.12229

Rizky, M. A., Utami, B., Budhiretnani, D. A. (2016). Inventarisasi Tumbuhan Paku (Pteridophyta) Di Kawasan Wisata Air Terjun Dholo, Kabupaten Kediri. *Prosiding Seminar Nasional Biologi*, 9-11.

Sari, H. dan Mukti, B.H. (2019). Keanekaragaman Tumbuhan Paku (Pteridophyte) di Kawasan Hutan Desa Banua Rantau Kecamatan Batang Alai Selatan Kabupaten Hulu Sungai Tengah. *Jurnal Pendidikan Hayati*, 5(3), 107 - 114.

Shital P. Misra S. N. Pandey. (2009). *A Textbook of Botany: Bryophyta, Pteridophyta, Gymnosperms and paleobotany. 2nd Edition* . Vikas Publishing House Pennsylvania State University.

Siska, et al. (2019). Karakter Morfologi dan Tipe Stele Tumbuhan Paku Terestrial di Hutan Lindung Juwata Kerikil Kota Tarakan sebagai Sumber Belajar Biologi. *Biopedagogia*, 1(2), 84. https://doi.org/10.35334/BIOPEDAGOGIA.V1I2.1702

Suraida, Susanti, T., & Amriyanto, R. (2013). Keanekaragaman Tumbuhan Paku di Taman Hutan Kenali Kota Jambi. *Prosding Semirata FMIPA Universitas Lampung*.

Van Steenis, C. G. G. J., Hamzah, A., & Toha, M. (2006). *Flora Pegunungan Jawa*, Pusat Penelitian Biologi-LIPI: Bogor.

Vijayakanth, P., & Sathis, S. S. (2016). Studies on the Spore Morfology of Pteridophytes from Kolli Hills, Eastern Ghats, Tamil Nadu India. *International Journal of Research in Engineering and Bioscience*, 4(1), 1–12.

Wahyuna, U. S. (2014). Inventarisasi Pteridophyta di lahan peti dan implementasinya pada pembuatan flipbook sub materi pencemaran lingkungan. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa*, 3(4), . http://dx.doi.org/10.26418/jppk.v3i4.5211

Wahyuningsih, D., Murniningtyas, E., & Effendy S, S. (2016). *Indonesian Biodiversity Strategy and Action Plan 2015-2020*. Bogor: Bappenas.

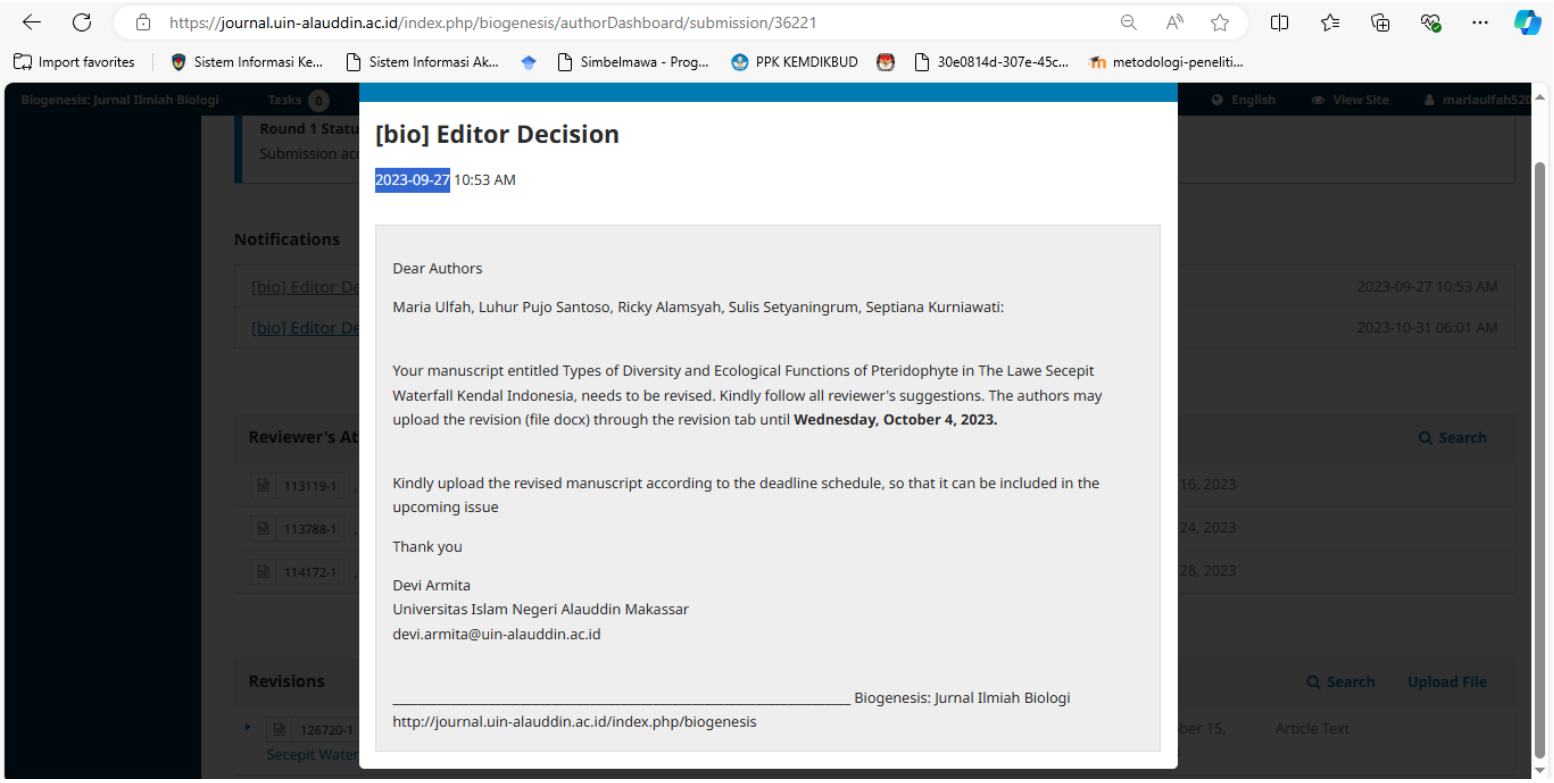
Windari, K. L. & Murningsih. (2021). Keanekaragaman Jenis Tumbuhan Paku (Pteridophyte) di Kawasan Wisata Air Terjun Jurang Nganten Kabupaten Jepara. *Bioma*, 23(2),107- 111. https://doi.org/10.14710/bioma.23.2.107-111

Zar, H.J. (2010). *"Biostatistical analysis". 5th Edition, Prentice Hall Inc.* Upper Saddle River, New Jersey.

Zelnik, I., Kuhar, U. Holcar, M. Germ, M. Gaberš˘cik, A. (2021). *Distribution of vascular plant communities in Slovenian watercourses*. Water,13, 1071.

Zhang, X., Lu Shugang, L. Y. and Q. X. (2013). Polypodiaceae. *Flora Of China.*, 2(3), 758-764.

5.Revision Manuscript (27-9-2023)



[bio] Editor Decision

2023-09-27 10:53 AM

Dear Authors

Maria Ulfah, Luhur Pujo Santoso, Ricky Alamsyah, Sulis Setyaningrum, Septiana Kurniawati:

Your manuscript entitled Types of Diversity and Ecological Functions of Pteridophyte in The Lawe Secepit Waterfall Kendal Indonesia, needs to be revised. Kindly follow all reviewer's suggestions. The authors may upload the revision (file docx) through the revision tab until **Wednesday, October 4, 2023.**

Kindly upload the revised manuscript according to the deadline schedule, so that it can be included in the upcoming issue

Thank you

Devi Armita
Universitas Islam Negeri Alauddin Makassar
devi.armita@uin-alauddin.ac.id

5.Reminder Manuscript Revisions Deadline (8-10-2023)

mariaulfah upgris <mariaulfah@upgris.ac.id>

LAST REMINDER FOR YOUR MANUSCRIPT REVISIONS-DEADLINE OCTOBER 14, 2023

2 pesan

Biogenesis Jurnal Ilmiah Biologi <biogenesis@uin-alauddin.ac.id> 8 Oktober 2023 pukul 14.51
Kepada: mariaulfah@upgris.ac.id, luhurpujo.s27@gmail.com, rickyalamsyah05@gmail.com, sulistyan24@gmail.com, sa6529526@gmail.com

Dear Authors
Maria Ulfah, Luhur Pujo Santoso, Ricky Alamsyah, Sulis Setyaningrum, Septiana Kurniawati:

Your revision of the manuscript entitled Types of Diversity and Ecological Functions of Pteridophyte in The Lawe Secepit Waterfall Kendal Indonesia, should be uploaded on **October 4, 2023,** in our OJS, as the notification we sent before the time. We **extend and remind** you for the last time if the manuscript is not uploaded on **October 14, 2023**, then this manuscript will be rejected in our journal.

Kindly upload the revised manuscript according to the deadline schedule, so that it can be included in the upcoming issue.

Thank you for your cooperation

Thank you
Best Regards,
Isna Rasdianah Aziz
Editor in Chief Biogenesis: Jurnal Ilmiah Biologi SINTA 2
Department of Biology, Faculty of Science and Technology
Universitas Islam Negeri Alauddin Makassar
South Sulawesi, Indonesia. 92113
Ph./WA/Telegram: +6285242001984
SCOPUS ID: 57203528937
E-mail: isna-rasdianah@uin-alauddin.ac.id

mariaulfah upgris <mariaulfah@upgris.ac.id> 9 Oktober 2023 pukul 11.24
Kepada: Biogenesis Jurnal Ilmiah Biologi <biogenesis@uin-alauddin.ac.id>

Thank you, I will revise it soon
[Kutipan teks disembunyikan]

6.Revised Version Received (14-10-2023)

https://jppipa.unram.ac.id/index.php/jppipa/authorDashboard/submission/8095

Import favorites | Sistem Informasi Ke... | Sistem Informasi Ak... | Simbelmawa - Prog... | PPK KEMDIKBUD | 30e0814d-307e-45c... | metodologi-peneliti...

Jurnal Penelitian Pendidikan IPA

← Back to Submissions

[JPPIPA] Editor Decision	2024-07-17 12:13 PM
[JPPIPA] Editor Decision	2024-07-31 11:01 AM
[JPPIPA] Editor Decision	2024-07-31 11:27 AM

Reviewer's Attachments Search

43228	Review_8095_.docx	July 17, 2024

Revisions Search Upload File

43793	Revisi JPPIPA (Maria Ulfah).docx	July 26, 2024	Article Text

Edit Delete

Review Discussions Add discussion

7. Paper accepted for publication (31-7-2023) - Final paper

mariaulfah upgris <mariaulfah@upgris.ac.id>

[JPPIPA] Editor Decision

Editor <jppipa@unram.ac.id> 31 Juli 2024 pukul 10.27
Kepada: Maria Ulfah <mariaulfah@upgris.ac.id>, Octavia Devi Puspita Sari <octdevipuspitasari@gmail.com>, Muhammad Syaipul Hayat <m.syaipulhayat@upgris.ac.id>

Maria Ulfah, Octavia Devi Puspita Sari, Muhammad Syaipul Hayat:

The editing of your submission, "Bioremediation of Nitrate and Nitrite on the Rehabilitation of Contaminated Jatibarang Landfill and the Application of Calla Lily ," is complete. We are now sending it to production.

Submission URL: https://jppipa.unram.ac.id/index.php/jppipa/authorDashboard/submission/8095

[Kutipan teks disembunyikan]

8. Paperpublished (31 Juli 2023)

pISSN 2302-1616, eISSN 2580-2909
Vol 11, No. 2, December 2023, pp. 160-167
Available online http://journal.uin-alauddin.ac.id/index.php/biogenesis
DOI https://doi.org/10.24252/bio.v11i2.36221

Types of diversity and ecological functions of Pteridophyte in the Lawe Secepit Waterfall Kendal

Maria Ulfah[1*], Luhur Pujo Santoso[1], Ricky Alamsyah[1], Sulis Setyaningrum[1], Septiana Kurniawati[1]
[1]Faculty of Mathematics, Natural Sciences and Information Technology Education, Universitas PGRI Semarang
Jl. Sidodadi Timur No 24, Semarang, Central Java, Indonesia. 50125
*Email: mariaulfah@upgris.ac.id

ABSTRACT. Lawe Secepit Waterfall Limbangan Kendal has an environmental condition that is still very natural because there is no further management from the local government. This area has the potential as a habitat for various Pteridophyte species, both epiphytic and terrestrial. This study aims to determine Pteridophyta's biodiversity and conservation status in the area of Lawe Secepit Waterfall Limbangan Kendal. This research was conducted through field research activities with the method of observation and literature study in August-December 2022. Data collection was carried out by making four research stations with a size of 5 m x 5 m at each station with a distance between stations of ± 10 m. The results showed that there were 17 types of Pteridophyte consisting of 3 orders, 10 families and 15 genera. Diversity Pteridophyte species in the Lawe Secepit Waterfall Limbangan Kendal area is included in the moderate criteria with a species diversity index value of 2.48. Pteridophyte play a role as producers in the food chain, forming soil nutrients, regulating water systems, and preventing erosion. Environmental conditions have an influence on the diversity of Pteridophyte in the area. Diversity Pteridophyte in the Lawe Secepit Waterfall Limbangan Kendal can be used as supporting data in decision makers related to environmental management, development, and conservation.

Keywords: ecological function; Lawe Secepit Waterfall; Pteridophyte; species diversity; water management

Article History: Received 31 January 2023; Received in revised form 18 March 2023; Accepted 18 May 2023; Available online 30 December 2023.
How to Cite This Article: Ulfah M, Santoso LP, Alamsyah R, Setyaningrum S, Kurniawati S. 2023. Types of diversity and ecological functions of Pteridophyte in the Lawe Secepit Waterfall Kendal. *Biogenesis: Jurnal Ilmiah Biologi*. vol 11(2): 160–167. doi: https://doi.org/10.24252/bio.v11i2.36221.

INTRODUCTION

Indonesia is one of the countries with a very abundant level of biodiversity, both flora and fauna(Sari & Mukti, 2019). Such biodiversity includes plants and animals which is spread throughout the territory of Indonesia. Indonesia ranks fourth the world for plant species diversity, which has approximately 38,000 species. The diversity of these plant species is depicted in the forests that spread throughout Indonesia (Hidayat et al., 2018). *Pteridophyta* being one type of flora that has high diversity and large distribution (A'tourrohman, 2020). This makes biodiversity in Indonesia to be predicted as a long-term asset that needs to be studied, studied, and researched continuously for the welfare of the country in the future. Biodiversity is a term used to describe the diversity of living things found in an area. The abundance of biodiversity in Indonesia is caused by the location of Indonesia which is in the tropics with a geological location at the confluence of three large tectonic plates (the Indo-Australian plate, the Eurasian plate, and the Pacific plate), as well as its geographical location which is right on the equator with a geographical location. islands that are separated and far from each other so that it can cause speciation and produce very abundant genetic variation, both in plants and animals. *Pteridophytes* are vascular plants without seeds currently with about 12,000 known species.

Pteridophytes are widely distributed, from the tundra to tropical forests, being more diverse in the equatorial region. *Pteridophyta*, which are cosmopolitan; that is, *Pteridophytes* can grow in all areas, both in the highlands and lowlands, is one of the reasons these plants have high diversity (R. W. Saputro & Utami, 2020). Pteridophyta is classified into three habitats: lithophytes, epiphytes, and terrestrial (Priambudi et al., 2022). Although lycophytes and ferns reach high frequency and abundance in humid forests, they also occur in dry environments. The *Pteridophyte* have a distinctive form of young leaves, shaped like a loop of rope (krozier; ental), which is not found in other plants.

In addition, all of these species produce spores that form in sporangium (Nasution & Kardhinata, 2018). Locally *pteridophytes* are not randomly distributed, as their presence or absence reflects microhabitat characteristics. *Pteridophyte* is a group of plants that can be found in almost every region in Indonesia. *Pteridophyte* always grow a lot near waterfalls. *Pteridophyte* are grouped into cryptogamae that prefer to grow in moist areas. Waterfalls are open spaces in forests and give epiphytic plants the opportunity to settle terrestrially in rocks. The presence *Pteridophyte* in an area can be used as an indicator of environmental conditions in the area. The presence of *Pteridophyte* in an area can indicate whether the area can support the life of an organism or not, because it has interaction and dependence with its environment. Diversity *Pteridophyte* can be used as supporting data in decision makers related to environmental management, development, and conservation. This is the reason why the existence of *Pteridophyte* needs to be maintained.

Habitat for *Pteridophyta* in Indonesia is usually in a humid place which is a habitat for terrestrial, epiphytic, and aquatic (Ramadhan & Sianturi, 2022). In general, *pteridophyte* plants grow in sheltered and moist places (Dayat, 2020). The waterfall area can be one of the habitats of *Pteridophyte* because it has a relatively good bioecology, so it can support the life of *Pteridophyte*. The environmental condition of Lawe Secepit Waterfall is still very natural because there is no further management in the area of Lawe Secepit Waterfall so that access to the location is quite difficult and has the effect of not too many visitors touching the area. The area of Lawe Secepit Waterfall has the potential as a habitat for various *Pteridophyte*, but until now there has been no research on the diversity of Pteridophyte in the area. The research aimed are to document the pteridophyte species with ecological function and to evaluate the ecological knowledge of the local inhabitants of Lawe Secepit Waterfall regarding the *Pteridophytes*. Diversity *Pteridophyte* in the Lawe Secepit Waterfall Limbangan Kendal can be used as supporting data in decision makers related to environmental management, development, and conservation. We provide a conceptual synthesis of the rapidly expanding field of *Pteridophyte* ecology in order to establish a framework for future research and to encourage interdisciplinary approaches to studies of *Pteridophyte*.

MATERIALS AND METHODS

Study site. This research was conducted along the Lawe Secepit Waterfall area in Ngesrepbalong Limbangan Kendal Central Jawa. Lawe Secepit Waterfall located in the village of Ngesrepbalong Limbangan Kendal. Lawe Secepit Waterfall can be accessed by walking for 20 minutes from the parking location. Lawe Secepit Waterfall has a waterfall as high as 20 meters with a water discharge that is not too heavy.

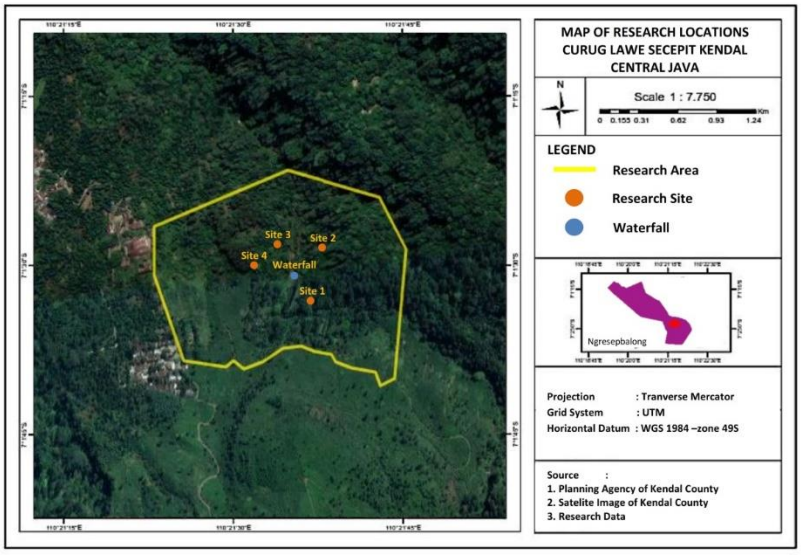


Fig. 1. Research Site

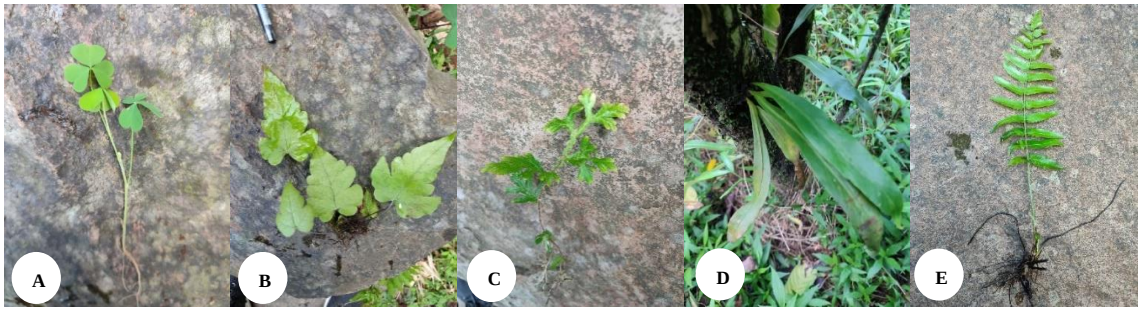
Field exploration research and literature review were used in this study. The research activity uses a descriptive quantitative method with the sampling method using the quadratic method. The sampling step was carried out at four sites (Fig. 1). The population in this study is the entire *Pteridophyte* vegetation in the Lawe Secepit Waterfall area in Ngesrepbalong Limbangan Kendal Central Java. While the research sample is *Pteridophyte* plants contained in sample plots measuring 5x5 meter. Plant sampling is divided into three parts at each site.

Pteridophytes found in each plot were recorded with the names given by taxonomists, counted the number of species, and captured. Then, samples of plants of unknown species were taken. For identification purposes, all parts of plants are taken and preserved using 70% alcohol. The determination of *Pteridophyta* species was carried out by the method of comparing the morphological features of the identified *Pteridophyta* plants, using the identification key, create a description, comparing with specimen, and comparing Images (Books / Online Media). The instrument used in this stage was the *Pteridophyta* plant observation sheet. Sample identification was conducted at the Biology Education Laboratory Universitas PGRI Semarang to determine the type of *Pteridophyta* using an identification book, A Textbook of Botany by (Shital et al., 2009) and Ferns : British and Exotic by (Lowe, 2015).

Data analysis. Data analysis was conducted qualitatively and quantitatively. Descriptive qualitative data analysis is presented in a table containing the names of order, family, genus and species. The morphological data from the *Pteridophytes* were analyzed through a qualitative approach viewed based on the characteristics of the plant through the results of field observations environmental aspects (temperature, air humidity, soil moisture, light intensity, and soil pH). Quantitative analysis about diversity index of Pteridophyte can be calculated using the formula by Shannon-Weiner. Points of the Species Diversity Index, according to Shannon Wiener based on the following the value of $H' > 3{,}00$ indicates that the species diversity on a transect is high. The value of $1{,}00 \leq H' \leq 3{,}00$ indicates that the species diversity on a transect is of moderate diversity. The value of $H' < 1.00$ indicates that the species diversity on a transect is small or low. In addition to identify the diversity of *Pteridophyte*, this study also aims to determine the ecological function of *Pteridophyte*. The results of the diversity found and ecological functions were analyzed by descriptive analysis.

RESULTS AND DISCUSSION

Species diversity. The individual number of *Pteridophyte* found in the whole plot location in the Lawe Secepit Waterfall Limbangan Kendal was 545 individuals from 3 order, 17 species, 15 genera, and 10 families. The most abundant species was *Marsilea crenata*.



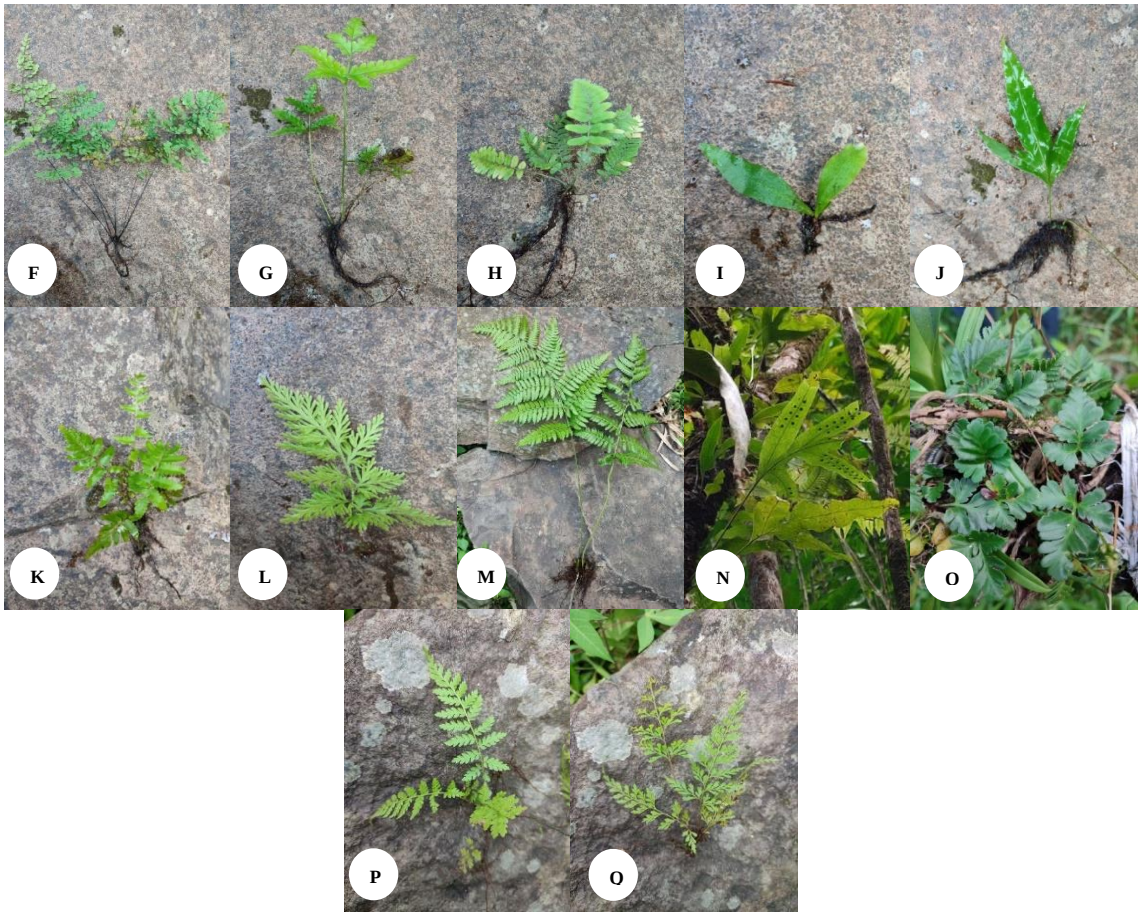


Fig. 2. *Pteridophyte* found in Lawe Secepit Waterfall Limbangan Kendal A. *Marsilea crenata* B. *Pteris biaurita* L C. *Selaginella intermedia* D. *Pyrrosia angustata* E. *Christella parasitica* (L.) H.Lev F. *Adiantum capillus veneris* G. *Doryopteris concolor* H. *Phymatosorus scolopendria* I. *Pityrogramma calomelanos* J. *Cystopteris fragilis* K. *Orthioptheris saccolama* L. *Nephrolepis biserrata* M. *Tectaria heracleifolia* N. *Phymatodes nigrescens* O. *Sphenomeris chinesis* P. *Selaginella plana* Q. *Pyrossia lanceolata.*

The diversity of *Pteridophyte* found in the area of Lawe Secepit Waterfall Limbangan Kendal is indicated in Table 2.

Table 2. Diversity of *Pteridophyte* found in Lawe Secepit Waterfall Limbangan Kendal.

Order	Family	Genus	Species
Marsileales	Marsileaceae	Marsilea	*Marsilea crenata (C.) Presl*
Selaginellales	Selaginellaceae	Selaginella	*Selaginella intermedia (Bl.) Spring*
			Selaginella plana (Desv. ex Poir.) Hieron
Polypodiales	Polypodiaceae	Pyrrosia	*Pyrrosia angustata (Sw.) Ching*
			Pyrossia lanceolata (L.) Farw
		Phymatodes	*Phymatodes nigrescens (Blume) Pic.Serm*
		Phymatosorus	*Phymatosorus scolopendria (Burm.f.) Pic.Serm*
	Tectariaceae	Tectaria	*Tectaria heracleifolia (Willd.) Underw*
	Nephrolepidaceae	Nephrolepis	*Nephrolepis biserrate (Sw.) Schott*
	Dennstaedtiaceae	Orthioptheris	*Orthioptheris saccolama*
	Pteridaceae	Doryopteris	*Doryopteris concolor (Langsd. & Fisch.) Kuhn*
		Pteris	*Pteris biaurita* L.
		Adiantum	*Adiantum capillus veneris Linn*
		Pityrogramma	*Pityrogramma calomelanos Linn*
	Cystopteridaceae	Cystopteris	*Cystopteris fragilis (L.) Bernh*
	Lindsaeaceae	Sphenomeris	*Sphenomeris chinesis (L.) Maxon*
	Thelypteridaceae	Christella	*Christella parasitica* (L.) H.Lev

Species diversity index. The species diversity index *Pteridophyte* found in the Lawe Secepit Waterfall Limbangan Kendal area was analyzed using the Shannon-Whiner formula, This Shannon-Wiener Index shows the level of diversity within a community. The higher level of domination of a species in a place, the less diversity. That can make it easier to know a species' diversity in a particular community. The results obtained can be seen in Table 3.

Table 3. Diversity index of *Pteridophyte*

Species	Sites				∑	H'
	1	2	3	4		
Marsilea crenata	-	72	-	55	127	0,339
Pteris biaurita L.	31	7	12	23	73	0,268
Selaginella intermedia	31	17	-	-	48	0,213
Pyrrosia angustata	-	-	32	7	39	0,187
Christella parasitica (L.) H.Lev	24	-	-	14	38	0,184
Adiantum capillus veneris	36	-	-	-	36	0,179
Doryopteris concolor	-	-	31	-	31	0,161
Phymatosorus scolopendria	-	-	27	-	27	0,147
Pityrogramma calomelanos	-	9	16	-	25	0,139
Cystopteris fragilis	-	-	-	22	22	0,128
Orthioptheris saccolama	19	-	-	-	19	0,114
Nephrolepis biserrata	17	-	-	-	17	0,107
Tectaria heracleifolia	-	13	-	-	13	0,086
Phymatodes nigrescens	8	3	-	-	11	0,078
Sphenomeris chinesis	-	-	-	9	9	0,066
Selaginella plana	5	-	-	-	5	0,042
Pyrossia lanceolata.	5	-	-	-	5	0,042
TOTAL					545	2,48

Based on the results of research *Pteridophyte* in the Lawe Secepit Waterfall Limbangan Kendal, the results of the calculation of the diversity index are 2.48. Based on the Shannon-Weiner law, the diversity index value is included in the moderate criteria. (Hoshur et al., 2022) state high values of the Shannon Wiener Index (H') indicate a greater number of species sharing more or less equally. Therefore, the lower Diversity Index could be due to the dominance of a few species. Diversity can be used as a parameter to measure community stability. The higher the diversity index value, the more stable the community will be. This shows that the *Pteridophyte* community in the Lawe Secepit Waterfall Limbangan Kendal is relatively stable.

Environmental conditions. Environmental conditions in the area of Lawe Secepit Waterfall Limbangan Kendal are very supportive for the growth of *Pteridophyte*. Data of environmental conditions at each research site can be seen in Table 1.

Table 1. Environmental conditions

Site	Temperature (ºC)	Air Humidity (%)	Soil Moisture (%)	SoilpH	Light Intensity (lux)
I	24	91	60	6.5	3250
II	26	78	30	6.5	2280
III	25	90	70	6.2	1470
IV	26	90	70	5.9	1270

The development of *Pteridophyte* is strongly influenced by the surrounding environmental conditions. Abiotic factors that affect *Pteridophyte* are climate (air temperature, air humidity, light intensity), soil and other environmental physical conditions. Each type of plant has a minimum, maximum, and optimum condition for existing environmental factors as well as survival against various environmental conditions (Windari et al., 2021). Based on the data obtained, environmental conditions in the Lawe Secepit Waterfall Limbangan Kendal area have the potential for the growth of various types of *Pteridophyte*.

Lawe Secepit Waterfall Limbangan Kendal has a temperature in the range of 24ºC – 26ºC, where the temperature is suitable for *Pteridophyte*, so that *Pteridophyte* will grow and develop optimally and in the end their distribution will increase. *Pteridophyte* that grow in the tropics generally require a temperature range of 21 – 27°C for growth (I. Lestari et al., 2019). *Pteridophyta* generally lives in humid environments with temperatures ranging from 21–27ºC at varying altitudes and habitats in aquatic, terrestrial, and epiphytic areas (Nabila et al., 2021).

Habitat for *Pteridophyta* in Indonesia is usually in a damp place, such as near a waterfall which is a habitat both terrestrial, epiphytic, and aquatic(Ramadhan & Sianturi, 2022). Generally, *Pteridophyte* live in shady places with high humidity levels. Their presence is also used as a bioindicator in a humid environment(I. Lestari et al., 2019). Air humidity in Lawe Secepit Waterfall ranges from 78 - 91%, so it is still within the tolerance range for its growth. Light intensity ranging from 200-600 fc is suitable for the growth of *Pteridophyte* (S. Lestari, 2018). Ecosystems are affected by sunlight because the sun determines the temperature at that place. In addition, the process of photosynthesis in plants also requires sunlight. *Pteridophyte* need a minimum amount of light to be able to obtain energy for growth and development. An acidic pH between 5.5 – 6.5 is a suitable soil pH for *Pteridophyte*, but a more alkaline pH ranging from 7-8 is needed *Pteridophyte* to grow in rocky areas (Siska et al., 2020). *Pteridophyte* prefer acidic pH, except in some members. Growth *Pteridophyte* is influenced by pH because it affects the absorption of nutrients.

Ecological functions. The *Pteridophyte* have a role both ecologically and economically. Pteridophyta is a group of plants that have a role as pioneers. The characteristics of Pteridophytes that make them pioneers are their adaptability and wide distribution due to their light spores being carried by the wind so that they can colonize large numbers of degraded areas (Dwisutono et al., 2019). The existence of *Pteridophyte* is one of the components of the ecosystem that can indicate whether the environment can support the life of the organism or not. This *Pteridophyta* plant belongs to the crypto game plant, which means that this plant is vascular but does not have flowers but spores. This plant can be found in terrestrial and aquatic habitats or propagates on its host or epiphytes. The function of these spores is as a propagation tool for the *Pteridophyta* itself in the regeneration process (Atho et al., 2020). Ecologically, the existence of *Pteridophyte* acts as a producer in a food chain and components in the nitrogen cycle. The substrate of *Pteridophyta* is also one of the influential biotic factors, especially in the type of host tree epiphytic habitat, which is an important factor in the life of ferns (Majid et al., 2022). Pteridophytes are a group of plants commonly found on the forest floor. The presence of forest floor plants is useful as a provider of organic matter, which can increase water absorption capacity (Afriana et al., 2021). Meanwhile economically, *Pteridophyte* has the potential for trade commodities because of its role as an ornamental plant, medicinal plants, vegetables, and as a protector of seedlings. The role of *Pteridophyta* for humans as a source of germplasm, including for consumption needs, raw materials for traditional medicine, ornamental plants, handicrafts, and fertilizers for soil improvement (Ciawi et al., 2022). *Pteridophyte* as part of biodiversity which has quite important ecological functions. In general, *Pteridophyte* have ecological functions as litter mixers for the formation of soil nutrients, as producers in the food chain, and habitats for several other organisms, as well as acting as ground cover so that they can regulate water systems. For humans, *Pteridophyte* have been a lot used among others as an ornamental plant (Nurcahyani, 2021), vegetables and medicinal materials (Zelnik et al., 2021). But not in a way directly, the presence of spike plants also providing benefits in maintaining forest ecosystems, among others, in the formation of soil, soil security against erosion, as well as helps the weathering process of forest litter. *Pteridophyta* for the environment has an ecological role, such as covering soil, protecting the soil from erosion, mixing litter for soil nutrient formation, and acting as producers in the food chain. In addition, humans can use *Pteridophyta* as a source of food and medicine (Nikmatullah et al., 2020), materials for handicrafts (Syukur, 2019), ornamental plants, and planting moderate (Suryana et al., 2018). Ecological function of each species of *Pteridophyte* found can be seen in Table 4.

Table 4. Ecological function of *Pteridophyte* found in Lawe Secepit Waterfall Kendal

Species	Functional Roles
Marsilea crenata	Contributing organic matter to the soil, improving soil physical properties, and increasing soil microbial activity.
Pteris biaurita L.	As a hyperaccumulator of heavy metals because it has phytokelanin compounds that function to bind heavy metals arsenic and mercury.
Selaginella intermedia	Fertilize soil, control water system, as ground cover vegetation, and maintain soil moisture.
Pyrrosia angustata	As a habitat for insects, retaining water and moisture.
Christella parasitica (L.) H.Lev	As a producer of the food chain, regulate water management, cover soil, and prevent erosion.
Adiantum capillus veneris	Retaining surface runoff (*run off*) by inhibiting and holding rainwater continuously.
Doryopteris concolor	Source of food for other organisms and produce soil nutrient-forming litter.
Phymatosorus scolopendria	Bioindicator of humidity.
Pityrogramma calomelanos	As a food chain producer and natural photoremediation for arsenic contaminated soil.
Cystopteris fragilis	Helps weathering forest litter, prevents erosion, maintains water use in the soil and regulates water management.
Orthioptheris saccolama	As a cover vegetation, mixing of litter for the formation of soil nutrients, and producers in the food chain.
Nephrolepis biserrata	Cleans the air of toxic pollutants, and can maintain soil moisture and temperature.
Tectaria heracleifolia	Helps the weathering process of dry leaf litter, as a ground cover, and prevents erosion,
Phymatodes nigrescens	Fertilizes the soil because it acts as a source of nutrients and natural fertilizer
Sphenomeris chinesis	Prevents erosion and maintains water use in the soil.
Selaginella plana	An antidote to poisonous snakes, traditional medicine, ground cover, pioneer plant in the succession process of an ecosystem.
Pyrossia lanceolata.	Habibat for insects.

CONCLUSION

Based on the results of research conducted in the Lawe Secepit Waterfall Limbangan Kendal, 545 individuals from 3 order, 15 genera, 10 families and 17 species of *Pteridophyte* with a species diversity index value of 2.48 that was included in the moderate criteria, analyzed using the Shannon-Whiner formula. *Pteridophyte* have ecological functions as litter mixers for the formation of soil nutrients, as producers in the food chain, bioindicator of humidity and habitats for several other organisms, as well as acting as ground cover so that they can regulate water systems. Diversity *Pteridophyte* in the Lawe Secepit Waterfall Limbangan Kendal can be used as supporting data in decision makers related to environmental management, development, and conservation.

ACKNOWLEDGEMENTS

Authors thankfully acknowledge the financial assistance provided by UPGRIS Research Programme SK No.20.a/MAWA/UPGRIS/II/2022 for providing the infrastructural facility and consistent encouragement during the course of studies.

REFERENCES

Afriana, M., Darwin, C., Lubis, R., & Saroni, S. (2021). Keanekaragaman Jenis Tumbuhan Paku (Pteridophyta) DI Kecamatan Ketahun Kabupaten Bengkulu Utara. *Jurnal Riset Dan Inovasi Pendidikan Sains (JRIPS)*, *1*(1). https://doi.org/10.36085/jrips.v1i1.2785

Atho, M. A., Akmal, M. A. S., Riza, R. E. N., Sinta, S. D. R., Fatim, S. F., Dian, D. N. M., & Lianah, L. (2020). The diversity of fern species (Pteridophyta) and their potential use studies in the Ulolanang Kecubung Nature Reserve. *Bioeduscience: Jurnal Pendidikan Biologi Dan Sains*, *4*(1), 73–81. https://doi.org/10.29405/j.bes/4173-814991

A'tourrohman, M. (2020). Keanekaragaman Jenis Paku-Pakuan (Pteridophyte) dan Kajian Potensi Pemanfaatannya di Cagar Alam Ulolanang Kecubung. *Jurnal Bioeduscience*, *4*(1), 73–81.

Ciawi, Y., Made Alit Karyawan Salain, I., & Agung Gede Sutapa, A. (2022). The potency of fern stem as the carbon material for clay-based ceramic filter. *IOP Conference Series: Earth and Environmental Science*, *999*(1), 012020. https://doi.org/10.1088/1755-1315/999/1/012020

Dayat, E. (2020). *Studi floristik tumbuhan paku (Pteridophyta) di hutan lindung gunung dempo Sumatera Selatan*. Institut Pertanian Bogor.

Dwisutono, A. N., Budi, S. W., & Istomo, I. (2019). Plant Diversity in Different Land Use Types at The Peat Hidrological Unit (PHU) of Mendahara – Batanghari River, Jambi Province. *Media Konservasi*, *24*(2), 141–151. https://doi.org/10.29244/medkon.24.2.141-151

Hidayat, M., Laiyanah, L., Silvia, N., Putri, Y. A., & Marhamah, N. (2018). Analisis Vegetasi Tumbuhan Menggunakan Metode Transek Garis (Line Transek) di Hutan Seulawah Agam Desa Pulo Kemukiman Lamteuba Kabupaten Aceh Besar. *Proceedings of Biotik*, 85–91.

Hoshur, S., Jadeyegowda, M., Shivakuma, B., Bhat, S., & Jagadish, M. (2022). Ferns diversity in sacred groves of Kodagu: Central Western Ghat. *Pharma Intl J*, *11*(9), 800–809.

Lestari, I., Murningsih, M., & Utami, S. (2019). Keanekaragaman jenis tumbuhan paku epifit di Hutan Petungkriyono Kabupaten Pekalongan, Jawa Tengah. *NICHE Journal of Tropical Biology*, *2*(2), 14–21.

Lestari, S. (2018). *Identifikasi Tumbuhan Paku Sejati (Filicinae) Epifit di Gunung Pesagi Kabupaten Lampung Barat*. Universitas Islam Negeri Raden Intan.

Lowe, E. J. (2015). *Ferns : British and Exotic. 8th Edition*. Arkose Press.

Majid, A., Ajizah, A., & Amintarti, S. (2022). Keragaman Tumbuhan Paku (Pteridophyta) di Taman Biodiversitas Hutan Hujan Tropis Mandiangin. *Jurnal Al-Azhar Indonesia Seri Sains Dan Teknologi*, *7*(2), 102. https://doi.org/10.36722/sst.v7i2.1117

Nabila, F., Sulistyowati, D., Isolina, I., Yani, R., Sigit, D. V., & Miarsyah, M. (2021). Keanekaragaman jenis-jenis epifit pteridophyta dan epifit spermatophyta di kawasan Kebun Raya Bogor. *Proceeding of Biology Education*, *4*(1), 36–50. https://doi.org/10.21009/pbe.4-1.4

Nasution, J., & Kardhinata, E. H. (2018). Inventarisasi Tumbuhan Paku di Kampus I Universitas Medan Area. *KLOROFIL: Jurnal Ilmu Biologi Dan Terapan*, *1*(2), 105–110.

Nikmatullah, M., Rwnjana, E., Muhaimin, M., & Rahayu, M. (2020). Potential of Cibodas Botanical Garden Fern and Lycophytes Collection as the Source of Medicine. *Al-Kauniyah: Jurnal Biologi*, *13*(2), 278–287. https://doi.org/10.15408/kauniyah.v13i2.16061

Nurcahyani, P. (2021). *Identifikasi Jenis dan Potensi Tumbuhan Paku di sekitar Curug Lontar Desa Karyasari Kecamatan Leuwiliang Kabupaten Bogor*. Syarif Hidayatullah Islamic University State.

Priambudi, A., Chikmawati, T., Sulistijorini, & Fakhrurrozi, Y. (2022). Diversity and ecology of Pteridophytes in Cendil heath forest and Gurok Beraye tropical rainforest, Belitung, Indonesia. *Biodiversitas*, *23*(9), 4775–4782.

Ramadhan, L., & Sianturi, RL. (2022). Inventarisasi jenis paku-pakuan (Pteridophyta) pada Pekarangan di Desa Muka Paya, Langkat, Sumatera Utara. *Pros Sem Nas Peningkatan Mutu Pendidikan* , 51–54.

Saputro, R. W., & Utami, S. (2020). Keanekaragaman tumbuhan paku (Pteridophyta) di kawasan Candi Gedong Songo Kabupaten Semarang. *Bioma*, *22*(1), 53–58.

Sari, H., & Mukti, B. H. (2019). Keanekaragaman Tumbuhan Paku (Pteridophyta) di Kawasan Hutan Desa Banua Rantau Kecamatan Batang Alai Selatan Kabupaten Hulu Sungai Tengah. *Jurnal Pendidikan Hayati*, *5*(3), 107–114.

Shital, P., Misra, S., & N, P. (2009). *A Textbook of Botany: Bryophyta, Pteridophyta, Gymnosperms and paleobotany. 2nd Edition* . Vikas Publishing House Pennsylvania State University.

Siska, S., Marwiyah, M., Santi, S., Hasdar, H., & Aditiyanto, M. (2020). Karakter Morfologi dan Tipe Stele Tumbuhan Paku Teresterial di Hutan Lindung Juwata Kerikil Kota Tarakan Sebagai Sumber Belajar BiologI. *Biopedagogia*, *1*(2), 79–86. https://doi.org/10.35334/biopedagogia.v1i2.1702

Suryana, S., Iskandar, J., Parikesit, P., & Partasasmita, R. (2018). Ethnobotany of tree ferns in Pasir Menyan Hamlet, Sukamandi Village, Subang, West Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(6), 2044–2051. https://doi.org/10.13057/biodiv/d190609

Syukur, M. (2019). Jenis Dan Pemanfaatan Paku Pakuan Oleh Masyarakat Desa Ulak Jaya Kecamatan Sintang Kabupaten Sintang. *PIPER*, *15*(28). https://doi.org/10.51826/piper.v15i28.296

Windari, W., Perwati, L. K., & Murningsih, M. (2021). Keanekaragaman Jenis Tumbuhan Paku (Pteridophyta) di Kawasan Wisata Air Terjun Jurang Nganten Kabupaten Jepara. *Bioma : Berkala Ilmiah Biologi*, *23*(2), 107–111. https://doi.org/10.14710/bioma.23.2.107-111

Zelnik, I., Kuhar, U., Holcar, M., Germ, M., & Gaberščik, A. (2021). Distribution of Vascular Plant Communities in Slovenian Watercourses. *Water*, *13*(8), 1071. https://doi.org/10.3390/w13081071