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

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**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

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## 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.

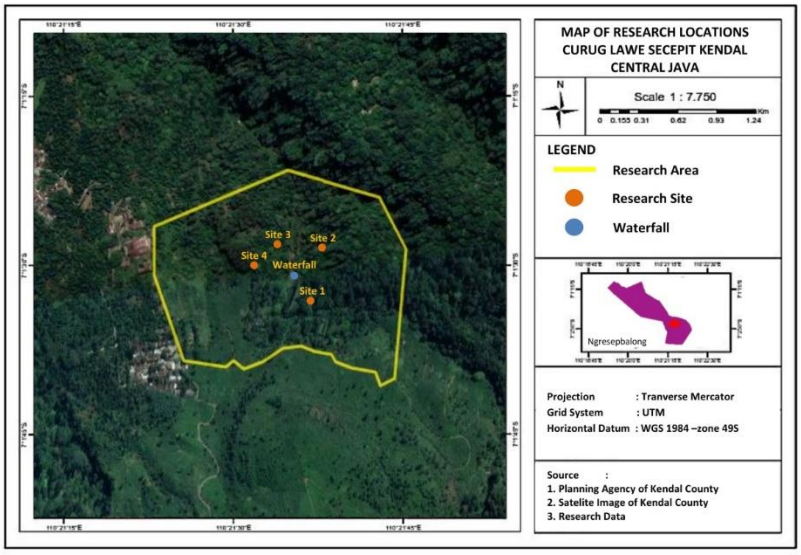



**Fig. 1.** Research Site

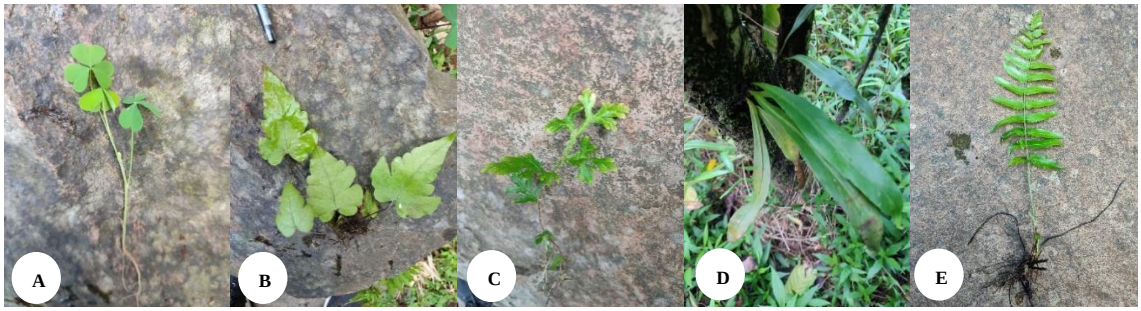
Field exploration research and literature review were used in this study. The research activity uses a descriptive quantitative method with the sampling method using the quadratic method. The sampling step was carried out at four sites (Fig. 1). The population in this study is the entire *Pteridophyte* 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*.



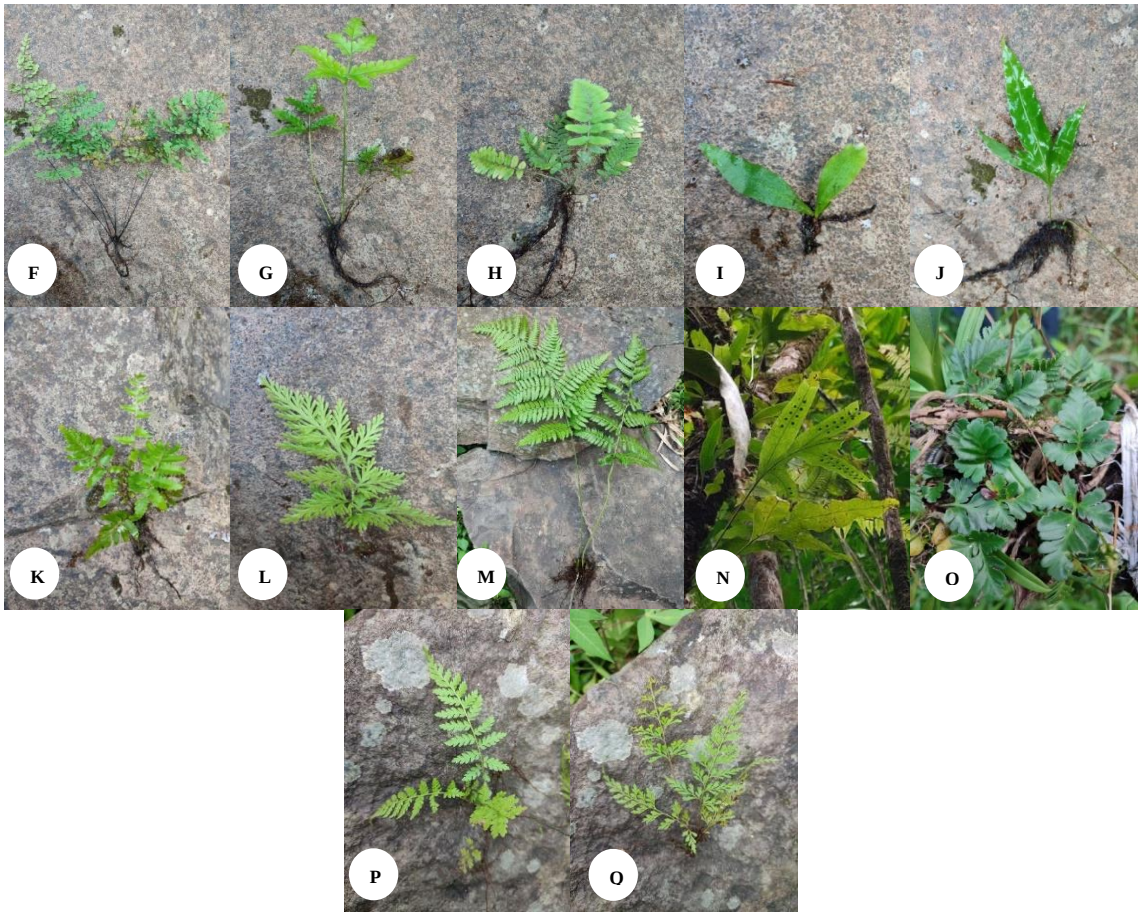



**Fig. 2.** *Pteridophyte* found in Lawe Secepit Waterfall Limbangan Kendal A. *Marsilea crenata* B. *Pteris biaurita* L C. *Selaginella intermedia* D. *Pyrrosia angustata* E. *Christella parasitica* (L.) H.Lev F. *Adiantum capillus veneris* G. *Doryopteris concolor* H. *Phymatosorus scolopendria* I. *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.

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