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Species Diversity of Epiphyte Fern Plants in Curug Lawe Waterfall Region, Semarang District

Rizky Wahyu Saputro, Sri Utami*, Lilih Khotimperwati

Department of Biology, Faculty of Science and Mathematics, Diponegoro University, Indonesia
*Corresponding E-mail: utami.biologi@gmail.com

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Abstract. Epiphyte fern plants are fern plants that grow attached to the phorophyte tree. Existence of fern plants are effected by tree bark and environmental condition in which they grow. This research aimed to study the species composition, important value index, diversity index, evenness index, and similarity index of epiphyte fern plants in the Curug Lawe Waterfall Region Semarang District. This research was conducted on 5 research stations i.e. clove plantations area (CPA), irrigation canal (IC), mixed forest (MF), river flow (RF), and waterfall area (WA). The research used plot technique with plot size 10 m x 10 m. The results showed 11 species of epiphyte fern from 8 families were found. The highest important value index is obtained by *Goniophlebium serratifolium*. The diversity index of epiphyte fern plants are categorized as low and moderate. The evenness index of epiphyte fern plants are categorized as not evenly distributed, quite evenly distributed, and almost evenly distributed. The highest similarity index is in irrigation canal (IC) and river flow (RF). Environmental conditions in Curug Lawe Waterfall Region are suitable for epiphyte fern plants habitat. This research is novel as it provides some information about the community structure of epiphyte ferns in Curug Lawe Waterfall Region and to engage all peoples to maintain our biodiversity keep sustainable.

Key words: Species Composition, Diversity, Epiphyte Ferns, Curug Lawe Waterfall Region

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INTRODUCTION

Ferns are plants that with high species diversity in Indonesia, one of them is epiphyte fern plants. Epiphyte fern plants commonly grow attached to the phorophyte tree. Zhao et al. (2015) said that epiphytes are plants that attach themselves to and grow on other plants. Praptosuwiryo et al. (2019) added that epiphyte ferns do not extract nutrients from the host's vascular system, because the host provides only a place to grow. The distribution, composition, and abundance of epiphytes in the host tree are closely related with the bark characteristics, the slope of the stem, the branching and twig systems, canopy shape, water availability, temperature, humidity, and light intensity. Anderson (2021) stated that epiphyte fern is a fern that grow on the other plants and are vulnerable to desiccation stress. It is because they are particularly exposed to atmospheric and meteorological variables. Murdjoko et al. (2016) also stated that ferns have a short time to reach the reproductive stage that resulting in new individuals.

Epiphyte ferns has many uses ecologically and economically. Callado et al. (2015) defined ferns as pioneer plants in succession process and as environmental bioindicator. Praptosuwiryo et al. (2019) and Donald et al. (2017) added that epiphyte ferns are important component for global plant diversity, biogeochemical processes, a conspicuous component of tropical wet forest regions around the world, and provide a resource for reptiles populations in the rainforest canopy. Economically, epiphyte ferns can be used as decorative plants, foods material, drugs material, handcraft, etc. Batoro et al. (2017) stated that ferns can be used as vegetable food.

Waterfall is suitable habitat to support the growth of epiphyte ferns. Imaniar (2017) found 30 ferns species in the Kapas Biru Waterfall Lumajang District with Polypodiopsida as the dominant class with 24 species. Kurniawati (2016) also did the research in the Girimanik Waterfall Wonogiri District and found a total of 20 species with Polypodiaceae as the most abundant family.

Epiphyte ferns in Curug Lawe Waterfall Region are various. However, the study on the species diversity of epiphyte fern plants in Curug Lawe Waterfall Region has never been done before. Therefore, it is necessary to conduct research about species diversity of epiphyte fern plants in this region in order to collect data on the epiphyte ferns. This research aimed to study the species composition, important value index, diversity index, evenness index, and similarity index of epiphyte fern plants in the Curug Lawe Waterfall Region Semarang District. The study was expected to provide some information to other researchers and institutions about community

structure of epiphyte ferns in the Curug Lawe Waterfall Region Semarang District.

METHODS

Study area

Curug Lawe Waterfall Region in Semarang District is a waterfall that comes from Ungaran Mountain with an altitude of about 800-900 masl. Curug Lawe Waterfall is located in Kalisidi Village, West Ungaran Subdistrict, Semarang District. It is also located in clove plantations area that currently managed by Perum Perhutani KPH Kedu Utara. The clove plantations area are under the auspices of PT. Cengkeh Zanzibar that distributed from the entrance of Perum Perhutani Region to the Curug Lawe Waterfall entrance. The field work was conducted in January-February 2021.

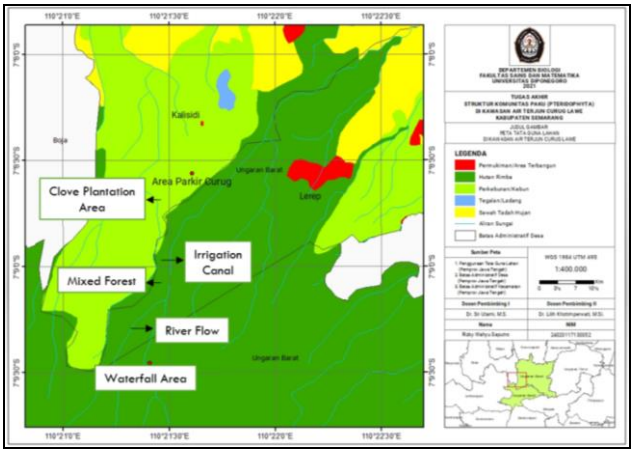

Figure 1. Map of Research Station in Curug Lawe Waterfall Region, Semarang District

Establishment of sampling plots

Based on the results of preliminary survey, 5 locations of observation station that represent the Curug Lawe Waterfall Region were determined. The observation stations were included Clove Plantation Area (CPA), Irrigation Canal (IC), Mixed Forest (MF), River Flow (RF), and Waterfall Area (WA). This research used purposive sampling method and plot technique with plot size of 10 m x 10 m. All of epiphyte ferns species within the plot were identified. Total number of species and individuals within the plot were tallied and documented.

Plant species identification

Identification of epiphyte ferns was done through the use of some fern identification books (Epiphytic ferns and allies of Podocarpus Biosphere Reserve, Plant Resources of South-East Asia – Cryptogams: Ferns and Fern Allies, A Guide to Cumbrian Ferns and Fern-Allies, What's That Fern?, Native Plants for Georgia: Ferns, Field Guide to Pteridophytes, Flora of Australia: Ferns, Gymnosperms, and Allied Groups) and fern identification websites (http://www.plantsystematics.org/, https://plantsam.com/ferns/, and http://ontarioferns.com/id/)

Data analysis

Data obtained was analyzed using Important Value Index (IVI), Diversity Index (H'), Evenness Index (E), and Similarity Index (SI).

Important Value Index (IVI) was determined by adding the value of relative density (RD) and relative frequency (RF) to find the most affected species in each habitat. Important value index was calculated according to Kartawinata & Abdulhadi (2016) as follows:

$$IVI = RD + RF$$

Note:

$$\text{Density (D)} = \frac{\text{number of a species}}{\text{total area sampled}}$$

$$\text{Relative Density (RD)} = \frac{\text{density of a species}}{\text{total density of all species}} \times 100\%$$

$$\text{Frequency (F)} = \frac{\text{area of plot in which a species occurs}}{\text{total plot sample}}$$

$$\text{Relative Density (RD)} = \frac{\text{frequency of a species}}{\text{total frecuency of all species}} \times 100\%$$

Shannon-Wiener diversity index (H') can be used to compare various epiphyte fern plant communities. Shannon-Wiener diversity index was counted by using the following formula (Mulya et al., 2021):

$$H' = -\sum\left[\left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right)\right]$$

Note:
H' : Shannon-Wiener diversity index
ni : Total of individuals from each species
N : Total of individuals from all species

Species evenness index (E) was counted by using the following formula (Mulya et al., 2021):

$$E = \left(\frac{H'}{\ln S}\right)$$

Note:
E : Species evenness index
H' : Shannon-Wiener diversity index
S : Total number of species

Similarity index (SI) is an index to determine the level of similarity plant that will be compared in two habitats. Species similarity index was counted by

using the following formula (Kartawinata & Abdulhadi, 2016):

$$SI = \left(\frac{2w}{a+b}\right) \times 100\%$$

Note:

SI : Species similarity index

w : Same number of species between community a and b

a : Number of species at community a

b : Number of species at community b

RESULTS AND DISCUSSION

Species composition

Table 1. Epiphyte fern plants composition in Curug Lawe Waterfall region

No	Species	Family	Total of Individuals				
			St 1 (CPA)	St 2 (IC)	St 3 (MF)	St 4 (RF)	St 5 (WA)
1	*Drynaria rigidula*	Polypodiaceae	6	-	19	-	-
2	*Goniophlebium serratifolium*	Polypodiaceae	69	10	-	6	-
3	*Lepisorus longifolius*	Polypodiaceae	-	-	16	-	-
4	*Onychium japonicum*	Pteridaceae	-	-	-	21	-
5	*Antrophyum* sp.	Pteridaceae	-	8	-	10	-
6	*Davallia trichomanoides*	Davalliaceae	4	-	-	-	-
7	*Hecistopteris* sp.	Vittariaceae	4	-	-	-	-
8	*Nephrolepis brownii*	Lomariopsidaceae	-	15	-	-	-
9	*Athyrium filix-femina*	Athyriaceae	-	20	73	20	-
10	*Christella dentata*	Thelypteridaceae	-	4	-	-	-
11	*Tectaria dissecta*	Tectariaceae	-	10	9	8	-
Total of species			4	6	4	5	-

Note: St 1 (1st station), CPA (Clove Plantation Area), St 2 (2nd station), IC (Irrigation Canal), St 3 (3rd station), MF (Mixed Forest), St 4 (4th station), RF (River Flow), St 5 (5th station), WA (Waterfall Area), and "-" (not found).

A total of 11 species were recorded in the Curug Lawe Waterfall Region. The species were categorized into 8 families (Table 1). Polypodiaceae was the greatest in species richness, while Pteridaceae was in the second place with 2 species, and Davaliaceae, Vittariaceae, Lomariopsidaceae, Athyriaceae, Thelypteridaceae, and Tectariaceae were each represented by a single species. Suryana et al. (2020) said that Polypodiaceae is the family with the most number of species because this family is the most diverse and abundant type of vascular plant group in tropical and subtropical forests. In Harmida's et al. research (2018), Polypodiaceae was the most common epiphyte ferns with the amount of 9 species. It is caused by the spores that carried by the wind are more easily attached to the stem.

According to Rahayuningsih et al. (2019), Polypodiaceae have a large number of species because they have high tolerance to the environment. Polypodiaceae can grow at altitudes 795 – 878 masl (Table 2). With increasing elevation, there is a decrease in temperature and an increase in air humidity (Patil et al., 2016). Epiphyte ferns were most commonly found in irrigation canal (IC) with the amount of 6 species. The epiphyte ferns in this station were found in various trees, while there were no epiphyte ferns found in waterfall area (WA), since the phorophyte tree was not found.

Table 2. Environmental parameters in Curug Lawe Waterfall region.

Parameters	Score
Altitude (mdpl)	795 – 933
Air temperature (^oC)	24 – 29.67
Air humidity (%RH)	72.33 – 86.33
Light intensity (lux)	46.9 – 497.33
Soil pH	5.37 – 6.67

Note: St 1 (1st station), CPA (Clove Plantation Area), St 2 (2nd station), IC (Irrigation Canal), St 3 (3rd station), MF (Mixed Forest), St 4 (4th station), RF (River Flow), St 5 (5th station), and WA (Waterfall Area).

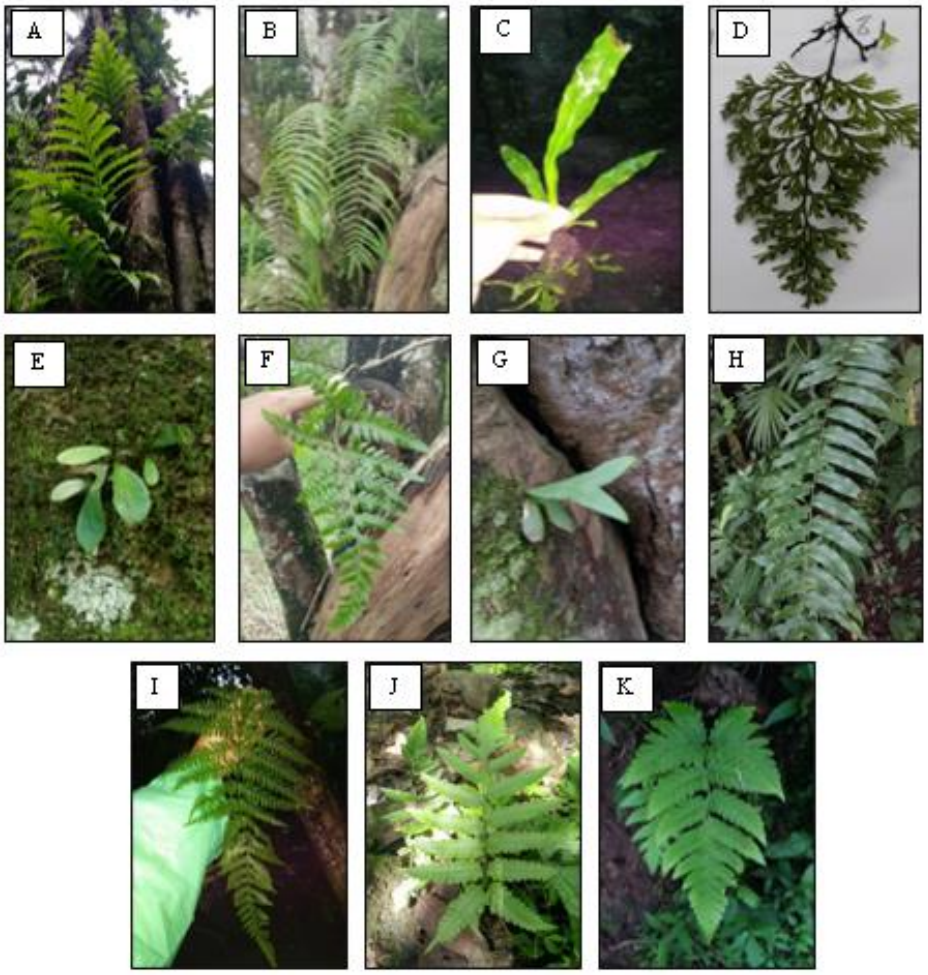

Figure 2. Epiphyte Fern Plants in Curug Lawe Waterfall Region. A. *Drynaria rigidula;* B. *Goniophlebium serratifolium;* C. *Lepisorus longifolius;* D. *Onychium japonicum;* E. *Anthrophyum* sp; F. *Davallia trichomanoides,* G. *Hecistopteris* sp.; H. *Nephrolepis brownie;* I. *Athryium filix-femina;* J. *Christella dentata;* K. *Tectaria dissecta*

There were many species of epiphyte ferns found in the Curug Lawe Waterfall Region since the bark of phorophyte tree and environmental parameters are suitable for their growth. Epiphyte fern plants commonly grow attached to the phorophyte tree with hard and rough bark, huge diameter, and wide cover. According to Hoshizaki & Moran (2001), fern plants generally live in shaded places that have sufficient light intensity and not exposed to excessive sunlight. Rahayuningsih et al. (2019) added that light intensity impacted to the ferns growth and development because of their need for photosynthesis process.

Important value index of epiphyte fern species

Important value index (IVI) is an index to analyze the dominance of a species in certain community. This index is used to find the most dominant species in each habitat and to determine the overall importance of each species in the community structure (Noraimy et al., 2014). Reshad et al. (2020) said that it was also calculated to examine which species were ecologically significant in the ecosystem and used to relate how importance they were in providing ecosystem goods. According to Kartawinata & Abdulhadi (2016), important value index (IVI) was determined by adding the value of relative density (RD) and relative frequency (RF).

In clove plantations area (CPA), the highest IVI was obtained by *Goniophlebium serratifolium* with the percentage of 133.13% and the species with the lowest IVI was *Hecistopteris* sp. with the percentage of 17.32%. In irrigation canal (IC), *Athyrium filix-femina* showed the highest IVI with the percentage of 75.66% and *Christella dentata* showed the lowest IVI with the percentage of 17.76%. In mixed forest (MF) and river flow (RF), species with the highest IVI was *Athyrium filix-femina* and the lowest was *Tectaria dissecta*.

Table 3. Important Value Index of epiphyte fern plants in Curug Lawe Waterfall region.

Species name	IVI (%)				
	St 1	St 2	St 3	St 4	St 5
	CPA	IC	MF	RF	WA
Davallia trichomanoides	17.32	0	0	0	0
Drynaria rigidula	32.23	0	30.53	0	0
Goniophlebium serratifolium	133.13	25.66	0	34.23	0
Hecistopteris sp.	17.32	0	0	0	0
Lepisorus longifolius	0	0	27.96	0	0
Onychium japonicum	0	0	0	44.81	0
Antrophyum sp.	0	23.03	0	27.88	0
Nephrolepis brownii	0	32.24	0	0	0
Athyrium filix-femina	0	75.66	119.54	68.27	0
Christella dentata	0	17.76	0	0	0
Tectaria dissecta	0	25.66	21.98	24.81	0

Note: IVI (Important Value Index), St 1 (1st station), CPA (Clove Plantation Area), St 2 (2nd station), IC (Irrigation Canal), St 3 (3rd station), MF (Mixed Forest), St 4 (4th station), RF (River Flow), St 5 (5th station), and WA (Waterfall Area).

Athyrium filix-femina is epiphyte fern attached to the various trees in irrigation canal (IC), mixed forest (MF), and river flow (RF). This species has the highest relative density and relative frequency value in three research stations. It is showed that the existence of *Athyrium filix-femina* has high dominance and affected by environmental condition changes in this station.

The important value index (IVI) shows the vital role of the plant species in the community. The species with the highest IVI can be categorized as the dominant species. The dominant species has such a big impact in changing the environmental conditions and the existence of other species in the community (Muhyi et al., 2020). The IVI is affected by the biotic and abiotic factors. The biotic factors such as competition between the individuals, while the abiotic factors are including light intensity, air humidity, soil, climates, and topography. The more extreme the condition of environment, the less the diversity of the plants. Species with high IVI are considered to have more ecological importance than those with low IVI (Reshad et al., 2020) and more stable from the point of view of species survival and growth (Al-Reza et al., 2016). Destaranti et al. (2017) added that the high IVI is caused by a species that has a great adaptation ability compared to the other species.

Diversity and evenness index of epiphyte fern species

Diversity index is a description of the level of species diversity within a community that can be used to express the relationship of species abundance in the community (Haryadi et al, 2019). Diversity index is determined by the number of species and total of individuals of each species. According to Ulfah et al (2021), species diversity are categorized as high H' > 3, moderate H' = 1-3, and low H' < 1.

Table 4. Diversity Index and Evenness Index of epiphyte fern plants in Curug Lawe Waterfall region

Stations	H'	E
1st Station (CPA)	0.64	0.46
2nd Station (IC)	1.22	0.68
3rd Station (MF)	0.49	0.36
4th Station (RF)	0.84	0.52
5th Station (WA)	0	0

Note: H' (Diversity Index), E (Evenness Index), CPA (Clove Plantation Area), IC (Irrigation Canal), MF (Mixed Forest), RF (River Flow), and WA (Waterfall Area).

The diversity index of epiphyte fern plants were categorized as low and moderate, since the values were only 0.64, 1.22, 0.49, 0.84, and 0 in station 1-5 respectively (Table 4). The highest diversity index of epiphyte fern plants was in irrigation canal (IC) by 1.22, while the lowest diversity index of epiphyte fern plants was in waterfall area (WA) by 0. It means all stations has unstable ecosystem, low species productivity, and heavy ecology pressure. If a community generally consists of various types of plants, the species diversity will increase and ecosystem will be stable. A community is said to have low species diversity, if the community is composed by only a few species. According to Anandan et al. (2014), the characteristics of low species diversity are relatively few successful species in the habitat, the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that

environment, food webs which are relatively simple, and change in the environment would probably have quite serious effects.

Species evenness is a description of the distribution of abundance across the species in a community. Species evenness is higher when all species in a sample plot have similar abundance. According to Pielou (1997), plant evenness are categorized as not evenly distributed if E = 0.00 – 0.25, as less evenly distributed if E = 0.26 – 0.50, as quite evenly distributed if E = 0.50 – 0.75, as almost evenly distributed if E = 0.76 – 0.95, and as evenly distributed if E = 0.96 – 1.00.

The evenness index of epiphyte fern plants in this study were categorized as not evenly distributed, quite evenly distributed, and almost evenly distributed. The highest evenness index of epiphyte fern plants was in irrigation canal (IC) by 0.68, while the lowest evenness index of epiphyte fern plants is in waterfall area (WA) by 0 (Table 4).

Similarity index of epiphyte fern species

Similarity index is an index to determine the level of similarity plant that will be compared in two habitats. It is divided into two criteria i.e. high similarity if the index value is >50% and low similarity, if the index value is <50% (Suryana et al., 2020). This value indicates that there is a difference in epiphyte fern plants among five areas observed (Table 5).

Table 5. Similarity Index of epiphyte fern plants in Curug Lawe Waterfall region

	IS (%)				
	St 1CPA	St 2 IC	St 3 MF	St 4 RF	St 5 WA
St 1 (CPA)	-	-	-	-	-
St 2 (IC)	23.53	-	-	-	-
St 3 (MF)	44.44	43.48	-	-	-
St 4 (RF)	21.05	58.33	40.00	-	-
St 5 (WA)	15.38	44.44	52.63	40.00	-

Note: SI (Similarity Index), St 1 (1st station), CPA (Clove Plantation Area), St 2 (2nd station), IC (Irrigation Canal), St 3 (3rd station), MF (Mixed Forest), St 4 (4th station), RF (River Flow), St 5 (5th station), and WA (Waterfall Area).

The highest similarity index was found in irrigation canal (IC) and river flow (RF) with the percentage about 58.33%, while the lowest similarity index was in clove plantations area (CPA) and waterfall area (WA) with the percentage about 15.38%. Muhyi et al. (2020) said that high percentage of similarity index indicates that the species composition and the communities of these two plots are similar, while low percentage indicates the different composition of species and communities between these two plots. According to Al-Reza et al. (2016), the difference of similarity index is influenced by same species in two habitats that will be compares. This index is also influenced by microclimate conditions which tend to be the same so that it will be occupied by the individuals of the same species, because species naturally have some developed mechanisms and tolerance to their habitat.

Research about epiphyte ferns diversity was the first time has been conducted in Curug Lawe Waterfall Region. So, the result of this research will provide some information to other researchers and institutions about community structure of epiphyte ferns in the Curug Lawe Waterfall Region Semarang District. Besides, it can increase the curiosity from publics about the diversity and use of epiphyte ferns. Epiphyte ferns has many uses that can be used from various sides. Indirectly, this research also engage all peoples to maintain our biodiversity keep sustainable.

CONCLUSION

A total of 11 epiphyte fern species from 8 families were found in Curug Lawe Waterfall Region. Polypodiaceae is the most commonly found family with 3 species. The highest important value index is obtained by *Goniophlebium serratifolium*. The diversity index of epiphyte fern plants are categorized as low and moderate. The evenness index of epiphyte fern plants are categorized as not evenly distributed, quite evenly distributed, and almost evenly distributed. The highest similarity index is in irrigation canal (IC) and river flow (RF). Environmental conditions in Curug Lawe Waterfall Region are suitable for epiphyte fern plants habitat.

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