



The Phenetic Relationship of Ferns (Polypodiaceae) at the Ascent of Cemoro Kandang, Mount Lawu

Hubungan Kekerabatan Tumbuhan Paku Famili Polypodiaceae di Pendakian Cemoro Kandang, Gunung Lawu

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Abstract

The fern is one of the highly diverse vascular plant species, which has a unique characteristic. The closely related at the family level because the genera within each family have some uniformity so that the relationship and groupings cannot be distinguished. One example of a diverse fern family is Polypodiaceae. Consequently, it is necessary to simplify the classification; one of them is through phenetic relationship analysis. This study aimed to analyze the phenetic relationship of the Polypodiaceae ferns in Climbing Cemoro, Mouth Lawu enclosure, Karangayar Regency, based on the similarity index on the dendrogram. The data were collected using the exploration method and the sporophyte morphological characters were observed. The observations obtained 13 variations of characters. The relationship analysis was carried out with the hierarchical cluster program using SPSS 23. There were six species found from the Polypodiaceae family, there were including *Belvisia mucronata*, *Goniophlebium* sp, *Lepisorus* sp, *Pyrrosia piloselloides*, *Crypsinus taeniatus* and *Drynaria sparsisora*. The finding suggests that six species are divided into two clusters, the Group I consisting of *Goniophlebium* sp, *Lepisorus* sp, *Lepisorus* sp, and *Pyrrosia piloselloides* with a similarity coefficient index of 53% and Group II consisting of *Drynaria sparsisora*, *Goniophlebium* sp, and *Pyrrosia piloselloides* with a similarity index of 46%.

Abstrak

Tumbuhan paku salah satu spesies tumbuhan vaskular yang memiliki keragaman tinggi. Kedekatan kerabatan pada tingkat famili dikarenakan antara genus dalam tiap famili memiliki beberapa keseragaman, sehingga tidak bisa dibedakan pengelompokannya. Salah satu contoh famili tumbuhan paku yang memiliki keragaman adalah Polypodiaceae. Penelitian ini bertujuan untuk mendeskripsikan hubungan kekerabatan secara fenetik tumbuhan paku famili Polypodiaceae di Pendakian Cemoro Kandang Gunung Lawu, berdasarkan indeks kesamaan pada dendrogram. Pengumpulan data dilakukan menggunakan metode eksplorasi dan dilakukan pengamatan karakter morfologi sporofit. Hasil penelitian diperoleh 13 macam karakter. Analisis hubungan kekerabatan dilakukan dengan program hierarchial cluster menggunakan SPSS 23. Terdapat enam spesies yang ditemukan dari famili Polypodiaceae di antaranya *Belvisia mucronata*, *Goniophlebium* sp, *Lepisorus* sp, *Pyrrosia piloselloides*, *Crypsinus taeniatus* dan *Drynaria sparsisora*. Hasil penelitian menunjukkan bahwa keenam spesies tersebut terbagi menjadi dua klaster, yaitu Kelompok I terdiri atas *Goniophlebium* sp, *Lepisorus* sp, dan *Pyrrosia piloselloides* dengan indeks koefisien kesamaan 53% dan Kelompok II terdiri atas *Drynaria sparsisora*, *Goniophlebium* sp, dan *Pyrrosia piloselloides* dengan indeks kesamaan 46%.

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INTRODUCTION

Indonesia is one of the countries that has the highest biodiversity in the world, both plant and animal diversity. One of the species of plant division found in Indonesia is ferns (Pteridophyta). The number of Pteridophyta species in Indonesia was 2,197 species and the latest study results in the last 2019 showed that the Pteridophyta in Indonesia reached 1,611 taxa from 37 families (Nurchayati, 2007). This amount is obtained when using the classification basis used in the Herbarium Bogoriense (Wijayanti *et al.*, 2015).

The fern is a division that has corms, meaning that its body can be differentiated into three main parts, namely roots, stems, and leaves. Besides, this plant also has a vessel/file system in the form of xylem and phloem, which is not found in moss. Roots in ferns are like fibers and the ends are protected by calyptra (root caps). The stems of most ferns are not visible because they are in the soil in the form of rhizomes/rhizomes (Holtum, 1959). Ferns have unique characteristics in sporophyte and gametophyte generation, which is mutually independent. One of the ferns' unique characteristics lies in the morphological character of the sporophyte, which is used as a determinant of ferns in terms of shape, size, location, and spores' types (Suryadi *et al.*, 2020, Apriyanti *et al.*, 2017). Ferns are very heterogeneous when viewed in terms of habitus and way of life. Based on the habit, there are a few species of ferns with small leaves and a very simple structure. On the others, there were large with leaves that could reach up to two or more with a complex structure. Based on the way of life, there are species of ferns that live on the ground (terrestrial), some live on other plants (epiphytes), and also water ferns (hygrophytes). Ferns tend to like shady places with a high degree of humidity and cannot stand it. in conditions with limited water availability.

There are five families of pteridophytes with the largest proportion included Polypodiaceae, Thelypteridaceae, Pteridaceae, Hymenophyllaceae, and Cyatheaceae families, which cover almost 50% of the total diversity (Tjitrosoepomo, 1993). This value has decreased significantly from the previous pteridophyte diversity data, considering that this time information on the status of scientific names is more widely available and the progress of taxonomic revisions is quite rapid. However, it should be noted that there are still many species richness or taxa under species that have not been

revealed and recorded, both their identity and presence in the archipelago.

The diversity of ferns is very large in nature, so that ferns are one of the plants that cannot be separated from the effort to simplify the object of study. Ferns are the most primitive vascular plants than other vascular plants. The fern has gone through various stages of evolution from the Devonian to the present. However, research on the classification and relationship of Pteridophyta has not been widely carried out, however, only a few studies on fern relationship have been conducted (Nurchayati, 2007). Ferns play important roles in maintaining the forest ecosystem (Suryadi *et al.*, 2020), therefore, it is required to improve conservation and inventory of relationship to prevent biodiversity extinction. Phenetic relationship is a pattern of relationship or total similarity between groups based on their certain characteristics from each group.

Ferns are often found in humid areas such as mountain areas. One of the habitat ferns is Mount Lawu, or Gunung Lawu, this mount massive compound stratovolcano, straddling the border between Central Java and East Java, Indonesia. Mount Lawu has an important function for the protection of natural resources and ecosystems. This area is a buffer zone that limits the distribution of dry-type ecosystems in eastern Java and wet-type ecosystems in western Java. The high diversity of ferns is caused by environmental factors where the elevation of the area increases, the soil condition changes. According to Krebs (1985), soil moisture affects the geographic distribution of most trees in mountain forests and affects the content/availability of groundwater where the relationship with temperature can affect the balance of plant water. Other environmental factors that affect the growth of ferns are temperature, air humidity, soil pH, and light intensity.

MATERIALS AND METHODS

This study was conducted in the Cemoro Kandang hiking trail, Mount Lawu, Karangayar Regency, Central Java Province. The Parameters used in the study were morphological characteristics of habitat, stems, roots, leaves, and sorus.

The steps of data collection were as follows. (a) The morphological observation of the species include habitat (the type of habitat), stem (color and fiddlehead; color, shape, and stipe characteristics; color and shape of the rachis surface), leaf (type,

location, structure, shape, venation, and costa), root (rhizome and rhizoid) and sorus (location, shape, and color). (b) Designing observation table (table of Operational Taxonomy Unit) by providing numeric symbols. The description of Operational Taxonomy Unit feature can be described as number 0 if the feature does not have number 1 as well as if the observed characteristics are in that type. (c) Perform calculations using the SPSS program in the observation table. (d) The determination of the relationship between the ferns of the Polypodiaceae family was carried out by measuring the similarity or Similarity Index (IS) and measuring the dissimilarity or dissimilarity index (ID) using the following formula:

$$(IS) = \frac{2(\Sigma C)}{(\Sigma A) + (\Sigma B)} \times 100\%$$

(Hasanuddin & Fitriana, 2014)

Note:

ID = Dissimilarity Index

IS = Similarity Index

ΣC= Number of the same Characteristics in individuals being compared

ΣA = number of individual characteristics A

ΣB = number of individual characteristics B

Analysis of sample data that has been identified in accordance with *Operational Taxonomy Unit* was then analyzed using *Taxonomic Distance* formula to identify the relationship, which will be presented in the form of dendrogram.

The observed morphological characteristics of ferns consisted of several types (Table 1). The sporophyte morphological character data were analyzed using a phenetic approach using the SPSS 23 Hierarchical Cluster dendrogram program.

RESULTS AND DISCUSSION

The ferns was found and identified on Mount Lawu, the Cemoro Kandang hiking trail consists of 15 families including *Gleicheniaceae*, *Woodsiaceae*, *Vittariaceae*, *Pteridiaceae*, *Nepheolepidaceae*, *Davalliaceae*, *Polypodiaceae*, *Marattiaceae*, *Lycopodiaceae*, *Dennstaedtiaceae*, *Dipteridaceae*, *Blechnaceae*, *Adiantaceae*, distributed in 33 species. The highest number of species found were in the *Polypodiaceae* family as many as 6 species. The relationship of several species of ferns in the *Polypodiaceae* family of other species has been previously studied at the Purwodadi Botanical Garden, Pasuruan.

Table 1. List of characters for phenetic analysis of Family *Polypodiaceae*

No.	Character	Character code
1.	Habitat	Terrestrial (0), Epiphytic (1)
2.	Leaf	Single or pinnatifid (0), leaves 1 - pinnate (1)
3.	Leaf margins	Flat (0), Pinnatifid (1)
4.	Build leaves	Lanset (0), elliptical-lancet (1)
5.	Leaf shape	monomorphic (0), dimorphic (1)
6.	Rhizome	Upright (0), Creeping (1)
7.	Sorus	Small circle, near midrib (0), linear, marginal (1)
8.	Sorus location	On the lower surface of the leaf, Varies (0), at the tip of the fertile leaf spike (1),
9.	Sorus form	Sorus linear, ablique, extending from midrib to margin (0), sorus round, forming a single row to several irregular rows (1)
10.	Sorus size	Sorus until 2/3 of the leaves are towards the base (0), sorus until 1/2 - 1/3 towards the apex (1)
11.	Sorus diameter	Less than 0.1 cm (0), less than 0.2 cm (1)
12.	Sorus arrangement	Forming irregular, rather dense (0), regular sorus (1)
13.	Leaf species	There are 1 species, leaves foliage (0), there are 2 species of leaves, nest leaves and foliage leaves (1)

The results showed that *Adiantum caudatum* was related to *Nephrolepis falcate* with a similarity coefficient of 66.7% (Nurchayati, 2016). The results of sporophyte morphological observations of the sporophyte family of the Polypodiaceae Gunung Lawu climbing Cemoro Kandang were obtained as follows:

Belvisia mucronata

Epiphytic, short creeping rhizomes, growing 4-6 tightly, dense scaly, 3 cm long stipe, linear lanceolata leaves, single, sterile leaves 15-18 cm long, 2 cm wide, shrinking at the base and tip, curling at the margins, narrowing at junction with fertile leaf, short winged towards the stipe, veins generally not clear, midrib visible on both surfaces, sorus at apical fertile leaf, linear shape with tapered tip, 12 cm long, 0.4 cm wide, sporangium covering the abaxial leaves except midrib (Figure 1.A).

Crypsinus taeniatus

Terrestrial, creeping rhizome, dense scaly, scales taper slowly to the apex, pale brown, slightly dark in the middle, flat edges slightly jagged, stipe 15-30 cm; pinnate leaf, 30 - 40 cm long, with 7-10 pairs of pinna, narrow ellipse shape, long apex acuminate, thickened edges, with short serrations of each main vein, round sorus, forming a single row between midrib and pina edge, slightly raised adaxial, a diameter of 2 - 3 mm. The sporangium is reddish brown in color (Figure 1.B).

Drynaria sparsisora

Epiphyte, erect rhizome, short scaly, tapering from the round base, stiff, deciduous after growing leaves (base leaves / nest leaves and foliage leaves), dense, short scaly, shrinking, from apex to ovate,

dimorphic leaves, foliage, pinnatifid, length 60-70 cm including stipe, sorus generally small, in regular rows, always with irregular space between rows (Figure 1.C).

Goniophlebium sp

Epiphyte, creeping rhizome, white chalky surface, scaly young part, light brown scales, slightly jagged edges, pinnate leaves, 0.7 cm in diameter, brown, slightly scaly stipe and rachis. Sorus forms a single row on each side of the midrib, between the veinlets, the hollow, shallow, yellowish sporangium (Figure 1.D).

Lepisorus sp

Epiphytic, rhizome spreads long, grows 2 rows of leaves, 1 cm apart, dense scaly, 4 - 6 cm long, wingless, fertile leaf type is longer than sterile leaves, dark brown scaly at the base, single lamina, 10 - 12 long cm, 2 cm wide, sorus forms a single row at each midrib, round, 2 mm in diameter, brown sinks in the cavity, adaxial embossed (Figure 1.E).

Pyrrosia pillosellides

Epiphytes, creeping rhizomes, small scales with long hairy edges, no stipe on sterile leaves, 1 cm long fertile leaves, 3-6 cm long sterile leaves, and 1 cm wide, close to blat, sometimes elliptic widened, crossed, tapers slowly to base, wide round apex, very fleshy texture, smooth surface, scattered stellate hairs, clear midrib on half of the leaves from the base, 3-6 cm long and 0.8 cm wide fertile leaves, tapers slowly to the base, wide round apex, very fleshy texture, sorus forms a wide band at the marginal, present in a semicircle from the apex to almost near the base (Figure 1.F).

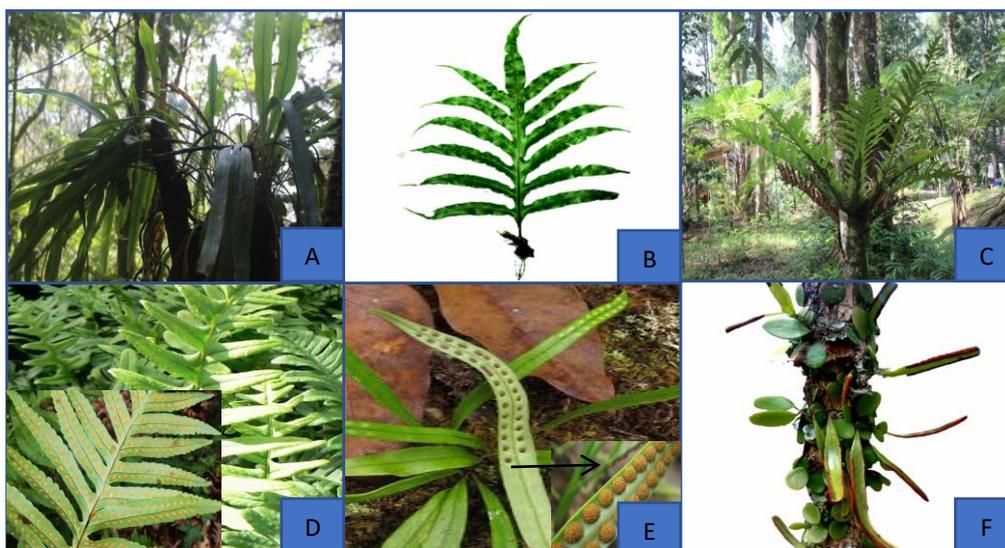


Figure 1. A) *Belvisia mucronata*; B) *Crypsinus taeniatus*; C) *Drynaria sparsisora*; D) *Goniophlebium* sp; E) *Lepisorus* sp; F) *Pyrrosia pillosellides*

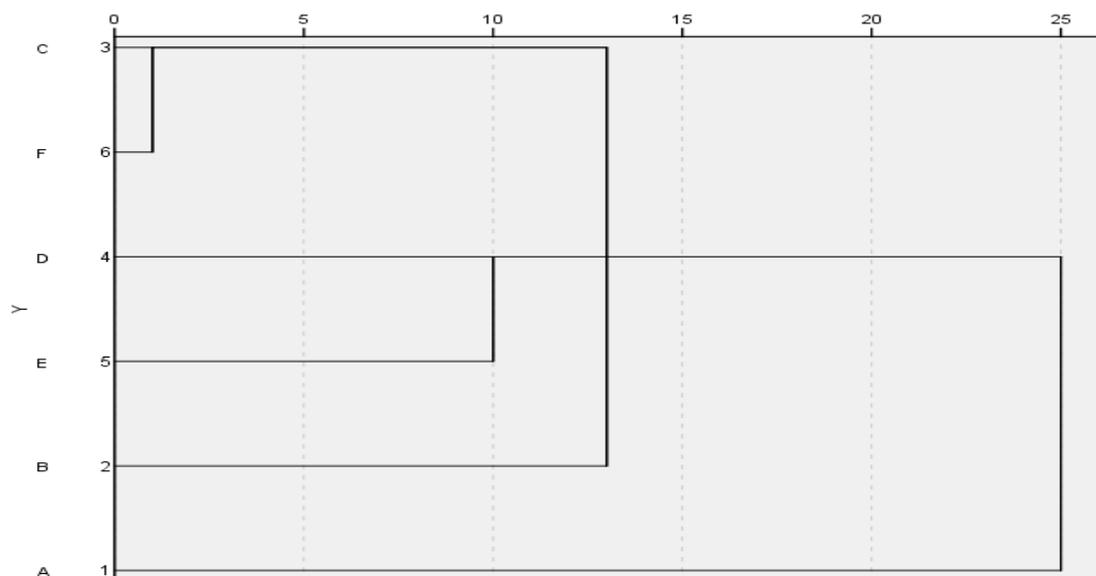


Figure 2. Dendrogram of six species of ferns, Family *Polypodiaceae*. A = *Belvisia mucronata*; B = *Crypsinus taeniatus*; C = *Drynaria sparsisora*; D = *Goniophlebium* sp; E = *Lepisorus* sp; F = *Pyrrosia piloselloides*

The results of the dendrogram construction using 13 morphological features showed that the six species of ferns found were divided into two main clusters, namely cluster I consists of *Goniophlebium* sp, *Lepisorus* sp, and *Pyrrosia* and cluster II consists of *Drynaria sparsisora*, *Goniophlebium* sp, and *Pyrrosia piloselloides*. The following is the dendrogram of the results of cluster analysis of 6 plant species that have been analyzed for their morphological characterization.

Based on the calculation of the Similarity Index, *Goniophlebium* sp is closely related to *Lepisorus* sp at a similarity coefficient of 53% and also *Lepisorus* sp is closely related to *Pyrrosia piloselloides* at a coefficient of 53%. *Drynaria sparsisora* and *Goniophlebium* sp are closely related to *Pyrrosia piloselloides* with a similarity coefficient of 46%. Then followed by *Crypsinus taeniatus* which is related to *Goniophlebium* sp, *Lepisorus* and *Pyrrosia piloselloides* with a similarity index of 38%. *Belvisia mucronata* is closely related to *Lepisorus* sp and *Pyrrosia*. In addition, the influence of diversity in a type is caused by two factors, namely the environment and traits inherited by genetics (Chao & Huang, 2018).

Group I consisted of *Goniophlebium* sp, *Lepisorus* sp, and *Pyrrosia piloselloides*. Those that are united based on the same habitat are epiphytes, creeping rhizomes, and have scales on the rhizomes. Group II consisted of *Drynaria sparsisora*, *Goniophlebium* sp, and *Pyrrosia piloselloides* which were united by habitat type characteristics,

rhizomes and spore arrangement that were single rows in each midrib sequence.

In accordance with the opinion of Radford (1986), the closely relationship can be seen by the number of similarities in characters or characteristics, so they have a kinship with a greater similarity coefficient, hence the relationship is closer. This is same opinion with (Vasco et al., 2013) opinion that the classification is based on the characters' correlation so that two plants that have similar characteristics are considered closely relationship than two plants that have few characters in common. Based on the dendrogram above, a grouping system can also be made among species in the *Polypodiaceae* family based on their relationship. While, Apriyanti et al. (2017) stated that more similarities of characteristics they have, the smaller the number of taxonomic distance value based on plant combinations. Besides that, it was concluded that the grouping based on the percentage of similarity of qualitative and quantitative characters observed produce a picture of the position of each accession in a dendrogram, generic distance values as well as showing the closeness of relationships or the similarity of characters between accessions.

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