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RELATIONSHIPS OF FERNS IN THE POLYPODIACEAE FAMILY IN THE BUKIT KUJAU AREA, TEMPUNAK DISTRICT, SINTANG REGENCY, BASED ON MORPHOLOGICAL CHARACTERISTICS

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ABSTRACT

Ferns belonging to the Polypodiaceae family are widely distributed across various regions of the world, particularly in forested areas and regions characterized by high humidity levels. The analysis of relationships among ferns can be conducted based on their morphological characteristics. The aim of this study was to determine the relationships among ferns of the Polypodiaceae family in the Bukit Kujau area of Tempunak District, Sintang Regency, utilizing morphological traits. This research was conducted from October to December 2023, during which 35 samples were collected in the Bukit Kujau area through purposive sampling. The relationships were analyzed using the UPGMA method in the NTSys program. The study identified seven species of ferns from the Polypodiaceae family: *Platycerium bifurcatum* (Cav.), *Dynaria querfolia* (L.), *Davallia denticulatum* (Burm.f.), *Phymatodes scolopendria* (Burm.), *Diplazium esculentum* (Rezt.), *Pyrrosia numularifolia* (Sw.), and *Drymoglossum piloselloides* (Linn.). Based on the grouping analysis, the seven species of ferns exhibited a similarity coefficient ranging from 0.37 to 1.00. At a similarity coefficient of 0.47, the species were grouped into three clusters, each distinguished by morphological characteristics such as sorus shape, sorus type, and sorus color.

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INTRODUCTION

Ferns belong to the Pteridophyta group with a body consisting of clearly divided roots, stems, and leaves. Ferns are among the most primitive vascular plants compared to other types of vascular plants. The main uniqueness of this fern lies in its ability to produce spores (Tjitrosoepomo, 2009). Ferns play an important role in maintaining the balance of the ecosystem as producers in the food chain, as well as a component in the nitrogen cycle. Ferns also help prevent erosion, regulate water management, and accelerate the process of soil weathering. In addition to their benefits to the ecosystem, ferns also have significant economic value.

The fern family that has the largest number of members is Polypodiaceae. This grouping is based on morphological characteristics such as the location of sori on leaves, sporangium shape, spore shape, rhizome morphology, and leaf reinforcement patterns. Molecular analysis can also be used for grouping, as done by Smith et al. (2006), stating that the Polypodiaceae family consists of about 35-40 genera with about 600 species. Looking at the level of kinship, ferns from the Polypodiaceae Family are included in the Polyphyletic group, which means they have a variety of different lineages. Lawrence (1964) stated the complexity of evolutionary relationships among members of the family. The diversity of sporophytic characters, especially those that can be observed macroscopically, has been a focus in fern taxonomy for many years.

West Kalimantan, one of Indonesia's biodiversity-rich regions, is home to a variety of ferns. A number of studies have been conducted to reveal the diversity of ferns in this region. Based on research on the types of ferns, Syufardian (2003) conducted research in the Mount Biwa Protected Forest Area of Sanggau Regency and found 23 species of ferns, Anggraeni (2005) in the Customary Forest Area of Sanjan Hamlet, Mawang Village found 18 species of ferns. Ekoyani (2007) in the Gunung Bawang Protected Forest Area of Bengkayang Regency found 20 species of ferns with the largest family, Dennstaedtiaceae.

The dense tropical forest in Bukit Kujau provides an ideal environment for ferns to thrive. Humid conditions around the hill are also very supportive of the existence of ferns. Based on surveys conducted in the Bukit Kujau area, several species of ferns from the Polypodiaceae family have been identified. This opens up opportunities to conduct further research on the relationship between ferns of the family, by paying attention to their morphological characters.

MATERIALS AND METHOD

Research on the types of ferns was conducted in Pulau Jaya Village, Tempunak District, Sintang Regency, precisely in the Bukit Kujau area (Figure 1). The method used in sampling ferns (Pteridophya) is the cruising method. Samples were taken as many as 5 individuals of each plant that had been found in the Bukit Kujau area. Sampling of ferns was carried out at Bukit Kujau. Sampling begins with preparing the tools used and continuing with determining the sample area. Determination of the sampling area is done by purposive sampling, namely by visiting several locations that have varieties of ferns. After that, the ferns found were documented using a camera.

Morphological character data were scored and then analyzed using clustering analysis. Grouping analysis and making dendrograms were carried out using the Unweighted Pair-Group Method with Arithmetic (UPGMA) method through the program (NTSYS) version 2.1 (Rohlf, 2001).

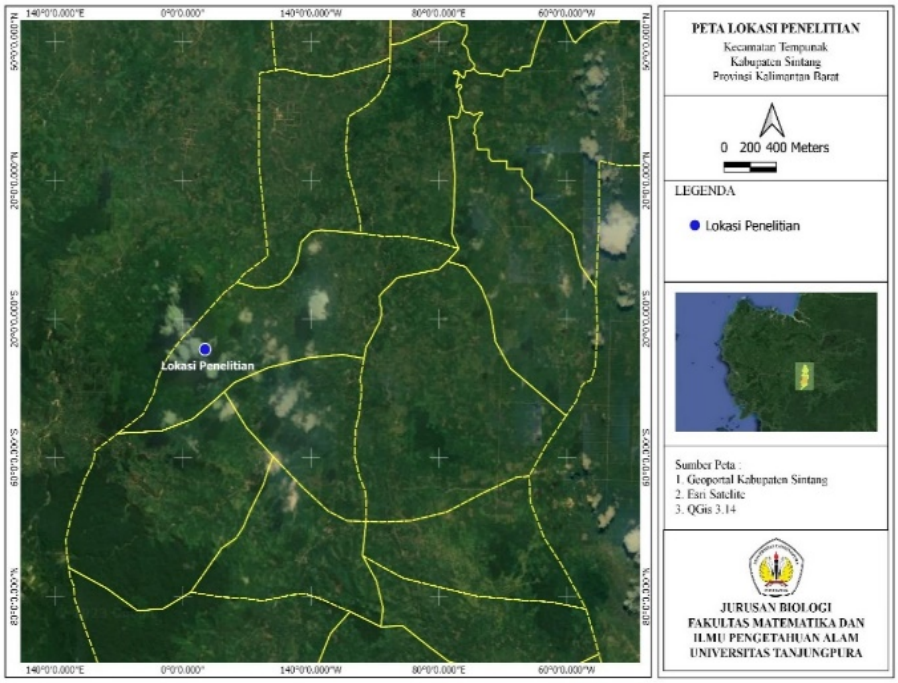

Figure 1 Research Location Map

RESULTS AND DISCUSSION

Results

Ferns found in the Bukit Kujau area consisted of 35 individuals including 7 species namely Platycerium bifurcatum (Cav) (PB), Dynaria querfolia (L) (DQ), Davallia dentuculum (Burm.f.) (DD), Phymatodes scolopendria (Burm) (PS), Diplazium esculentum (Rezt) (DE), Pyrrosia numularifolia (Sw) (PN), Drymoglossum piloselloides (Linn) (DP). Morphological characters observed include 23 qualitative characters with 22 characters having variation and 1 character having no variation.

Table 4.1 Morphological characteristics of ferns found in the area Bukit Kujau, Tempunak District, Sintang Regency

No	Character	DD	PB	PS	DP	DQ	DE	PN
1	Habitus	Epiphytes	Epiphytes	Terrestrial	Epiphytes	Epiphytes	Terrestrial	Epiphytes
2	Rhizome type	Spreading	Spreading	Does not spread	Spreading	Spreading	Does not spread	Spreading
3	Rhizome color	Blackish brown, Greenish brown	Brown, Blackish brown	Brown, Blackish brown	Brown, Greenish brown,	Brown, Blackish brown, Greenish brown	Brown, Blackish brown	Chocolate
4	Leaves	Compound	Single	Compound	Compound	Compound	Compound	Compound
5	Leaf Size	Macrophiles	Macrophiles	Macrophiles	Macrophiles	Macrophiles	Microfil	Microfil
6	Leaf Type	Tripalnatifid	Bipinnatifid	Pinnatifid	Pinnatifid	Pinnatifid	Binnatifid	Pinnatifid
7	Leaf Shape	Monomorphic	Monomorphic	Monomorphic	Dimorphic	Monomorphic	Monomorphic	Dimorphic
8	Leaf Build	Triangle	Cufflinks	Cufflinks	Linear, Lancet	Cufflinks	Cufflinks	Elliptical, ovoid
9	Leaf Location	Alternating	Root rosette	Rosette stem	Root rosette	Alternating	Rosette stem	Root rosette
10	Leaf Base	Blunt, Notched	Blunt	Blunt	Tapered	Blunt	Notched	Rounded
11	Leaf Tip	Pointed, Tapered	Blunt, Tapered	Pointed, Tapered	Rounded, Tapered	Pointed, Tapered	Tapered	Rounded
12	Leaf Edge	Serrated	Flat, Wavy	Flat	Flat	Flat	Beringgit	Flat
13	Leaf Surface	Smooth glossy	Slippery, Slippery	Slippery	Slippery	Slippery, Slippery-haired	Slippery, Slippery-haired	Slippery, glossy slippery
14	Leaf Color	Dark green	Dark green, Light green	Dark green, Light green	Dark green, Light green	Dark green, Light green	Dark green, Light green	Light green

15	Rod Shape	Round	-	Round, Flat	-	Round	Round	-
16	Growth Direction	Perpendicular	-	Perpendicular	-	Perpendicular	Perpendicular	-
17	Stem Color	Green-brown	-	Green-brown	-	Dark green, Brown green	Dark green, Brown green	-
18	Sorus	Small round	-	Margin, Rounded	Margin	-	-	-
19	Sorus type	Homospora	-	Heterospores	Homospora	-	-	-
20	Sorus location	On the edge of the leaf	-	On the edge of the leaf	On the edge of the leaf	-	-	-
21	Sorus Shape	Rounded	-	Rounded, Elliptical	Rounded	-	-	-
22	Sorus arrangement	Regular spores	-	Somewhat dense, irregular spores	Somewhat tight	-	-	-
23	Sorus color	Chocolate	-	Yellowish Brown	Chocolate	-	-	-

Based on the results of observations obtained 5 species of ferns with epiphytic habitats namely *P. bifurcatum* (Cav), *D. quercifolia* (L), *D. denticulum* (Burm.f.), P. *numularifolia* (Sw) and *D. piloselloides* (Linn) and 2 species of ferns with terrestrial habitats namely *P. scolopendria* (Burm) and *D. esculentum* (Rezt). Based on the results of observations on the morphological characters of leaf shape, 5 species were found to have monomorphic leaf shapes, namely *P. bifurcatum* (Cav), *D. quercifolia* (L), D. *denticulum* (Burm.f.), *P. scolopendria* (Burm) and *D. esculentum* (Rezt) and 2 species had dimorphic leaf shapes, namely *P. numularifolia* (Sw) and *D. piloselloides* (Linn). The results of observations of morphological characters on leaves that have single leaves are 1 species, namely *P. bifurcatum* (Cav) (Figure 2).

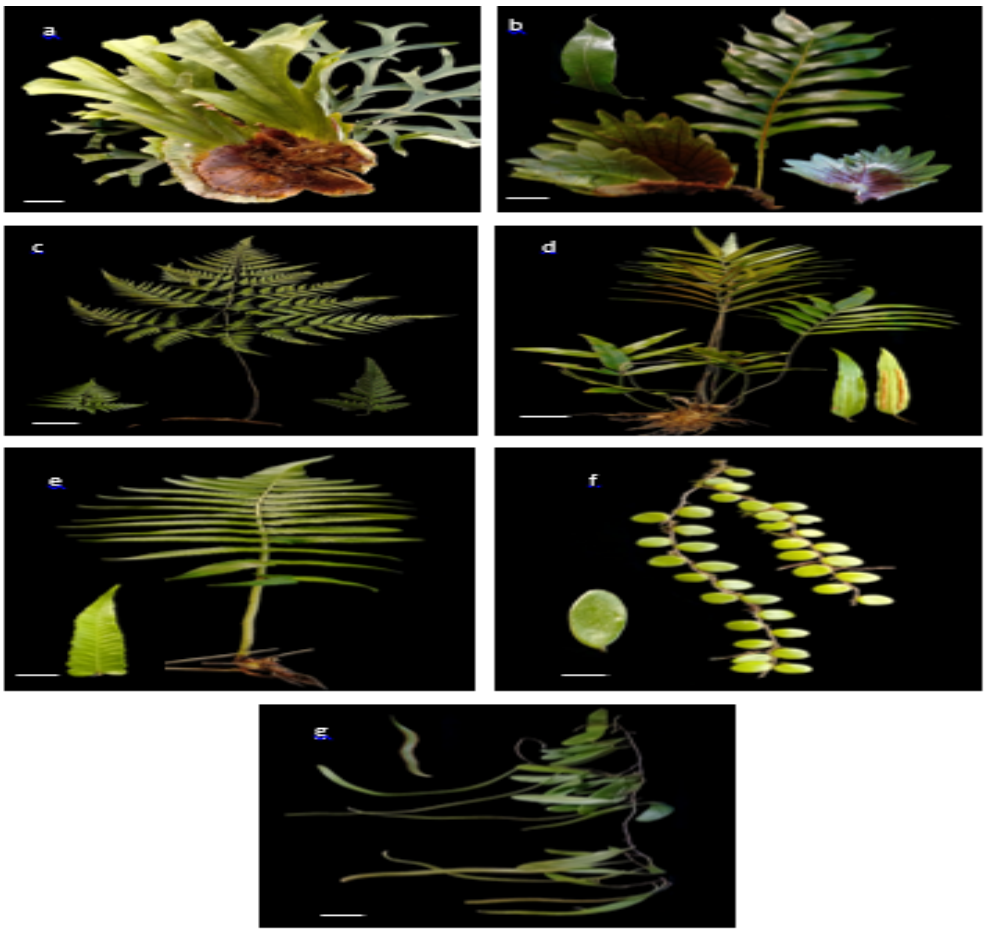

Figure 2 Seven ferns found in Bukit Kujau area, a. *Platycerium bifurcatum* (Cav), b. *Dynaria querfolia* (L), c. *Davallia dentuculum* (Burm.f.), d. *Phymatodes scolopendria* (Burm), e. *Diplazium esculentum* (Rezt), f. *Pyrrosia numularifolia* (Sw), g. *Drymoglossum piloselloides* (Linn). Scale Size: 4 cm

The results of the clustering analysis that has been carried out based on 23 morphological characters in 35 individuals of ferns of the Polypodiaceae family form 1 group at a similarity level of 0.37 or 37% (Figure 4.2). Grouping is divided into 3 clusters at a similarity level of 0.47 or 47%. Cluster 1 consists of *Davalia denticulum* (Burm f) and *Diplazium esculentum* (Rezt) species, namely DD1, DD2, DD3, DD4, DD5, DE1, DE2, DE3, DE5 and DE4 with a similarity coefficient of 0.49 (49%). Cluster 2 consists of *Platycerium bifurcatum* (Cav), *Phymatodes scolopendria* (Burm) and *Dynaria quecifolia* (L) species namely PB1, PB3, PB4, PB2, PB5, PS1, PS5, PS3, PS2, PS4, DQ1, DQ5, DQ4, DQ2 and DQ3 with a similarity coefficient value of 0.51 (51%). Cluster 3 consists of *Drymoglossum piloselloides* (Linn) and *Pyrrosia numularifolia* (Sw) species, namely DP1, DP3, DP5, DP2, DP4, PN1, PN5, PN3, PN2 and PN4 with a similarity coefficient value of 0.59 (59%) and PN4 with a similarity coefficient value of 0.59 (59%).

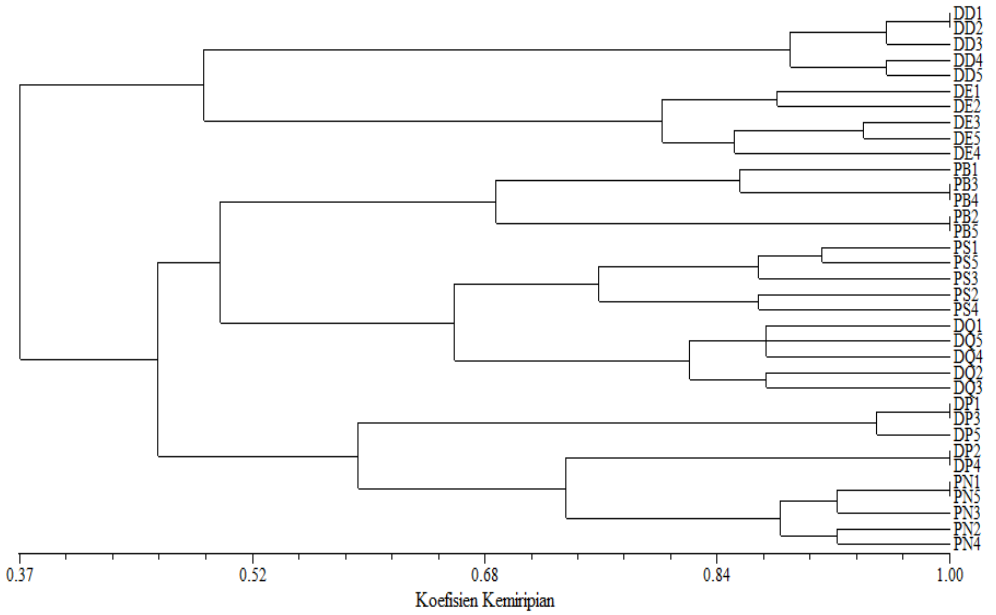

Figure 4.2 Dendrogram of Similarity Coefficient of Ferns found in Bukit Kujau Area

Discussion

Based on the data obtained from ferns, in general it can be seen that each type shows variation or genetic diversity between species. The results of dendrogram analysis show that there is diversity among the 7 species of ferns that form 3 clusters, each cluster will show the level of kinship in each species. This genetic diversity reflects the tendency of individuals in the population to display variation in their morphological characters, which in turn is important for population adaptation to the environment as well as to maintain biological diversity (Suryati, 2008 in Astuti, 2014).

The results of morphological observations of ferns studied obtained a combined character of 23 characters including the appearance of rhizome habitus, leaf edges, leaf wake, leaf location, leaf edges and sorus location. The results of characterization based on the morphology of ferns observed obtained dendrogram which is divided into three clusters as follows: Based on the dendrogram (Figure 4.2) it can be seen that cluster I has a similarity coefficient value of 0.49 (49%), cluster II has a similarity coefficient value of 0.51 (51%) and cluster III has a similarity coefficient value of 0.59 (59%). Cluster I is arranged based on the similarity of monomorphic leaf shape, round stem shape, perpendicular growth direction, small round sorus shape, homospora sorus type and brown sorus color. Cluster II is arranged based on the similarity of epiphytic habitat, macrophilous leaf size, monomorphic leaf shape, sorus location on the edge of the leaf, heterosporous sorus type and yellow sorus color. Cluster III is arranged based on the similarity of epiphytic habitats, creeping rhizomes, pinnatifid leaf types, dimorphic leaf shapes, marginal sorus shapes, homosporic sorus types and brown sorus colors. The similarity of morphological characters among the 3 clusters has a small value. This is in accordance

with the statement of Cronquist (1982), which states that higher hierarchies have fewer similarities among their members, while lower hierarchies have more character similarities.
Based on the cluster results, it can also be seen that the fern species in the Polypodiaceae family have different kinship relationships with each other. In accordance with the opinion of Radford (1986), the closeness of the kinship relationship can be known by the number of similarities in characters or characteristics possessed. The results of the dendrogram can also be seen that species that have many similarities in characters or characteristics have a kinship with a greater similarity coefficient, so the kinship relationship is closer. Species that have few similarities in characters or characteristics have a smaller similarity coefficient value so that the kinship relationship is relatively far away. Apriyanti et al. (2017) stated that the more characteristics they have in common, the smaller the taxonomic distance. Research on the relationship between morphological characters in ferns from the Polypodiaceae family found that the dendrogram showed a similarity level of 0.37, which means that the level of similarity is around 37%. This indicates that the diversity among the species is relatively high. Goncalvales et al. (2013) stated that if the similarity coefficient reaches 75% or more, then we can conclude that the germplasm studied has a high level of similarity or low diversity. Efendi et al. (2015) also emphasized that the higher the coefficient of genetic similarity, the greater the likelihood of close relationships between individuals. Warhamni et al. (2015) stated that the higher the number of dissimilarities, the smaller the similarity between individuals.

CONCLUSION

Protoplasts of *D. macrocarpus*, *S. tuberosum*, and *Spirulina* sp. can be isolated using a combination of cellulase enzyme solution and macerozyme enzyme. The results of isolated protoplasts in B. braunii and P. tricornutum could not be observed properly because the cells were round in shape, so they could not be distinguished from isolated protoplasts. The most protoplasts that were successfully isolated were orchid protoplasts and then continued with FDA staining. The staining results showed that several protoplasts glowed green under a fluorescence microscope, indicating a viable protoplast population.

AUTHORS CONTRIBUTION

W.M. designed and conducted the research, analysed and interpretation the data, and wrote the draft of manuscript, S.W. analysed and intrepetation the data.

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