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SORUS MORPHOLOGY OF FERNS OF THE FAMILY *Dryopteridaceae* AND THE FAMILY *Polypodiaceae* THE TATANGGE UNIVERSITY FOREST, SOUTHEAST SULAWESI

Morfologi Sorus Tumbuhan Paku Familia *Dryopteridaceae* dan Familia *Polypodiaceaea* di Kawasan Hutan Pendidikan Tatangge Sulawesi Tenggara

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ABSTRACT

This study aims to determine the morphology of the sorus of ferns *(Pteridophyta) Dryopteridaceae* and *Polypodiaceae* families in the Tatangge Education Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi. This research involved exploration in the Tatangge University Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi to collect samples, then identifying and observing sorus characteristics in the Laboratory of the Biology Education Department, Faculty of Teacher Training and Education, Halu Oleo University, Kendari. *The* research data were processed and analysed descriptively, regarding the characteristics of the sorus of ferns *(Pteridophyta) Dryopteridaceae* family including location, shape, colour, and annulus. The results of the study found 5 (five) species of ferns *(Pteridophyta) Dryopteridaceae* family, and 5 (five) species of *Polypodiaceae family* that have different sorus characteristics. The *Dryopteridaceae* family consists of the species *Dryopteris celsa*, Dryopteris *filix-mas*, *Dryopteris marginalis*, *Nephrolepis biserrata* (Sw) Schoot, and *Polistichopsis hasseltii. The* family *Polypodiaceae consists* of the species *Drynaria sparsisora* (Desv.) T. Moore *Pyrrosia longifollia* (Burm. f), *Pyrrosia lanceolata* L Farw, *Pyrrosia piloselloides* M.G. Price, and *Polypodium glycyrriza* Licorice Fern.

Keywords*: Dryopteridaceae* and *Polypodiaceae* families, Sorus morphology, *Pteridophyta*.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui morfologi sorus tumbuhan paku *(Pteridophyta)* familia *Dryopteridaceae* dan *Polypodiaceae* di kawasan Hutan Pendidikan Tatangge Taman Nasional Rawa Aopa Watumohai Sulawesi Tenggara. Penelitian ini melibatkan penjelajahan di kawasan Hutan Pendidikan Tatangge Taman Nasional Rawa Aopa Watumohai Sulawesi Tenggara untuk mengumpulkan sampel, kemudian dilakukan indentifikasi dan pengamatan karakteristik sorus di Laboratorium Jurusan Pendidikan Biologi, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Halu Oleo, Kendari. Data hasil penelitian diolah dan dianalisis secara deskriptif, mengenai karakteristik sorus tumbuhan paku *(Pteridophyta)* familia *Dryopteridaceae* meliputi letak, bentuk, warna, dan annulus. Hasil penelitian ditemukan 5 (lima) spesies tumbuhan paku *(Pteridophyta)* familia *Dryopteridaceae,* dan 5 (lima) spesies familia *Polypodiaceae* yang memiliki karakteristik sorus yang berbeda-beda. Familia *Dryopteridaceae* terdiri dari spesies *Dryopteris celsa*, *Dryopteris filix-mas*, *Dryopteris marginalis*, *Nephrolepis biserrata* (Sw) Schoot, dan *Polistichopsis hasseltii.* Familia *Polypodiaceae* terdiri dari spesies *Drynaria sparsisora* (Desv.) T. Moore *Pyrrosia longifollia* (Burm. f), *Pyrrosia lanceolata* L Farw, *Pyrrosia piloselloides* M.G. Price., dan *Polypodium gliycyrriza* Licorice Fern.

Kata Kunci: Familia Dryopteridaceae dan Polypodiaceae, Morfologi Sorus, Pteridophyta.

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INTRODUCTION

Indonesia is a megabiodiversity country with very high plant diversity (Nasution et al, 2018: 65). (Ferns *(Pteridophyta)* is one of the cormus plants, meaning that the roots, stems, and leaves can be clearly distinguished (Tjitrosoepomo, 2014: 206). The main characteristic that distinguishes ferns *(Pteridophyta)* with other plants is having young leaves that roll up, and have a means of reproduction in the form of spores produced from sporangium (spore boxes). Ferns *(Pteridophyta) is* divided into several families, such as the family *Dryopteridaceae* and *Polypodiaceae*.

Ferns *(Pteridophyta*) of the *Dryopteridaceae* family vary in size from small to large. The leaf blade is separated from each other, thin, hairy or bald (Sianturi, et al. 2020: 76). Other characteristics of ferns *(Pteridophyta) Dryopteridaceae*) is a large and diverse family comprising mainly terrrestrial species with erect rhizomes, although a few species have long-creeping rhizomes. The fronds are monomorphic, usually 2-5 pinnate (but rarely only 1-pinnate), abundantly scaly and sometimes also hairy. Some species are bulbiferous, and the naturalised species are often deciduous. The veins are usually free, except in Cyrtomium. The sori are round, protected by round or reniform, peltate indusia or occasionally (Brownsey & Perrie, 2021: 3). . Sori is protected by a goblet-shaped to kidney-shaped indusium that opens towards the leaf tip (Meliza et al, 2019: 2). (The main characteristic that distinguishes ferns *(Pteridophyta)* other families is the first leaflets resemble the letter V.

The family *Polypodiaceae* is characterised by epiphytic, epilithic and only partly tertiary, single or compound leaves, having young leaves that roll spirally (circular), leaf margins are usually straight and wavy, leaf veins are free (reticulate). Sorus shallow, oval, rounded, and usually elongated (acrosticoid), scattered over all or part of the lower surface of the leaf, located parallel to the leaflets and between the leaflets. Spores are bilateral, rounded (monolete), smooth (verrucose), tuberculate or spinulose. (Negi, et al., 2009: 48). The *Tectariacea* family has morphological characteristics with upright to creeping rhizomes, stems covered with scales, single to double pinnate leaves, round sorus scattered on the underside of the leaves and several types located along the leaf bones arranged in a row (Jayanti, 2020: 50). Many types of ferns have diverse sorus morphology. The morphology of the sorus is in the form of shape, colour, sorus place, and the presence or absence of annulus on the sporangium which is a very important identifying feature. The influence of the environment plays an important role in the sorus rupture of ferns. The location and shape of the sorus in ferns are different, ranging from the location of the sorus on the edge or near the edge of the leaf, there is also on the veins of the leaves, shaped lines, elongated and rounded (Tjitrosoepomo, 2007).

Sorus morphologica characteristics are important in classifying ferns *(Pteridophyta*), which can be seen based on the location, shape, colour, and presence or absence of annulus (Nafili, et al. 2019: 227). In general, the sorus of ferns *(Pteridophyta*) is located below the surface of the leaves, with different distribution, namely the edge of the leaf, following the leaf reinforcement, the tip of the leaf, and scattered. The shape of the sorus varies, namely the shape of the line, oval, bowl, kidney, letter U, and round (Zulfia, et al. 2016: 195). Sorus has several colours, namely brown, black, yellow, and green (Mardiyah, et al. 2016: 223).

Based on the results of research that has been done by previous researchers that in the Education Forest area of Rawa Aopa Watumohai National Park found 30 genera of ferns *(Pteridophyta*) consisting of 54 species, one of the families of ferns (*Pteridophyta)* found is the *Dryopteridaceae* family as many as two species. Until now, in the Education Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi, there are no more research results on ferns *(Pteridophyta*), this allows the addition or reduction of fern species *(Pteridophyta*) in the area, especially in the *Dryopteridaceae family (*Munir, 2003: 1).

In Southeast Sulawesi, there have been many studies on ferns *(Pteridophyta*), but until now there has been no research on sorus characteristics in ferns *(Pteridophyta*). Sorus characteristics are one of the main

characteristics of each fern, where each family of ferns (*Pteridophyta*) has different sorus characteristics. So that researchers are interested in conducting research on "**Sorus Morphology of Ferns of the Family *Dryopteridaceae* and the Family *Polypodiaceae* the Tatangge University Forest, Southeast Sulawesi".** Therefore, to find out the characteristics of different sorus in the Dryopteridaceae and Polypodiaceae families and can be used as a reference in monitoring biological wealth, especially ferns and make a significant contribution in enriching knowledge about ferns, especially from the Dryopteridaceae and Polypodiaceae families

MATERIAL AND METHODS

This research was conducted in August - November 2023 at Tatangge University Forest, Rawa Aopa Watumohai National Park, Southeast Sulawesi. This research involved exploration in the Tatangge Education Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi to take samples of ferns *(Pteridophyta)* of the *Dryopteridaceae* family and *Polypodiaceae* family that have sorus, then identification and observation of sorus characteristics in the Biology Education Laboratory, Faculty of Teacher Training and Education, Halu Oleo University KendarI.

RESULTS

Based on the results of research conducted in the Tatangge Education Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi, 5 species of ferns of the *Dryopteridaceae* family and 5 species of the *Polypodiaceae* family were found, *which* have diverse sorus morphology and each species has an annulus. The research data are presented in Table 1.1 and Table 1.2.

Table 1.1 Morphology of Sorus of Ferns of the *Dryopteridaceae* Family in the Tatangge University Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi

No.	Species name	Sorus characteristics				Image
		Location	Shape	Colour	Annulus	
1	*Dryopteris celsa*	Below the leaf surface, located between the leaf veins	Irregular round	Chocolate	 There is Position: not exactly in the centre of the sorus, slightly off the centre of the sorus	
2	*Dryopteris filix-mas*	Below the leaf surface, located in the leaf veins	Letter u	Light green colour	 There is Does not have a clear annulus, sorus is usually covered by an indusium	

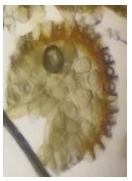
No.	Species name	Sorus characteristics				Image
		Location	Shape	Colour	Annulus	
3	*Dryopteris marginalis*	Below the leaf surface, located at the tip of the leaf blade but not at the leaflet tip	Round and thick	Sorus edges blackish brown, centre light brown	 There is Located on the edge or margin of the underside of the pinnule	
4	*Nephrolepis biserrata* (Sw) Schoot	Below the leaf surface, located between the leaf veins	Round (the ends are not joined and the centre is empty)	Chocolate	 Available The sorus is usually covered by an indusium	
5	*Polistichopsis hasseltii*	Beneath the leaf surface, located in each indentation of the leaf margin	Round and embedded	Yellowish green colour	 There is The sorus is usually covered by a kidney-shaped indusium	

Table 1.2. Morphology of the sorus of ferns (Ptridophyta) of the family *Polypodiaceae* in the Tatangge University Forest area of Rawa Aopa Watumohai National Park, Southeast Sulawesi

No.	Species Name	Sorus Morphology				Image
		Location	Shape	Colour	Annulus	
1	*Drynaria sparsisora* (Desv.) T. Moore	Located beneath the leaf surface, scattered along the leaf bone, starting from the base of the leaf to almost the tip of the leaf.	Round, elongated, triangular, attached to the leaf surface, not easily detached	Golden brown	 There is Circular with serrated edges	

No.	Species Name	Sorus Morphology				Image
		Location	Shape	Colour	Annulus	
2	*Pyrrosia longi-folliaI* (Burm. f)	Located below the leaf surface, it spreads over the leaf from the middle of the leaf bone to the tip of the leaf.	Round, clus-tered like vel-vet, and dense (less visible or indistinct)	Dark brown	 Available Not a perfect circle but rather elongated and curved,the top is thick and has a deep inden-tation, the bottom part is thin and flat	
3	*pyrrosia lance-olata* L Farw	Located below the leaf surface, they are scat-tered along the edge of the leaf, from the centre of the leaf bone, to the tip of the leaf and aligned in the mother row of the leaf bone.	Round and dense (sorus clearly visible) densely cover-ing the leaves	Light brown	 There is Not a perfect circle but rather elongated and curved	
4	*Pyrrosia pilo-selloides* M.G. Price.	Located below the surface of the leaf, like a circle, surround-ing the edge of the leaf.	Small round, thin, and at-tached to the leaf	Chocolate	 There is not a perfect circle but is elongated and curved, flatter	
5	*Polypodium glycyrrhiza* Lic-orice Fern	Below the leaf surface, located between the leaf bones, the first row is regularly aligned near the leaf veins, the second row is aligned near the leaf margins.	Oval round, centre not full	Black	 There is Not a perfect circle but an oval with a pointed tip	

DISCUSSION

Based on the results of research in the Tatangge University Forest area of Rawa Aopa Watumohai National Park, 5 species of ferns *(Pteridophyta) of the Dryopteridaceae* family and 5 species of the *Polypodiaceae family were* found. *Dryopteridaceae* family consists of *Dryopteris celsa, Dryopteris filix-mas, Dryopteris marginalis, Nephrolepis biserrata,* and *Polistichopsis hasseltii*. The family *Polypodiaceae* comprises *Drynaria sparsisora* (Desv.) T. Moore *Pyrrosia longifollial* (Burm. f)*, Pyrrosia lanceolata* L Farw, *Pyrrosia piloselloides* M.G. Price, and *Polypodium glycyrrhiza* Licorice Fern. All of these species have different sorus characteristics. Differences in sorus morphology are not only found in different families, but in the same family the morphology of the sorus is also different. This is in accordance with the statement of Mardiyah, et al (2016: 226) which states that ferns *(Pteridophyta)* have different sorus characteristics, both in terms of location, shape, and colour, as well as annulus.

Sorus ferns *(Pteridophyta) Dryopteridaceae* family found are all under the surface of the leaves, this is in accordance with the statement Andrews (1990: 130), which states that in general sorus ferns *(Pteridophyta) Dryopteridaceae* family is under the surface of the leaves. The location of the sorus found also varies, namely between the leaf veins, namely in the species *Dryopteris celsa* and *Nephrolepis biserrata*, in the leaf veins, namely in the species *Dryopteris filix-mas*, at the end of the leaf veins but not at the end of the leaflets, namely in the species *Dryopteris marginalis*, and in each indentation of the leaf edge, namely in the species *Polistichopsis hasseltii*. This is in accordance with the statement of Sianturi, et al (2020: 76), which states that the sorus of ferns *(Pteridophyta) of the Dryopteridaceae* family is located on the leaf reinforcement, leaf edge, leaf tip. The shape of the sorus consists of an irregular round shape, namely in the *Dryopteris celsa species, round* and thick, namely in the *Dryopteris marginalis species,* round (the ends are not connected and in the middle are empty), namely in the *Nephrolepis biserrata species,* round embedded, namely in the *Polistichopsis hasseltii* species, and the letter U, namely in the *Dryopteris filix-mas species*. This is in accordance with the statement of Zulfia, et al (2016: 195), which states that the sorus of ferns *(Pteridophyta)* has the shape of a line, oval, bowl, kidney, letter U, and round. The colour of the sorus consists of brown, namely in the species *Dryopteris celsa, Dryopteris maginalis, Nephhrolepis biserrata* and green, namely in the species *Dryopteris filix-mas* and yellowish green in the species *Polistichopsis hasseltii*. This is in accordance with the statement of Mardiyah, et al (2016: 223), which states that the sorus of ferns *(Pteridophyta) has* brown, black, yellow, and green colours. Of the five species of ferns *(Pteridophyta)* found all have annulus, with different shapes, namely round shape in *Dryopteris celsa* and *Polistichopsis hasseltii species*, oval shape in *Dryopteris marginalis* and *Nephrolepis biserrata species,* and the letter U in *Dryoteris filix-mas species*. The sorus surface is rough, except for *Dryopteris filix-mas* which has a smooth sorus surface. The sorus bundle is thick, except in *Dryopteris celsa* species where the sorus bundle is thin. Sorus spacing is sparse, except in *Dryopteris marginalis* species where sorus spacing is tight and sparse. Sorus form rows that face each other, except in *Polistichopsis hasseltii, where the sorus* do not form rows but are arranged following the pattern of the curve of the leaf edge.

The ferns (*Pteridophyta*) of the *Polypodiaceae* family found from these five species have different sorus morphology. The location of the sorus found also varies, but generally is below the surface of the leaf. The sorus is located below the surface of the leaf, scattered along the leaf bone, starting from the base of the leaf to almost the tip of the leaf, such as in the spike *Drynaria sparsisora* (Desv.) T. Moore*.* Sorus location Below the leaf surface, scattered over the leaf from the middle of the leaf bone to the tip of the leaf, as in the spike *Pyrrosia longifollia* (Burm. f). Below the leaf surface, scattered along the edge of the leaf, from the middle of the leaf blade, to the tip of the leaf and aligned in the mother row of the leaf blade, *Pyrrosia lanceolata* L Farw*.* Located below the surface of the leaf, scattered along the edge of the leaf, from the middle of the leaf

bone, to the tip of the leaf and parallel to the mother row of leaf bones, in the type of nail *Pyrrosia piloselloides* M.G. Price Located below the surface of the leaf, located between the leaf bones, the first row is regularly aligned near the leaf veins, the second row is aligned near the edge of the leaf, in the type of nail *Polypodium glycyrrhiza* Licorice Fern. This is in accordance with the opinion of Mardiyah, et al (2016: 220), that the sorus of ferns (*Pteridophyta*) of the *Polypodiaceae* family is located on the edge or near the edge of the leaf, leaf veins, along the leaf reinforcement, or up to the middle of the leaf reinforcement. The sorus is round, elongated, triangular, attached to the leaf surface, not easily detached, found in the spike *Drynaria sparsisora* (Desv.) T. Moore. Rounded, clustered like velvet, and dense (less visible or unclear) are found in *Pyrrosia longifollia (*Burm. f). The round shape and dense (sorus is clearly visible) tightly covering the leaves are found in *Pyrrosia lanceollata* L Farw. The round shape is small, thin, and attached to the leaves, namely found in the *Pyrrosia piloselloides spike*. The shape of the sorus is oval, the centre is not full in the type of species *Polypodium glycyrrhiza* M.G. Price. This is in line with Nafili, et al (2019: 229) which states that the sorus of ferns (*Pteridophyta*) of the *Polypodiaceae* family is round, rounded, elongated round, triangular. The sorus colour is golden brown as in the species *Drynaria sparsisora* (Desv.) T. Moore*, Pyrrosia longifollia* (Burm. f) dark brown*, Pyrrosia lanceollata* L Farw light brown*, Pyrrosia piloselloides* M.G. Price., brown. Black colour in *Polypodium glycyrrhiza* Licorice Fern species. This is in line with Seno, et al (2012: 22) state that the sorus colour consists of black, yellow, brown, dark brown, light brown, golden brown and whitish green. The ferns (*Pteridophyta*) of the Polypodiaceae family of the five types of species found all have annuli with different shapes, namely, in the *Drynaria sparsisora* (Desv.) T. Moore species, in the form of a circular ring like the letter u. The annulus of the species *Pyrrosia longifollia* (Burm. f) is oval round. The annulus of the species *Pyrrosia lanceolata* L Farw, is a u-shaped circular ring (the circle is not perfect), as is the species *Pyrrosia piloselloides* M.G. Price. Annullus *Polypodium gliycyrrhiza* Licorice Fern is round.

Pramudita, et al (2021: 23), state that an important factor in the growth and development of ferns *(Pteridophyta)* is the environment, in the form of air temperature and humidity. The results of measuring air temperature parameters in the Rawa Aopa Watumohai National Park Education Forest area show a value of 31-32 ° C. While the results of measuring air humidity parameters in the area show the results of measuring air humidity parameters in the area. While the results of measuring the air humidity parameters in the area show measurement results of 35-41%, this is in accordance with the statement of Pramudita, et al (2021: 23), which states that the appropriate environmental temperature for the growth of ferns *(Pteridophyta)* is 22-37 ° C, while the appropriate air humidity for the growth of ferns *(Pteridophyta)* is 20-90%. Based on the measurement results of these environmental parameters, it shows that the air temperature and air humidity in the Rawa Aopa Watumohai National Park Education Forest area are still within the tolerance range for the growth and development of ferns *(Pteridophyta)*, so that in the area ferns *(Pteridophyta) are* found, one of which is from the *Dryopteriaceae* family.

CONCLUSION

Based on the results of the study, it can be concluded that there are 5 (five) species of ferns *(Pteridophyta) of the Dryopteridaceae* family*,* and 5 (five) species of the *Polypodiaceae family*. The *Dryopteridaceae* family consists of *Dryopteris celsa*, *Dryopteris filix-mas*, *Dryopteris marginalis*, *Nephrolepis biserrata* (Sw) Schoot, and *Polistichopsis hasseltii. The* family *Polypodiaceae* consists of the species *Drynaria sparsisora* (Desv.) T. Moore *Pyrrosia longifollia* (Burm. f)*, Pyrrosia lanceolata* L Farw, *Pyrrosia piloselloides* M.G. Price, and *Polypodium glycyrriza* Licorice Fern. All ferns of the *Dryopteridaceae* family and *Polypodiaceae* family found have different sorus morphologies in terms of shape, location, sorus colour and annulus.

Overall, the findings of sorus morphology of ferns of the Dryopteridaceae and Polypodiaceae families in Tatangge University Forest have broad implications and are beneficial to various parties. These findings can help increase knowledge about biodiversity, encourage economic development, improve education and research, support conservation efforts, and develop ecotourism.

The research findings on the morphology of the sorus of Dryopteridaceae and Polypodiaceae ferns in Tatangge University Forest open up exciting opportunities for further research. Some potential areas that can be explored for future research include biodiversity, ecology and physiology, evolution and phylogeny, conservation, ethnobotany, educational outreach that can contribute significantly to our understanding of fern biodiversity, forest ecology, and the impact of human activities on the environment.

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