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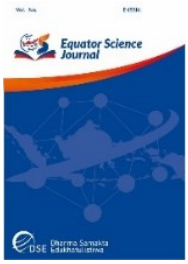

Diversity of Fern Species (Pteridophyta) in Sipeso Village, Sindue Tobata District, and Their Utilization as Learning Media

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ABSTRACT
Biodiversity is very high, both in flora and fauna, and this abundance should be utilized for community needs. One of the biological potentials is the natural resource of flora, including ferns (Pteridophyta). This study aims to describe the abundance of fern species (Pteridophyta) found in the plantations of Sipeso Village, Sindue Tobata District, and to use the results as an educational medium in the form of a flipbook suitable for use. This type of research is descriptive quantitative, with the research location determined through purposive sampling, selecting two observation stations. Sampling was conducted using line transects with a plot method, with a research area of 5000 m², where each station covers 2500 m². In each station, a 50-meter line transect was placed, and plots of 10m x 10m were systematically arranged using a zig-zag method. Samples within the plots were then collected. The results showed that 12 species of ferns were found, which belong to the class Polypodiopsida, including 2 orders and 8 families. Based on their habitat, 8 species of terrestrial ferns and 4 species of epiphytic ferns were identified. The abundance of fern species (Pteridophyta) in the Sipeso Village plantations is classified as low with an abundance value of R1 = 1.76. The percentage of the educational media's suitability is 83.25%, indicating that the flipbook as an educational medium is highly suitable for use.

INTRODUCTION

A plantation is a large-scale agricultural area, typically located in tropical or subtropical regions, used for producing trade commodities on a large scale. Plantations can be planted with industrial crops such as cocoa, coconut, tea, oil palm, pepper, and coffee. Plantations provide a suitable habitat for the growth of various types of plants due to their relatively complex ecosystem, which supports a range of plant species, including herbs and shrubs. One type of shrub commonly found in plantations is ferns (Listiyanti et al., 2022; Desi et al., 2023).

Ferns (Pteridophyta) are a division of Cryptogamae plants, each species of which clearly possesses a kormus with true roots, stems, and leaves, as well as vascular bundles including xylem and phloem (Ulfa, 2017; Wugaje et al., 2023). Ferns play a crucial role in humus formation, protecting soil from erosion, and maintaining soil moisture. Additionally, ferns have high economic value as ornamental plants and can be utilized as food ingredients. Ferns can spread easily through spore dispersal, leading to their abundance (Jubaidah et al., 2018).

Abundance refers to the number of individuals of each species, and it is also defined as the number of individuals per unit area. The abundance of ferns is greatly influenced by environmental factors such as soil moisture, air humidity, light intensity, temperature, and various other factors (Michael, 1984). This condition is similar to what is found in the plantations of Sipeso Village.

Sipeso Village is one of the villages located in the Sindue Tobata District, Donggala Regency, Central Sulawesi Province, with a village area of 37.96 km² and a plantation area of 50 hectares. In the plantations of Sipeso Village, there are many types of plants ranging from trees and shrubs to lower-level plants such as moss, fungi, and ferns.

Based on observations conducted in the plantations of Sipeso Village, five fern species were found: *Lygodium circinnatum*, *Lygodium longifolium*, *Polystichum setiferum*, *Cyclosorus aridus*, and *Nephrolepis bisserata*. This information indicates that Sipeso Village has potential fern abundance. Additionally, the location has very supportive environmental conditions such as air humidity, soil moisture, temperature, and light intensity. Unfortunately, this information is still limited among the local community, and it could serve as a valuable resource to enhance knowledge for anyone. Therefore, to disseminate this information more widely, the author plans to use the research findings as an educational medium in the form of a flipbook.

A flipbook is a software with editing functions used to add hyperlinks, images, videos, and audio to support material and include multimedia objects on pages that can be flipped like a real book (Ilham, 2014). The purpose of a flipbook is to assist learners in understanding the material, improve learning outcomes, enhance creative thinking skills, and increase student motivation (Hayati et al., 2015; Rochman et al., 2024). Flipbooks are chosen as a medium because they are suitable for use in learning. According to previous research, the use of flipbooks as an educational medium can boost motivation (Anandari et al., 2019; Ismail et al., 2024).

METHOD

This type of research is descriptive quantitative research. Descriptive quantitative research is a study that shows, describes, explains, or summarizes various conditions, situations, phenomena, or specific data without manipulation from quantitative or statistical data collection. Sampling techniques are carried out using the transect method with an area of 5000 m², which is then divided into two stations, each with an area of 2500 m² for sampling using the plot method.

Data analysis of fern species in Sipeso Village, Sindue Tobata District, uses the Margalef Richness Index formula (Magurran, 2004).

$R1 = (s - 1) / (Ln (NO))$

Where: R1 = Species richness index (Margalef index)
S = Total number of observed species
NO = Total number of observed individuals

Where: R1 < 3.5 indicates low species richness, R1 between 3.5 – 5.0 indicates moderate species richness, and R1 > 5.0 indicates high species richness.

Analysis of the Feasibility of Learning Media

The feasibility of the flipbook learning media will be determined by the scores given by 3 expert validators. Arikunto (2009) states that the percentage of media feasibility data is calculated using the following formula: Result = (total score obtained) / (maximum score) × 100%. Once the percentage value is obtained, it is interpreted into a statement with criteria as presented in Table 1.

Table 1. Criteria for Media Feasibility Percentage

No	Percentage Score (%)	Feasibility Category
1	< 21%	Very Unfit
2	21% - 40%	Unfit
3	41% - 60%	Adequately Fit
4	61% - 80%	Fit
5	81% - 100%	Very Fit

RESULTS AND DISCUSSIONS

Overview of the Research Location

The research location is in Sipeso Village, which is one of the villages in the Sindue Tobata District, Donggala Regency, Central Sulawesi Province. Station 1 is situated in a highland plantation to the south of Sipeso Village, with relatively good environmental conditions and moist soil. In addition to ferns, this area also includes coconut, cocoa, clove, durian, and coffee plants. Station 2 is located in a lowland plantation to the north of Sipeso Village, where, besides the ferns, there are teak trees and shrubs (Table 2).

Tabel 2. Types of Ferns (Pteridophyta) in Sipeso Village Plantation

Order	Family	Species	Habitat
Polypodiales	Dryopteridaceae	Polystichum setiferum	Terrestrial
Polypodiales	Dryopteridaceae	Dryopteris cristata	Terrestrial
Polypodiales	Nephrolepidaceae	Nephrolepis biserrata	Terrestrial
Polypodiales	Nephrolepidaceae	Nephrolepis cordifolia	Terrestrial
Polypodiales	Pteridaceae	Pteris vittata	Terrestrial
Polypodiales	Tectariaceae	Tectaria gemmifera	Terrestrial
Polypodiales	Aspleniaceae	Asplenium nidus	Epiphytic
Schizaeales	Lygodiaceae	Lygodium scandens	Epiphytic
Schizaeales	Lygodiaceae	Lygodium longifolium	Terrestrial
Schizaeales	Lygodiaceae	Lygodium circinnatum	Epiphytic
Polypodiales	Thelypteridaceae	Cyclosorus aridus	Terrestrial
Polypodiales	Polypodiaceae	Microgramma lycopodioides	Epiphytic

The classification and description of the ferns (Pteridophyta) found in the Sipeso village plantation are as follows:

1. *Polystichum setiferum (Forssk) T*

Kingdom Plantae
Division Pteridophyta
Class Polypodiopsida
Order Polypodiales
Family Dryopteridaceae
Genus Polystichum

Species Polystichum setiferum (Forssk) T.

Polystichum setiferum is found terrestrially. It has a length of 66 cm, with soft-textured fronds. The leaves are bright green with four to ten fronds on mature plants. The leaf shape is simple on young and small plants, with opposite pinnae on the stalk. Each leaflet measures 4–14 cm in length, with large pinnules at the base that curve upwards, and the other pinnules decreasing in size towards the tip of the pinna. The pinnules have soft, fuzzy tips. Each leaf remains lush and looks fresh throughout the season. The plant lives for nine to fifteen months and produces light yellow spore.

2. *Nephrolepis biserrata Sw.*

Kingdom Plantae
Division Pteridophyta
Class Polypodiopsida
Order Polypodiales
Family Nephrolepidaceae
Genus Nephrolepis
Species *Nephrolepis biserrata Sw*.

Based on research, *Nephrolepis biserrata* is found terrestrially. It has fibrous roots that are brown in color and a length of 64 cm, with a rhizome surface covered in hairs. The leaf stalks are flat and quadrangular with a hairy surface. Young leaves are light green with curled tips. The leaves are compound, pinnate, with an elongated shape, serrated edges, and pointed tips and bases. The leaf surface is hairy, and the maximum leaf width is approximately 2 cm.

3. *Dryopteris cristata L. A. Gray*

Kingdom Plantae
Division Pteridophyta
Class Polypodiopsida
Order Polypodiales
Family Dryopteridaceae
Genus Dryopteris
Species *Dryopteris cristata L. A. Gray*

Dryopteris cristata is found terrestrially. It has fibrous roots. The rhizome is upright, 70 cm long, slender, with a smooth brown surface and is unbranched. The leaves are delta-shaped with pinnate edges, and the sporophylls are located on the ventral side. The leaf tips are pointed, with serrated edges. The leaves come in two sizes: one larger and one smaller (anisophyllous). The leaf color is green-brown, with a texture covered in leaflets. The ventral surface of the leaf is covered with spores, while the dorsal side is smooth.

4. *Lygodium scandens L. Sw*

Kingdom Plantae
Division Pteridophyt
Class Polypodiopsida
Order Schizaeales
Family Lygodiaceae
Genus Lygodium
Species *Lygodium scandens L. Sw*

Lygodium scandens is found as an epiphyte or attached to surfaces. It has fibrous roots that are dark brown, located on the rhizome. The rhizome is small and grows upright, with a brown color and a scaly surface. The stems are green, round, and grow in a climbing fashion, turning green to brown as

they mature, with branching occurring particularly on the first branches. In this study, the length of the stems was recorded as 12 cm.

5. *Lygodium longifolium Willd. Sw*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Schizaeales
Family	Lygodiaceae
Genus	Lygodium
Species	*Lygodium longifolium Willd. Sw*

Lygodium longifolium is found terrestrially. It has a length of 45 cm. The leaves are single with pointed tips, relatively thick texture, and a shiny surface, and are green in color. The stem is round, slender, and green to brown in color, with a fibrous root system. The sori are elongated and located underneath the leaves. The plant grows upright. The leaf stalks (tropophyte and sporophyte) are green to brownish. The tropophyte leaves are single and lobed with 6 lobes. It has bifurcating branching and grows by climbing on other plants.

6. *Nephrolepis cordifolia L. C. Presl*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Polypodiales
Family	Nephrolepidaceae
Genus	Nephrolepis
Species	*Nephrolepis cordifolia L. C. Presl*

Nephrolepis cordifolia is found terrestrially. It reaches a height of 50 cm and has densely packed fronds. The leaflets are arranged very closely together, with bases that are pointed. The rachis has brown, hair-like scales and features leaf stalks that are 2.5–20 cm long. The leaflets are densely clustered, overlapping like roof tiles, with heart-shaped or truncate bases and ears on the upper edges, while the lower ones are very small. Fertile leaflets measure 1.5–4 cm by 0.5–1.5 cm, with shallowly serrated margins and parallel veins that end in sori or water pores. It is valued as an ornamental plant and can also be used medicinally.

7. *Asplenium nidus L.*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Polypodiales
Family	Aspleniaceae
Genus	Asplenium
Species	*Asplenium nidus L.*

Asplenium nidus is found as an epiphyte or attached to surfaces. It has a length of 26 cm, with elongated leaves that are bright green and darken as they mature. The leaves are 20 cm wide, with undulating edges, lance-shaped, and arranged in a circular pattern, with pointed tips. The leaf stalk is sturdy and black, and the leaf texture is paper-like. The rhizome is short and covered with fine, dense scales. The sori are located on the underside of the leaves, arranged along the venation. The sori are

narrow and positioned above the leaf veins. It has spore sacs on the left and right surfaces. *Asplenium nidus* is commonly used as an ornamental plant because it thrives in shaded, humid conditions, making it suitable for indoor environments.

8. *Pteris vittata L.*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Polypodiales
Family	Pteridaceae
Genus	Pteris
Species	*Pteris vittata L.*

Pteris vittata is found terrestrially. It has a length of 110 cm, with a rhizome that is upright or creeping, short, and with short segments. The leaves are arranged alternately or in a cross pattern, with pointed tips and lobed bases. The lowest leaves are the shortest, and the leaves become progressively longer towards the top. The leaf venation is forked. The petioles are green with white hairs. The sori are line-shaped and located along the edges on the underside of the leaves. The plant has short petioles.

9. *Microgramma lycopodioides L. Kopel.*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Polypodiales
Family	Polypodiaceae
Genus	Microgramma
Species	*Microgramma lycopodioides L. Kopel.*

Microgramma lycopodioides is found as an epiphyte or growing attached to surfaces. It reaches a length of 45 cm, with frond-like leaves that are green, thin, and flat. The plant spreads through creeping rhizomes and is stalked, with numerous sporangia on the underside of the leaves. This fern has a slow growth rate and thrives in moderate light. It prefers shaded and humid environments, and can suffer damage from direct sunlight in open areas.

10. *Tectaria gemmifera Alston.*

Kingdom	Plantae
Division	Pteridophyta
Class:	Polypodiopsida
Order	Polypodiales
Family	Tectariaceae
Genus	Tectaria
Species	*Tectaria gemmifera Alston.*

Tectaria gemmifera is found terrestrially. It has a length of 78 cm and is considered a shrub or somewhat woody. The leaves are lance-shaped, tapering to a pointed tip. The color is green, but not deep green. The stem of this fern is round and has fibrous roots, brown in color, with no branching on the stem. This fern is commonly used as an ornamental plant for outdoor settings.

11. *Lygodium circinnatum Burm. Fil. Sw*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Schizaeales
Family	Lygodiaceae
Genus	Lygodium
Species	*Lygodium circinnatum Burm. Fil. Sw*

Lygodium circinnatum thrives in open areas. This plant is characterized by its ability to climb several meters up other plants to access sunlight for growth and has rhizomes located in the soil. It grows by climbing and has a length of 35 cm, with upright stems that are yellow in color. The leaves are pinnate, situated at the tip of the stem, with 5 leaflets, each about 2-4 cm wide and dark green in color. The sori are located on the underside of the leaflets along the veins and are brown. Spores are found on the lower side of the fertile leaves. This fern plays a role in enriching the soil. Additionally, it is commonly used as a remedy for insect stings and wounds

12. *Cyclosorus aridus D. Don Ching*

Kingdom	Plantae
Division	Pteridophyta
Class	Polypodiopsida
Order	Polypodiales
Family	Thelypteridaceae
Genus	Christella
Species	*Cyclosorus aridus D. Don Ching*

Cyclosorus aridus is found terrestrially. It has a total length of 103 cm, with a stipe of 21 cm and a lamina of 27 cm. The stipe is covered with scales at the base, which decrease in number towards the tip. The scales are pointed and range in color from brown to black from the base to the tip. In addition to scales, the stipe also has fine hairs. The lamina is pinnate-pinnatifid, with the first leaflets (pinnae) being the longest and tapering towards the tip of the lamina.

The Abundance of Fern Species (Pteridophyta) in the Sipeso Village Plantation

This study was conducted in the Sipeso Village plantation. Ferns of various species can be found in different locations that are suitable for their environment and habitat. One such suitable environment is the Sipeso Village plantation, where 12 fern species were discovered. Based on their habitat, the fern species found include 8 terrestrial ferns and 4 epiphytic ferns, as shown in Table 2. Each species appears to differ in the area, which is due to the habitat and environmental conditions, leading to varying numbers and percentages of fern abundance obtained.

The abundance of ferns is greatly influenced by environmental factors such as temperature, humidity, light intensity, and soil pH, which support the survival of ferns. The number of fern species observed is closely related to the physical-chemical factors of the environment in the Sipeso Village plantation.

Based on the measurement results of the physical-chemical parameters in the Sipeso Village plantation, the temperature ranged from 30°C to 31°C, humidity from 84% to 86%, light intensity from 57 cd to 48 cd, and soil pH from 6.5 to 6.7, as shown in Table 3. Sugiarti (2017) states that ferns can grow at an optimal temperature of 21°C to 27°C, with humidity between 60% and 80%. This is in line with the opinion of Prastyo et al. (2015), who mention that ferns with small leaves require temperatures of 13°C to 18°C, while those with large leaves need temperatures ranging from 15°C to 21°C, with relative humidity for fern growth between 60% and 80%. Therefore, the temperature and humidity in the Sipeso Village plantation are less suitable for fern growth.

The presence of ferns in the Sipeso Village plantation is greatly influenced by the physical-chemical environmental factors in the area, including soil pH, air temperature/humidity, and light intensity. The study location has a soil pH classified as acidic, ranging from 6.5 to 6.7, indicating that the soil is acidic and thus highly supportive of fern (Pteridophyta) growth. Susan (2016) states that if the soil pH is < 7, the soil is acidic, and if the pH is > 7, the soil is alkaline. Most ferns thrive in acidic soils with a pH between 5.5 and 6.8.

Based on the research conducted, at Station 1 (highland plantation), where, in addition to ferns, there are coconut, cocoa, clove, durian, and coffee plants. At Station 2 (lowland plantation), where, in addition to ferns, there are teak trees and shrubs. Both Station 1 and Station 2 have a relatively low abundance of species, with R1 values of 1.99 and 1.25, respectively, as shown in Tables 4 and 5. This is influenced by the physical-chemical environmental factors and competition among species for nutrients, light, and habitat. According to Syafrudin et al. (2016), low abundance means fewer individuals within the same broad scale, affected by surrounding physical-chemical factors and competition among species for space, nutrients, and light.

The number of fern species obtained in this study was categorized as having low abundance in the plantation of Sipeso Village, with a Margalef index (R1) value of 1.76, as shown in Table 6. This value falls into the low category according to the Margalef index calculation where R1 < 3.5 (Magurran, 2004). The low abundance of fern species is attributed to abiotic factors and spore dispersal, which is a biotic factor. This aligns with the statement by Saputro and Sri (2020), who noted that spore dispersal significantly affects fern abundance in an environment. If spore dispersal is low, the abundance of ferns is also expected to be low. Windadri (2010) added that the abundance of low-level plants is determined by spores because spores are easily carried by the wind and settle in suitable places to grow into new individuals. Thus, spore dispersal is the key factor influencing the number of ferns that will grow.

Another factor affecting the abundance of fern species in the Sipeso Village plantation is human activity. Frequent clearing around the plantation is carried out because ferns are considered nuisance plants. They are often seen as habitats for pests like rats, which can disrupt the productivity of crops. Ferns (Pteridophyta) offer various benefits to the community of Sipeso Village. Here are some of the key benefits: Ferns play a significant role both ecologically and economically. Their ecological functions include serving as ground cover, providing litter to form soil nutrients, and acting as producers in the food chain. Ferns (Pteridophyta) with attractive forms or shapes can be used as ornamental plants. Additionally, some ferns are utilized as food sources and raw materials for handicrafts (Sastrapradja, 1980).

Ferns offer many benefits, such as the species Davallia solida, Davallia trichomanoides BI, Nephrolepis biserrata, Phymatosorus scolopendria, and Vittaria elongata, which are valued as ornamental plants due to their beautiful and attractive leaves. Besides being used as ornamental plants, ferns can also be used as food, such as the species Stenochlaena palustris in Sumatra, where its young shoots are utilized as vegetables (National Biological Institute-LIPI, 1980).

Feasibility of Learning Media

The role of learning media is highly significant in the educational process. With the use of learning media, teachers are better supported in delivering information to students. Learning media includes all software or hardware that functions as a tool to transmit educational messages from the sender to the recipient. The primary goal is to ensure that these messages capture attention and stimulate the thoughts and feelings of students, making the learning process more effective and efficient.

This flipbook is designed with an attractive layout to engage readers. Its design is simple and practical, making it easy for users to access. However, the sample images used in the flipbook have low quality, which makes it difficult for readers to see the texture of ferns (Pteridophyta). According to Susiliana and Riyana (2008), flipbooks have several advantages, including the ability to present learning material in the form of words, sentences, and images. They can also be enhanced with colors to attract students' attention, are easy to create and inexpensive, portable, and can increase learning activity.

Learning media is considered highly feasible if it scores a percentage between 81% and 100% (Arikunto and Safruddin, 2010). Based on the validation of this flipbook learning media, the content expert scored 80%, the design expert achieved 80%, and the media expert reached 82.2%. A trial

conducted with 25 Biology Education students showed a percentage of 90.8%. With an average score of 83.25%, the flipbook is deemed highly suitable as a learning media.

CONCLUSION AND SUGGESTION

Based on the research findings, the conclusions are as follows: Twelve fern species (Pteridophyta) were identified in the Sipeso Village plantation, with the abundance level categorized as low, having an R1 value of 1.76. Regarding the feasibility of the learning media, which was presented in the form of a flipbook, evaluations yielded the following results: content experts rated it at 80%, design experts also at 80%, media experts at 82.2%, and student trials showed a rating of 90.8%. The average validation score for the learning media's feasibility was 83.25%, indicating that the flipbook is highly suitable for use as a learning tool.

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