Species richness of Pteridophyta in Mount Merbabu National Park

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Abstract. Mount Merbabu National Park is a conservation area with a high diversity of unique flora and fauna. The purpose of this study was an inventory of Plantae Divisio of Pteridophyta in Mount Merbabu National Park, Selo, Boyolali Regency. The method used was exploration with a zoning system, namely the utilization zone and the core zone. The results were analyzed descriptively on characteristics, habitus, benefits, and distribution. Based on the results of the study, it was found that the diversity of Pteridophyta was 41 species in 2 classes and 14 families. Pteridophyta in 2 classes, namely Lycopodiinae and Filicinae. The species included in the Lycopodiinae were Lycopodium clavatum and Huperzia squarrosa. Other species belong to the Class Filicinae. Pteridophyta characteristics that are most easily seen are sorus and leaf shape. Pteridophyta whose terrestrial habitus was more dominant than epiphytic habitus. The benefits of Pteridophyta include ornamental plants, growing media, various kinds of traditional medicine, and a mixture of organic fertilizers. The spread of Pteridophyta is in a place where the higher it is, the less the number of Pteridophyta is. Pteridophyta in Sabana with an altitude of 2,571 masl, there was only one species, namely Pteridium aquillinum.

1. Introduction

Mount Merbabu National Park (TNGMb) is a highly diversified conservation area with endemic flora and fauna. Mount Merbabu National Park has very drastic differences in temperature and rainfall, which creates various ecosystems. Mount Merbabu National Park with quite diverse natural ecosystems, namely low mountain tropical rainforest ecosystems, high mountain tropical forest ecosystems, and subalpine forest ecosystems. Mount Merbabu National Park is an area with temperatures around 17°C to 30°C and receives rainfall around 2,000 to 3,000 mm, causing a unique climate for storing various types of Pteridophyta.

The richness of Pteridophyta species in Mount Merbabu National Park has many uniqueness that are not found in the surrounding environment. Pteridophyta has benefits that are not widely known by the public. Identification and inventory of Pteridophyta species in TNGMb compiled in modules need to be conducted, so the richness of Pteridophyta species in TNGMb is known by the public, can be used as tourist attraction and education on the Selo hiking trail, TNGMb.

2. Methods

This research used exploration method. Exploration was carried out based on a zoning system including: use zone and core zone. Exploring around the utilization zone on the Selo hiking trail through POST I, POST II to Sabana II, while the hike around the core zone included the forests Park of Mount Merbabu National. The tools used in this research were: camera, GPS, barometer, tallysheet, and stationery. Field
research procedures: 1) photographed Pteridophyta specimens in their natural habitat, 2) recorded morphological characteristics on a tally sheet and writing code photos on the camera, 3) took the specimen, cleaned it from the soil attached to the roots, then packed it in brown envelope or clear plastic and put, specimens label.

3. Results and Discussion

3.1. Result

The results of Pteridophyta research in TNGMb on the Selo hiking trail, Boyolali Regency, found 41 species consisted of, 2 classes and 14 families. The two classes of Pteridophyta in TNGMb were Lycopodinae and Filicinae. The species included in the Lycopodinae Class are were Lycopodium clavatum and Huperzia squarrosa. Other species belonged to the Class Filicinae (Table 1).

Data shows that terrestrial Pteridophyta were more than epiphytes. Pteridophyta epiphytes that had been identified were 13 species, namely Lycopodium clavatum, Huperzia squarrosa, Asplenium adiantum-nigrum, Pyrrosia ligua, Goniphlebium percussum, Anthrophyum sessilifolium, Anthrophyum sp, Davallia solida, Davallia. While the terrestrial Pteridophyta that had been identified were 28 species (Table 1).

### Table 1. Species, habitat, and distribution of Pteridophyta in TNGMb

| Family           | Species                      | Habitat                  | Utilization Zone | Core Zone |
|------------------|------------------------------|--------------------------|------------------|-----------|
| Lycopodiaceae    | Lycopodium clavatum          | √                        |                  | √         |
|                  | Huperzia squarrosa           |                          |                  |           |
| Aspleniaceae     | Asplenium adiantum-nigrum    | √                        |                  |           |
|                  | Asplenium aethiopicum        | √                        |                  |           |
|                  | Asplenium lividum            | √                        |                  |           |
|                  | Asplenium pellucidum         | √                        |                  |           |
|                  | Asplenium playanaeun         |                          |                  |           |
| Polypodiaceae    | Pyrrosia ligua               | √                        |                  |           |
|                  | Goniphlebium percussum       | √                        |                  |           |
| Blechnaceae      | Blechnum patersonii         | √                        |                  |           |
| Pteridaceae      | Adiantum hispidulum         | √                        |                  |           |
|                  | Adiantum cuneatum            | √                        |                  |           |
|                  | Adiantum raddiuanum          | √                        |                  |           |
|                  | Anthrophyum sessilfolium     | √                        |                  |           |
|                  | Anthrophyum sp               | √                        |                  |           |
|                  | Onychium japonicum           | √                        |                  |           |
| Davalliaceae     | Davallia solida              | √                        |                  |           |
|                  | Davallia denticulata         | √                        |                  |           |
|                  | Davallia canariensis         | √                        |                  |           |
|                  | Davallia trichomanoidea      | √                        |                  |           |
| Dennstaedtiaceae | Ptidium aquilinum            | √                        |                  |           |
| Selaginellaceae  | Selaginella padangennis      | √                        |                  |           |
| Dryopteridaceae  | Deparia petersenii           | √                        |                  |           |
|                  | Nephrolepis biserrata        | √                        |                  |           |
|                  | Woodsiia ilvensis            | √                        |                  |           |
|                  | Polystichum acrostichoide    | √                        |                  |           |
|                  | Dryopteris sp                | √                        |                  |           |
| Thelypteridaceae | Chrisistella parastica      | √                        |                  |           |
|                  | Chrisistella dentata         | √                        |                  |           |
|                  | Phegopteris connectilis      | √                        |                  |           |
|                  | Thelyptera leprieurii        | √                        |                  |           |
|                  | Oreopteris limbosperma       | √                        |                  |           |
|                  | Sphaerostephanos unius      | √                        |                  |           |
| Gleicheniaceae   | Gleichenia linearis          | √                        |                  |           |
|                  | Gleichenia sp                | √                        |                  |           |
| Cyatheaceae      | Cyathus contaminans          | √                        |                  |           |
Cyathea medullaris √ √
Cyathea sphinulosa √ √
Cyathea sp √ √

Vittariaceae
Vittaria ensiformis √ √

Hymenophyllaceae
Hymenophyllum tunbrigense √ √

Description: E = Epiphytic, T = Terrestrial

The location of sorus on leaves varies, namely attached to the leaf edge (*Adiantum*) (Figure 1), attached to the leaf abaxial and appeared to arise on the leaf axial (*Goniphlebium percussum*) (Figure 2), attached to the abaxial near the costule (*Deparia petersenii*) (Figure 3). The costule is the main axis of a pinnule [8] and attached to the leaf parallel to a two-row shape (*Sphaerostephanos unitus*) (Figure 4).

![Figure 1. Sorus Adiantum lies on the edge of the leaf](image1)

![Figure 2. Goniphlebium percussum sorus attached to the abaxial leaves and appeared to arise on the leaves](image2)

![Figure 3. Deparia petersenii sorus attached to the abaxial near the costule](image3)

![Figure 4. Sphaerostephanos unitus sorus attaches to the abaxial of the leaves parallel in the two rows form](image4)

The shapes of Pteridophyta sorus are round and line. The round shape sorus was found on *Goniphlebium percussum, Davallia solida, Deparia petersenii, Dryopteris sp, Christella parastica, Christella dentata, Phegopteris connectilis, Oreopteris limbosperma, Sphaerostephanos unitus,* and *Hymenophyllum tunbrigence* (Figure 5). The lines shape sorus was found in *Asplenium aethiopicum, Asplenium pellucidum, Anthrophyum sessilifolium,* and *Anthrophyum sp* (Figure 6).

![Figure 5. Spherical Shape Sorus on (a) Christella dentata and (B) Goniphlebium percussum.](image5)
Figure 6. Lines Shape Sorus on (A) Asplenium pellucidum and (B) Anthrophyum sessilifolium.

Figure 7. (A) False indusium and (B) Bivalvate indusium

The family of Pteridophyta has sorus with or without indusium. Most of the Polypodiaceae are exindusive, where sorus does not have an indusium, while the Pteridaceae and Aspleniaceae are indusiate, where sorus has an indusium [1]. The indusium has a circular, semicircular and a kidney shape. Some taxa do not have an indusium, but have a reflex extension of the blade margins called the false indusium, which overlaps the sorus [1]. Sorus with false indusium was found in Adiantum cuneatum and sorus with bivalvate indusium was found in Hymenophyllum tunbrigense (Figure 7).

Lycopodiaceae family found in TNGMb with epiphytic habitats were Lycopodium clavatum and Huperzia squarrosa. Lycopodium clavatum grows upright and short (5-8 cm) in the forest and the stems have dichotomous branching. Huperzia squarrosa grows downward and long (up to 20 cm) in the forest and the trunk has pseudomonopodial branches (Figure 8). The spore carrier is a strobilus. The distribution was uneven, only found in the core zone of TNGMb. This was due to a more humid environment, low light intensity, and shaded places in the forest. This core zone supported the growth of these species.

Figure 8. (A) Lycopodium clavatum and (B) Huperzia squarrosa

Aspleniaceae has plantlets (bulbil), vegetative propagation growing from leaves. Asplenium pellucidum shows plantlets that formed at the tips of the leaves after touching the substrate (Figure 9).

Goniophlebium percussum is an epiphytic Pteridophyta that grows attached to trees, yellowish round sorus, very easy to distinguish from other species because sorus appears to arise on existing leaves (Figure 10).

Figure 9. Plantlet on Asplenium pellucidum

Figure 10. (A) Goniophlebium percussum epiphytic (B) Sorus arises on leaf adaxial (C) Sorus round yellowish on leaf abaxial.

The Blechnaceae family has the characteristics of young, reddish leaves that are parallel to the lengths on both sides of the midrib. Usually whole leaves are 1-pinnate (Blechnum) or 2-pinnate (Salpichlaena). The sorus is linear and parallel to the midrib, the leaves grow reddish when young. The indusium opens towards the midrib, not the pinna margin [2].
The Pteridaceae family is characterized by a black stipe (Figure 12). In addition, the leaves are pinnate or double pinnate, sometimes branched or leg-shaped, attached to the rhizome. Rhizome creeps. Sorus extends linearly, there is also sorus shape kidney, located on the edge of the leaf that folds down and serves as an indusium [3]. False indusium (Figure 13).

Davalliaceae family have two or more double pinnate leaves, with free veins. Small epiphytes distributed in tropical and subtropical areas. Sorus round or elongated, found on the underside of the leaf, along the edge or near the edge of the leaf, separated at the vein apex, near or behind the margin. Sorus round or elongated, found on the underside of the leaf, along the edge or near the edge of the leaf, separated at the attached to the base or spherical elongated and attached along the sides. Rhizome creeps with long knots, tight scaly [3].

Selaginellaceae family are characterized by leaf microfiles placed in two dorsal rows and two lateral rows with flat branches divided dichotomously (Figure 14C). Rhizomes are very elongated and do not branch until they touch the ground, can be formed axially or axially on dichotomous branches [2].

Dennstaedtiaceae family have leaf characteristics of 3-4 pinnate-pinnatifid. Round or linear sori, round sori often form in the sinuses and are supplied by a single vein and linear sori are not formed in the sinuses and supplied by several veins. Indusium is glass or linear. Rhizome creeps long and sparsely haired [2]. Pteridium aquilinum has a wide creeping rhizome under the ground, making it difficult to remove. Leaves are wide, stiff, erect, 0.5-1.75 m high, often forming large and dominant colonies in suitable habitats (Figure 15).
Family Dryopteridaceae are characterized by monomorphic, rarely dimorphic, pinnate leaves, pinnate or branched veins. Sorus is round or line (lengthwise). *Deparia petersenii* has scaly under surface, has an unpleasant aroma, long creeping rhizome, and paired long sorus is white (Figure 16).

![Figure 16. Abaxial Leaves Deparia petersenii](image16)

Family Thelypteridaceae has the characteristics of sterile leaves and generally monomorphic fertile leaves. All species of Thelypteridaceae have unicellular acicular hairs throughout the plant. Sorus round or rarely elongated. *Christella parastica* has a round, lamina of about 20 pairs of pinnae (Figure 17 A). *Christella dentata* has a yellowish round sorus with black edges, a regular arrangement, the lamina is about 15 pairs of pinnae (Figure 17 B). *Phegopteris connectilis* has brownish yellow round sorus, non-black edges, regular arrangement, less than 15 or ± 13 pairs of pinnae lamina (Figure 17 C). *Thelypteris leprieurii* has a brown non-circular sorus, irregular arrangement or diffuse sorus, the lamina is more than 20 pairs of pinnae (Figure 17 D). *Sphaerostephanos unitus* has hair on the rachis (Figure 18), round sorus on the abaxial leaf, yellow color, regularly lined up on the leaflets (Figure 19).

![Figure 17. (A) Christella parastica (B) Christella dentata (C) Phegopteris connectilis (D) Thelypteris leprieurii](image17)

![Figure 18. Sphaerostephanos unitus haired rachis](image18)

![Figure 19. Round sorus of Sphaerostephanos unitus](image19)

![Figure 20. Gleichenia linearis colony](image20)

![Figure 21. Cyathea sphinulosa](image21)

![Figure 22. Vittaria ensiformis](image22)

![Figure 23. Hymenophyllum tunbrigense](image23)
Family Gleicheniaceae discrete dorsal leaves arranged in one rows of fresh, light green or yellowish green leaves often stand out on foliage darker than the surrounding vegetation. The laminae with branches *pseudodichotomy* i.e. branches of unequal length. Plants often form large colonies in disturbed environments, such as steep cliffs, roadsides, and landslides [2].

Family Cyatheaceae called a tree fern leaf traits have big and tall stems. Single-stemmed, the base of the petiole is not prickly or if there is, the spines are not shiny black. The indusium when present is like a plate, bivalvate, or globose and completely surrounds the sporangium [2]. *Cyathea sphinulosa* grows on steep cliffs with stems 3m high.

Family Vittariaceae has the characteristics of a single leaf, lanceolate or linear, 2-3 mm wide, very narrow. Linear sorus in one line between richis and margin, parallel to margin, sinking into the groove. Sorus is located in an indentation on the leaf edge or along the leaf edge (Figure 22). Creeping rhizomes are rarely erect and internodes are short [3].

Family Hymenophyllaceae has one cell thick leaves, very thin. Sorus is located on the edge of the leaf, the sporangium extends continuously with the tip of the vein. The indusium is present, conical, tubular, or bivalvate [1]. *Hymenophyllum tunbrigense* green leaf color resembling moss, as an epiphyte in very humid forests, the core zone of TNGMb (Figure 23).

The richness of Pteridophyta species in TNGMb seen at POST I was in the high category. Pteridophyta species richness in TNGMb can be seen in POST II, savanna II, and forests were in the low category (Figure 24). Measurement results using a barometer and soil pH in TNGMb (Table 2).

![Figure 24. Species Richness of Pteridophyta in TNGMb](image)

| No | Measurement | Use Zone Ascent of Selo | Core Zone Forest | Savanna |
|----|-------------|-------------------------|------------------|---------|
| 1. | Temperature | 23°C                    | 21°C             | 16°C    |
| 2. | Relative Humidity | 68% RH                  | 73% RH           | 75% RH  |
| 3. | Air pressure | 1,063 hpa               | 1,062 hpa        | 1,068 hpa |
| 4. | Soil pH    | 5.6                     | 6.8              | 7.2     |

3.2. Discussion

Mount Merbabu National Park (TNGMb) has a hilly to mountainous topography with a slight to steep slope. Slopes slightly gently reaching> 15% in traditionally cultivated fields that occupy the highlands until the steep slope reaches> 30% with an altitude of> 2,000 masl in the upper volcanic forest landform [4]. TNGMb with its topography from slightly sloping to steep showed that abundant Pteridophyta species richness can be identified in 15 families (Table 1).

The spread of Pteridophyta is influenced by environmental factors, namely abiotic and biotic factors. Abiotic factors that affect the spread of Pteridophyta are climatic factors including air humidity, air temperature, and light intensity, and soil factors including soil pH. Biotic factors that affect the spread of Pteridophyta are competition between Pteridophyta plants themselves for nutrition or food and plants associated with Pteridophyta [5].

The growth of terrestrial pteridophyta is scattered in various locations, namely open habitat, shaded habitat, and shady habitat. TNGMb has open habitats such as savanna, shaded habitats such as forests,
and shady habitats such as POST I and POST II on the Selo hiking trail. The location of the open habitat is Sabana II, that has an altitude of 2,845 meters above sea level, there was only one Pteridophyta species. The only species capable of grow in the Savanna was *Pteridium aquilinum*. This was due to the excellent adaptability of *Pteridium aquilinum* to the extreme environment in Sabana II, namely high humidity, frequent rainfall with high water flow, thick fog, and low temperatures reaching ± 16°C. The location of the shady habitat is POST I Doc Malang with an altitude of 2,189 masl there were 33 species of Pteridophyta. The location of the shady habitat besides that is POST II Simpang Macan City with an altitude of 2,270 meters above sea level, there were 9 species of Pteridophyta. Pteridophyta were more widely distributed in shady habitat of POST I rather than shady habitat of POST II and open habitat of Sabana. This was because the Selo 0 KM resort, with an altitude of 1,836 masl and POS I, with an altitude of 2,189 masl, have high humidity and low light intensity so that it can make Pteridophyta grow optimally.

Based on the results of research in TNGMb, only 2 classes were found, namely Lycopodiinae and Filicinae. The Psilophytinae class is considered to be vascular plants showing very primitive morphological and anatomical features, to grow it requires special conditions. Psilophytinae like the species *Psilotum*, has stems but do not have true true leaves and roots in both the gametophyte phase and the sporophyte phase. The absorption of water, minerals or nutrients in *Psilotum* relies on rhizomes that propagate horizontally. The reproductive structure of the *Psilotum* contains spore-containing sinangia, resulting from the fusion of three adjacent sporangia [6]. *Psilotum* mostly grows as epiphytes in humid habitats. Environmental conditions after fires in TNGMb, become higher temperatures, decreased humidity, and no rainwater, caused Psilophytinae can not be found.

The temperature suitable for the growth of Pteridophyta in tropical areas is generally 21°C - 27°C. The temperature in the utilization zone and the core zone of TNGMb shows temperatures that are in accordance with the growth of Pteridophyta, so that the diversity of Pteridophyta species in these locations was very abundant. The temperature decreases in line to the altitude rises. The temperature in the savanna is getting lower, so that the diversity of Pteridophyta species becomes homogeneous, only one species was found, namely *Pteridium aquilinum*. *Pteridium aquilinum* has high adaptability and tolerance to low temperatures, can survive in shaded and open areas exposed to direct sunlight and high rainfall.

The lowest humidity percentage level for Pteridophyta growth is 30%. TNGMb has many types of trees so there are lots of shady places and shaded with high humidity, causes more types of Pteridophyta can grow. Humidity causes several types of Pteridophyta plants to achieve optimal growth. Soil acidity (pH) tends to increase with increasing altitude increasing. Causative factors that can increase soil pH are higher quality and amount of soil organic matter which is higher. The increase in pH is due to the decomposition process of various types of organic matter resulting in alkaline cations. The main source of organic matter is litter or humus, which comes from the abundance of leaves and twigs from plants. As the amount of litter or humus, resulted from higher rainfall and lower temperatures in savanna location, the availability of the main source of organic matter is ggetting higher [7] which ultimately increases the soil pH in savanna.

4. Conclusion

Based on the results of the study, it was found that the diversity of Pteridophyta was 41 species in 2 classes and 14 families. Pteridophyta in 2 classes, namely Lycopodiinae and Filicinae. The species included in the Lycopodiinae Class are *Lycopodium clavatum* and *Huperzia squarrosa*. Other species belong to the Class Filicinae.

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