

## Factors Influencing Species Diversity of Ferns in Mt. Makulot, Cuenca, Southern Luzon, Philippines

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**Abstract.** We investigated the relationship between species diversity of pteridophytes and the environmental factors on 4 study sites in Mt. Makulot forest, Cuenca, Batangas, Southern Luzon, Philippines. Study sites were selected based on accessibility, elevation, and type of vegetation. Among the 4 study sites, Site 3 (13°55.241 N, 121°3.083 E) has the highest number of fern species influenced by low temperature, high moisture content, and less disturbances on the area. There were 40 fern species identified belonging to 13 genera and 13 families. The most represented family is the family Polypodiaceae having 9 genera and 17 species. *Adiantum philippense* is the most common species since it is found in the four study sites. Three endemic species namely: *Elaphoglossum copelandii*, *Davallodes hirsutum*, and *Peranema luzonica* were identified contributing to high fern diversity in this area.

**Keywords:** Species diversity, Ferns, Maculot, Factors, Philippines

### 1. Introduction

Ferns, though often times neglected, obviously play a very important role in the environment and in man's life. These seedless vascular plants maintain the balance of nature by being one of the primary sources of the food in the food chain. Nowadays, these simple plants are used in man's everyday life by being the sources of income due to its ornamental purpose. The soil where ferns grow should not be very hard to allow their roots to get enough air and nutrients. Moist soil also facilitates reproduction by allowing the sperms to reach the eggs during fertilization. Too wet or too dry soil invites disease. Direct sunlight is not appropriate for ferns. Shady areas where temperature averaged only about 23°C would be enough. Some ferns are limited to definite ranges of soil acidity or alkalinity. Some ferns grow well up on acidic rocks like granites, and sand stones and quantities<sup>1</sup>.

Mt. Makulot in Cuenca, Batangas is located in the northern part of the town having an altitude of 3193 feet. It is a place where temperature and soil is very appropriate for growing plants that needed a neutral to moist environment. Many plants grow in the area because of its favorable condition. Orchids, shrubs, flowering plants, and ferns grow abundantly in the forests of this mountain. Many studies have been published regarding the dominant families of vascular plants in Mt. Makiling<sup>[1]</sup>, Mt. Banahaw<sup>[2]</sup>, Mt. Palaypalay<sup>[3]</sup> and Mt. Maculot<sup>[4]</sup>. However, these studies focused mainly on woody tree species and not on lower vascular plant such as ferns. Data on fern diversity in the area is very limited. Approximately 12,000 living species or about two-thirds of ferns are found in tropical regions. In the Philippines, it is represented by more than 1,031 species of which 30% are endemic and 2 are considered as threatened species<sup>[5]</sup>.

This research aims to identify species of ferns in the different study sites and its relationship with environmental factors (climatic and edaphic factors) such as temperature, elevation, relative humidity, air pressure and soil.

### 2. Methodology

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## 2.1. Study Site

Mt. Maculot is located in the southern part of Luzon and part of Cuenca, Batangas. The mountain, strategically located at the heart of the Batangas province, serves as wind breaker shielding the town from harsh winds of the North. It too, is a protection against Taal volcano's eruption. It is one of the most popular mountaineering destinations located in Batangas. It is 73 km south of Manila with coordinates of 13°55.241'N latitude and 121°02.513'E longitude. The altitude ranges from 200 to 963 masl. The mountain range lies within the municipality of Cuenca, Batangas and it is bounded by five barangays namely: Pinagkaisahan, Barangay 7, San Isidro, Don Juan and Dita <sup>[2]</sup>.

The four study sites were selected based on vegetation types and altitude. Site 1 is situated 13°54.813'N latitude and 121°3.267 E longitude. It is located in Station 5 (14 stations during holy week pilgrimage) characterized by having a lowest elevation and agricultural zone. It has a temperature ranging from 24 to 28.9°C with an altitude of 1,730 feet above sea level. Site 2 has a coordinate of 13°54.927 N latitude and 121°3.239 E longitude at an elevation of 1,993 feet above sea level. It has a temperature of 30°C. The site is known for the natives as the "Katangan" because of the presence of streams that supply water to the hikers. Site 3 is located at the summit of the mountain located with a coordinates of 13°55.241'N latitude and 121°3.083 E longitude and an elevation of 3193 feet. The temperature ranges from 22 to 28.9 °C. The area is dominated with mosses and some other epiphytes. Site 4 is located in the Dead Falls, located near the Rockies and campsite, which is known for its spring and located at 13°55.284 N latitude and 121°2.621 E longitude. It has an elevation of 2,198 feet above sea level with temperature range of 27.2 to 27.8°C.

## 2.2. Methods

The study sites were identified based on altitudinal range as well as the presence of dominant pteridophyte species. In each study site, transect line was set using the line intercept technique. All the pteridophyte species found intercepting the transect line were listed and their intercept length was measured. Climatic factors such as temperature, altitude, relative humidity and air pressure were obtained. Likewise, random soil samples were obtained from 10 different areas of each site. The collected soil samples were then analyzed in the laboratory for pH, and organic matter content using the soil test kit.

Voucher specimens were collected for each species. Specimens were then identified using Fern Flora of the Philippines<sup>[6]</sup> and Guide to Philippine Flora and Fauna, Vol. 6<sup>[5]</sup>. The unknown species were brought to the Philippine National Herbarium for verification and authentication.

## 3. Results and Discussion

A total of 40 pteridophyte species representing 25 genera and 13 families were found within the study area (Table 1). The most represented families were Polypodiaceae (12 spp), Adiantaceae (3 spp), Aspleniaceae (3 spp.) and Thelypteridaceae (3 spp.), while the most represented genera were *Asplenium* (3 spp), *Microsorium* (3 spp.), *Pyrrosia* (3 spp.), *Adiantum* (2 spp.), and *Elaphoglossum* (2 spp.). The diversity is brought by similar amount of requirements that would make them grow and thrive in the given area. This primarily includes the physico-chemical parameters like soil organic matter content, pH, and the extrinsic factors including the location, elevation, temperature and air pressure.

The distribution of ferns per site is shown in Figure 1. Ferns are found abundant in Site 3 having 51% of the total collection. This site has an elevation that reaches up to 968 masl, and moisture content is relatively high. This is favorable for the ferns to thrive. The sufficient amount of potassium produces stiff, erect stems, and disease-resistant plants. It prevents having mottled, spotted or streaked fronds. The medium amount of nitrogen is appropriate in promoting the growth of vegetative parts like frond, rhizome, rachis and stipe. Too much or too low nitrogen in the soil may affect growth of the ferns by causing too rapid development and producing a tall but soft and fragile plants. This resulted to short, thin and yellowish green fronds. The low phosphorus content is acceptable. For extrinsic factors determined at Site 3, the lowest recorded temperature is 22°C (71.6°F) which, in turn is the ideal day time temperature (72°F) for fern. Also, most ferns grow on higher elevation because the temperature is lower and has a high level of moisture in the air is higher. The humidity and soil moisture interact and provide enough water to allow the process of fern reproduction. The highest elevation at site 3 where collection was done is about 3,193 feet making it unaccessible for common

climbers. The steep slope and tricky trail going to the peak causes the area to be hardly reached; thus, less disturbed. This is important because the natural status of the area is maintained.

Table 1. List of ferns found in four sites of Mt. Maculot, Cuenca, Batangas, Philippines.

SPECIES	Site 1	Site 2	Site 3	Site 4
Adiantaceae				
<i>Adiantum caudatum</i> L.	*	-	-	-
<i>A. philippense</i> L.	*	*	*	*
<i>Onychium siliculosum</i> (Desv.) C. Chr.	*	-	-	-
Aspidiaceae				
<i>Tectaria hilocarpa</i> (Fee) Price	-	*	-	*
Aspleniaceae				
<i>Asplenium decorum</i> Hort.	-	-	*	-
<i>A. nidus</i> L.	-	-	*	-
<i>A. pellucidum</i> Lam.	-	-	*	-
Cyatheaceae				
<i>Cyathea contaminans</i> Copel.	-	-	*	-
Davalliaceae				
<i>Davallia hymenophylloides</i> (Blume) Kuhn	-	-	*	-
<i>Davallodes hirsutum</i> (J. Sm.) Copel.	-	-	*	-
Dryopteridaceae				
<i>Perenama luzonica</i> Copel.	-	-	*	-
Hymenophyllaceae				
<i>Hymenophyllum</i> sp.	-	-	*	-
Lomariopsidaceae				
<i>Elaphoglossum copelandii</i> Christ.	-	-	*	-
<i>Elaphoglossum luzonicum</i> Copel.	-	-	*	-
Marattiaceae				
<i>Angiopteris palmiformis</i> (Cav.)	-	*	-	-
Oleandraceae				
<i>Nephrolepis falcata</i> (Cav.) C. Chr.	-	*	-	*
Polypodiaceae				
<i>Aglaomorpha spendens</i> (J. Sm.) Copel.	-	*	-	-
<i>Belvisia squamata</i> (J. Sm.) Copel.	-	-	*	-
<i>Drynaria quercifolia</i> (L.) J. Sm.	-	-	*	-
<i>D. sparsisora</i> (Desv.)	*	-	-	-
<i>Gonophlebium subauriculatum</i>	-	-	*	-
<i>Lemmaphyllum accidens</i>	-	-	*	-
<i>Microsorium longissimum</i> Fee	-	-	*	-
<i>M. membranaceum</i> (Don) Ching	-	*	-	*
<i>M. scolopendria</i> (Burm.) Copel.	-	-	*	-
<i>Pyrrosia adnascens</i> Ching	-	-	*	-
<i>P. nummularifolia</i> L.	-	-	*	-
<i>P. piloselloides</i> Price	-	-	*	-
Pteridaceae				
<i>Pteris mutilata</i> L.	*	-	-	*
<i>P. longipes</i> Blume	-	*	-	-
Schizaeaceae				
<i>Lygodium circinatum</i> Sw.	*	-	-	-
<i>L. caudatum</i> L.	*	-	-	-
Thelypteridaceae				
<i>Christella parasitica</i> (L.) H. Lev.	-	*	-	-
<i>Christella</i> sp.	-	*	-	-
<i>Pneumatopteris laevis</i> (Mett.) Holttum	*	-	-	-
Vittariaceae				
<i>Antrophyum alatum</i> Brack.	-	-	*	-
<i>Vittaria ensiformis</i>	-	-	*	-
<b>TOTAL NUMBER OF SPECIES</b>	<b>8</b>	<b>9</b>	<b>25</b>	<b>5</b>

Legend: \* : present

- : absent

There is variation in the distribution of fern species and is brought about by increasing elevation and decreasing soil pH. The first two sites are more disturbed and correspond to the mixed grassland/brushland and agricultural zones. Patchy distribution of ferns was observed because habitats are limited to tolerant fern species that can surmount relatively drier and exposed conditions. It was also observed that the distribution of ferns is dependent on the floristic composition and structure of the woody vegetation along the slope. Sites 1 and 2 are related to each other spatially and floristically than the other sites. Site 2 is characterized as a disturbed secondary forest where there is less forest cover and more open condition favoring the accessibility of the hikers. Since the area is open, it encourages the growth of *Adiantum*, *Lygodium* and *Pneumatopteris*.

Site 4 has the least collected species with 6 out of the 40 species which mostly comes from the genus, *Pteris*. The collection is too minimal because the conditions encountered in Sites 1 and 2 are also present on this site. Site 4 has a stream (the Dead Falls) which explain the reason why it is greatly disturbed. Also, it is a suitable campsite for hikers because of the wide grassland in the area. The recorded pH is 6.02 which is near the ideal reading. The organic matter content is the same with Site 2 (P: Low, K: Sufficient amount and N: Low). The temperature ranges from 27.22- 27.78°C. This is considered higher compared to the ideal temperature which is 21°C.

Site 2 has only 9 species of ferns. Though the area has a stream which may indicate high moisture content, the collected species is lesser compared to Site 3. The mountaineers exploited the area because they fetched water and stayed there for meals. The dominant plants common in the site are: *Lansium domesticum* (lansones), *Sandoricum koetjape* (santol), *Artocarpus heterophylla* (jackfruit), and some shrubs which prove that there is human interference in the area that is why it needs preservation. The pH of the soil is near the ideal with 6.45. The organic content, on the other hand, is the same with Site 3 (P: low and K: sufficient amount) except for low nitrogen. The recorded temperature is 30°C far from the ideal reading of 21°C. This gradually affects the distribution and diversity of ferns in the area.

Site 3 coincides to the mossy forest characterized by the presence of epiphytic plants and trees dominated with mosses. This site offers a variety of microenvironments for many fern species where environmental conditions (low temperature, high relative humidity, high air pressure) and favorable for the growth of filmy ferns (Hymenophyllaceae). Since the area has higher elevation and very steep, the visitors opted not to climb hence this area is less disturbed. In the study of Banaticla and Buot (2005), they mentioned that there is a strong relationship between the fern distribution and elevation in Mt. Banahaw which shows similarity with our present results. With increasing elevation, decreasing temperature and increasing precipitation and relative humidity it increases soil moisture and slows down the rate of litter decomposition that will lead to increasing soil organic matter content that favors the growth of ferns. The fern species composition in Mt. Makulot is similar to Mt. Banahaw and Makiling. Most of the species in this site belongs to Polypodiaceae which are epiphytic in nature. As the altitude increases, epiphytes become very distinct and higher in number. Epiphytic mosses and liverworts as well as ferns and orchids form dense growth on the trunks of trees indicating that the mountain is mossy forest. This feature is also similar to Mt. Makiling. The above condition leads to the increase of soil organic matter content, less acidic soil as the amount of organic acids increases. The topography also changes from steep to steeper, the wind pressure becomes higher as the altitude increases and the trees have stunted growth. The plant community structure also changes with altitude due to the climatic and soil gradient <sup>[2, 4]</sup>.

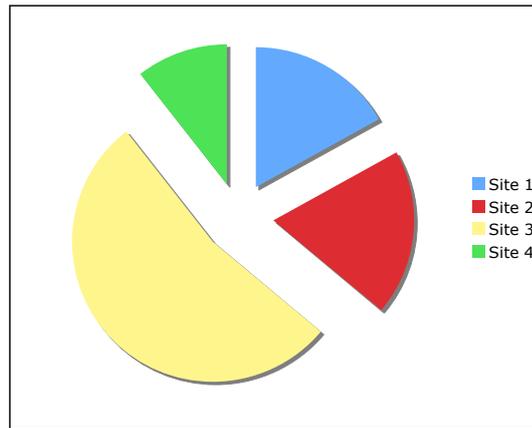


Fig. 1: Distribution of ferns per study sites in Mt. Makulot, Cuenca, Batangas

The dominant species and altitudinal range of the fern zone in Mt. Makulot differs from Mt. Banahaw de Lucban. This is because Mt. Makulot is in the opposite side, occupying a small area and located near Taal Lake while Mt. Banahaw de Lucban is higher, has large area and exposed to the northeast monsoon as it faces Pacific Ocean. Mt. Makulot, Cuenca, Batangas was declared as a protected spot in 1996 because it nestled endemic species that need conservation and protection. Three endemic species; namely, *Elaphoglossum copelandii*, *Davallodes hirsutum*, and *Peranema luzonica* were found in the study sites. *E. copelandii* belongs to category 4 which is infrequent but widespread through out the country. *Peranema luzonica* belongs to category 8 which is rare and known only in one locality<sup>[5]</sup>. *D. hirsutum* belongs to the list of Philippine endemic ferns. Site 3 has been the ideal place for the growth of ferns.

#### 4. Conclusion

The total number of fern species recorded in four study sites was 40 species belonging to 13 families and 26 genera. The site with the highest species diversity is Site 3 having 25 species. The site with the least diversity is Site 4 has 5 species only. The increasing altitude and air pressure, decreasing temperature and low soil pH occur in Site 3 characterizing it as a mossy forest favoring the growth of Polypodiaceae and Hymenophyllaceae. Most ferns collected are epiphytic represented by 21 species. Based on the findings, it was further recommended that the area should be protected from exploitation to avoid the loss of fern species.

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