

*Original Article*

## Diversity, characteristics, and altitudinal distribution of pteridophytes in Manleluag Spring Protected Landscape (MSPL), Mangatarem, Pangasinan, Philippines

Jomar L. Aban<sup>1\*</sup>, Weenalei T. Fajardo<sup>2</sup>, Helen A. Maddumba<sup>3</sup>,  
and Paulina A. Bawingan<sup>4,5</sup>

<sup>1</sup> Don Mariano Marcos Memorial State University, Bacnotan, La Union, 2515 Philippines

<sup>2</sup> Pangasinan State University, Lingayen, Pangasinan, 2401 Philippines

<sup>3</sup> Department of Environment and Natural Resources,  
Cordillera Administrative Region, Benguet, 2600 Philippines

<sup>4</sup> Maritime Academy of Asia and the Pacific, Mariveles, Bataan, 2105 Philippines

<sup>5</sup> Saint Louis University, Baguio, Benguet, 2600 Philippines

Received: 24 January 2024; Revised: 31 May 2025; Accepted: 6 October 2025

---

**Abstract**

The Manleluag Spring Protected Landscape (MSPL) was included among protected areas under the NIPAS Act of 1992. It covers 12% of the forestlands of Mangatarem, Pangasinan, which harbors some endemic unique and threatened species of plants and animals, including ecologically important Pteridophyte species. The undisputed ecological and economic contributions of the pteridophytes at the global and local scale were the basis for the conduct of this study. It aimed to identify the different Pteridophyte species present in selected forest sites of MSPL; to prepare voucher herbarium specimens as inventory materials for future conservation purposes; to determine Pteridophyte zones based on different altitudinal zones; and to assess and compare the species richness, evenness, and diversity of the different sites at MSPL. Fourteen fern species under seven (7) genera and five (5) families were collected, identified, and classified, constituting 1.35% species richness, 4.86% genera richness, and 12.82% familial richness compared to the total Pteridophyte richness in the Philippines. The biodiversity and species richness were relatively low due to several dominant Pteridophyte species in the different study sites and the classification of Manleluag as a secondary forest by the Haribon Foundation. Pteridophyte zones were also observed. Some families dominated low altitudes, some preferred mid-altitudes, and others favored high altitudes. The researchers highly recommend intensified implementation of the Manleluag Spring Protected Landscape (MSPL) management plan and continuous monitoring of the diversity and abundance of different Pteridophyte species.

**Keywords:** ferns in secondary forests, fern zonation, Philippine pteridophytes

---

\*Corresponding author

Email address: [jaban@dmmmsu.edu.ph](mailto:jaban@dmmmsu.edu.ph)

## 1. Introduction

There are about 13,600 Pteridophyte species worldwide (Moran, 2008). Around 1,100 species under 144 genera and 39 families of Pteridophytes have been reported in the Philippines. However, the sustained degradation of resources making the country known as one of the biodiversity hotspots in the world (Delos Angeles & Buot, 2012) has resulted in a drastic decline in its flora, including the Pteridophytes. To prevent the rapid decline of natural resources, guidelines for the establishment of protected areas were initiated together with the passage of RA 7586, otherwise known as the National Integrated Protected Area System (NIPAS) Act of 1992.

The forest of the Municipality of Mangatarem, Pangasinan, Philippines, is the largest remaining forest in the province of Pangasinan and the whole Zambales Mountains, and is considered an Important Biodiversity Area (IBA). It is also among the few remaining tropical rainforests in the Philippines that serve as a barrier against environmental disasters. It harbors some endemic, unique, and threatened species of plants and animals, including ecologically important Pteridophyte species. Manleluag Spring Protected Landscape (MSPL) comprises 12% of the forestlands of Mangatarem. The NIPAS Act of 1992 included the MSPL as a protected area. It aimed to ensure the protection of the park and its resources from human exploitation and to maintain genetic diversity, which is necessary to perpetuate the species in the ecosystem it represents. With such status, Pteridophyte biodiversity is anticipated in the area (Manleluag Spring Protected Landscape-Management Plan [MSPL-MP], 2012).

Pteridophyte biodiversity is necessary due to its undisputed ecological contributions. Not only do they contribute to the resiliency of the ecosystem, but also to the survival, growth, and development of other key individual plant and animal species present in the ecosystem. In addition, ferns are also recognized for the presence of important phytochemicals, which have potential to serve as medicinal drugs. For example, the fern *Dryopteris filix-mas* (male fern) is a valuable source of bioactive compounds, specifically phloroglucinol derivatives that exhibit significant medicinal properties. Recent investigations have established its potential against intestinal parasites (anti-helminthic) and its anti-inflammatory, antimicrobial, and antioxidant activities. Hence, this fern serves not only ecological functions in forest undergrowth but also supplies material to the discovery of novel drug compounds in modern medicine (Femi-Adepoju *et al.*, 2021). Despite this acknowledged importance, there are only a few studies conducted in the Philippines highlighting the ecological diversity and taxonomy of Philippine fern species.

This study is therefore conducted to (1) identify, classify, and characterize the different Pteridophyte species present in selected forest sites of the Manleluag Spring Protected Landscape; (2) determine the distribution of Pteridophyte species on different altitudinal gradients; (3) to compare biodiversity parameters such as species richness, evenness, abundance, and diversity indices, across the study sites to determine ecological health and variation.

## 2. Materials and Methods

### 2.1 Study area

The forest of the municipality of Mangatarem covers 44.7% of the total land area of Mangatarem. Meanwhile, 12% of forestlands is the Manleluag Spring Protected Landscape (MSPL), which is one of the oldest national parks in the Philippines and was included as a protected area under the NIPAS Act of 1992 (MSPL-MP, 2012). In this study, nine (9) sites were randomly selected as study areas within the forestlands of the Manleluag Spring Protected Landscape. Coordinates and altitudes of the nine sites are shown in Table 1.

Table 1. Global coordinates and altitudinal positions of the nine study sites in Manleluag Spring Protected Landscape

Site no.	Latitude	Longitude	masl <sup>a</sup>
1	16°49.663'N	123°52.523 E	233
2	15°42.334'N	120°15.622' E	253
3	15°42.314'N	120°16.764'E	268
4	15°42.387'N	120°16.766'E	276
5	15°42.198'N	120°16.827'E	261
6	15°42.280'N	120°17.021'E	222
7	15°42.287'N	120°17.007'E	220
8	15°42.294'N	120°16.989'E	215
9	15°42.334'N	120°17.000'E	204

<sup>a</sup>masl – meters above sea level

### 2.2 Sampling technique

Random sampling using the quadrat method was used in the study. Nine (9) 20m x 20m quadrats were randomly laid within the forestlands of the Manleluag Spring Protected Landscape. The number of fern species and individuals per species were counted within each quadrat for species richness, species evenness, and biodiversity assessment. Representative species were collected as herbarium vouchers.

### 2.3 Fern collection

The collection followed the standard protocol for plants as presented by Calabrese (2005) and the British Columbia Ministry of Forests Research Branch (1996). Before collection, pictures were taken for documentation. Collected materials possess all the vegetative and reproductive parts of a matured fern species. The plant samples were pressed and dried before identification. Herbarium vouchers of the ferns are kept at SLU Father Braeckman Museum of Natural History.

### 2.4 Plant identification

Fern collections were identified based on the plant's features including taxonomic features such as frond structure, spore-bearing structures (sori), and rhizome type, at Fr.

Braeckman Museum of Natural History, Saint Louis University, Baguio City. Identification was guided by various fern taxonomic keys including GoBotany (2011) dichotomous key for true ferns, Yatskievych and Pickering (2016) ID Nature Guide to Ferns, and Smith *et al.* (2006). The plant samples were also compared to online photos from GoBotany (2011) and Yatskievych and Pickering (2016) ID Nature Guide to Ferns. Fern specialists were consulted to verify the fern identifications. The World-Wide Flowering Plant Family Identification (Hansen & Rahn, 1969), FloraGator (2012), and Smith *et al.* (2006) were used for family identification. The families were also arranged according to the system described by Smith *et al.* (2006).

**2.5 Fern altitudinal distribution**

The distribution of the fern species was determined based on specific altitudinal gradients and specific Pteridophyte zones adopting methods described by Banaticla and Buot (2005), Delos Angeles and Buot (2011), and Langenberger and Belonias (2011). A handheld GPS (Garmin eTrex) was utilized to measure both altitude and coordinates of the collection sites. This device provided accurate elevation data, allowing for precise correlation between fern occurrence and altitude (Roszkowski & Kowalczyk, 2016).

**2.6 Biodiversity indices**

The fern diversity, species richness, evenness, and dominance of species were assessed at different levels: (1) per study site to determine which among the sites have the highest species richness, evenness and biodiversity and which is the least bio-diverse and has dominant species on it; and (2) the overall biodiversity, species richness, and evenness of the entire study area in the species, genus, and family levels.

Species richness refers to the number of fern species found in the area (per collection site and overall study site). Special evenness refers to how similar are species abundance in each collection site and in the overall study site. It is often calculated using Pielou’s J, which is the Shannon index (H) divided by the natural logarithm of the number of species (ln(S)). The Shannon-Wiener index, a measure of species

diversity that considers both the number of species (species richness) and species evenness (relative abundance of each species) is calculated using the formula:  $H' = - \sum (p_i * \ln(p_i))$ , where 'H' is the index, 'p<sub>i</sub>' is the proportion of individuals belonging to species 'i', and 'ln' represents the natural logarithm (Nolan & Callahan, 2006). Higher Shannon Index values indicate greater diversity. Simpson's Diversity Index (D) is also a measure of biodiversity that considers both the number of species (species richness) and the abundance of each species, with values ranging from 0 to 1, where a higher value indicates lower diversity (Barcelona Field Studies Centre, 2023). It has the formula  $D = 1 / \sum(p_i^2)$ , where D is Simpson's diversity index, p<sub>i</sub> is the proportion of individuals belonging to species i, and Σ (sigma) represents the sum of all species. The Reciprocal Simpson Index, often denoted by 1/D, is calculated by taking the reciprocal of the Simpson's Index (D), which is  $1/D = 1 / (\sum(n_i/N)^2)$ , where 'n<sub>i</sub>' is the number of individuals in species 'i' and 'N' is the total number of individuals. Reciprocal Simpson Index (1/D) is used to measure evenness and dominance of particular fern species in the area.

Microsoft Excel and an online biodiversity calculator (Easy Calculation, 2016; Young, 2016) were used in the computation of various biodiversity parameters. Analysis of Variance (ANOVA) and the *post hoc* Duncan’s Multiple Range Test (DMRT) were used to determine significant differences between and among the computed biodiversity indices with significance level (p value threshold) set at α= 0.05.

**3. Results and Discussion**

Fourteen (14) species, seven (7) genera, and five (5) families were identified in the survey. The families, genera and species identified, including species abundance are listed in Table 2. Species abundance refers to the number of individuals of each species. The data show that the genus *Microsorium* in the family Polypodiaceae has the highest number of species (4) followed by *Adiantum* (3) in the family Pteridaceae. However, *Pneumatopteris* sp. (Thelypteridaceae) has the highest species abundance. *Thelypteris* sp. in the same family also shows high species abundance (third among all

Table 2. Fern taxonomy and species abundance at Manleluag Spring Protected Landscape (MSPL)

Family	Genus	Species	n
Aspleniaceae	<i>Asplenium</i>	<i>Asplenium auriculatum</i> Sw.	2
Lygodiaceae	<i>Lygodium</i>	<i>Lygodium circinatum</i> (Burm.f.) Sw.	61
Polypodiaceae	<i>Microsorium</i>	<i>L. japonicum</i> (Thunb.) Sw.	7
		<i>Microsorium longissimum</i> Fée	11
		<i>M. membranifolium</i> (R.Br.) Ching.	5
		<i>M. palmatum</i> (Blume) Fée	2
Pteridaceae	<i>Adiantum</i>	<i>M. scolopendria</i> (Burm.fil.) Copel.	25
		<i>Adiantum caudatum</i> L.	27
		<i>A. gomphophyllum</i> Baker	5
Thelypteridaceae	<i>Pteris</i>	<i>A. philippense</i> L.	6
		<i>Pteris mutilata</i> L.	24
		<i>Reholttumia laevis</i> (Mett.) S.E.Fawc. & A.R.Sm.	2
Five Families	Seven Genera	<i>Pneumatopteris</i> sp.	211
		<i>Thelypteris</i> sp.	49
		Number of species= 14	437

n = species abundance

collected species). *Lygodium circinatum* of the family Lygopodiaceae comes second in species abundance, then by *Adiantum caudatum* (Pteridaceae), *Microsorium scolopendria* (Polypodiaceae), and *Pteris mutilata* (Pteridaceae). On the other hand, *Asplenium auriculatum* (Aspleniaceae), *Microsorium palmatum* (Polypodiaceae) and *Reholtium laevis* (Thelypteridaceae) showed the lowest species abundances.

Table 3 presents the different species that occupy the nine study sites in Manleluag Spring Protected Landscape (MSPL). Site 6 has the highest number of species (5): *Microsorium membranifolium*, *Thelypteris sp.*, *Asplenium auriculatum*, *Lygodium circinatum* and *Pneumatopteris laevis*. However, these 5 species only constitute a total of 33 individuals. On the other hand, site 8 has a total of 210 individuals but only with three (3) different species: *Pneumatopteris sp.*, *Microsorium longissimum* and *Lygodium circinatum*. Site 9 has only *Thelypteris sp.* with 14 individuals.

Table 4 displays the different diversity indices measured for the nine (9) study sites at Manleluag Spring Protected Landscape (MSPL). As shown in the Table, Site 6 has the highest species richness followed by Site 5. For the sites with more than one fern species, in terms of species evenness, Site 8 has the highest meaning that the numbers of individuals of the species (species abundances) in the area are not very different from each other. Several dominant species of ferns exist in the different sites such as the dominance of *Lygodium circinatum* (Lygodiaceae) in site 2, *Microsorium scolopendria* (Polypodiaceae) in site 4, *Adiantum caudatum* (Pteridaceae) in site 5, *Thelypteris* (Thelypteridaceae), and *Pneumatopteris sp.* (Thelypteridaceae) in site 8. The lowest species evenness is in Site 8 indicating the presence of a dominant species. Three fern species were collected in the

area but *Pneumatopteris sp.* is the most abundant, hence, the dominant species (Table 3).

Based on the Shannon Diversity Index (H) (Table 4), Site 6 has the highest diversity index but Simpson's Diversity Index (D) and Reciprocal Simpson Index (1/D) show Site 7 to have the highest fern diversity. However, ANOVA reveals that Sites 6 and 7, including Site 5, do not differ significantly in fern diversity. It means that when taking both the number of fern species and species abundance into consideration, Sites 5, 6, and 7 are comparable in biodiversity. On the other hand, the least biodiverse areas are Site 1, Site 3, and Site 9, which have one fern species each and fewer individuals per species. Other sites with comparable low diversity indices are Sites 4 and 8.

Table 4. Fern diversity indices of the different study sites in Manleluag Spring Protected Landscape (MSPL)

Site no.	Species richness	Species evenness	H	D	1/D
1	1	-	0 <sup>c</sup>	1 <sup>c</sup>	1 <sup>c</sup>
2	3	0.61	0.67 <sup>b</sup>	0.63 <sup>b</sup>	1.59 <sup>b</sup>
3	1	-	0 <sup>c</sup>	1 <sup>c</sup>	1 <sup>c</sup>
4	2	0.235	0.16 <sup>c</sup>	0.92 <sup>c</sup>	1.09 <sup>c</sup>
5	4	0.649	0.90 <sup>a</sup>	0.51 <sup>a</sup>	1.96 <sup>a</sup>
6	5	0.611	0.98 <sup>a</sup>	0.50 <sup>a</sup>	2 <sup>a</sup>
7	3	0.833	0.92 <sup>a</sup>	0.41 <sup>a</sup>	2.43 <sup>a</sup>
8	3	0.188	0.21 <sup>c</sup>	0.91 <sup>c</sup>	1.10 <sup>c</sup>
9	1	-	0 <sup>c</sup>	1 <sup>c</sup>	1 <sup>c</sup>
Over-all	7	00.	0.43	0.76	1.46

\*All values followed by different letters within the same column indicate significant differences at  $\alpha=0.05$

Table 3. Distribution and abundance of the different fern species in the different study sites in Manleluag Spring Protected Landscape (MSPL)

Site no	Number of different species per site	Species present	n	n <sup>b</sup>
1	1	<i>Lygodium circinatum</i>	8	8
2	3	<i>Lygodium circinatum</i>	51	
		<i>Lygodium japonicum</i>	7	65
		<i>Pteris mutilata</i>	7	
3	1	<i>Pteris mutilata</i>	17	17
4	2	<i>Microsorium scolopendria</i>	25	
		<i>Microsorium palmatum</i>	1	26
5	4	<i>Adiantum caudatum</i>	27	
		<i>Adiantum philippense</i>	6	39
		<i>Adiantum gomphophyllum</i>	5	
		<i>Microsorium palmatum</i>	1	
6	5	<i>Microsorium membranifolium</i>	5	
		<i>Thelypteris sp.</i>	23	
		<i>Asplenium auriculatum</i>	2	33
		<i>Lygodium circinatum</i>	1	
		<i>Pneumatopteris laevis</i>	2	
7	3	<i>Pneumatopteris sp.</i>	11	
		<i>Thelypteris sp.</i>	12	25
		<i>Microsorium longissimum</i>	2	
8	3	<i>Pneumatopteris sp.</i>	200	
		<i>Microsorium longissimum</i>	9	210
		<i>Lygodium circinatum</i>	1	
9	1	<i>Thelypteris sp.</i>	14	14
N = 437				

Note: n = species abundance; n<sup>b</sup> = number of ferns per site; N = total number of ferns in the nine collection sites

### 3.1 Pteridophyte altitudinal distribution pattern

Different Pteridophyte zones were observed in the study (Figure 1). The members of the family Thelypteridaceae (*Thelypteris sp.*, *Pneumatopteris sp.*, and *Pneumatopteris laevis*) seemed to have occupied the lower altitudinal gradient from 204 masl to 222 masl. On the other hand, the members of the family Pteridaceae (*Adiantum caudatum*, *A. philippense*, *A. gomphophyllum* and *Pteris mutilata*) were observed to occupy the higher altitudinal strata as they were found distributed in areas ranging from 261 masl to 268 masl. Majority of the members of Lygodiaceae (*Lygodium circinatum* and *L. japonicum*) seemed to occupy mid-strata from 222-253 masl together with a member of the family Aspleniaceae (*Asplenium auriculatum*) although *Lygodium circinatum* was also found to be distributed at 215 masl. The members of the family Polypodiaceae was found to be distributed in different altitudinal zones. Some members (*M. palmatum*, and *M. scolopendria*) were found dispersed in the highest measured altitudinal zones (261 to 276 masl). However, other members of the family (*M. longissimum* and *M. membranifolium*) were found at the lower altitudinal level (215 to 222 masl).

These results were similar to the results of other related studies on the altitudinal distribution patterns of Pteridophytes. Banaticla and Buot (2005) determined five altitudinal slopes of 33 fern species in Mt. Banahaw de Lucban, Quezon, Luzon Island, Philippines. The study mentioned that these fern species preferred specific microenvironments along the altitudinal gradient, thus making them effective altitudinal zone markers and biodiversity conservation indicators for the forest ecosystem of the mountain. A hierarchical cluster analysis on the elevational distribution of ferns and lycophytes in Mts. Palay-Palay Mataas-na-Gulod Protected Landscape, Luzon Island, by de Villa and Lagat (2024), also identified three elevational zones for ferns and lycophytes – namely Zone 1 for *Lygodium-Pteris* present at 200–300 meters above sea level (masl), Zone 2 for *Bolbitis-Microsorium* (300–500 masl), and Zone 3 for *Microsorium-Pteris-Tectaria* (500 masl up to the peak). Alcala *et al.* (2019) also showed fern species diversity across various land use types with different altitudes in Mt. Makiling, Luzon Island. *Pteris blumeana* C. Agardh and *Tectaria crenata* Cav. were found only in buffer zone area (365 masl); *Dennstaedtia philippinensis* Copel., *Lygodium circinatum* (Burm. f.) Sw. and *Microlepia sp.*, were found only in agroforest area (368 masl); *Sphaerostephanos unitus* (L.) Holtum found only in agricultural (355 masl); *Bolbitis heteroclita* (C. Presl) Ching and *Microsorium membranifolium* (R. Br.) Ching were found in roadside (455 masl); and, *Asplenium tenerum* G. Forst., *Christella sp.*, *Lindsaea fissa* Copel. and *Nephrolepis cordifolia* (L.) C. Presl were found in forest area (482 masl).

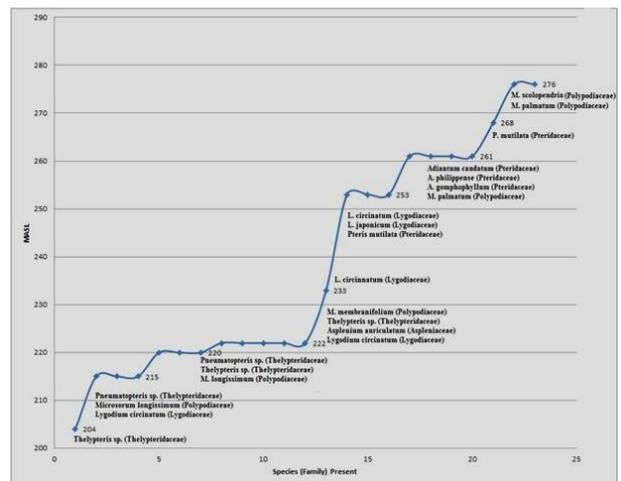
The distribution of Pteridophytes along altitudinal gradients is often affected by several ecological factors. Temperature is a critical factor that influences ferns. According to Anderson (2021), ferns' physiological response to temperature determines their ecological distribution and resilience. In Figure 1, Thelypteridaceae is the fern family with the greatest number of representative samples and these ferns are widely distributed at the lowest altitudinal gradient

(204-222 masl). As altitude increases, temperature typically decreases. This limits the growth and reproductive success of fern species because these organisms prefer warm, humid environments. Therefore, those adapted to lower altitudes may experience stress in higher elevations where temperatures are lower.

Based on the number of species and abundance of ferns collected in Manleluag Spring Protected Landscape (MSPL), Pteridophyte richness in the area is low compared to the Pteridophyte richness in the Philippines reported by Delos Angeles and Buot (2011). Only about 12.82% at the family level, only 4.86% of 144 genera, and only 1.36% species of the total Pteridophytes present in the country were reported in Manleluag. One possible reason could be the presence of dominant pioneer species that outcompete others, leading to reduced species richness (Delos Angeles & Buot, 2012). The dominance of these species has led to diminished species richness and diversity in the different study sites.

In addition, the floral survey of Haribon Foundation (2006) in the lowland forests of MSPL classified its habitat type as secondary forest, which could also be a potential reason why there was low species diversity in the area. Secondary forests generally manifest low habitat complexity compared to primary forests, restricting the variety of ecological niches available for Pteridophyte biodiversity (Anderson, 2021; Banaticla & Buot, 2005). In addition, because of shorter regeneration durations, change in species composition, and the possibility of re-clearing, secondary forests frequently show lesser biodiversity than primary (old-growth) forests (Klorane Botanical Foundation, 2025).

Also, Delos Angeles and Buot, Jr. (2015) mentioned that species richness of ferns increased with altitude. This study only covered an altitude range of 204 to 276 masl; hence, only the species that prefer conditions in these altitudes were collected and identified. Surveying ferns in higher altitude areas could have resulted in the identification of more species.



y-axis scale: meters above sea-level (masl); x-axis scale: number of different species per site (for details, refer to Table 2).

Figure 1. Distribution of Pteridophyte species on different altitudinal gradients

### 3.2 Characterization of the fern species

#### 3.2.1 *Adiantum caudatum* L. (Figure 2a)

This lithophytic fern has short, erect rhizomes, scales golden-brown. Fronds tufted, to 15(–40) cm long, stipe to 5(–10) cm long, dark brown, hairs multicellular and dark brown to brown, lamina 1-pinnate, lanceolate in outline, rachis dark brown (Lucid Central, 2022). Apex usually prolonged into a whiplike stolon rooting at tip to form new plantlet. Pinnules alternate, or lower ones subopposite, horizontally spreading or slightly obliquely spreading. Lobes linear, margins entire, upper part again lobed into fine linear segments. Sori 5–12 per pinna; false indusia dark brown, orbicular or oblong, hairy, upper margins flat and straight, entire (Lucid Central, 2022).

#### 3.2.2 *Adiantum gomphophyllum* Baker (Figure 2b)

Like other *Adiantum* species, *A. gomphophyllum* is characterized by its delicate, bright green, and finely cut leaves. It has dark stipules and rachises. The sori are located submarginally, covered by reflexed flaps of leaf tissue that act like indusia. These ferns are often found in moist, well-drained areas.

#### 3.2.3 *Adiantum philippense* L. (Figure 2c).

Commonly called the walking maidenhair fern because of its creeping type of growth, *A. philippense* has a short-creeping, erect or suberect rhizome, with yellow to dark red-brown scales. Fronds tufted, arching; stipe, glabrous and smooth. Lamina is narrowly triangular, rachis glabrous, occasionally extended past lamina. The sori occupy the entire lobe margin; soral flaps linear to almost crescentric, glabrous. This fern prefers moist areas like stream or riverbanks, or grow on rocks in forests.

#### 3.2.4 *Asplenium auriculatum* Sw. (Figure 2d)

Rhizomes creeping, ascending, or suberect, bearing clathrate scales at apices and petiole bases (and sometimes other axes); petioles with back-to-back C-shaped vascular strands, these fusing distally into an X-shape; blades monomorphic, usually lacking acicular hairs on axes and/or lamina, often with microscopic clavate hairs; veins pinnate or forking, usually free, infrequently reticulate and then without included veinlets; sori elongate (linear) along the veins, not usually back-to-back on the same vein, usually with laterally attached, linear indusia; sporangial stalks long, 1-rowed; spores reniform monolet.

#### 3.2.5 *Lygodium circinatum* (Burm.f.) Sw. (Figure 2e).

The leaves of *L. circinatum* are palmate with two to seven divisions or finger-like elongation, reaching up to 20 cm, the margins entire; the main nerve is clearly visible at the center of each lobe with a stramineous color. The secondary nerves are forked with small veins starting from the main one and reaching the leaf margin. The fertile leaves have a similar palmate shape but with a smaller dimension. The *Lygodium* genus has the reproductive structure at the edge of the leaves



Figure 2. Some ferns collected in Manleluag Spring Protected Landscape: a- *Adiantum caudatum*; b- *A. gomphophyllum*; c- *A. philippense*; d- *Asplenium auriculatum*; e- *Lygodium circinatum*; f- *L. japonicum*.

and not at the lower side (adaxial side) as most of the ferns. The sori is individually protruding from the margin of the leaf with the indusia arranged in alternate disposition. The fertile leaves are not concentrated in some part of the plants but rather distributed along the entire stipe of the plants.

#### 3.2.6 *Lygodium japonicum* (Thunb.) Sw. (Figure 2f).

This perennial climbing fern with creeping rhizome has fronds that are opposite, compound, usually triangular in shape, and finely dissected. Rachis sparsely pubescent, subterete, flattened on 1 side with ridged edges. Primary rachis branches c. 2 mm long, secondary pinnae broadly lanceolate-triangular, 3-pinnate; pinnule stalks reducing in length towards pinna apex; ultimate pinnules ovate, lanceolate to triangular; sterile pinnules fused, palmately-lobed; terminal lobe much longer, membranous, sparsely pubescent. Sporogenous pinnules smaller and more finely dissected than sterile ones.

#### 3.2.7 *Microsorium longissimum* Fée (Figure 3a)

This fern is epiphytic or lithophytic with slender, short-creeping rhizomes covered in lattice-like scales. Due to its long, leathery fronds, *Microsorium longissimum* is known as the "long-leaved *Microsorium*" or "long-leaved fern." The fronds are thick, leathery, simple or deeply lobed. Lobe fronds may have a variety of shapes, including narrowly egg-shaped, elliptic, or lanceolate. The midrib is raised on both sides of the fronds. The sori, lacking in indusium, are small, round, and scattered along the veinlets on the underside of the fronds.



Figure 3. Some ferns identified at Manleluag Spring Protected Landscape: a- *Microsorium longissimum*; b- *M. membranifolium*; c- *M. palmatum*; d- *M. scolopendria*; e- *Reholtumia laevis*; f- *Pteris mutilata*.

### 3.2.8 *Microsorium membranifolium* (R.Br.) Ching. (Figure 3b)

*Microsorium membranifolium* is characterized by its short-creeping, fleshy rhizomes, fronds that could be over 1 meter in length, and pale, glossy stipes. Its fronds have a deeply pinnatifid (finely divided) lamina, with lobes that are narrowly ovate to strap-shaped. The sori located on the underside of the lobes are deeply impressed into the lamina, forming prominent, rounded-conical protuberances; hence, the name "pimple fern."

### 3.2.9 *Microsorium palmatum* (Blume) Fée (Figure 3c)

This epiphytic or lithophytic fern got its name from its palmate or lobed fronds with the segments resembling fingers. Fronds are typically dark green and leathery. The midrib and veins are raised on both surfaces of the leaves. The rhizomes are long and creeping. The sori on the leaf undersurface are rusty orange-brown, round to elliptic.

### 3.2.10 *Microsorium scolopendria* (Burm.fil.) Copel. (Figure 3d)

*Microsorium scolopendria* is an epiphytic or lithophytic fern with long creeping rhizomes. Its fronds are light green, leathery, deeply lobed, with up to 6 lateral lobes; mid rib and main veins of lobes raised on both surfaces. Sori rusty orange-brown, round - elliptic, set in irregular rows on either side of the midrib, sunken or in shallow pits, raised on upper surface. The specific epithet "scolopendria" refers to the numerous sori seemingly following the arrangement to the legs of a millipede (National Parks Board, 2025).

### 3.2.11 *Reholtumia laevis* (Mett.) S.E.Fawc. and A.R.Sm. (Figure 3e)

(In S. E. Fawc., A. R. Sm. (2021). In: A Generic Revision of the Thelypteridaceae: 78.)

The fronds (leaves) of *R. laevis* are pinnate, meaning the leaflets or pinnae are arranged along a central stalk. The pinnae are lanceolate, meaning they are elongated and pointed at both ends. The stipes, or leaf stalks, are clumped or tufted.

### 3.2.12 *Pteris mutilata* L. (Figure 3f)

The specific epithet of this fern refers to its distinctly broken leaf structure, specifically to its pinnate frond, hence, the common name broken Fern. It's known for Leaves are often oblanceolate, with the terminal leaflet at the tip. *Pteris mutilata* may exhibit frond sexual dimorphism, meaning differences in size and shape exist between fertile and infertile fronds. The rhizome is creeping, lithophilic. Sori located on the underside of the pinnae are either along the margin or along the veins.

## 4. Conclusions

Being a secondary forest, the Manleluag Spring Protected Landscape (MSPL) showed low diversity of ferns. The ferns also showed zone distribution as affected by altitude indicating the effect of atmospheric conditions on the growth and abundance of the ferns. Other sites are recommended for further pteridophyte studies. The researchers also recommend intensified implementation of the MSPL management plan and continuously monitoring the presence and abundance of different Pteridophyte species in Manleluag Spring Protected Landscape.

## Acknowledgements

The authors wish to thank the following: Saint Louis University (SLU), Don Mariano Marcos Memorial State University (DMMMSU), Pangasinan State University (PSU), Department of Environment and Natural Resources (DENR), and the Maritime Academy of Asia and the Pacific (MAAP) for their support in the study.

## Author Contributions

Jomar L. Aban: Methodology, Software, Data curation, Writing - original draft, Visualization. Weenalei T. Fajardo: Methodology, Data curation, Writing - original draft. Helen A. Maddumba: Methodology, Data curation, Writing - original draft. Paulina A. Bawingan: Conceptualization, Methodology, Software, Writing - reviewing and Editing, Supervision.

## References

Anderson, O. R. (2021). Physiological ecology of ferns: Biodiversity and conservation perspectives. *International Journal of Biodiversity and Conservation*, 13(2), 49-63.

- Banaticla, M. C. N., & Buot, I. E. (2005). Altitudinal zonation of pteridophytes on Mt. Banahaw de lucban, luzon Island, Philippines. *Plant Ecology*, 180, 135-151.
- Barcelona Fields Studies Centre. (2024). Simpson's diversity index. Retrieved from <https://geographyfieldwork.com/Simpson'sDiversityIndex>
- British Columbia Ministry of Forests Research Branch (1996). *Techniques and procedures for collecting, preserving, processing, and storing botanical specimens* (Volume 18). British Columbia, Canada: Author.
- Calabrese, L. (2005). *The use and methods of making a herbarium/plant specimens. An herb society of America guide* (Revised edition 2005). Kirtland, OH: The Herb Society of America.
- Delos Angeles, M., & Buot, I. (2012). Orders and families of Philippine pteridophytes. *Journal of Nature Studies*, 11(1&2), 19-33.
- Easy Calculation (2016, May 23). Easycalculation.com. HIOX Softwares Pvt Ltd., No.7A-F, Ganesha Complex Campus, N. K. Palayam Road, Singanallur, Coimbatore, Tamilnadu - 641005, India. Retrieved from <https://www.easycalculation.com/statistics/shannon-wiener-diversity.php>.
- Femi-Adepoju, A., Oluyori, A. P., Fatoba, P. O., & Adepoju, A. (2021). Phytochemical and antimicrobial analysis of dryopteris filix-mas (L.) schott. *Rasayan Journal of Chemistry*, 14(1), 616-621.
- FloraGator (2012). A multiple-entry key for flowering plant family identification, Fifield Hall, FL: Department of Environmental Horticulture, College of Agricultural and Life Sciences, University of Florida. Retrieved from <http://hort.ifas.ufl.edu/floragator/>.
- GoBotany (2011). New England Wild Flower Society. Retrieved from <https://gobotany.newenglandwild.org/dkey/lamiaceae/>.
- Hansen, B., & Rahn, K. (1969). Determination of angiosperm families by means of a punched-card system. *Dansk Botanisk Arkiv*, 26(1), 7. Retrieved from <http://www.colby.edu/info.tech/BI211/PlantFamilyID.html>.
- Haribon Foundation. (2006) *Biophysical Survey in the Zambales Mountain Range, IBA, 16 to 22 November*. Pangasinan, Philippines: Author.
- Klorane Botanical Foundation. (2025). Primary, secondary, virgin or natural...the different types of forests. Retrieved from <https://www.kloranebotanical.foundation/en/primary-secondary-virgin-or-natural-different-types-forests>.
- Lucid Central. (2022). Australian tropical ferns and lycophytes. Retrieved from [https://apps.lucidcentral.org/ferns/text/entities/adiantum\\_caudatum.htm#](https://apps.lucidcentral.org/ferns/text/entities/adiantum_caudatum.htm#).
- Moran, R. (2008). Diversity, biogeography, and floristics. In T. A. Ranker, & C. H. Haufler (Eds.), *Biology and Evolution of Ferns and Lycophytes* (pp.367-394). Cambridge, England: Cambridge University Press.
- Manleluag Spring Protected Landscape-Management Plan [MSPL-MP]. (2012). Manleluag Spring Protected Landscape-Management Plan.
- Nakazato, T., & Gastony, G. J. (2003). Molecular phylogenetics of Anogramma species and related genera (Pteridaceae: Taenitidoideae). *Systematic Botany*, 28(3), 490-502.
- National Parks Board. (2025). Flora and fauna. Retrieved from <https://www.nparks.gov.sg/florafaunaweb/flora/1/5/1560>
- Petchsri, S. & Boonkerd, T. (2023). An updated account of *Adiantum* (Pteridaceae: subfamily Vittarioideae) in Thailand. *Australian Systematic Botany*, 36(6), 437-456. Retrieved from <https://doi.org/10.1071/SB23006>.
- Singh, P (2024). Simpson's diversity index calculator. Retrieved from <https://www.omnicalculator.com/statistics/simpsons-diversity-index>.
- Smith, A. R., Pryer, K. M., Schuettpelz, E., Korall, P., Schneider, H., & Wolf, P. G. (2006). A classification for extant ferns. *Taxon*, 55(3), 705-731.
- Yatskievych, G., & Pickering, J. (2016, May 23) IDnature guide to ferns. Discover life. Retrieved from <http://www.discoverlife.org/mp/20q?guide=Ferns>.
- Young, A. (2016, May 23). Biodiversity calculator. Retrieved from [http://www.alyoung.com/labs/biodiversity\\_calculator.html](http://www.alyoung.com/labs/biodiversity_calculator.html).