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Composition and Diversity Variation of Ferns (*Pteridophyta*) at Barangay San Rafael, Prosperidad, Agusan del Sur Philippines: Distribution and Conservation Status

Jeffry M. Saro[1*], Jeffrey Q. Apat[2], John Mark C. Sarongon[3]

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ABSTRACT

Ferns (*Pteridophyta*) are free-sporing vascular plants with a unique life cycle with free-living gametophyte and sporophyte phases. The fern species has nearly 90% of the extant diversity, it was the first higher-level of pteridophyte classification in the world. This study aimed to assess and identify the different species composition and diversity variation of ferns found in the lower elevations at the primary forest in Barangay San Rafael, Prosperidad Agusan del Sur, Philippines. Moreover, the researchers were used the quadrat sampling method as one of the best and classic tools utilized in ecology especially determining the diversity of a specific sampling sites. Also, the study used Shannon's diversity index method in determining the biological diversity of plant species particularly ferns (*Pteridophyta*). The total number of ferns that was primarily collected at Barangay San Rafael, Prosperidad, Agusan del Sur are nine (9) species from 5 families. The researchers linked the gathered data of ferns (*Pteridophyta*) by calculating its diversity index of 1.864, were showed medium diversity because most likely the pteridophyte communities were similar in all transects. Thus, the study area has medium species diversity results in a more complex, stable, and productive ecosystem as could be observed in San Rafael Forest. The results show that the growth and distribution of ferns was inhibited significantly by the environment properties.

INTRODUCTION

The Pteridophytes, is very well-known as the seedless vascular plants. It had a very flourishing and increasing past in dominating the vegetation on the Earth about 280 to 230 million years ago. Though, they are now widely spread and largely replaced by the seed-bearing vascular plants in the extant flora today, however they explicitly constitute a fairly prominent part of the present age vegetation of the world (Aishan *et al.*,2018). The ferns are greatly composed of 20,000 species of plants in the world and 943 are known to occur in the Philippines, it was classified in the phylum or division of *Pteridophyta*, also known as Filicophyta. Ferns are very subjected for various biological studies since ferns comprise several species and in fact new pteridophytes species are still being found unexplored in tropical areas. In addition, the ferns have a very distinctive form of young leaves and the shaped like a loop of rope, which is not present in other plant species (Yusuf, 2010).

Several studies have plainly analyzed that fern have a significant role both ecologically and economically. Ecologically, the existence of ferns acts as a producer in a food chain and has a great component in the nitrogen cycle. Whereas economically, the fern has a substantial potential for trade commodities because of its role and characteristic as an ornamental plants and medicinal plant species (Zhang Xianchun *et al.*, 2016). According to the research on several aspects of ferns in various regions in Indonesia have been carried out and accomplished before, including the distribution of pteridophytes in Mt. of Selamat (Widhiastuti, 2006), the correlation of various plant species of ferns of the polypodiaceae family (Nurchatyati, 2010).

Community composition was greatly influenced by the changed in altitude, precipitation, and the abundance of plant species. Forests and mountains are strongly and ideally suited to study the effect of climate change on species distributions through to their rapid variability and properties of climate over short altitudinal distances and geographic features (Kessler *et al.*, 2016; Rogora *et al.*, 2018). The ferns (*Pteridophyta*) and lycophytes are especially vulnerable to increased temperatures and well-decreased precipitation, wherein both of them are predicted underneath future climate change and their responses to these conditions will likely differ between terrestrial and epiphytic species (Mandl *et al.*, 2010). Additionally, climate has a significant role in the ecosystem and climate is very sensitive, globally distributed and diverse group of plant species such as pteridophytes has received substantial attention in the literature on global altitudinal distribution pattern studies premise (Sanchez-Gonzalez *et al.*, 2010).

This study aimed to assess and identify the different species composition and diversity variation of ferns found in the lower elevations at the primary forest in Barangay San Rafael, Prosperidad, Agusan del Sur where lots of different species of ferns are well-located. The site selection was based on the relative homogeneity of vegetation and topography. The plant samples of each species were collected for examination and screening by noting on the description of the pteridophytes. The study area is situated at Barangay San Rafael, Prosperidad, Agusan del Sur, Philippines. The researchers find interest in this particular study since the area has not yet been conducted for any research concerning on species

[1] San Vicente National High School, Prosperidad, Agusan del Sur, Philippines
[2] Division of Agusan del Sur, Prosperidad, Agusan del Sur, Philippines
[3] St. Peter's College of Misamis Oriental Inc., Balingoan, Misamis Oriental, Philippines
[*] Crresponding author's e-mail: jeffrysaro123@gmail.com

composition and diversity of ferns (*Pteridophyta*).

MATERIALS AND METHODS

The study was conducted in the lower elevations at the primary forest of Barangay San Rafael, Prosperidad, Agusan del Sur, Philippines. The researchers were gathered the needed data to assess and identify the species composition and diversity variation of pteridophytes. The documentation and survey were started last June 29, 2022 during the study period. During the field visits, various collections of plant species of ferns and experiments were properly conducted.

Collection and identification methods

The researchers were properly utilized one of the classic tools used in ecology especially determining the diversity of specific location is so-called quadrat sampling. There was three-10m by 10m quadrats established in each study sites of Barangay San Rafael with an interim of 100 meters. All plant species intercepted in every quadrant were listed. The representative samples of each species were collected for proper examination through their distinct morphological features and specially their leaf structure.

Diversity Indices Screening

For the quantitative analysis of the study, the researchers were positively counted the numbers of different ferns in the quadrat creating the diversity index called the species richness. Moreover, the researchers were counted the number of pteridophytes per individual species to represent species evenness. Lastly, to precisely calculate and interpret the diversity index, the researchers used the Shannon's diversity index and equitability in Excel which

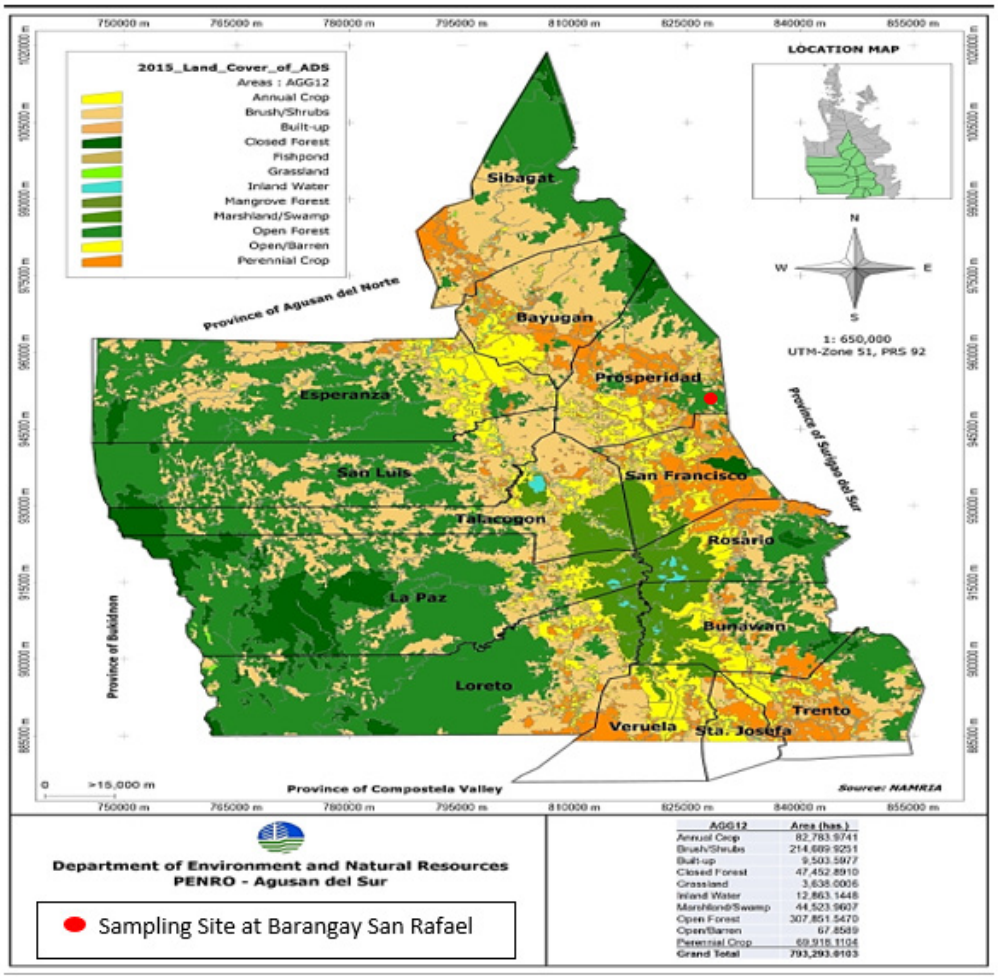

Figure 1: The Map of the Study Area

was used to determine and evaluate if the study area has a low, medium, or high diversity of ferns (*Pteridophyta*).

Species richness and Species evenness

The species richness was probably the first measure used for assessing and evaluating biological diversity. Counting the number of taxa in the sample under consideration is always the first step. Wherein, often richness or just an estimate of it is the only measure available for large unexplored locations. In species evenness, the individuals are not evenly distributed among species. An area containing dozens of species might not be seem particularly diverse if 99.9% of the individuals belong to the same population. With that, evenness is defined as the ratio of observed diversity to maximal possible diversity if all species in a sample were definitely equally abundant.

Shannon's diversity index. The Shannon diversity index or well-known as Shannon -Wiener diversity index is one of a so-called family of heterogeneity indices. Also, is a popular metric used in ecology. These indices do not particularly take taxa richness into account yet also depend on the relative distribution of individual species. Withal, the logarithm can be taken to any base but taken to these of two gives H a special meaning: bits per species. It is the mean number of binary decisions necessary to determine the exact taxum of an individual species. Different fields of application might be use in different terminology for these concepts in analysis.

RESULTS AND DISCUSSIONS

The total number of ferns (*Pteridophyta*) that were primarily collected at Barangay San Rafael, Prosperidad, Agusan del Sur was nine (9) species from 5 families. The family of Polypodiaceae had three-identified fern species that includes Belvisia revoluta, Drynaria Sparsisora, and Pyrrosia lanceolata. Pteridaceae family had 2 found species in the study location, these includes Pityrogramma calomelanos and Pityrogramma chrysophylla. Whereas, the family of Aspidiaceae had one-identified fern species in the area, the Tectaria crenata or well-known as Halberd Fern. Also, the family of Thelypteridaceae had one-identified species, such as Christella arida, this plant species found at the extent of terrestrial land in Barangay San Rafael. Lastly, the Nephrolepidaceae family had 2 well-identified pteridophytes in the sampling site, namely, Nephrolepis biserata and Nephrolepis falcata. In Table 1, it was shown that most of the surveyed pteridophyte species were not yet assessed by the International Union for the Conservation of Nature due to its abundance in the field or specific area (Sastrapradja *et al*., 1979). Hence, there are 4 pteridophyte species were regarded as least concern based on the conducted assessment in the area, these were P. calomelanos, P. chrysophylla, N. biserata, and N. falcata. These pteridophytes were greatly distributed from various parts of the world and was not yet assessed might be due to wide range of distribution of plant species which can be harmful to the terrestrial environment that might causes a widespread unhealthy or weak condition for cultivation (Kobayashi *et al*., 2007). The polypodiaceae family were mostly have epiphytic

Table 1: The Distribution and Conservation Status of Pteridophytes species in Barangay San Rafael, Prosperidad, Agusan Del Sur, Philippines.

Scientific Name	Family Name	Common Name	Life Form	Distribution Status	Conservation Status
Belvisia revoluta	Polypodiaceae	Blume Copel	Epiphytic	NE	NYA
Drynaria Sparsisora	Polypodiaceae	Oak Leaf Fern	Epiphytic	NE	NYA
Pyrrosia lanceolata	Polypodiaceae	Tongue Fern	Epiphytic	NE	NYA
Pityrogramma calomelanos	Pteridaceae	Silver Fern	Terrestrial	N	LC
Pityrogramma chrysophylla	Pteridaceae	Island Fern	Terrestrial	N	LC
Tectaria crenata	Aspidiaceae	Halberd Fern	Terrestrial	NE	NYA
Christella arida	Thelypteridaceae	Christ Fern	Terrestrial	NE	NYA
Nephrolepis biserata	Nephrolepidaceae	Broad Sword Fern	Terrestrial	N	LC
Nephrolepis falcata	Nephrolepidaceae	Fishtail Sword Fern	Terrestrial	N	LC

**IUCN status: NYA = Not Yet Assessed; NE = Non-Endemic; LC = Least Concern; N = Native*

properties. The shape and size of the leaves of the ferns is very wide, with several distinctive and peculiar shapes. The morphological composition of the species in polypodiaceae family are widely utilized as ornamental plants in various location, particularly in parks, malls, and rooms (Zhang *et al*., 2013). The family of Pteridaceae is in the major group of Pteridophytes (Ferns and fern allies). The distribution of this Pteridaceae were mostly in terrestrial habitat, growing on rock and some trees (Christenhusz and Byng, 2016). Nephrolepidaceae plant species were widely distributed in tropical regions and sometimes cultured as ornamental and medicinal species. Nonetheless, the leaf morphology of Nephrolepidaceae is quite variable yet most commonly dimorphic (immature leaves have a different appearance than mature leaves) (Kobayashi *et al*., 2007).

A total of 344 individual pteridophyte species was recognized as present in the research field at Barangay

Table 2: Types of individual pteridophyte species observed in Barangay San Rafael, Prosperidad Agusan del Sur

Family	Types of Pteridophytes	Number of Individual Species
Polypodiaceae	*Belvisia revoluta*	39
	Drynaria Sparsisora	42
	Pyrrosia lanceolata	58
Pteridaceae	*Pityrogramma calomelanos*	35
	Pityrogramma chrysophylla	32
Aspidiaceae	*Tectaria crenata*	25
Thelypteridaceae	*Christella arida*	24
Nephrolepidaceae	*Nephrolepis biserata*	47
	Nephrolepis falcata	42
Total		**344**

San Rafael, Prosperidad Agusan del Sur. Table 2 shows the types of pteridophytes observed in the study location. Based on the conducted surveyed, the most consistent observation of this study was the determination of fern classification in the area. Several pteridophyte species found in the sampling site, these plant species are Belvisia revoluta (39), Drynaria Sparsisora (42), Pyrrosia lanceolata (58), Pityrogramma calomelanos (35), Pityrogramma chrysophylla (32), Tectaria crenata (25), Christella arida (24), Nephrolepis biserata (47), and Nephrolepis falcata (42). The number of species of terrestrial ferns at the study sampling site was 205 species from 4 families, these includes Pteridaceae, Aspidiaceae, Thelypteridaceae, and Nephrolepidaceae, whereas the number of epiphytic ferns at the research field was 139 from 1 family, which is Polypodiaceae (Table 1 and Table 2). According to the study of Sastrapradija *et al.*, 1979, these species of ferns (*Pteridophyta*) is very suitable for ornamental plants and commonly found in the forest. Furthermore, the young leaves are utilized for various purposes, particularly vegetables and medicinal treatments in some disease (Arini and Kinho, 2012; Zelnik *et al.*, 2021). Based on some review, various pteridophytes have properties that explicitly be used in alternative medicine for treatment of various human diseases and illnesses. Herein, it has a significant growth in synthetic organic chemistry in the 20th century (over 25%) of approved drugs in industrialized (Newman *et al.*, 2000).

Several studies were scrutinized that ferns are the most diverse group of vascular plants after seeded plants.

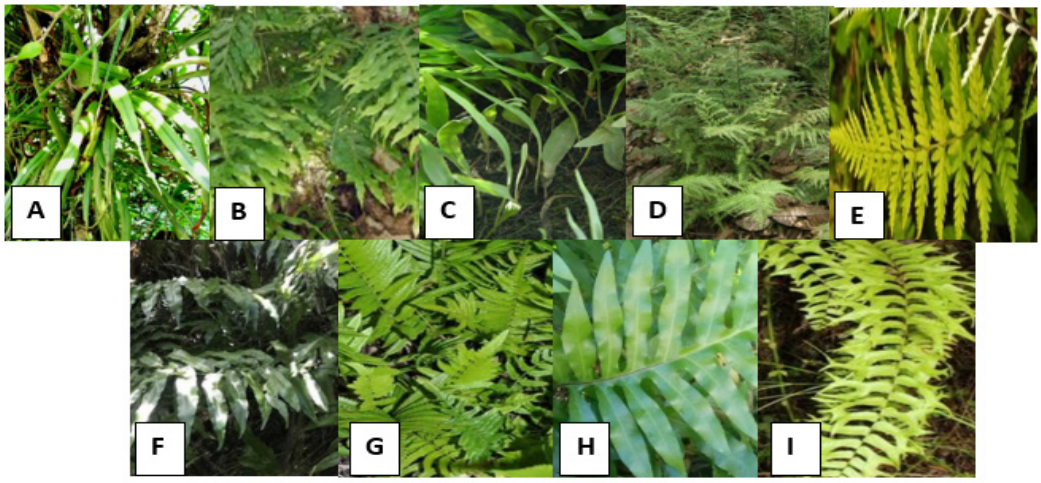

Figure 2: The morphology of the species of ferns (*Pteridophyta*) at the study sampling site in Barangay San Rafael, Prosperidad Agusan del Sur. *(A) Belvisia revoluta (B) Drynaria Sparsisora (C) Pyrrosia lanceolata (D) Pityrogramma calomelanos (E) Pityrogramma chrysophylla (F) Tectaria crenata (G) Christella arida (H) Nephrolepis biserata (I) Nephrolepis falcata*

Moreover, the recent morphological and molecular phylogenetic analysis indicate and stipulate that the existence of the species ferns are vital as ornamental plants. The proponents concluded that the molecular genetics of fern leaves has an impact in ecological ecosystem and in the evolution of pteridophyte species development (Raubenson & Jansen, 1992 & Pryer *et al.*, 2001).

Moreover, there has been limited research study into the distribution and composition patterns of epiphytic and terrestrial fern species along the forest and mountain ranges, especially in the context of climate condition and change (Freeman *et al.*, 2018). The present study provides an information regarding to the distribution of ferns (*Pteridophyta*) in the sampling site of Barangay San Rafael, the researchers were congruously gathered three (3) epiphytic ferns and 6 terrestrial ferns (Table 1).

The Shannon's diversity index is very frequently that utilized to assess and identify the diversity of plant species particularly in pteridophyte species. Based on the findings, the dominance of the plant species in the research field at Barangay San Rafael, are greatly influenced by the most

Table 3: The Shannon's Diversity index of Pteridophytes found in Barangay San Rafael, Prosperidad Agusan del Sur.

Species	Number (p)	pi	Ln(pi)	pi*Ln(pi)	- pi*Ln(pi)
Belvisia revoluta	39	0.113	-2.177	-0.247	0.247
Drynaria Sparsisora	42	0.122	-2.103	-0.257	0.257
Pyrrosia lanceolata	58	0.169	-1.78	-0.300	0.300
Pityrogramma calomelanos	35	0.102	-2.285	-0.233	0.233
Pityrogramma chrysophylla	32	0.093	-2.375	-0.221	0.221
Tectaria crenata	25	0.073	-2.622	-0.191	0.191
Christella arida	24	0.070	-2.663	-0.186	0.186
Nephrolepis biserata	47	0.137	-1.99	-0.272	0.272
Nephrolepis falcata	42	0.122	-2.103	-0.257	0.257
Total	**344**				**1.864**

Note: <1.5 = low diversity; 1.5-2.5 = medium diversity; > 2.5 = high diversity

common and diverse species. Additionally, the species identification is very important and has a significant impact and well distributed which decorates community composition and affected by the environmental condition and other physiochemical components (Nsor *et al.*, 2019). The results show that the growth and distribution of ferns was inhibited significantly by the environment properties. The researchers identified common conservation priorities among the species population of pteridophytes, thus, the adaptation of the trait and characteristic of species are considered. The researchers linked the gathered data of ferns (*Pteridophyta*) by calculated its diversity index of 1.864, were showed medium diversity because most likely the pteridophyte communities were similar in all transects. Thus, the study area has medium species diversity results in a more complex, stable, and productive ecosystem as could be observed in San Rafael Forest.

CONCLUSION

The study provides information regarding the ferns (*Pteridophyta*) composition and diversity variation in the sampling site of Barangay San Rafael, Prosperidad Agusan del Sur. Based on the results of research and discussion, it could be concluded as follows. The composition of pteridophyte species were determined based on the habitat of the plant in the site. Also, the diversity of ferns in the study area is very different from several studies. The total number of ferns (*Pteridophyta*) that was primarily collected at Barangay San Rafael, Prosperidad, Agusan del Sur was nine (9) species from 5 families. Nonetheless, the total individual pteridophyte species was recognized as present in the research field is 344.

Therefore, the diversity index of the ferns in the study site is in medium species diversity (1.864). In the future, studies should precisely aim to increase and expand species sampling in abundance and seek precision in understanding species response variables in more diverse forest regimes. Furthermore, this research might be utilized as a guideline for future study, particularly in the context of the ecosystem services and premises, sustainable pteridophytes species monitoring and conservation initiatives.

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