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Species richness and diversity of pteridophytes along the vicinity of Mt. Kibuwa, Impalutao, Impasug-ong, Bukidnon

Joevi Jhun A. Idul [1,*] and Cristy-ann A. Cayme [2]

[1] *Bukidnon National High School, Division of Malaybalay City, Department of Education, Philippines.*
[2] *San Martin Agro-Industrial National High School, Division of Malaybalay City, Department of Education, Philippines.*

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Abstract

Bukidnon being in a tropical country is composed of the richest and most diverse ecosystems. Mt. Kibuwa, the location of this study exhibits this diversity through its vast vegetation of pteridophytes or ferns along its area. Ferns are important ecological indicators since they can live in different niches and they have a variety of commercial uses—thus, there is a need for these species to be conserved. This study assessed the species richness and diversity of ferns along the vicinity of Mt. Kibuwa, Impalutao, Impasug-ong, Bukidnon to heighten up ecological conservation efforts within the area. In this study, Mt. Kibuwa was divided in to ten (10) sampling quadrats measuring 10m by 10m. The researchers collected seven (7) fern species and were confirmed and identified by the Central Mindanao University- Center for Biodiversity Research and Extension in Mindanao (CMU-CEBREM) as: *Sphenomeris chusana*, *Pteridium aquilinum, Pityrogramma calomelanos*, *Culcita sp.*, *Cyathea dregei, Nephroliphios exaltata*, and *Dricanopteris linearis*. Using Menhinnick's index of species richness and Shannon-Weinner species diversity index, results show that the species richness in all the sampling sites are closely similar with *Pteridium aquilinum* being the richest species and Site 1 on the lower elevation being the richest site. In terms of species diversity, this research concludes that Mt. Kibuwa has a good diversity of fern species and can be promoted for high ecological conservation and protection.

Keywords: Pteridophytes; Ferns; Species diversity; Species richness; Conservation status; Ecological indicators; Biodiversity

1. Introduction

Species richness is one of the methods utilized in assessing ecological diversity. It is broadly used as a measure of biodiversity with various objectives such as monitoring biodiversity in order to prioritize management or conservation action or design ecological indicators. There has been an emphasis of locating centers of species richness to optimize conservation strategies [1].

The ability to measure biodiversity is critically important, given the soaring rates of species extinction and human alteration of natural habitats. The frequently used measure of biological diversity is species richness, the number of species per unit area. Species richness is generally used as a measure of diversity within a single ecological community [2]. In this study, an alpha-diversity measure of species richness is utilized. It measures at the local scale and consists of a count of species within a relatively homogeneous area.

Most of the species richness-related researches depict that broad-scale patterns of plant richness have been documented showing that mountains in the tropical regions have the highest levels of plant diversity and thus are considered as highly valuable for conservation [3,4]. Bukidnon being one of the ecologically diverse provinces in the country displays different mountains and hills potential for conducting species richness studies. Mt. Kibuwa, a mountain

* Corresponding author: Joevi Jhun A. Idul; Email: joevijhun.idul@deped.gov.ph

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range located at Impalutao, Impasug-ong is the focus of this study since ferns and other pteridophytes are vastly growing in most of its area.

However, recent studies show up that conducting species richness can be at times unreliable and may have limitations. Species richness cannot directly compare two communities especially if the areas are not homogenous with each other. Ecologists must not presume the difference of two communities based on the abundance of the individuals found in the sample areas unless the areas are exactly the same with each other [5]. Mt. Kibuwa, the subject of this study is a mountain range that exhibits different landforms and compositions from the foot, to the lower elevation and up. Hence, species richness cannot give an exact information about the real status of ferns in the area.

To solve this inadequacy, a species diversity index is utilized. Species diversity takes into account both the numbers of species present and the dominance or evenness of species in relation to one another. In this way, the distribution of the fern species along different sites is considered [5]. This study is based on the concept of ecological diversity which states that the comprehensive measure of biodiversity should include components of both species richness and the relative abundances of the species that are present [6]. Such measures are the species richness and species diversity or evenness.

Ferns have a wide range of habitat preferences and are widely disseminated that is why they are an ideal group for understanding how diversity is distributed. Most of the understanding of fern distribution derives from transects documenting richness and its relationship to environmental variables [7]. Fern richness is greatest in areas of high topographic relief and complexity, high evapotranspiration, and with a high humidity [8]. Thus, the Mt. Kibuwa in the municipality of Impasug-ong is a prospective location for the richness and diversity of pteridophytes species.

Ferns are diverse, estimated to a tune of 15,000 species of which 12,000 are described species of ferns and lycophytes [9]. This group has a longer evolutionary history than any other vascular plant and as a result, many of the phylogenetically informative characters may have been lost in the process. Lycophytes and ferns have traditionally been grouped together because they are characteristically all spore bearing and seed-free vascular plants. Because of these common features, their extant members have often been treated as a single entity under various terms, such as ‘pteridophytes’ or ‘ferns and fern allies’ which are a paraphyletic assemblage and should be avoided [10]. Ferns make up an important component of tropical pteridoflora and serve important functions in ecosystem processes. They occur abundantly in these forests and are highly sensitive to ecological conditions, making them potential indicators of environmental change [11]. Ferns also help in soil formation and preventing erosion. Many ferns can harbor nitrogen-fixing bacteria, thus making it a vital part in nutrient cycling.

Aside from the ecological importance of ferns as environmental indicators, it also has economic significance. Early uses of ferns have been dated in history. It was used as a stuffing for mattresses, pillows and furniture. Native Americans used it to clean pots and polish brass. Now, it is widely cultivated for its horticultural and aesthetic value. There are also species such as the bracken fern that are consumed by humans as food [12].

Since ferns have a variety of uses, may it be ecological or commercial, there is a need for ferns to be protected and be conserved. There is also a need to determine the hotspots where ferns are abundant and rich, hence the reason for conducting this study. This study measured the species richness of ferns and fern allies specifically along the vicinity of Mt. Kibuwa. This also identified the existing species found in the area and determined their corresponding conservation status. Moreover, this study classified the distribution and diversity of these fern species as low, good, or high using diversity index. The results of this study may contribute to the further promotion of the upkeep of ferns species in the area, and prove that Mt. Kibuwa is a potential site for ecological conservation.

2. Material and methods

2.1. Research Design

This study utilized a descriptive research design to describe the species richness and diversity of pteridophytes along the vicinity of Mt. Kibuwa, Impalutao, Impasug-ong, Bukidnon. This study identified the fern species located at Mt. Kibuwa, assessed their conservational status, and calculated its species richness and diversity. Furthermore, the researchers used the indices of species richness and diversity to treat the data gathered from the ten (10) sampling sites distributed at the lower, middle, and higher elevation points of Mt. Kibuwa.

2.2. Research Locale

This study was conducted on Mt. Kibuwa located at Barangay Impalutao, Municipality of Impasug-ong. Mt. Kibuwa stands at 1159 meters above sea level and is located at 8º15'14" latitude and 125º3'11.02" longitude. Residents in the neearby community reported that Mt. Kibuwa was once a mining and quarrying site few years ago, which explains the recent situation of the mountain. Mt. Kibuwa is mostly covered with rocks, and there are only few trees or mostly shrubs and ferns that grow in the area, hence, Mt. Kibuwa is currently undergoing a secondary ecological succession and it is still on the young forest stage. The vast growth of ferns along the area is the primary interest of this study.

An average of 10 quadrats would be sufficient to describe a vegetation in a community [13], and so, in this study, Mt. Kibuwa was also divided into 10 sampling sites. Each site had an area of 10 x 10 meters. Three sites (Sites 1, 2 and 3) were located at the foot or the lower elevation of the mountain, four sites (Sites 4, 5, 6 and 7) at the higher elevation, and another three (Sites 8, 9 and 10) at the middle elevation.

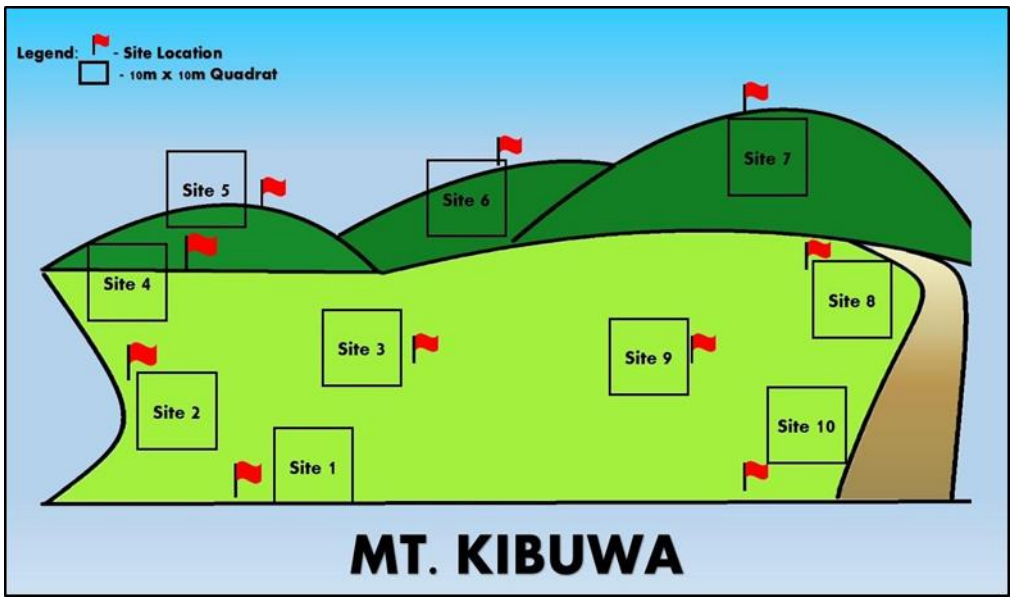

Figure 1 Mt. Kibuwa Study Sites

2.3. Data Gathering Procedure

The researchers started the study by surveying the area and locating the sampling sites for the study. Next was the collection and pre-identification of the sample fern species. The researchers gathered all the possible fern species found in the area and then proceeded to Central Mindanao University- Center for Biodiversity Research and Extension in Mindanao (CMU-CEBREM) for further confirmation and identification. With the fern species samples having been identified, the making of the ten 10mx10m quadrats followed using site marks, improvised boundaries and a calibrated measuring device. In each site, the researchers determined the abundance of each fern species by counting the number of individuals found and filling the data in a species richness table. After all the data were completed, statistical instruments were then applied: these are the Species Richness Index of Menhinnick and the Diversity Index of Shannon and Weiner.

2.4. Species Richness

Species richness is a straightforward measure that simply counts the number of species in a particular area. Richness (R) is calculated as the total count of species within each grid cell unit [14]. However, since quadrats are made to serve as samples, another method of computing species richness is utilized, the Menhinick's Index (D). This index states that species richness is a measure of the number of species found in a sample. The larger the sample, the more species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. Menhinicks's Index known as D is represented by the formula $D= s/\sqrt{n}$ where s equals the number of different species represented in sample, and n equals the total number of individual organisms.

2.5. Species Diversity Index

Measuring species richness has many limitations. It cannot reliably compare the abundance of different communities since the sites along the vicinity of Mt. Kibuwa are not homogenous. The standard in comparing communities is not depicted by the intensity of the species found in each area. While many studies include species richness as a descriptive factor associated with the community, it is largely informative in as much as it does not reflect relative abundance [13]. One way to overcome this problem is to incorporate both species richness and abundance information into one diversity index.

Diversity index is a mathematical expression that combines species richness and evenness with which individuals are distributed among species [15]. Shannon-Weiner Index (H') is used in this study for it is more sensitive in evenness and richness than the other indices. The Shannon-Weiner Index assumes that all species are all represented in a sample and that all are obtained randomly. This is equated as $H' = \Sigma\ pi\ ln\ pi$, where *pi* is the proportion of individuals found in the i^{th} species and ln is the natural logarithm.

High values of H' would be representative of more diverse communities. A community with only one species would have an H' value of 0 because pi would equal 1 and be multiplied by *ln pi* which would equal to zero. If the species are evenly distributed, then the H value would be high. Studies proposed that an H' value that is in between 0 and 1 suggests a low diversity. H' between 1 and 2 means a good diversity, and value better than 2 would depict a high diversity [16].

3. Results and discussion

3.1. Identification of Sample Fern Species

Table 1 shows the identified sample fern species from Mt. Kibuwa, its scientific name, family classification, and its common name. The researchers collected seven (7) different species of fern at Mt. Kibuwa, Impasug-ong. After which, the samples were sent to the Central Mindanao University- Center for Biodiversity Research and Extension in Mindanao (CEBREM). The following ferns were identified as:

Table 1 Identified fern species from Mt. Kibuwa

Scientific Name	Family	Common Name
Sphenomeris chusana (L.) Copel	Lindsaeaceae	Chinese creeping fern
Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae	Bracken fern
Pityrogramma calomelanos (L.) Link	Ptiredaceae	Silverback fern
Culcita sp.	Culcitaceae	Soft bracken fern
Cyathea dregei	Cyatheaceae	Tree fern
Nephrolophis exaltata (L.) Schott	Dryopteridaceae	Sword fern
Dicranopteris linearis	Gleicheniaceae	Forked fern

- *Sphenomeris chusana (L.) Copel* or commonly known as the Chinese creeping fern or palae's skirt is one of the most common and widespread of native Hawaiian ferns. It is not always easy to grow and is not commonly seen in cultivation specially in tropical countries. But since this fern is by no means scarce, all attempts to grow this native fern is worth the effort. This species of fern is indigenously distributed, non-woody, clumping fern and grows up to 3 feet. It has a dark to medium green leaves [17].
- *Pteridium aquilinum (L.) Kuhn*, also known as bracken fern, is a species of large, coarse ferns in the family Dennstaedtiaceae. Brackens are noted for their large, highly divided leaves. They are found on all continents except Antarctica and in all environments except deserts, though their typical habitat is moorland. The genus probably has the widest distribution of any fern in the world. Like other ferns, brackens do not have seeds or fruits, but the immature fronds, known as fiddleheads, are sometimes eaten, although some are thought to be carcinogenic [18].
- *Pityrogramma calomelanos (L.) Link*, or the silverback fern, is a short, erect rhizome which is covered with scales, upright fronds, can reach up to about 30 - 45 cm tall. It has stipes measuring to about 20 - 30 cm long,

fronds oblong, acuminate apex, bipinnate and fern blade measuring about 15 - 30 cm long and 10 - 15 cm wide. It has an evergreen foliage retention and has the distinct silver color at the back [19].

- *Culcita sp.,* or the soft bracken fern is a small Australian fern in the tree fern family. It is very common within its range, and often seen growing on the poorer quality soils. It is an easy plant to grow in the garden. The fronds arise from the thick brown haired rhizomes and are anywhere from 0.4 to 1.5 m in height. The foliage is a more yellow green color, in contrast to the darker shiny green. The stipe changes from dark brown, through reddish- to yellow brown, and is covered with soft brown hairs. The fronds are triangular overall and tripinnate-pinnatifid in shape. The sori occur near the margin [20].
- *Cyathea dregei*, or generally known as the native African tree fern has an erect, stout trunk is up to 5 metres (16 ft) tall and 20-45 cm in diameter. It is a variable species, usually having a thick trunk and dense crown. It is sometimes branched. Fronds are bi- or tripinnate and may reach 3 m in length. They are characteristically large and arching, with the lowest pinnae usually reduced. The rachis and stipe are brown in coloration and have a rough surface. The stipe is covered in brown scales [21].
- *Nephrolophis exaltata (L.) Schott*, known as sword fern or is an evergreen fern that grows with an upright spreading habit to 3' tall and as wide. In its native habitat, it may grow to as much as 7' tall. Generally, sword-shaped fronds have shallow toothed to entire pinnae. Fronds initially grow upward but arch gracefully with age. Its fronds are broader and droop more than those of the species herein [22].
- *Dicranopteris linearis*, or the forked fern is a fern that spreads via cloning, spreading along the ground and climbing on other vegetation, often forming thickets 3 meters deep or more. The stem grows from the rhizome, branches at a 45° angle, and forms fronds that continue to bud and branch. In this way the growth can continue for a long distance as the plant forms a mat, grows over itself in layers, and spreads. The ultimate segments of the leaves are linear in shape, up to 7 centimeters long by a few millimeters wide. The undersides are hairy and sometimes waxy. The fern grows easily on nutrient-poor soils and in disturbed habitat and steep slopes [23].

3.2. Conservational Status

Table 2 shows the conservational status per fern species labeled according to the Nature Serve Global Conservation Status Ranks. The ranks which the sample fern species obtained were least concern, secured, apparently secured, protected and locally exotic. Least concern fern species are species that have no immediate threat to survival. Secured species are species that are common, widespread and abundant. Apparently secured fern species are uncommon species but not rare. Protected species are not threatened species but the trades are controlled. Locally exotic species are those species that are rare in some areas of the globe.

In this study, it shows that three (3) out seven (7) fern sample species are least concern, one (1) is secured, one (1) is apparently secured, one (1) is protected and one (1) is locally exotic.

Table 2 Conservational Status of Ferns found in Mt. Kibuwa

Fern	Conservational Status
Sphenomeris chusana (L.) Copel	Secured
Pteridium aquilinum (L.) Kuhn	Least Concern
Pityrogramma calomelanos (L.) Link	Locally Exotic
Culcita sp.	Apparently Secured
Cyathea dregei	Protected
Nephrolophis exaltata (L.) Schott	Least Concern
Dicranopteris linearis	Least Concern

3.3. Species Richness of Ferns in Mt. Kibuwa

Figure 2 shows the species accumulation of ferns along different sites in Mt. Kibuwa. It shows that *P. aquilinum, N. exaltata*, and *S. chusana* dominate the whole area, while *C. dregei* and *Culcita sp.* are the fern species found least in the area. The domination of *P. aquilinum* in the vicinity of Mt. Kibuwa is a depiction of its feature being widespread and its ability to live in diverse ecological niches.

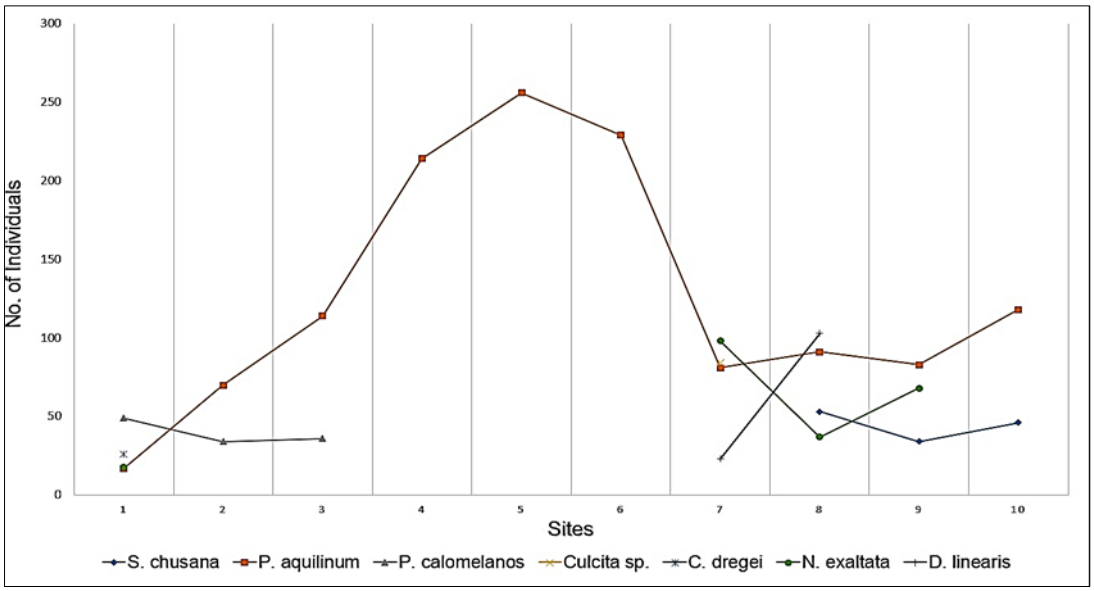

Figure 2 Species Accumulation Curve

Table 3 shows the species richness data of the fern samples found in Mt. Kibuwa, Impalutao, Impasug-ong, Bukidnon using Menhinnick's Index of Species Richness (D). Menhinick's Index known as D is represented by the formula $D = s/\sqrt{n}$ where s equals the number of different species represented in sample, and n equals the total number of individual organisms.

Table 3 Species Richness Index per Sampling Site

Sites	s	n	D
1	4	110	0.3814
2	2	104	0.1961
3	2	150	0.1633
4	1	214	0.0684
5	1	256	0.0625
6	1	229	0.0661
7	1	179	0.0747
8	5	288	0.2946
9	3	195	0.2148
10	3	257	0.1871

The results show that the Menhinnick's Index of Species Richness among all the sites are relatively similar with 0.0625 as the minimum value and 0.3814 as the maximum value. This means that Site 1 is the richest site, and site 5 is the least. Although the number of species (s) found on Site 8 is greater than in Site 1, the number of individuals (n) in Site 1 is more proportional and stable with the number of species. However, Sites 1 and 8 have a very close gap, which means that Site 8 can also be considered as one of the richest sites in the area with five different fern species out of seven.

On the contrary, Sites 4, 5 and 6 with Site 5 being the least abundant site obtained such rating since it is dominated by a particular fern species. Apparently, as observed from the data, the richness on the sites are on the same range. Thus, it can still be inferred that the species richness in accordance with the number of species and individuals found in the area are closely similar.

3.4. Species Diversity of Ferns in Mt. Kibuwa

Table 5 shows the species diversity of pteridophytes along the vicinity of Mt. Kibuwa using the Shannon-Weinner Index. The Shannon-Weinner Index assumes that all species are all represented in a sample and that all are obtained randomly. This is equated as $H' = \Sigma\, p_i\, ln\, p_i$, where p_i is the proportion of individuals found in the i^{th} species and *ln* is the natural logarithm.

Table 4 Species Diversity of Fern Samples in Mt. Kibuwa

Species	Individuals	p_i	$\lvert\ln(p_i)\rvert$	$p_i x \lvert\ln p_i\rvert$
Sphenomeris chusana (L.) Copel	133	0.07	2.66	0.1862
Pteridium aquilinum (L.) Kuhn	1273	0.6	0.51	0.306
Pityrogramma calomelanos (L.) Link	119	0.06	2.81	0.1686
Culcita sp.	84	0.04	3.22	0.1288
Cyathea dregei	26	0.01	4.60	0.046
Nephrolophis exaltata (L.) Schott	221	0.2	1.61	0.322
Dicranopteris linearis	126	0.06	2.81	0.168
TOTAL	1982	1.00		1.3256

Studies proposed that an H' value that is in between 0 and 1 suggests a low diversity. H' between 1 and 2 means a good diversity, and value better than 2 would depict a high diversity. The data on Table 5 shows that the Shannon Species Diversity Index of Mt. Kibuwa is 1.3256, therefore the area has a good diversity.

The good diversity of ferns along the vicinity of Mt. Kibuwa shows that the area is stable and is a suitable ecosystem for living things since ferns are important ecological indicators and are sensitive to environmental conditions. Fern richness is greatest in areas of high topographic relief and complexity, high evapotranspiration, and with a high humidity [24]. Ferns also help in soil formation and preventing erosion. Many ferns can harbor nitrogen-fixing bacteria, thus making it a vital part in nutrient cycling. Thus, these features can be found on Mt. Kibuwa.

4. Conclusion

The richness and diversity of ferns on Mt. Kibuwa, Impalutao, Impasug-ong, Bukidnon proves that Mt. Kibuwa must be on for ecological conservation and protection. Conserving these diverse pteridophytes is not just about protecting species and habitats for their own sake. It is also about maintaining nature's capacity to deliver the goods and services for various human consumptions, and whose loss comes at a high price.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Statement of ethical approval

The authors ensure that no animals/ humans were harmed during the conduct of the study. All protocols were observed in the study site. All procedures were followed with respect to the needs of the study.

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