The American Journal of Social Science and Education Innovations
ISSN 2689-100X | Open Access

TYPE Original Research
PAGE NO. 07-15
DOI 10.37547/tajssei/Volume07Issue04-02

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Diversity Assessment of Pteridophytes: Species Richness, Environmental Correlates and Its Uses in Hinulugan Falls

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OPEN ACCESS

SUBMITED 22 February 2025
ACCEPTED 20 March 2025
PUBLISHED 07 April 2025
VOLUME Vol.07 Issue04 2025

CITATION

Philomel Innocent P.Obligar, Eric Esteban Contreras, & Elizabeth Dayal. (2025). Diversity Assessment of Pteridophytes: Species Richness, Environmental Correlates and Its Uses in Hinulugan Falls. The American Journal of Social Science and Education Innovations, 7(04), 07–15. https://doi.org/10.37547/tajssei/Volume07Issue04-02

Abstract: This study entitled "Diversity Assessment of Pteridophytes: Species Richness, Environmental Correlates and Its Uses in Hinulugan Falls" aimed to identify the different species of Pteridopytes, determine the species richness and environmental correlated and to determine its ethno-medicinal uses. Opportunistic random sampling technique or visual encounter technique and transect walk technique were used to gather data. Species identification were identified with the help of Co's Digital Flora of the Philippines and diversity of pteridophytes were determined using Simpson's Diversity Index. Environmental correlates or predictor such as soil analysis and soil pH was done on laboratory with the assistance from the Municipal Agriculture Office.

Fourteen (14) species of pteridophytes were found in Hinulgan Falls. Among the types of habitat identified, the higher species richness of Pteridophytes were in the lower stream and the lowest species richness were at the upper stream. Furthermore, in terms of diversity index the highest diversity index were at the lower stream and the midstream and the lowest diversity index were at the upper stream.

Among the pteridophytes collected from site were used to cure common ailments such as wounds and skin disease and were applied directly using the leaves of the plants. The pteridophytes have higher species richness in lower and midstream in loamy type of soil having a soil ph of 4.9-5.0 which is acidic and have lowest species richness in upperstream with a clay loamy types of soil with a ph of 6.8 which is slightly acidic. Such environmental predictors such as soil type and soil ph have no impact on the species richness and diversity of pteridophytes.

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Keywords: environmental correlates, ethno-medicinal usage, Hinulugan falls

Introduction: Hinulugan Falls is one of the tourist attractions in the Municipality of Pilar. It is located the mountainous area barangay Tabun-acan. It is inhabited by many species of plants and animals making it a subject for many researchers that studies flora and fauna.

Pteridophytes are vascular plants and have leaves (known as fronds), roots and sometimes true stems, and tree ferns have full trunks. Examples include ferns, horsetails and club-mosses. Fronds in the largest species of ferns can reach some six metres in length. Many ferns from tropical rain forests are epiphytes, which means they only grow on other plant species; their water comes from the damp air or from rainfall running down branches and tree trunks. There are also some purely aquatic ferns such as water fern or water velvet (Salvinia molesta) and mosquito ferns (Azolla species). Pteridophytes do not have seeds or flowers either, instead they also reproduce via spores. There are around 13,000 species of Pteridophytes. (http://www.theplantlist.org/)

Pteridophytes range greatly in size. There are tiny floating ferns used as "green fertilizer" in rice paddies because they partner with bacteria that pull nitrogen from the air and "fix" it in chemical compounds that other plants can use. In some tropical forests, the largest plants are tree ferns that can be up to 30 meters (100 feet) tall and have huge spreading leaves up to 4.5 meters (15 feet) in length. Pteridophytes also show a transition from simple to complex leaves. Some pteridophyte groups, including the club mosses and horsetails (classes Lycopodiopsida and Equisetopsida), have simple microphyllous leaves, featuring a single, unbranched vein and modest vascular supplies that do not cause breaks or gaps in the stem vasculature. The true ferns (class Filicopsida), however, have larger, more complex macrophyllous leaves whose veins are usually extensively branched, placing such large demands on the plant's vasculature that distinctive gaps form in the xylem and phloem of the stem. All pteridophytes have a true alternation of generations, in which a dominant sporophyte generation produces spores through meiosis, and a free-living gametophyte generation forms gamete (egg and sperm) by mitosis. Ferns can be used to illustrate the life cycle stages common to all pteridophytes. Diploid (2n) fern sporophytes are familiar to most people and are often found as quiet accompaniments in floral arrangements. When mature, the undersides of fern leaves produce clusters of capsular structures called sporangia, within which meiosis forms the haploid (n) spores. These spores are released from the sporangia, often when dry wind currents cause the active snapping of the capsules, lofting the spores into the air.

Although most pteridophytes are homosporous (produce spores that are all the same size), a few groups are heterosporous with large megaspores and small microspores. The megaspores produce megagametophytes that only form eggs, and microspores only produce microgametophytes and sperm. Heterospory evolved independently in several groups of vascular plants, including all members of the orders Selaginellales and Isoëtales and those in a few fern groups (the families Marsileaceae and Salviniaceae of the class Filicopsida). The most successful origin of heterospory ultimately resulted in the great diversity of seed plants. (http://www.biologyreference.com/Po-Re/Pteridophytes.html)

Mustacisa (2016) stated that to elevate awareness among people and give value to ferns which rapidly grow anywhere but being deracinated because of its low livelihood potential a scientific study was conducted and aimed to generate a theory that can shed light on how the participants develop awareness without formal education and their knowledge on ferns come into being. To properly meet the aims of the study, the researcher utilized a grounded theory combined with axiomatic approach and descriptive research design to which, the verification used was in-depth interview in semi-structured type given to the eighteen farmers. Corollary, the study revealed that research participants has no formal education but they are able to distinguish the different members of the fern family, and tend to develop indigenous knowledge from the practiced of their ancestors, these lead to Epistemological Perception theorized by the researcher that, an indigenous knowledge and informal education is not enough, it must be transformed to scientific facts. As such, the researcher recommends that the local government unit (LGU) of the research environment together with the provincial office of the Department of Environment and Natural Resources (DENR) must come up with a program that will divert indigenous knowledge into scientific facts through formal education. With that collaboration, the rapid growth of ferns in the place will turn to an opportunity to form a new livelihood. This is one way to recognize the diversity, uses and economic value of ferns.

Amoroso (1998) stated that the economic ferns of Mindanao, Philippines are slowly being lost and threatened because of deforestation and increasing population. This study was conducted to find ways of conserving these ferns before they would completely disappear from their natural habitats. Spores of some economic ferns viz. Platycerium grande, Asplenium nidus, Blechnum orientale, Cyathea contaminans, Leucostegia immersa, Asplenium decorum, Pteris mutilata, Adiantum capillus-veneris, Pteris mutilatavar. victoriae, Osmunda banksiifolia, Lygodium japonicum and Lygodium flexuosum were cultured in vitro to find out the appropriate conditions for spore germination and to monitor prothallial and sporophyte development. Among these species of ferns, the highest percentage of spore germination was observed in Lygodium flexuosum, Asplenium nidus and Blechnum orientale (94%–95%) thirty days after sowing. All of them formed prothalli which later gave rise to sporophytes (plantlets). The sporophytes of Platycerium grande, Blechnum orientale, Asplenium nidus and Lygodium flexuosum were successfully transplanted in potting medium. Thus, spore culture is one way of conserving and propagating these ferns.

This study was conducted to determine the diversity assessment of pteridophytes, species richness, its uses and environmental correlates in Hinulugan Falls. Specifically, this study was conducted with the following objectives: 1. to identify the pteridophytes species present in the upper, mid and lower stream of Hinulugan Falls, 2. to determine the species richness, diversity index of pteridophytes species present in the upper, mid and lower stream of Hinulugan Falls, 3. to determine the ethno-medicinal uses of pteridophytes species, and 4. to determine the environmental correlates of pteridophytes such as soil type and soil ph to the species richness and diversity.

Results of this study will give a baseline data on the species of pteridophytes present in Hinulugan Falls. Many people living in rural or mountainous areas are economically challenged and do not have sufficient access to modern medicine. The knowledge about those local medicinal resources were handed down through many generations. Ferns have various ethno botanical uses which could either be for food consumption, aesthetic value and medicine. This will also give them idea what are the uses of some pteridophytes species found in their areas.

RESEARCH METHODOLOGY

This study used the descriptive survey methods. It was conducted at Hinulugan Falls located at the mountain ranges of Pilar, Capiz. Most of the area were privately owned but is one of the tourist attractions of the municipality. During the conduct of the study the following materials were used: camera, digital microscope, calculator, a pen, notebook, laptop computer, and a specimen jar. Before the conduct of the study, a permit regarding the conduct was secured from the Municipal mayor and barangay captain of Barangay Tabun-acan, Pilar, Capiz. Permit was also secured from the Municipal Environment and Natural Resources. A preliminary survey was done to familiarize the area. First Survey was done on September 15-16, 2018, and the second survey followed on September 29-30 and the last was on October 14-15, 2018. The survey was done only on Saturdays and Sundays. Opportunistic random sampling technique or commonly known as visual encountered method and transect walk technique were the survey techniques used in the assessment of pteridopyhtes. During the survey, species of Pteridophytes were enumerated, photograph and were collected and compared to available protologues for identification. Data bases such as Co's Digital Flora of the Philippines, Philippineplant.org and other publication on ferns were also used. Expert from Biodiversity.org were also asked for further identification. For ethnomedicial uses of ferns an 5 informant through the referral of barangay officials were interviewed on the uses of some pteridophytes. This informant were composed of a traditional healers, hilot, and an elderly person in the barangay that uses this plants to cure illnesses. To measure the species diversity of Pteridophytes in Hinulugan Falls, Simpson's Diversity Indices were used. A formula introduced by Curtis and McIntosh (1950) was also used to determine the species richness. Sample of soils were collected and were brought to the laboratory for the analysis of Soil Type and Soil Ph. Standard laboratory steps for soil analysis were followed. Soil analysis were done with the assistance form the personnel of the Municipal Agriculture Office. To determine the environmental correlates a spatial ecology analysis were done using Moran's I.

RESULT AND DISCUSSION

Species of Pteridophytes found in Hinulugan Falls

Fourteen (14) species of pteridophytes were found in Hinulgan Falls. There were more number ferns found in the lower stream of the falls with 524, followed by the middle stream with 337 and the last were at the upperstream with 172 . Pityrogramma calamelaros got the highest number with 124, followed by dryopteri with 113, Athyrium niponicum with 107, Davallia fejeensis with 104, Osmunda regalis with 98, Dryopteris rythosa, Woodwardia unigemmata, Pteridium aquilinum with 84 respectively, Micrusurum commutatum with 43, Odontosoria chinensis with 22, Nephrolepsis brownie with 20, and the lowest in number were Cyathea contaminans with only 7.

According to Amoroso, V. (2016) an updated species list and conservation assessment of ferns and lycophytes in Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental are provided on the basis of our recent field survey and examination of herbarium specimens. One hundred and fifty-two species, belonging to 27 families and 72 genera, are recorded. The species figure is about 13% of the total number of fern and lycophyte species in the Philippines and nearly 20% of the total number on Mindanao Island. Twelve species are broadly distributed Philippine endemics and three more are found only on Mindanao. Nine species are new records for Mindanao. A site-endemic species, Lindsaea hamiguitanensis, is also documented. Of the 18 threatened species recorded, one is critically endangered, seven are endangered, and 10 are vulnerable.

This suggest that pteridophytes grows better in an area with conducive ecological conditions. The upper stream were mostly rocky and are not suitable for plants to grow. Despite the ecological disturbance in the middle stream because it is the area where tourist frequently visits, still the plants grows very well.

Table 1. List and number of species of Pteridophytes found in upstream, midstream and lower stream of Hinulugan Falls

Scientific Names	No. of Species			Total
	Upper Stream	Mid Stream	Lower Stream	
Pityrogramma calamelaros	24	41	59	124
Nephrolepsis brownie	8	19	36	63
Xandenboschia auriculata	3	6	11	20
Dryopteris	22	39	52	113
Dryopteris rythosa	18	27	39	84
Osmunda regalis	18	33	47	98
Micrusurum commutatum	6	16	21	43
Athyrium niponicum	18	38	51	107

Odontosoria chinensis	3	7	12	22
Cyathea contaminans	0	3	2	5
Woodwardia unigemmata	10	25	49	84
Pteridium aquilinum	13	27	44	84
Davallia fejeensis	15	33	56	104
Cyathea	12	23	45	80
TOTAL	13	14	14	

Drypteris

Pityrogramma calamelaros

Cyathea contaminans

Woodwardia unigemmata

Davallia fejeensis

Nephrolepsis brownii

Dryopteris erythrosa

Xandenboschia ariculata

Odontosoria chinensis

Pteridium aquilinum

Microsurum commutatum

Osmunda regalis

Cyathea

Athyrium niponicom

Figure 1. Pteridophytes species found in Hinulugan Falls

Species Richness and Diversity Index of Pteridophytes

Among the types of habitat identified, table 2 showed that the higher species richness of Pteridophytes were in the lower stream with 14 followed by the midstream with 14 and the lowest species richness were at the upper stream with only 13. Furthermore, in terms of diversity index the highest diversity index were at the lower stream and the midstream and the lowest diversity index were at the upperstream.

Several factors affected the species richness in the upper stream such as the soil type, and climatic condition. Species richness in the lower and middle stream were affected by human activities and the conversion of the area into a tourist attraction.

Nagalingum, (2015) stated that because ferns have a wide range of habitat preferences and are widely distributed, they are an ideal group for understanding how diversity is distributed. Here we examine fern diversity on a broad-scale using standard and corrected richness measures as well as phylogenetic indices; in addition, we determine the environmental predictors of each diversity metric. Using the combined records of Australian herbaria, a dataset of over 60,000 records was obtained for 89 genera to infer richness. A molecular phylogeny of all the genera was constructed and combined with the herbarium records to obtain phylogenetic diversity patterns. A hotspot of both taxic and phylogenetic diversity occurs in the Wet Tropics of northeastern Australia. Although considerable diversity is distributed along the eastern coast, some important regions of diversity are identified only after sample-standardization of richness and through the phylogenetic metric. Of all of the metrics, annual precipitation was identified as the most explanatory variable, in part, in agreement with global and regional fern studies. However, precipitation was combined with a different variable for each different metric. For corrected richness, precipitation was combined with temperature seasonality, while correlation of phylogenetic diversity to precipitation plus radiation indicated support for the species-energy hypothesis. Significantly high and significantly low phylogenetic diversity were found in geographically separate areas. These separate areas correlated with different climatic conditions such as seasonality in precipitation. The phylogenetic metrics identified additional areas of significant diversity, some of which have not been revealed using traditional taxonomic analyses, suggesting that different ecological and evolutionary processes have operated over the continent. Our study demonstrates that it is possible and vital to incorporate evolutionary metrics when inferring biodiversity hotspots from large compilations of data.

Table 2. Species richness and diversity index of Pteridophytes in different types of habitat

Type of Habitat	Species Richness	Diversity Index
Lower Stream	14	0.998
Midstream	14	0.998
Upper stream	13	0.997

Ethno-medicinal Usage of Pteridophytes

Result showed in table 3 that among the ferns collected from site, were used to cure common ailments such as wounds and skin disease and were applied directly using the leaves of the plants.

According to Singh et. Al (2017) a total of 23 plant species belonging to the 18 genera in 15 families used in treating 16 different gynecological/reproductive health related diseases by the tribal women of Gond, Korku, Bharia, Bhil and Mabasi communities of Pachmarhi Biosphere Reserve which contribute to about 18.66% of total pteridophytic diversity (134 species) of the area. The medicines obtained from these ferns are used during pregnancy (antenatal), at delivery, and after delivery (post-partum). Oral consumption is the most frequently employed route of administration while inhalation appeared to be the least preferred route of administration. All plant parts such as rhizomes, tubers, fronds, leaves, stem and spores are used as medicine. Leaves were the most popular plant part utilized in herbal preparations (37%), rhizome (26%), whole plant (23%) while fronds (including spores) were used infrequently (14%). Out of 23 species of ferns utilized for the herbal preparation 52% are common, 26% are occasional and only 22% are rare to the area .On the basis of the occurrence of the plant habit 12 species are terrestrial, 9 are lithophytes, 2 are epiphytes on tree and only one is climber .

Timada (2015) find outs that Mt. Musuan was inhabited by 301 species of trees, 51 species of shrubs, 50 species of grasses/sedges, 46 species of herbs, 42 species of vines, 31 species of ferns, and 3 species of fern allies. In terms of species number, Mt. Musuan was dominated by trees. Family Euphorbiaceae had the highest number of genera and species. In terms of species number, the family Moraceae and Meliaceae ranked next to Euphorbiaceae. In terms of genus number, the family Leguminosae and Annonaceae ranked next to Euphorbiaceae. Endemism in Mt. Musuan was quite high, about 24% of all the toal plant species in the said place. There were 128 endemic species in Mt. Musuan. Furthermore, 188 species were recorded as economically important; 48 species, depleted; 9 species, rare; and 3 species, endangered, namely: Cananga odorata, Cynometra ramiflora and Tectona philippinensis. An unusual parasitic plant (Balanophora fungusa) and a rare gymnosperm (Gnetum gnemon) were observed in the natural forest. Trees recorded to have high dominance values were: Clausina brevistyla, Artocarpus blancoi, Antidesma ghaesambilia and Alstonia scholaris. Tree profile diagrams revealed that belt transects established near the forest trail had lesser number of species than those established in the inner part of the forest. In situ conservation of the endangered, rare, and economically important species, specifically those found in the natural forest should be done. For plants with botanical importance, an ex situ conservation should be conducted by establishing a Green House near the foot of Mt. Musuan. Mass propagation should be made by tissue or spore culture techniques for slow growing plants. Rules and regulations should be implemented to avoid the occurrence of fires and destruction of the flora of the said area. Since Mt. Musuan has been designated as a Zoological and Botanical Garden, plants which are endemic, endangered, rare, depleted, and economically important should be properly labeled (scientific and local names) for the students and visitors to easily identify the plants.

Table 3. Ethno-medicinal Uses of pteridophytes

Scientific Names	Disease	Plants part Used	Mode of Preparation
Pityrogramma calamelanos	Open Wounds	Leaves	Applied Directly
Nephrolepsis brownie	Skin Diseases	Leaves	Applied Directly
Xandenboschia auriculata	Open wounds	Leaves	Applied Directly
Dryopteris	Open wounds	Leaves	Applied Directly
Dryopteris rythosa	Open wounds	Leaves	Applied Directly
Osmunda regalis	Open wounds	Leaves	Applied Directly
Micrusurum commutatum	Open wounds	Leaves	Applied Directly
Athyrium niponicum	Open wounds	Leaves	Applied Directly
Odontosoria chinensis	Skin Diseases	Leaves	Applied Directly
Cyathea contaminans	Allergy	Leaves	Applied Directly
Woodwardia unigemmata	Allergy	Leaves	Applied Directly
Pteridium aquilinum	Open wounds	Leaves	Applied Directly
Davallia fejjensis	Open wounds	Leaves	Applied Directly
Cyathea	Open wounds	Leaves	Applied Directly

Species richness and Environmental Correlates

The data showed that pteridophytes have higher species richness in lower and midstream in loamy type of soil having a soil ph of 4.9-5.0 which is acidic and have lowest species richness in upper stream with a clay loamy types of soil with a ph of 6.8. The species richness and diversity index have a negative correlation with the environmental factors such as soil ph.

According Zhang et. Al (2017) the relationships between species richness and driving factors might vary with taxa and spatial scale. In this study they used plant species data of eight groups from nature reserves in China, namely pteridophytes, gymnosperms, angiosperms, vascular plants, Chinese endemic species, rare and endangered plants, woody plants, and herbaceous plants, and eight putative environmental predictors to explore the relationships between plant species richness and environmental factors at two spatial scales (temperate region and national scale). Our data suggested that area, mean annual temperature, and mean annual precipitation were the determinants of variation in species richness within these eight groups in the temperate nature reserves of Shandong Province in China. The relationships between plant species richness and environmental factors were consistent in different groups. However, the relationships between species richness and mean annual temperature varied with spatial scale. In the temperate region, species richness was negatively correlated with mean annual temperature and positively correlated with mean annual precipitation, whereas on a national scale species richness was positively correlated with both mean annual temperature and mean annual precipitation. Our study confirmed that the relationships between plant species richness and environmental factors in nature reserves were consistent in the studied groups and varied with spatial scale.

Table 4. Species richness and environmental correlates

Type of Habitat	Species Richness	Species Diversity	Soil Ph	Soil Type	Moran's I Correlation Coefficient	Phosphorous	Potassium
Lower Stream	14	0.998	5.0	Loamy	-0.99891	Moderate	Moderate
Midstream	14	0.998	4.9	Loamy	-0.99891	Moderate	moderate
Upper stream	13	0.997	6.8	Clay Loamy	-0.99890	moderate	Deficient

CONCLUSIONS

Result revealed that Fourteen (14) species of pteridophytes were found in Hinulgan Falls. There were more number ferns found in the lower stream of the falls with 524, followed by the middle stream with 337 and the last were at the upperstream with 172. Pityrogramma calamelanos got the highest number with 124, followed by dryopteri with 113, Athyrium niponicum with 107, Davallia fejjensis with 104, Osmunda regalis with 98, Dryopteris rythosa, Woodwardia unigemmata, Pteridium aquilinum with 84 respectively, Micrusurum commutatum with 43, Odontosoria chinensis with 22, Nephrolepsis brownie with 20, and the lowest in number were Cyathea contaminans with only 7.

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have a negative impact on the species richness and diversity of pteridophytes.

Recommendations

Based on the result of the study, an in-depth assessment of pteridophytes should be done to have a baseline data of the different species found in the municipality of Pilar. This could help them in policy making on the conservation of the species which is endemic and had potential ethno-medical value.

A scientific analysis should be done to analysis the ethno-medicinal uses of ferns to have a basis for further studies on its uses. Environmental policies both from municipal and barangay level be implemented for the conservation of this species and so regulate local exploitation practices.

Awareness campaign be conducted on the ecological importance of ferns and medicinal usage to make the public knowledgeable on its economic and ethno-medical value.

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Damaynati Jadhav1*, Manda Ghatage1, Vanita Karande21. Department of Botany, B V's M.B. S. K., Kanya Mahavdihyalaya, Kadegoan, PHYTOCHEMICALS STUDIES ON THREE EPIPHYTIC FERNS FROM MAHABALESHWAR AND PANCHGANI HILLS. 2019 Life Science Informatics Publication All rights reserved
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2019 May – June RJLBPCS 5(3) Page No.680