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Fern (PTEROPHYTA) Species Diversity in Caraga, Davao Oriental: Basis for Instructional Materials (IMs) Development

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Abstract— This quantitative-descriptive study focuses on the diversity of fern species in P.M. Sobrecarey, Caraga, Davao Oriental, and the development of instructional materials for high school students. The main goal of this study was to analyze the level of physicochemical parameters of the study site, such as temperature, humidity, altitude, and soil pH fern species, taxonomical classification and characteristics inhabiting the area, species composition, relative abundance, and fern species biodiversity indices. All fern species found in the identified study area were examined, recorded, and identified using quadrant sampling as methodology. Eleven fern species were found in the study area. It consisted of species from the families of Cyatheaceae, Selaginellaceae, Thelypteridaceae, Gleicheniaceae, Nephrolepidaceae, Blechnaceae, Athyriaceae, and Dryopteridaceae. Fern species were identified through their frond size, height, stipe, frond color, and frond type. The species with the highest number of individuals, totaling 493, was Nephrolepis biserrata from the family Nephrolepidaceae, with a relative abundance of 22 percent and a cumulative distribution of 62.56 percent. In comparison, Pleocnemia irregularis from the family Dryopteridaceae, with only 39 species obtained, had the lowest relative abundance of 1.73 percent. The research area has an average temperature of 30.8 degrees Celsius, low humidity of 73.7 percent, low elevation of 120 asl, and neutral soil pH level of 5.4. Furthermore, it was found that the instructional material in Science 8 that can be developed relative to the species diversity of ferns in Caraga, Davao Oriental, is the self-learning kit.

Keywords— Biodiversity indices, Fern species, Instructional Materials, Taxonomic classification.

I. INTRODUCTION

Teaching science competencies using instructional materials that are not localized is still the dominant learning resource for teaching plant biodiversity. The environment has great potential to be used as instructional material, but using the environment as the source of teaching and learning biodiversity has not been done much. Instructional materials are essential in achieving the learning competency that can be found in the surroundings. Further, appropriate and relevant instructional materials are necessary for the teaching and learning process to achieve the desired learning goals (Susilo & Yuningsih, 2022). According to Muldayanti et al. (2021), localized instructional materials are significant in teaching students since the subject matter has something to do with the learners. However, the resources present in the environment are not used as learning material.

In Indonesia, Mumpuni (2022) reports that a lack of modules about biodiversity and outdated science textbooks that did not use local plants resulted in the students' low curiosity and awareness of plant biodiversity. On the other hand, in Malaysia, plants that can be found in the locality are not used as instructional materials in science

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teaching, and there is a need to increase the motivation and concern of students for the local plant biodiversity (Yustina et al., 2020 & Zhang et al., 2020). Moreover, the teaching of biodiversity in Brazil is negatively affected by different factors. These factors include inadequate instructional materials that lead to a lack of knowledge about local plants and the use of conventional biodiversity concepts in teaching rather than local concepts (Araujo & Alitto, 2021). In Morocco, secondary school students are having difficulty classifying, identifying, and recognizing ferns and moss species' morphological features due to a lack of instructional resources about classifying plants, the traditional method of teaching, and outdated teaching materials and methods (Zghida et al., 2022).

Meanwhile, in Aurora, Philippines, Coracero (2022) has reported that many students were not environmentally educated about the conservation and protection of biodiversity. The knowledge and perspective of students about the Philippines' biodiversity need to be reviewed. Further, a study in Surigao Del Sur found that many schools have limited access to instructional materials for teaching and learning science, which results in low student performance (Montero & Geducos, 2022). Moreover, in Cebu, due to the inadequacy of science instructional materials, many schools could not provide students with concrete and relevant teaching and learning experiences (Rivera & Sanchez, 2020).

Locally, in Caraga South District, science teachers have used inadequate localized instructional materials to teach science competencies, especially biodiversity concepts. In addition, for the school year 2022-2023, localized instructional materials were developed by teachers in different subject areas. However, no localized printed instructional materials explain the biodiversity of fern species and their conservation that undergo validation checking (Learning Resources Management and Development System- Caraga South District, 2022).

The review of the problem of localized instructional materials described above prompted the researcher to conduct this study. Local plants, especially fern species, are given less importance in society, and their role in the teaching and learning process and importance in the environment are not fully realized. Further, fern species diversity is the focus of this research because this species is rich in number and can be easily found within the locality. Moreover, if the fern species found in the locality are not explored and not used in teaching species diversity, they will be left unidentified and undocumented.

There have been studies conducted on the species diversity and abundance of corals and fishes (Luna, 2021), distribution and diversity of Macrofungi (Rafol, 2021), and Mangrove species biodiversity (Punong, 2021) as the basis for the development of instructional materials in teaching science competencies. However, most of it is conducted outside the Province of Davao Oriental. The researcher has not found any study that uses fern species biodiversity as the basis for instructional materials development, especially in the municipality of Caraga, Davao Oriental. Thus, there is an urgency to conduct this study to develop localized instructional materials on fern species diversity.

Furthermore, this study's outcome will benefit science teachers and students as this research can be utilized in teaching and learning fern species diversity, the hierarchical taxonomic system of classification, and the protection

and conservation of endangered and economically important species like ferns. Finally, the researcher aims that the results of this study will be presented in scientific seminars and workshops focusing on the retooling of instructional materials, published in a research journal, and provide a copy of the manuscript to the district offices of Caraga North and South, and to be included in the (LRMDS) Learning Resources Management and Development System of the Division of Davao Oriental.

This research was intended to develop instructional materials that explain the fern species' biodiversity in Sitio Binaton, Pacifico Moralizon Sobrecarey, Caraga, Davao Oriental. Hence, to realize the said objectives, this research sought answers to the following questions: What is the level of Physicochemical parameters of the study site in terms of: temperature; humidity; altitude; and soil pH? What are the taxonomical classifications and characteristics of fern species inhabiting the study area? What are the species composition and relative abundance of the fern species in the study site? What are the fern species biodiversity indices in terms of: richness; and evenness? And lastly, what instructional material (IM) in Science 8 can be developed relative to the diversity of fern species in Caraga, Davao Oriental?

II. METHODOLOGY

A. Research Design

This research used a quantitative-descriptive design. Quantitative research involves the collection and analysis of numerical data used to obtain the general results collected from the wider population sample (Bhandari, 2020). The quantitative research design helped the researcher to determine the measurements of the parameters that contribute to the growth of the fern species. Quantitative research was used to determine the species composition, relative abundance, species indices (richness and evenness), and physicochemical parameters (temperature, humidity, altitude, and soil pH) found in the study area. In addition, a quantitative research design was utilized to list and identify fern species found in the study site. Descriptive research is an approach that deals with analyzing, gathering, and classifying data and making an accurate descriptive interpretation of the data collected (Calderon, 2006). A descriptive approach aided the researcher in describing and collecting data on fern species found in the study site. Further, descriptive research was utilized in gathering data such as determining the taxonomical classification and characteristics of fern species.

B. Research Subject

The research subjects of this study were the fern species that was collected in Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental. Ferns are one of the most diverse vascular seedless plants that occupy almost tropical and temperate forests. Ferns vary in size and volume and they can be easily seen as it grows in soil and tree trunks along the road. Thus, it's convenient for the researcher to collect the fern species as it is found directly.

C. Research Locale

The study was conducted along the road of Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental. Barangay P.M Sobrecarey is geographically located at a latitude of 7°20' N and 126°29' E. The elevation of the research locale is estimated at 65.0 meters or 213.3 feet above mean sea level, which makes the place a tropical and temperate forest

Volume: 03 / Issue: 04 / 2024 - Open Access - Website: www.mijrd.com - ISSN: 2583-0406

(PhilAtlas, 2023). Due to these reasons, the identified research locale is suitable to be the place as a study site for this research as it is the best place for the fern species to grow and survive (Priambudi et al., 2022). Shown in figure 1 is the map of Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental.

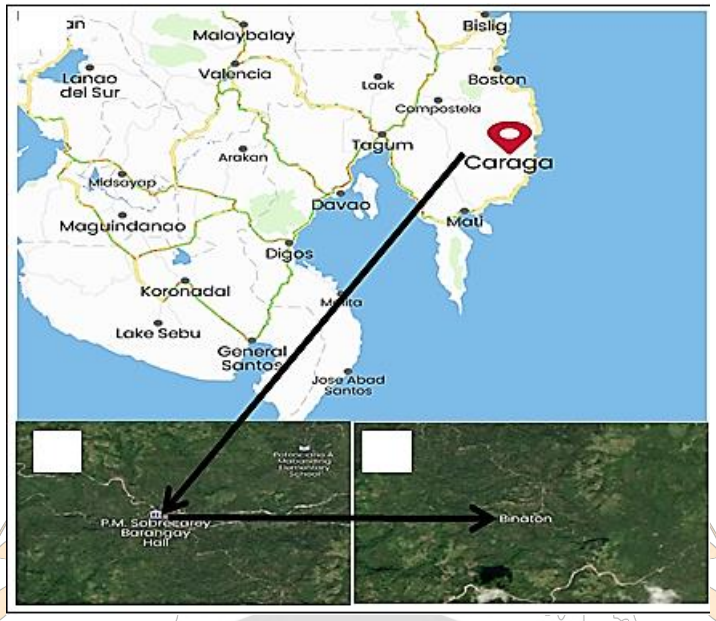

Figure 1. The Local Map of the Municipality of Caraga (A), the map of Barangay P.M. Sobrecarey (B), and the map of Sitio Binaton the research locale of the study (C). | Source: Mapcarta

C. Research Materials and Instruments

The research materials and instruments that were used in conducting this study were the transect lines with an interim of 90 meters long, a 10x10 meter quadrant, digital thermometer, hygrometer, altimeter, pH meter, camera for documentation, tape measure, and manual/book references for the identification, and the classification of fern species present in the study site. The transect line that measures 90 meters of rope length was laid perpendicular to the identified study area. A 10x10-meter bamboo quadrat was laid down along the transect line. Six quadrats were attached in every (1) transect line in four (4) different sampling areas. A 10x10 meter quadrat was used to identify the number of fern species present in the study area. A digital thermometer was used to measure the temperature of the study area. A hygrometer was utilized to measure the humidity of the study site. An altimeter was used to measure the altitude. The pH meter measures the pH level of the soil. The measuring tape is used to measure the height of fern species. Moreover, the camera was used for the documentation of the fern species present in the research locale. The Co's Digital Flora of the Philippines manual (Pelser et al., 2011), The Pteridophyte Phylogeny Group I classification system (PPG I 2016), Learn about Ferns: A guide to identifying ferns (Brennan et al., 2021), and What's that Fern? (British Pteridilogical Society, 2012) were used to name the fern species identified in the research area. Finally, the quality assurance tool developed by the Department of Education was utilized by the validators to validate and check the localized instructional materials.

Volume: 03 / Issue: 04 / 2024 - Open Access - Website: www.mijrd.com - ISSN: 2583-0406

In this study, relative abundance was determined by calculating the total number of each species divided by the totality of species present in the study area and multiplied by 100. Furthermore, the diversity of fern species was evaluated and interpreted using the Shannon-Weiner diversity index (H') and Simpson index of diversity (D) and evenness (Magurran, 1998). The value of Shannon-Weiner (H') Diversity Index will be calculated using the equation, H' = -∑ pi(LNpi), which H' is the species diversity index, pi is the proportion of individuals of one specific fern species found over the total number of individuals identified in the study site, and ln= is the natural log. The Shannon-Weiner diversity index was used to define the diversity of fern species identified in the study area. The value of Evenness Index was calculated using the equation E' = H'/LN(s) which E' is the evenness diversity index, H' is the species diversity index, Ln is the natural log, and s is the number of species. This study utilized this to determine the species evenness of fern species in the identified study site. The value of Simpson Index of Diversity was calculated using the equation $D = 1- \frac{\Sigma n(n-1)}{N(N-1)}$ which n is the total number of specific fern species, N is the total number of all fern species, and D is the diversity index which ranges between 0 to 1. This study utilized this to identify the diversity index of fern species in the study site.

Further, the researcher assessed and interpreted epiphytic plant diversity using the description of species indices.

Where:

(H')	<1.5	= Low Diversity
	1.5 < 2.5	= Medium Diversity
	> 2.5	= High Diversity
(E)	Closer to 1	= More Even
	Closer to 0	= Less Even
(D)	0.00	= Absence of Diversity (homogeneity)
	0.01-0.40	= A low degree of Diversity/heterogeneity
	0.41-0.60	= A moderate degree of diversity/heterogeneity
	0.61-0.80	= A moderately high degree of diversity/heterogeneity
	0.81-0.99	= A high degree of diversity/heterogeneity
	1.00	= Absolute (perfect) diversity/heterogeneity

D. Development of Localized Instructional Materials

The researcher developed an instructional material, specifically the self-learning kit, anchored on the results and findings of the research conducted in Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental. The self-learning kit contained information about the concept of species diversity and the taxonomical classification of fern species found on the study site. Also, this localized instructional material was comprised of learning and enrichment activities that will help the learners fully understand the concept of biodiversity. Furthermore, the development of localized instructional materials is in response to the Department of Education's vision of integrating localized instructional materials in the teaching and learning process (DepEd Order No. 35, s. 2016). The localized

instructional materials as the output of this study help make teaching and learning about the concept of species biodiversity more effective and interactive.

III. RESULT AND DISCUSSION

Physicochemical Parameters of the Study Area

Table 1 presents the physicochemical parameters that were measured and recorded during the sampling period in Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental.

Table 1. Level of Physicochemical Parameters of the Study Area

Sampling Plots	Temperature (°C)	Description	Humidity	Description	Altitude (asl)	Description	Soil pH	Description
1	27.3	Average Temperature	87	High Humidity	89	Low Elevation	7.1	Neutral
2	31.1	Average Temperature	73	Low Humidity	109	Low Elevation	5.6	Acidic
3	31.8	Average Temperature	74	Low Humidity	135	Low Elevation	6.7	Neutral
4	33.1	Average Temperature	61	Low Humidity	147	Low Elevation	6.8	Neutral
Average	33.1	Average Temperature	73.7	Low Humidity	120	Low altitude	6.5	Neutral

The temperature within the study area ranged from 27.3-33.1 degrees Celsius. The average of the temperature of the study area is 33.1, which means average temperature. There was a variation in the temperature in four sampling plots due to the difference in the day and the time when the data sampling was conducted. Temperature plays a significant role in the diversity and distribution of fern species as it contributes to the survival and existence of fern species. For instance, high air humidity is possible only when the temperature is low. Thus, this will make a suitable habitat for all fern species inhabiting the particular surroundings (Sianturi et al., 2020).

In terms of humidity, the study area had a humidity value of 87% in sampling plot 1; sampling plot 2 had a humidity value of 73%; sampling plot 3 had a humidity value of 74%; and sampling plot 4 had a humidity value of 61 %. The average value of the humidity of the study area is 73.7, which means low humidity. Fern species' existence, richness, and distribution are significantly affected by climatic conditions like the humidity level of the habitat. If the humidity level cannot provide the needs of the ferns in order to grow, their richness and existence will be affected (Pujiastuti et al., 2023).

The altitude in the study area ranged from 89 m to 147 m above sea level, with a median of 120 m above sea level in the four sampling plots, which means low altitude. According to Umair et al. (2023), the altitude has a unimodal relationship with fern species, and species richness is the largest at an altitude of 2,500 m. Thus, in this study, the richness of the fern species is at medium diversity due to its low altitude.

Sampling plot 1 had a soil pH level of 7.1; sampling plot 2 had a soil pH value of 5.6, sampling plot 3 had a soil pH value of 6.7, and sampling plot 4 had a soil pH value of 6.8. The average soil pH value of the study area is 6.5, which

means the soil pH of the study area is neutral. This result is parallel to the study of Rahmad and Akomolafe (2018), which states that the soil with a pH value approaching neutral conditions allows more plant types to grow and survive. Further, soil pH influences masses of soil biological, chemical, and physical properties and processes that affect plant growth and biomass yield (Leao, Mehltreter, and Lizandro, 2018).

Physicochemical parameters such as pH, humidity, light intensity, and temperature greatly influence the diversity of fern species (Neina, 2019). When humidity decreases, the richness of the fern species declines. Further, moisture, light, and temperature are the environmental conditions that establish ferns' diversity and composition (Sianturi et al., 2020; Carvajal-Hernandez, 2017).

Taxonomical Classification of Fern Species

The measurement of height and actual observation in the study area with photographs of leaves, spores, and stipes were utilized to create this taxonomic account and its characteristics. To further validate the taxonomical classification of fern species, Co's Digital Flora of the Philippines (CDFP) (Pelser et al., 2011), Pteridophyte Phylogeny Group I classification system (PPGI, 2016), and related literature were used, and the results were confirmed valid and accurate by the botanists.

The taxonomic classification and characteristics of fern species are seen in Table 2. There were 11 species found in the study site that belong to eight families, namely: The Family Cyatheaceae, Selaginellaceae, Thelypteridaceae, Gleicheniaceae, Nephrolepidaceae, Blechnaceae, Athyriaceae, Dryopteridaceae. The Family Cyatheaceae, which includes Sphaeropteris sp. The Family Selaginellaceae includes Selaginella delicatula. Family Thelypteridaceae includes Amblovenatum opulentum and Plesioneuron cf. ligulatum. The Family Gleicheniaceae includes Sticherus hirtus and Dicranopteris linearis. The Nephrolepidaceae includes Nephrolepis biserrata and Nephrolepis cf. acutifolia. Family Blechnaceae includes Blechnopsis orientalis. The Athyriaceae includes Diplazium esculentum. The Family Dryopteridaceae includes Pleocnemia irregularis.

Table 2. Taxonomical Classification and Characteristics of Fern species

Ferns Species			**Average Height of fern species**	**Average Frond (leaf) Size**		**Stipe (leaf stalk) color**	**Frond (leaf) Color**	**Frond (leaf) type**
Family	Genus	Species		Verti-cal	Hori-zontal			
Cyatheaceae	Sphaeropteris sp.	Sphaeropteris sp.	1.5 m	8 cm	2 cm	green	dark green	lobed (tripinnate)
Selaginellaceae	Selaginella	Selaginella delicatula	0.39 m	12 cm	2.3 cm	yellow green	green and yellowish green	lobed (bipinnate-pinnatifid)
Thelypteridaceae	Amblovenatum	Amblovenatum opulentum	1.13 m	13 cm	2.5 cm	yellow green	light green	undivided
	Plesioneuron	Plesioneuron cf. ligulatum	2 m	9 cm	3 cm	dark brown	light green	lobed (tripinnate-pinnatifid)
Gleicheniaceae	Sticherus	Sticherus hirtus	0.66 m	24 cm	4.5 cm	brown and green	yellow green	lobed (pinnate)

	Dicranopteris	Dicranopteris linearis	0.71 m	27 cm	5.2 cm	yellow green	yellow green and green	lobed (pinnate)
Nephrolepidaceae	Nephrolepis	Nephrolepis biserrata	1.97 m	18 cm	2 cm	dark brown	green	undivided
	Nephrolepis	Nephrolepis cf. acutifolia	0.57 m	8.8 cm	2.6 cm	brown and green	green	undivided
Blechnacaeae	Blechnopsis	Blechnopsis orientalis	1.35 m	24 cm	2.5 cm	dark brown and light green	green	undivided
Athyriaceae	Diplazium	Diplazium esculentum	1.21 m	17 cm	3.2 cm	light green	green	undivided
Dryopteridaceae	Pleocnemia	Pleocnemia irregularis	0.5 m	10 cm	3.3 cm	dark green	green	lobed (pinnate-pinnatifid)

Out of eleven fern species identified in the study area, the species that have almost the same average height that ranges from 2-1.97 m are the Plesioneuron cf. ligulatum and Nephrolepis biserrata. Followed by the group of species Sphaeropteris sp., Blechnopsis orientalis, Diplazium esculentum, and Amblovenatum opulentum that ranges from 1.13-1.5 m. The group of species that ranges from 0.39-0.71 m and tallied the shortest average height are the Dicranopteris linearis, Sticherus hirtus, Nephrolepis cf. acutifolia, Pleocnemia irregularis, and Selaginella delicatula.

In terms of the average vertical size of the frond, majority ranges from 8-18 cm, except for the family of Gleicheniaceae and Blechnacaeae that both ranges from 24-27 cm. For the average horizontal size of the frond, majority ranges from 2-3.3 cm, except for family Gleicheniaceae.

The dominant stipe colors of fern species in the study area are yellow, green, dark brown, green, brown, and light green, except for the color of the family of Dryopteridaceae, which is the color dark green. The frond colors that dominate the research area are the color green, yellow green, and light green except for the color dark green of the family of Cyatheaceae. Undivided and lobed (pinnate and tripinnate) frond are the commonly observed frond type in the research site except for the lobed (bipinnate-pinnatifid) of the Selaginellaceae family.

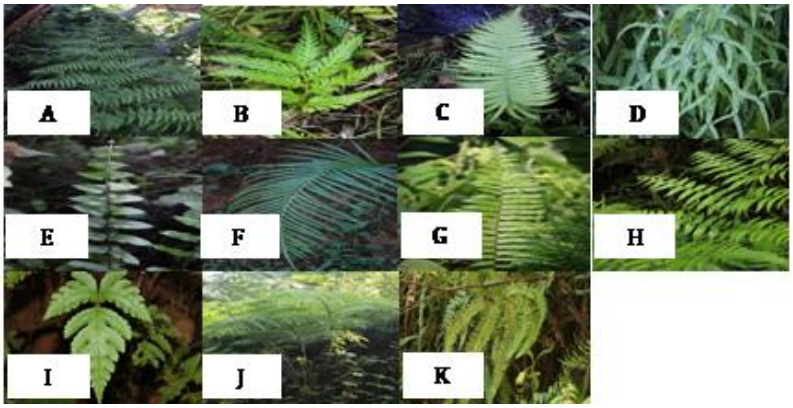

Figure 2. Fern Species in Sitio Binaton, P.M. Sobrecarey, Caraga, Davao Oriental.

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A.) Sphaeropteris sp., B.) Selaginella delicatula., C.) Amblovenatum opulentum., D.) Sticherus hirtus., E,) Nephrolepis biserrata., F.) Blechnopsis orientalis., G.) Nephrolepis cf. acutifolia., H.) Diplazium esculentum., I.) Pleocnemia irregularis., J.) Plesioneuron cf. ligulatum., K.) Dicranopteris linearis

The Species Composition and Relative Abundance of the Fern Species in the Study Area

Table 3 shows the composition and abundance of fern species in the study site.

Table 3. The Species Composition and Relative Abundance of the Fern Species

Family	Species	Number of Species				Total	Relative Abundance %
		Sampling Plots					
		1	2	3	4		
Cyatheaceae	Sphaeropteris sp.	56	12		31	99	4.40
Selaginellaceae	Selaginella delicatula	27		59	17	103	4.58
Thelypteridaceae	Amblovenatum opulentum	63	133	109	72	377	16.80
	Plesioneuron cf. ligulatum	36		4	13	53	2.36
Gleicheniaceae	Sticherus hirtus				118	118	5.25
	Dicranopteris linearis	79		82		161	7.17
Nephrolepidaceae	Nephrolepis biserrata	183	53	155	102	493	22
	Nephrolepis cf. acutifolia	29	184	123	74	410	18.26
Blechnaceae	Blechnopsis orientalis	96		49	83	228	10.15
Athyriaceae	Diplazium esculentum	58	106			164	7.30
Dryopteridaceae	Pleocnemia irregularis				39	39	1.73
Total		627	488	581	549	2245	100

Out of eleven species identified in the study area, the species Nephrolepis biserrata and Nephrolepis cf. acutifolia of the family Nephrolepidaceae and Amblovenatum opulentum of the family Thelypteridaceae got the highest number of individuals ranges from 377-493 and relative abundance that ranges from 16.80%-22% as compared to other species. The family of Nephrolepidaceae has the highest number of species because of its favorable environment. The temperature, humidity, soil pH, and altitude where this family found are average. These three species were considered the most abundant because they were all present in four sampling plots in the study area.

The species Blechnopsis orientalis, Diplazium esculentum, Dicranopteris linearis, Sticherus hirtus, Selaginella delicatula, and Sphaeropteris sp. were among the species present in three sampling plots and with relative abundance that ranges from 4.40%-10.15%. The least observed species in the study site are the Pleocnemia irregularis, with 39 totals of individuals and a relative abundance of 1.73%, and Plesioneuron cf. ligulatum, with a total number of 53 individuals and a relative abundance of 2.36%. Plesioneuron cf. ligulatum was observed in three sampling plots but its number of individuals is low while the Pleocnemia irregularis was observed in one out

of the four sampling plots laid in the study site. This is because of the absence of water and direct exposure to the sun. This result is affirmed by the study of Rambey et al. (2020), which stated in their study that the species with the lowest number of families found on the campus of Universitas Sumatera Utara is Dryopteridaceae, with 5% diversity compared to the other nine families identified in the study area. Furthermore, based on the result of the study conducted by Rambey (2020), the most abundant family ferns in Indonesian tropical rainforests are Polypodiaceae, Pteridaceae, Thelypteridaceae, Nephrolepidaceae, and Aspleniaceae.

The same result was shown in the study of Cabuga Jr. et al. (2023) that there are five dominant and least concern ferns species in Brgy. Tabon-Tabon, Sibagat, Agusan Del Sur, Caraga Region Philippines, namely: Nephrolepis cordifolia, Nephrolepis biserrata, Davalia solida, Diplazium esculentum, Tectaria athyriosora and Selaginella delicatula. The location where these five dominant and least concern fern species is similar to the research area of this study in a way that the temperature, humidity, altitude and soil pH of the environment of these two places were both in the average condition. Fern species richness and diversity were contributed to suitable conditions of the environment in which species have adapted to (Akomolafe & Sulaimon, 2018). In addition, fern species pattern of distribution is also greatly affected by different abiotic factors such as air, temperature and soil content (Rufila, et al.2022).

Fern Species Biodiversity Indices in Terms of Richness

Table 4 shows the fern species diversity indices in terms of richness in the study area.

In sampling plot 1, nine fern species were found and identified with a total number of 627 individuals, the highest among the four sampling plots. The Shannon-Weiner index of diversity had a value of 2.02, which is medium diversity, and Simpson's Diversity Index of 0.15, which is a low degree of diversity/heterogeneity, indicates lesser dominance of one or a few species with the evenness value of 0.91, which means that diversity is more even.

In sampling plot 2, five fern species were found in the study area, with 488 individuals. Sampling plot 2 has a Shannon-Weiner's Diversity Index of 1.39 with the descriptive equivalent of low diversity and the Simpson's Diversity Index of 0.27 with the descriptive equivalent of a low degree of diversity/heterogeneity, which indicates lesser dominance of one or a few species with the evenness value of 0.86, which means that the fern species found and identified in the study area are more even.

In sampling plot 3, there were eight species of ferns present in the study area with a total number of 581 individuals with a Shannon-Weiner's Diversity Index of 1.75, which means medium diversity, and Simpson's Diversity Index of 0.18, which means there is a low degree of diversity/heterogeneity which indicates lesser dominance of one or a few species with the evenness value of 0.89, which means that the fern species found and identified in the study area are more even.

In sampling plot 4, nine species of ferns were found in the study area, and 549 individuals were tallied. The Shannon-Weiner's Diversity Index had a value of 2.01, which means low diversity. The Simpson's Diversity Index

had a value of 0.14, which means there is a low degree of diversity/heterogeneity, which indicates lesser dominance of one or a few species, with the evenness value of 0.91, which means that the distribution of fern species found and identified in the study area are more even or evenly distributed.

Table 4. Fern Species Biodiversity Indices in Terms of Richness

Sampling Plots	Parameters					
	Taxa	Total Number of Species	Shannon-Weiner's Diversity Index (H')	Description	Simpson's Diversity Index (D)	Description
1	9	627	2.02	Medium Diversity	0.15	A low degree of Diversity/ heterogeneity
2	5	488	1.39	Low Diversity	0.27	A low degree of Diversity/ heterogeneity
3	7	581	1.75	Medium Diversity	0.18	A low degree of Diversity/ heterogeneity
4	9	549	2.01	Medium Diversity	0.14	A low degree of Diversity/ heterogeneity
Total		2,245	1.79	Medium Diversity	0.18	A low degree of Diversity/ heterogeneity

Generally, it is shown in the result that sampling plots 1 and plot 4 have the medium Shannon-Weiner's Diversity Index value among the other sampling plots indicated in Table 3 with the descriptive value of medium diversity and a low degree of diversity/heterogeneity. This is because both sampling plots 1 and 4 contain nine species each compared to other plots. The capacity of ferns to adapt to their surroundings and thrive in the shade, leading to a sufficient balance of species in an area, could potentially cause the species diversity index in the medium category (Sari & Mukti, 2019).

Fern Species Biodiversity Indices in Terms of Evenness

Table 4.1 shows the fern species diversity indices regarding evenness in the study area.

Table 4.1 Fern Species Biodiversity Indices in terms of Evenness

Sampling Plots	Parameters			
	Taxa (no. of species)	Total Number of Species	Evenness Index (E)	Description
1	9	627	0.91	More Even
2	5	488	0.86	More Even
3	7	581	0.89	More Even
4	9	549	0.91	More Even
Total		2,245	0.89	More Even

In Sampling plots 1 and 4, there were 9 species found that resulted in a 0.91 evenness index, which is more even. Sampling plot 3 has a total number of 7 species with an evenness index of 0.89, which is more even. Sampling plot 3 has a total number of 5 species with an evenness index of 0.86, which is more even. The average value of the

evenness index of the study area is more even, which means the number of individuals per species is distributed equally in four sampling sites. The distribution of individuals within each species influences diversity among species. Higher species diversity is associated with more evenly distributed individuals within each species (Hutasuhut & Febriani, 2019).

The results conform with Mildawati et al. (2020); the different conditions, such as biotic and abiotic factors present in the area, support the diversity of fern species. Abiotic conditions that greatly contribute to the abundance, presence, frequency, and distribution of fern species include temperature, humidity, altitude, soil pH and nutrients, topography, air humidity, light intensity, and precipitation. Further, a well-protected and maintained habitat will result in wealthy and abundant fern species (Della & Falkenberg, 2019). Moreover, Coritico et al. (2020) emphasized in their study that species richness may be influenced by several factors, including forest types present in the area and climatic conditions (temperature and humidity). However, species become less diverse and distributed due to different human activities such as land use, urbanization, over-exploitation of forest resources, environmental pollution, illegal logging, and shifting cultivation (Coritico & Amoroso, 2020).

Development of Instructional Materials (IMs) in Science Relative to Diversity of Fern Species in Sitio, Binaton, P.M. Sobrecarey, Caraga, Davao Oriental

The instructional material that was developed from the result of this study discussed about the taxonomical classification, species characteristics, diversity, composition, and richness of fern species. To ensure quality instructional materials, the developed self-learning kit underwent intensive validation by the two science master teachers and one associate professor. Using the Department of Education format, the evaluators assessed the instructional materials layout, format, biases, and errors, such as factual and conceptual. The objectives of the instructional materials were aligned with the learning competency indicated in the Most Essential Learning Competency (MELC) of the Department of Education. Contextualizing learning materials using the fern species found in the community where the learners belong can enhance the students' learning in terms of plant species diversity and its taxonomical classification. Moreover, after the validation of the master teachers and associate professor, it was found that the instructional materials in Science 8 that can be developed relative to the species diversity of ferns in Caraga, Davao Oriental, is the contextualized self-learning kit.

IV. CONCLUSION

The following conclusions were drawn from the study findings. Ferns in the study area come from eleven different species, namely: Sphaeropteris sp., Selaginella delicatula, Amblovenatum opulentum, Plesioneuron cf. ligulatum, Sticherus hirtus, Dicranopteris linearis, Nephrolepis biserrata, Nephrolepis cf. acutifolia, Blechnopsis orientalis, Diplazium esculentum, and Pleocnemia irregularis. Every taxonomical characteristic of a species leads to taxonomical classification. Nephrolepis biserrata recorded the highest number of individuals while Pleocnemia irregularis, had the lowest population. The index of fern species diversity is an average low. Furthermore, low species richness and evenness contributed to the low diversity of fern species in the study area. The physicochemical parameters such as temperature, humidity, altitude and soil pH of the study area are within the range for the existence and distribution of fern species. Lastly, the mastery of learning competencies in Grade 8 on

the topic Biodiversity is attributed to the developed Contextualized Self-Learning Kit in Science which supports the teacher learning process.

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