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Diversity Abundance and Distribution Patterns of Species Composition of Gastropods at Dapya Island, Barangay Day-Asan, Surigao City, Surigao Del Norte

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Abstract

This study investigates the gastropod diversity, relative abundance, and distribution pattern of the gastropods present in Dapya Island, Barangay Day-asan Surigao del Norte, Philippines. The sampling was done 2 - 3 days during the lowest low tide at daytime employing the transect-quadrat method and established three sampling stations. A total of 496 individuals distributed among 12 genera and 25 species of gastropods were identified in the study area during the sampling period. The three most abundant species in the area namely *Nerita chamaeleon, Nerita polita, Nipponacmea concinna* with relative abundance of 16.73%, 11.09%, and 9.88% respectively. The result of species diversity varied between stations; Station 1 was the most diverse among the 3 stations since 25 species of gastropods were identified and was evenly distributed, as it has the highest total of evenness but it has low dominance while station 2 has the highest species richness (267) and dominance but low in diversity. On the other hand, station 3 was highly distributed but had the lowest species richness. All gastropod species in the area were distributed at random and mostly inhabited the rocky substratum. In addition, the CCA between gastropod species and selected water quality parameters revealed that the pH level has a negative effect on the diversity of gastropods specifically the *V. turbinellus, Conus sp., Angaria sp.,* and *Cerithium coralium*. Whilst, Salinity, DO, and water temperature have a positive correlation to the other species and do not negatively influence the species diversity of gastropods in the area, instead they increase the richness and diversity of the species. Furthermore, analysis of variance (ANOVA) proved no significant difference in the abundance of gastropods in the three sampling stations (total value of 0.609 level of significance). This means the kind of stations cannot affect the abundance of gastropods. Thus, the area was considered diverse since there are no consequences for the illegal fishing and exploitation

that happened inside the MPA. Hence, it is still recommended to be more vigilant in the protection and management of the MPA.

Subject Areas

Arts in Education

Keywords

Angaria delphinus, Conus miles, Dapya Island, *Nerita chamaeleon*, Surigao del Norte

1. Introduction

The quality and other environmental and biological characteristics of intertidal zones influence the distribution of gastropod species along the entire coastline [1]. Their empty shells are widely collected and traded as raw materials for shell craft and ornament shell trade fetching good prices in both local and foreign markets. Residents in coastal areas collect vulnerable intertidal species mainly for food or fishing bait or their shells.

Dapya Island is one of the main locations in the Philippines where gastropods are harvested. One of the many cities with exceptional gifts is Surigao City, which is home to this island and serves as the entry point to Mindanao. Because of the mangrove trees that grow in the swampy areas surrounding Barangay Day-Asan, locals claim that in the past, a variety of wild fish appeared and traveled with the seawater. There is a lot of marine life, particularly gastropods, on Dapya Island's sizable tidal flat. Since these gastropods are collected for both food and profit, there may be a risk that some gastropod species will become extinct as a result of this practice. Although the Philippines is considered as a mega-diverse country in terms of molluscs, studies on mollusc diversity in Mindanao are considerably scarce [2]. Additionally, molluscs had the highest number of documented extinctions among the major taxonomic groups in the world [3].

This study generally aims to determine the species composition, relative abundance, and distribution pattern of the gastropods present in the Dapya Island Day Asan Surigao del Norte, Philippines. If possible, the species will be identified up to the lowest taxonomic level. The Physicochemical parameters will include temperature, salinity, and pH level. The duration of this study will last only for a month (November 2024), the sampling was conducted 2 to 3 days during low tide in the daytime. Nutrient content and organic matter will not be included and also the data on gastropod gleaning/fishery outside the MPA, because of limited time and financial resources.

2. Materials and Method

Study Site

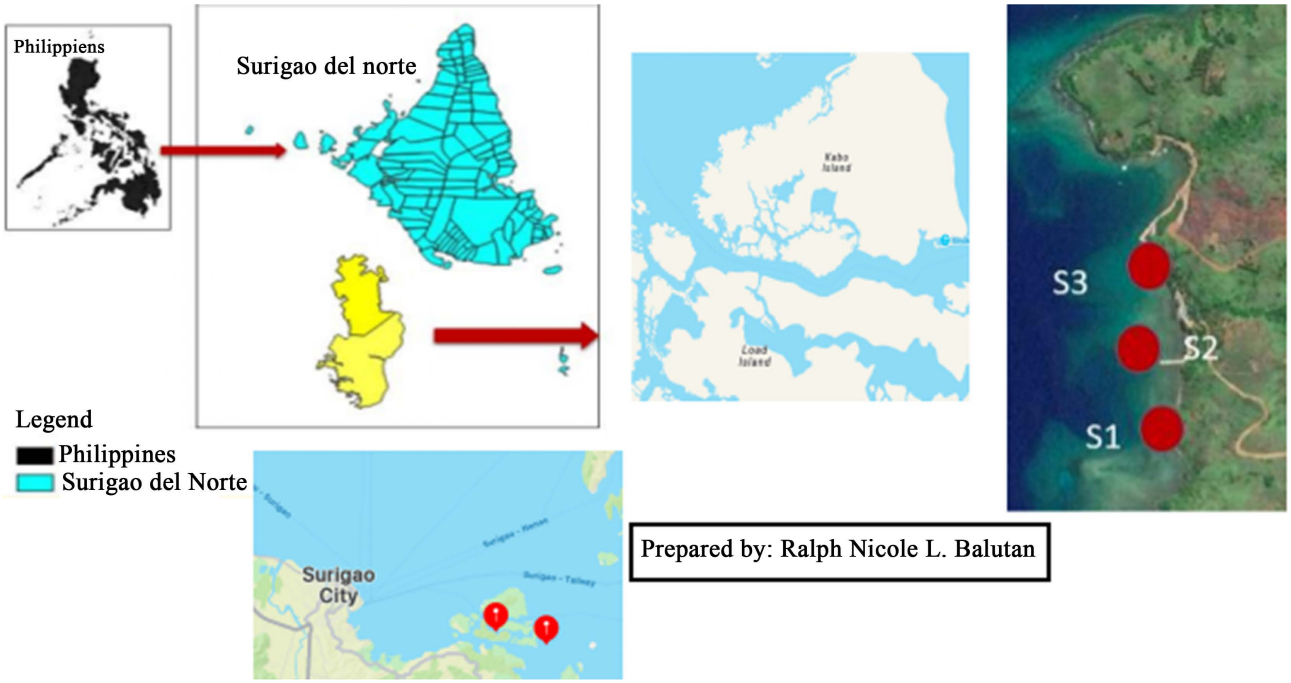

Figure 1. Study map.

The study was conducted in Dapya Island, Brgy. Day-asan, Surigao City, Philippines, with the geographic location at 90˚77'93"N and 125˚54'86"E (**Figure 1**) Day-asan is just 15 km away from the Surigao City Hall and can be accessed either by motorboat ride or land vehicle [4]. According to Edera (2010) [5], Day-asan is located at Arellano District with a total land area of 3040.447 ha, of which 554 ha are mangrove forests. There are 1572 inhabitants and a total of 341 households. Dapya Island Day-asan, Surigao del Norte, Philippines. Together with the 3 station). The shoreline of the area was composed of a small rocky shore and an abundance of seaweeds. The Global Positioning System (GPS) equipment was used to record the precise location and elevation of the three study stations designated as, Study Station 1, Station 2, and Station 3 that were chosen inside the study site. Each station had a 50 m belt transect line installed from land to sea, with a 1 m width (a total area of 50 × 1 m^2). Each station had 50 quadrats overall, each measuring 1 m^2. These quadrats were designated 1 - 50 (Q1 - Q50). Three well-established station plots were spaced roughly 100 meters apart. Henderson (2003) [6] suggested that the sample can be based on the number of quadrates to determine the species diversity, and this approach was in line with that. With a rough beach (large chunks of rock), mixed sandy and coralline, and some rocks in the substratum, Station 1 faces the open water of Surigao City. It was rich in marine life, including gastropods, as well as seaweeds and seagrasses. Nearer the mangrove region, but with the same habitat type, was station 2, which was 100 meters from station 1. Station 2 had fewer fauna companions, such as sea stars, than Station 1. Station 3 was established near a mangrove ecosystem which has a rocky shoreline and an abundance of seaweed; it is still the same as the station [6].

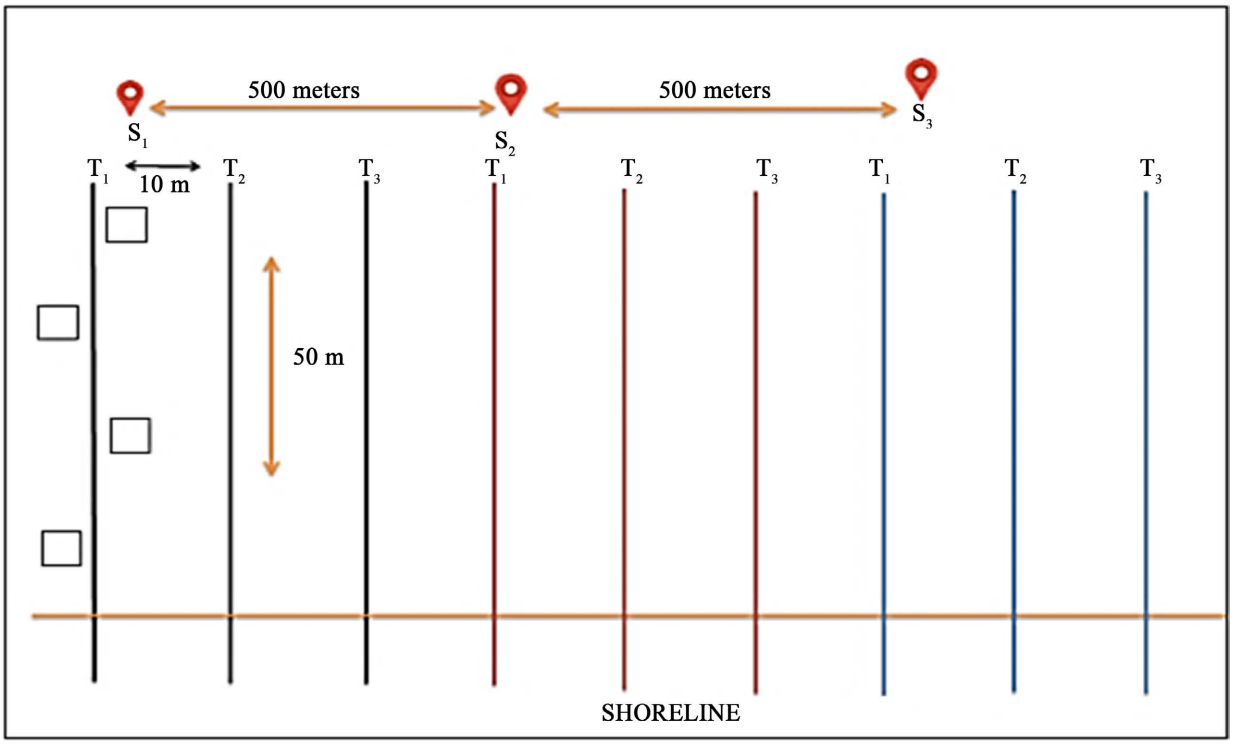

Figure 2. Lay-out of the transect line and quadrats [7].

Figure 2 represents a systematic sampling arrangement along a shoreline, presumably for coastal or ecological research. It shows three primary stations (S_1, S_2, S_3) that are positioned 500 meters apart, with each station having three transects (T_1, T_2, T_3) that run perpendicular to the shoreline at consistent intervals. At S_1, 10 cm quadrats are distributed along the transects for precise measurement or species analysis, and the transects seem to extend 50 meters inland or seaward, based on the specific focus of the study. This configuration indicates a stratified sampling approach, allowing researchers to gather data on environmental factors or biological communities at uniform distances along the coast, which promotes statistical reliability and comparability among locations [8]. Such a configuration is frequently utilized in marine biology, coastal ecology, or environmental monitoring to evaluate spatial patterns, biodiversity, or human impacts [8]. By ensuring fixed distances between stations and transects, the design reduces sampling bias and facilitates rigorous spatial analysis of coastal ecosystems.

Collection of Data

The sampling was conducted in the month of November 03, 04, & 05, 2024. 3 days within a month of November 2024 during low tide at daytime in the established stations in the MPA using the modified transect-quadrat method by Henderson (2003) [6]. For each station, three transect lines will be laid at ten meters intervals with 50 meters. The transect line will be laid perpendicular to the coastline and the reading of gastropods will be done every ten meters using a 1 m × 1 m quadrat. All live gastropods larger than 5 mm will be collected, recorded, counted, and identified. The gastropod species will be identified using the key identification

of Bouchet *et al* (2005) [9] and the representative sample will be documented using a digital camera for the identification of species that cannot be identified on-site.

Physico-chemical parameter

Water temperature, pH, Salinity and Dissolved Oxygen were measured taking account in *in-situ* using Water Quality Checker (HANNA). This parameter was observed three (3) times in each station [7].

Coordinates of the transect lines laid, transect length and the number of quadrats in Dapya Island, Day-asan Surigao del Norte, Philippines (See **Table 1**).

Table 1. Geographic coordinates.

Station	No. of Transect	No. of Quadrat	Length (m)	North	East
1	1	4	50	9.6772969	125.9205319
	2	4	50	9.6772979	125.9205629
	3	4	50	9.6783984	125.9206439
2	1	4	50	9.681555	125.919731
	2	4	50	9.681565	125.9206452
	3	4	50	9.681575	125.9206452
3	1	4	50	9.6830045	125.9198402
	2	4	50	9.6830155	125.9198412
	3	4	50	9.6830165	125.9198422

Diversity indices

Species diversity was estimated using Shannon-Wiener information statistics (H') referred to as Shannon-Wiener Index of Diversity. For the determination of biodiversity indices of gastropods, Paleontological Statistical Software Package (PAST) was used on the following indices (Odum, 1993) [10].

Shannon-Weiner index across study stations

$$H' = [\Sigma(pi/\ln pi)]$$

where: H= Shannon Index

'*pi*' = represents the proportion of total sample belong to each species

'ln*pi*' = represents the natural logarithm

Similarity indices of species composition using Bray-Curtis across study stations by,

$$Si = C/(a + b + c) \times 100$$

where: *Si* = species composition

C = total species common to all stations

a = study station 1

b = study station 2

c = study station 3

Canonical Correspondence Analysis (*CCA*)

It was used to correlate the physico-chemical parameters and the diversity indices of gastropods species found in the study area (PAST software).

Analysis of variance (*ANOVA*)

It will be used to determine the significant abundance of gastropods in the three sampling stations of the study area.

3. Result and Discussion

Species Composition

A total of 496 individuals distributed among 12 genera and 25 species of gastropods were identified in the study area based [7]. The number of species in three stations varies significantly, where there are 25 species found in station 1, 21 species in station 2, and 20 species in station 3 (See Table 2).

Table 2. The total number of gastropods in the area and their relative abundance gastropod in every station in Dapya Island, Dayasan Surigao del Norte, Philippines on Nov 10 & 11, 2024.

Family/Species Name	Local/Common Name	Stations			Total Counts (number of individuals)	RA%	IUCN
		1	2	3			
Neritidae							
Nerita chamaeleon	Sihi	+	+	+	83	16.73	NE
Nerita polita	Sihi	+	+	+	55	11.09	NE
Lottiidae							
Nipponacmea concinna	Sarok-sarok	+	+	+	49	9.88	NE
Patelloida saccharina	Sarok-sarok	+	+	+	39	7.86	NE
Conidae							
Conus ebraeus	Liswi/black white	+	+	+	43	8.67	NE
Conus marmoreus	Liswi	+	+	+	12	2.42	NE
Conus sp.	Liswi	+	+	+	10	2.02	NE
Conus auricomus	Gold-leaf cone	+	+	+	6	1.21	NE
Strombidae							
Lambis lambis	Saang	+	+	+	34	6.85	NE
Strumbus sp.	Sikad-sikad	+	+	+	5	1.01	NE
Cerithiidae							
Cerithium coralium	Tibo-tibo	+	+	–	32	6.45	NE
Turbinidae							
Turbo(*Lunella*) *cinereus*	Lumban	+	+	+	25	5.04	NE
Astralium calcar	Turban Snails	+	+	+	10	2.02	NE

Continued

Tegulidae							
Tectus pyramis	Samong	+	−	+	8	1.61	NE
Tectus fenestratus	Amomong-pong	+	+	+	16	3.23	NE
Turbinellidae							
Vasum turbinellus	Guba-guba	+	−	+	10	2.02	NE
Angariidae							
Angaria sp.	Bayongkot	+	+	+	10	2.02	NE
Trochidae							
Monodonta australis	Toothed topshell	+	−	+	8	1.61	NE
Muricidae							
Tenguella granulata	Mulberry shell	+	+	+	9	1.81	NE
Drupa ricinus	prickly spotted drupe	+	+	+	8	1.61	NE
Semiricinula konkanensis	Murex snails or rock snails	+	+	−	7	1.41	NE
Paratrophon quoyi	Murex snails	+	+	−	5	1.01	NE
Menathais intermedia	Murex snails	+	−	+	5	1.01	NE
Drupa rubusidaeus	Straw-berry drupe	+	+	−	4	0.81	NE
Clavatulidae							
Turricula nelliae spuria	Sea snail	+	+	−	3	0.60	NE
Total		129	267	100	496	100.0	

The presence (+) and absence (−) of species in every stations in the study area.

The most abundant species in the area in terms of relative abundance 16.73% and a total number of individuals 83 was Nerita chamaeleon and this followed by Nerita polita with the relative abundance of 11.09% and 55 total number of individuals. The Nipponacmea concinna was the third most abundant species in the area with a total number of 49 and a relative abundance of 9.88%. In addition, gastropod species found in the Sanctuary are mostly "not been evaluated" according to IUCN (International Union for Conservation of Nature) Red list Status.

Station 1 has a total of 25 species of gastropods and 129 total number of individuals found in the area (Table 3). There were 2 species dominated in area; *Nerita chamaeleon* and *Nipponacmea concinna* with a total number of 16 individual, and relative abundance of 12.4%. *N. chamaeleon* dominated in station 1 since the area has a rocky substrate and they were found on rocky substratum where seaweed was abundant [4]. They grazed on algae that thrive on the rocks, scraping this off through their radula and also eat lichen growing there. They are often found near their food source, where sunlight and water exchange are greatest. In addition, *N. concinna* also known as limpets, this kind of gastropods is usually found in the rocky substratum possibly due to its ability to tolerate high desiccation, salinity,

and temperature fluctuations. It was also observed to inhabit rocky substratum attached to rocks because usually they tend to attach where the splash of waves is available. The presence of flora and fauna associates were also observed in all stations. Sea grasses and seaweeds were the most common flora associates, while sea stars, sea urchins, corals, fish, clams, and sea anemones were the most common fauna associates.

Table 3. Gastropods species and relative abundance present in the Station 1 showing transect 1, 1 and 3 of Dapya Island, Day-asan Surigao del Norte, Philippines.

Species Name	Transect			Total Counts (number of individual)	Relative Abundance
	1	2	3		
Nipponacmea concinna	6	7	3	16	12.4
Nerita chamaeleon	4	5	7	16	12.4
Patelloida saccharina	7	4	4	15	11.6
Conus ebraeus	4	5	2	11	8.5
Lambis lambis	5	3	3	11	8.5
Cerithium coralium	7			7	5.4
Tectus fenestratus	3	2	1	6	4.7
Vasum turbinellus	4		1	5	3.9
Monodonta australis	2		3	5	3.9
Nerita polita	5			5	3.9
Turbo (*Lunella*) *cinereus*	2	2		4	3.1
Semiricinula konkanensis		2	2	4	3.1
Tectus pyramis	2	1		3	2.3
Paratrophon quoyi	1	1	1	3	2.3
Angaria sp.	1		1	2	1.6
Menathais intermedia	2			2	1.6
Astralium calcar	1	1		2	1.6
Tenguella granulata	1		1	2	1.6
Conus marmoreus	1		1	2	1.6
Drupa ricinus		1	1	2	1.6
Strumbus sp.		1	1	2	1.6
Conus auricosmus		1		1	0.8
Turricula nelliae spuria	1			1	0.8
Drupa rubusidaeus			1	1	0.8
Conus sp.		1		1	0.8
Total	59	37	33	129	100.0

Station 2 has a total of 21 species of gastropods and 267 individuals distributed in the area. Nerita chamaeleon still dominated and it was observed to have the same profile in station 1. It has a total number of 48 individuals with the relative abundance of 18.0% and this is followed by Nerita polita which has a total number of 32 individuals with a relative abundance of 12.0%. However, Strumbus sp. has been observed to have the lowest number of individuals as shown in Table 4.

Table 4. Gastropod species and relative abundance present in the Station 2 of Dapya Island, Day-asan Surigao del Norte, Philippines.

Species Name	Transect			Total Counts (number of individual)	Relative Abundance
	1	2	3		
Nerita chamaeleon	18	14	16	48	18.0
Nerita polita	10	11	11	32	12.0
Conus ebraeus	10	10	7	27	10.1
Nipponacmea concinna	9	8	8	25	9.4
Cerithium coralium	9	8	8	25	9.4
Patelloida saccharina	5	9	8	22	8.2
Lambis lambis	2	12	5	19	7.1
Turbo (*Lunella*) *cinereus*	8	7	1	16	6.0
Tectus fenestratus	1	2	5	8	3.0
Conus marmoreus		5	1	6	2.2
Angaria sp.	3		3	6	2.2
Drupa ricinus		3	2	5	1.9
Astralium calcar		3	2	5	1.9
Tenguella granulata		2	2	4	1.5
Conus auricosmus	3		1	4	1.5
Conus sp.	3		1	4	1.5
Drupa rubusidaeus		3		3	1.1
Semiricinula konkanensis			3	3	1.1
Turricula nelliae spuria		2		2	0.7
Paratrophon quoyi			2	2	0.7
Strumbus sp.	1			1	0.4
Total	82	99	86	267	100.0

Station 3 has a total of 20 species of gastropods and 100 total number of individuals found in the area. Nerita chamaeleon still dominated in area and has a total number of 19 individuals with the relative abundance of 19.0% and this followed by Nerita polita which has a total number of 18 individuals with a relative abundance of 18.0%. However, species such as Drupa ricinus and Conus auricosmus are

observed to have the lowest number of individuals shown in Table 5.

Table 5. Gastropod species and relative abundance present in the Station 3 of Dapya Island, Day-asan Surigao del Norte, Philippines.

Species Name	Transect			Total Counts (no. of individual)	Relative Abundance
	1	2	3		
Nerita chamaeleon	5	7	7	19	19.0
Nerita polita	6	5	7	18	18.0
Nipponacmea concinna	4	4		8	8.0
Vasum turbinellus	3	2		5	5.0
Conus ebraeus	2		3	5	5.0
Conus sp.	5			5	5.0
Tectus pyramis	2	2	1	5	5.0
Turbo (*Lunella*) *cinereus*	2	2	1	5	5.0
Conus marmoreus	2	2		4	4.0
Lambis lambis	1	1	2	4	4.0
Tenguella granulata		3		3	3.0
Astralium calcar		2	1	3	3.0
Menathais intermedia		3		3	3.0
Monodonta australis			3	3	3.0
Angaria sp.	1	1		2	2.0
Patelloida saccharina	2			2	2.0
Tectus fenestratus	2			2	2.0
Strumbus sp.	1	1		2	2.0
Drupa ricinus			1	1	1.0
Conus auricosmus		1		1	1.0
Total	38	36	26	100	100.0

Species Diversity

It showed the result of the general diversity of the gastropod species found in three stations in terms of the index of diversity, evenness and the index of dominance (Table 6).

Station 1 has the highest diversity with the total value of H = 2.953 and richness (taxa 25). And in terms of the number of individuals station 1 has the second highest with a total value of 129 with the evenness value of 0.7664. While the station 2 has the highest total number of individual species with a total number of 267 as well as the value of dominance (0.09014) but there were only 21 species found in station 2, and it has the lowest value of diversity (2.64) with the evenness of 0.67. However, in station 3 has the lowest number of taxa which means low

richness, only 20 species found in the area and it also has 100 number of individuals and low diversity (2.754) yet has the highest value of evenness which was 0.7849.

Table 6. Species diversity indices of the gastropods in every station of Dapya Island, Dayasan Surigao del Norte, Philippines.

	Station 1	Station 2	Station 3
Taxa_S	25	21	20
Individuals	129	267	100
Dominance_D	0.06613	0.09014	0.08687
Shannon_H	2.953	2.646	2.754
Evenness_e^H/S	0.7664	0.6716	0.7849

The three stations varied from one another in terms of species diversity. Station 1 was the most diverse among the 3 stations since 25 species of gastropods were identified and it was evenly distributed for it has the value of evenness = 0.7664 with the total value of 129 individuals but it has low dominance (0.06) for it has the highest value of diversity.

In station 2 has the highest number of individuals with the total number of 267 and also high in dominance with the value of 0.09014 highest total of evenness (Simpson_1-D = 0.93) with a total of 129 individuals found but it has low dominance (0.06) possible due to competition of the food sources and predation (). While station 2 has the highest species richness (267) and dominance (0.09014) but low in diversity. The high dominance value in the station was due to the high abundance of Nerita chameleon. On the other hand, station 3 was highly distributed with the evenness total value of 0.7849 but has the lowest species richness (100). It seems that Station 3 might be disturbed of any recreational activities happen in the area and since it is located near the Dapya Island which affect the diversity and stability of gastropods community.

Relative Abundance

The Nerita chamaleon dominated among 25 species in the study area with a highest relative abundance of 17% and followed by Nerita polita (11%), *Nipponacmea concinna* (10%), *Conus ebraeus* (9%), *Patelloida saccharina* (8%), Lambislambis (7%), *Cerithium coralium* (6%) and 18 species were compiled to the lowest relative abundance (**Figure 3**).

The pie chart illustrates the proportional abundance of mollusk species identified in the research area, emphasizing the composition of species and their relative representation. The category labeled "Others," which includes 18 species, is the most prevalent, making up 32% of the total, signifying a diverse range beyond the most frequently encountered taxa. Among the specific species, Nerita chamaeleon is the most prominent, representing 17%, followed by Nerita polita at 11%, Nipponacmea concinna at 10%, and Conus eburneus at 9%. Smaller proportions

include Patelloida saccharina at 8%, Lambis lambis at 7%, and Cerithium coralium at 6%. This distribution indicates that while some species are abundant in the area, the ecosystem also supports a wide variety of molluscan life, potentially reflecting diverse microhabitats and the availability of resources in the sampling region (Gaston, 1996) [11].

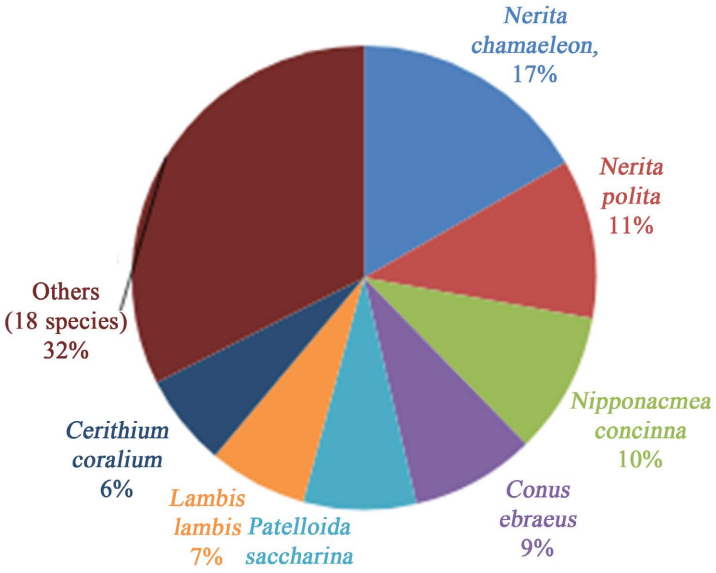

Figure 3. Relative abundance (%) of the Seven (7) dominant gastropod species in Dapya Island, Day-asan Surigao del Norte, Philippine (November 2024).

In summary, the chart illustrates a fairly equitable distribution among various dominant species, alongside a longer tail of less prevalent taxa, which is typical of many coastal ecosystems. Such patterns of biodiversity serve as crucial indicators of ecological stability and resilience, especially in intertidal or nearshore areas where species composition is influenced by both abiotic factors and biotic interactions (Magurran, 2004) [11].

Distribution Pattern

The distribution pattern of gastropod species did not differ in every station (**Table 7**). All gastropod species in Dapya were randomly distributed. Environmental factors such as food availability, larval dispersal and settlement, predation and community structure influence the distribution of benthic organism.

Physico-chemical parameter

Readings of physico-chemical parameters are shown in **Table 8**. Mean pH, salinity, temperature, and dissolved oxygen are 7.43, 34.33 ppm, 30.20˚C, and 7.50 ppm, respectively. The substrate type of each station was observed as sandy, rocky, muddy and coralline. A significant difference was only observed in DO and temperature. However, even with such variations, readings of the selected water quality parameters are still within DENR Standards for marine waters. Thus, these parameters may fall within the favorable environmental conditions suitable for the growth of gastropods.

According to Strzelec and Krolczyk (2015) [12], many gastropod species are

tolerant to most physico-chemical parameters and their occurrence is influenced by bottom sediment quality and vegetation quantity.

Table 7. Calculated variance, mean, standard deviation and distribution pattern of the species in Dapya Island, Day-asan Surigao del Norte, Philippines.

Scientific Name	Mean	Std.	Variance	Pattern
Angaria sp.	1.4	0.53	0.62	Random
Astralium calcar	1.4	1.61	0.29	Random
Cerithium coralium	4.5	0.45	2.62	Random
Conus auricosmus	1.2	0.74	0.20	Random
Conus ebraeus	2.05	0.76	0.55	Random
Conus marmoreus	1.71	0.82	0.57	Random
Conus sp.	1.67	0.52	0.67	Random
Drupa Ricinus	1.33	0.58	0.27	Random
Drupa rubusidaeus	1.33	1.90	0.33	Random
Lambis lambis	2.83	0.71	3.61	Random
Menathais intermedia	2.50	0.58	0.50	Random
Monodonta australis	2.67	2.23	0.33	Random
Nerita chamaeleon	6.92	0.85	4.99	Random
Nerita polita	5.50	1.37	0.72	Random
Nipponacmea concinna	4.46	0	1.87	Random
Paratrophon quoyi	1.00	1.13	0	Random
Patelloida saccharina	3.55	0.50	1.27	Random
Semiricinula konkanensis	1.75	0	0.25	Random
Strumbus sp.	1.00	0.76	0	Random
Tectus fenestratus	2.00	0.52	0.57	Random
Tectus pyramis	1.33	0.84	0.27	Random
Tenguella granulate	1.50	1.27	0.70	Random
Turbo (*Lunella*) *cinereus*	2.50	0	1.61	Random
Turricula nelliae spuria	1.00	0.52	0	Random
Vasum turbinellus	1.67	0.79	0.27	Random

Table 8. Physico-chemical parameters of three stations in Dapya Island, Day-asan Surigao del Norte, Philippines.

Stations	pH Level	Salinity (ppt)	Temperature (˚C)	Dissolved Oxygen (mg/L)
1	7.7	34	29.5	7.3
2	7.1	35	31.1	8.1
3	7.5	34	30	7.1

The presence of these floral assemblages serves as a natural haven as well as food for gastropods and other invertebrates. In this study, a few seaweeds were found like Actinotrichia sp., Padina sp., Halimeda sp. Sargassum sp. and Mastoporarosea throughout the three stations. The red algae Sargasssum sp. was observed in almost all quadrats. Thallasia hemprichii and Cymodocia rotundata were the only seagrass observed in all stations and it showed random because few quadrats were observed to have associated seagrass. Most faunal associates found were sea urchin, corals, fish, clams, star fish hermit crab, sponge and shrimp. The presence of the macro-faunal associates affects the diversity and abundance of gastropods, especially in terms of availability of foods and space [1].

Correlation analysis

Correlation analysis between gastropod species and selected water quality parameters is shown in **Figure 4** and **Table 8**.

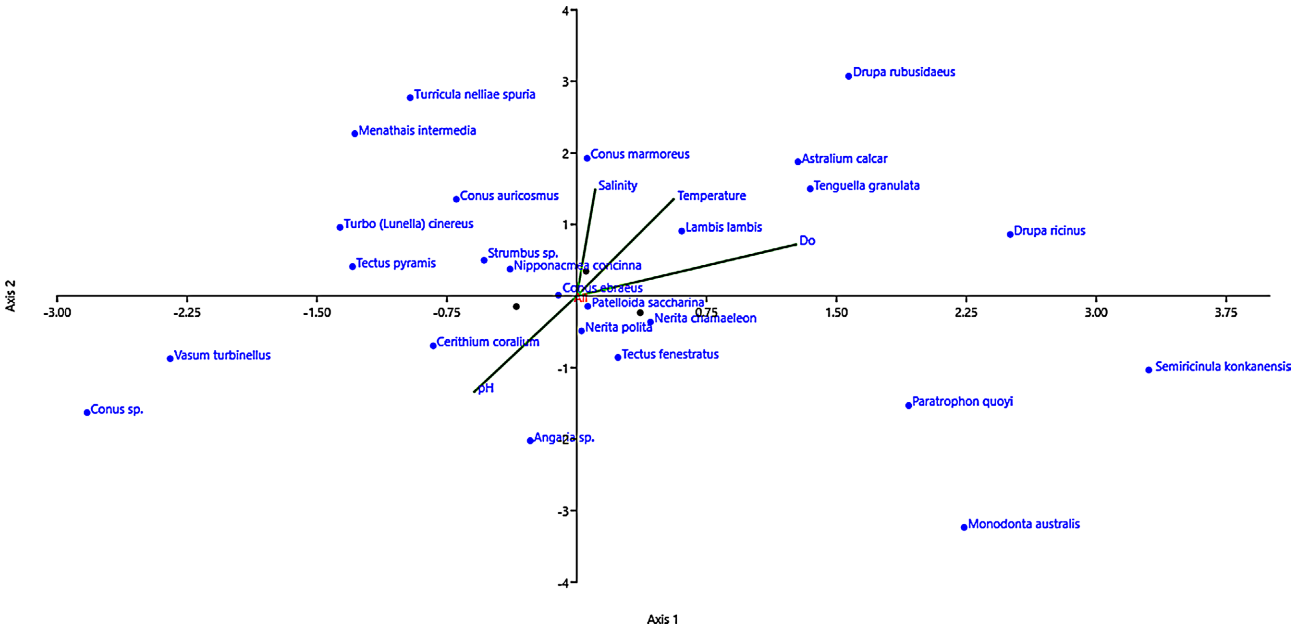

Figure 4. CCA triplot between physico-chemical parameters and species diversity of gastropods in the area [13].

Results showed the four (4) environmental factors; water temperature, salinity, DO and pH and the other variables which were the gastropods species found in the three sampling stations. The length of an arrow is proportional to the rate of change in this direction (Ter Braak & Verdonschot, 1995) [13]. It is found out that they were correlated to each other, the pH level has negative effect towards the diversity of gastropods specifically the V. turbinellus, Conus sp., Angaria sp., and cerithium coralium. Whilst, Salinity, DO, water temperature has positive correlation to the other species and does not negatively influence the species diversity of gastropods in the area instead it increased the richness and diversity of the species. In addition, eigen value shows the percentage of the two axis where axis 1 has 0.083775 and 56.14% with the P value of 0.171 while axis 2 has 0.06544 and 43.86% and P value of 0.652 (See **Table 9**).

Table 9. The Eigen value in Dapya Island, Day-Asan Surigao del Norte, Philippines.

Axis	Eigenval	p
1	0.08375	0.171
2	0.06544	0.652

Significant difference

The abundance of gastropods in the three sampling stations did not differ significantly with the following total value of Diversity indices of significance according to analysis of variance (ANOVA) shown in Table 10.

Table 10. One-way Analysis of Variance (ANOVA) [13] on the significant abundance of gastropods species in the three sampling stations in Dapya Island, Day-asan Surigao del Norte, Philippines.

ANOVA			
Diversity indices	Mean of Squares	F	p-value
Shannon –Weiner Diversity index	0.2709	1.546	0.2873
Evenness	0.4835	4.665	0.06
Dominance	0.09659	0.8703	0.4657

4. Conclusions and Recommendation

Based on the findings of the study, the following conclusions were drawn. There were 25 species of gastropods found in Dapya Island, Day-asan Surigao del Norte, Philippines. It is clear that the three stations varied from one another in terms of species diversity. Station 1 was the most diverse among the 3 stations since 25 species of gastropods were identified and it was evenly distributed, it has the highest total of evenness but it has low dominance while station 2 has the highest species richness (267) and dominance but low in diversity. On the other hand, station 3 was highly distributed but had the lowest species richness. In addition, the physico-chemical parameters such as water temperature, pH, dissolved oxygen and salinity are within normal range to support the life of gastropods. Furthermore, the CCA between gastropod species and selected water quality parameters revealed that the pH level has a negative effect on the diversity of gastropods specifically the *V. turbinellus*, Conus sp., Angaria sp., and *Cerithium coralium*. Salinity, DO, and water temperature have a positive correlation with the other species and do not negatively influence the species diversity of gastropods in the area; instead, they increase the richness and diversity of the species. Therefore, there is no significant difference between the three sampling stations and the abundance of gastropods.

On the basis of the conclusions, the following recommendations are offered. The residents should be informed and educated about the value and importance of a Marine Protected Area, not just for resource conservation, but also for their livelihood and proper management of marine resources. To ensure sustainable

resources, strict monitoring of resources within the MPA, as well as constant and strict implementation of laws, should be observed. Conduct more research on other marine resources in the MPA to improve the sanctuary's management.

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Conflicts of Interest

The authors declare no conflicts of interest.

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