Diversity of marine macro molluscan bivalves and gastropods in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines

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Abstract. There have been very few studies on mollusk diversity in remote areas of the Philippines. The coastal areas of Caramoan, Camarines Sur, are ideal for studying marine molluscs because they have been discovered to be abundant, diverse, and essential to the locals' livelihood. However, due to the remoteness of the mentioned area, this lack of information remains scientifically lacking. Thus, this study aimed to determine the diversity of marine macro-molluscan bivalves and gastropods in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. Purposive sampling and transect methods assessed the species composition, abundance, and occurrence of marine macro bivalves and gastropods. The Shannon-Wiener index was used to determine the area's diversity. A total of 557 individual molluscs were sampled and classified, obtaining 43 species of bivalves from 32 genera and 18 families and 47 species of gastropods from 34 genera and 20 families. The family Veneridae had the highest among the bivalves, and the family Strombidae had the highest species richness among the gastropods. This study provided baseline information on the status of marine macro molluscan bivalves and gastropods in the intertidal area of Barangay Paniman, Caramoan, Camarines Sur, Philippines. As a result, this will provide solid empirical evidence for conservation and sustainability plans.

Keywords: Coastal zones, conservation, Strombidae, remote areas, Veneridae

1. Introduction

As an archipelagic country, the Philippines has aquatic resources, particularly molluscs [1]. The country has continued to be the subject of investigations on biodiversity, specifically on marine macro

molluscans, such as bivalves and gastropods. Molluscs represent a taxonomically diverse species and are recognized as one of the Earth's most ancient animal groups [2]. After insects, they are the world's second-largest invertebrate group [3]. According to current estimates, there are currently between 34,000 and 120,000 described species of molluscs. The total diversity of molluscan species, encompassing both described and undescribed taxa, is frequently estimated at approximately 200,000, underscoring the considerable extensiveness within this taxonomic group [4]. Molluscs, characterized by their soft-bodied anatomy, constitute a taxonomic group of considerable commercial significance, notably serving as a staple food source within the region's indigenous communities.[5]. Moreover, marine macro molluscans such as bivalves and gastropods thrive primarily in intertidal zones, interacting with various anthropogenic activities [6]. These activities may result in various disturbances and changes to their habitat, including pollution, loss of primary resources, and overexploitation of some edible and ornamental species. As a result, opportunities to study species richness, diversity, composition, and abundance are being lost or neglected, resulting in a significant gap in the country's understanding of the richness and diversity of marine macro molluscan bivalves and gastropods.

According to Vallejo [7] in his comprehensive examination of molluscan biogeography in the Philippines, noted a predominant emphasis on macro molluscan diversity investigations at regional scales, often delineated by ocean basins, with a relative lack of attention at the local level [8]. This limited focus excluded remote and supposedly inaccessible locales, primarily due to logistical constraints associated with travel time and cost-efficient transportation methods. Most studies on mollusc species in the Philippines were based on the collections of mollusc species by many foreign researchers, such as Hugh Cummings' collections from 1836 to 1840 [9]. There have been a few studies focusing on the locality of marine macro molluscs, such as the studies conducted on Catanduanes Island by Masagca et al [10], in Binunsalian and Turtle Bays by Picardal and Dolorossa [11], in Iwahig River-Estuary by Dolorossa and Dangan-galon [12], in Tubbataha Reefs Natural Marine Park conducted by Dolorossa et al [13], and in Palawan, and Kalayaan Island Group (KIG) conducted by Batomalaque et al [9]. In addition to these, there are also a few studies conducted in part of Mindanao, such as the survey conducted in Hadji Panglima Tahil, Province of Sulu [14], in Alabel and Maasim, Sarangani Province [15], and in Padada, Davao del Sur [16]. Despite these efforts, few studies focus on the diversity of marine macro molluscan bivalves and gastropods in the Philippines, indicating a need for more data on how diverse these marine organisms are, particularly in remote areas.

Therefore, this study aimed to determine the diversity of marine macro molluscan bivalves and gastropods in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. This area is ideal for studying marine molluscs since they have been discovered to be abundant, diverse, and essential to the locals' livelihood. In addition, this area is experiencing anthropogenic activities due to commercialization, which may disturb the species composition and diversity in the area. Finally, the results obtained from this study could provide a new baseline study for marine macro molluscan bivalves and gastropods, resulting in new records and collections of these marine species that offer a more comprehensive overview of their diversity and composition in terms of locality in the country.

2. Materials and Methods

2.1. Description of the study site

The study site was located on the island of Luzon in Barangay Paniman, Caramoan, Camarines Sur, Philippines, with coordinates of 13.8114 and 123.8764 (130 49' North, 1230 53' East). Paniman, shown in Figure 1, is a coastal barangay in Caramoan, a second-class municipality in the Philippines' province of Camarines Sur. The climate in the area is hot, oppressive, windy, and overcast, with a seasonal shift between a wet season from July to January and a dry season from February to June. November has the rainiest days, averaging 21.4 days with at least 0.04 inches of rain. At the same time, April has the fewest wet days, with an average of 9.3 days with at least 0.04 inches of precipitation. The barangay's coastal

area was an intertidal zone with sandy and rocky shores. The study site was chosen since this barangay has more expansive shores during low tides than the other coastal barangays in Caramoan, Camarines Sur.

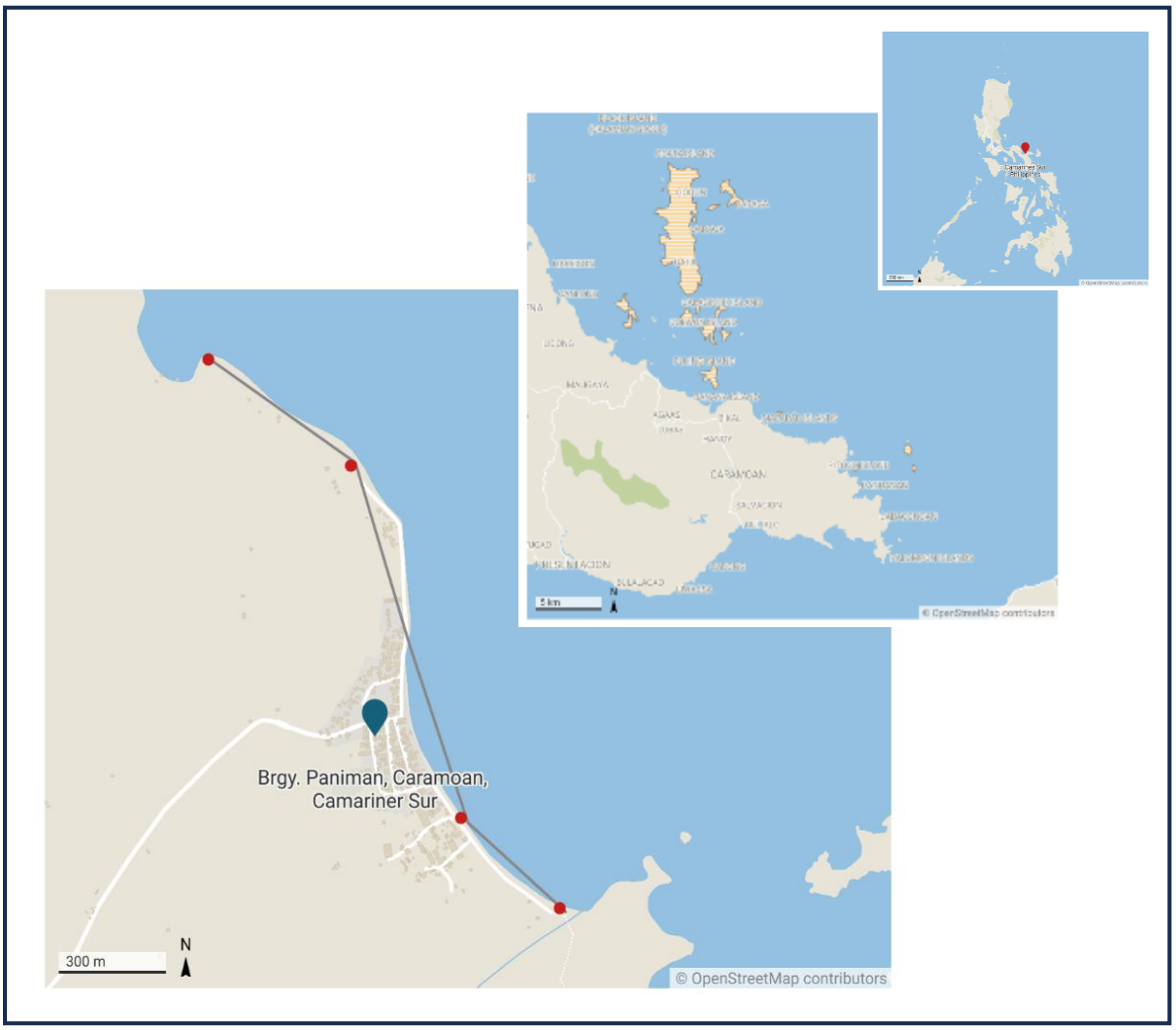

Figure 1. Collection sites of marine macro molluscan bivalves and gastropods in Barangay Paniman, Caramoan, Camarines Sur (left inset), Philippines (upper right inset) (Datawrapper 2023).

2.2. Sampling of macro molluscan bivalves and gastropods

The distribution and abundance of intertidal shore communities, such as sandy and rocky shores, were commonly surveyed using a purposive and transect method. Briefly, quantitative information such as species richness and diversity, abundance, and diversity were obtained from the transect method. Transect lines were set up seaward and perpendicular along the shore of the barangay. Specimens, along with the transect line, were purposively collected from the rocky, small patches of seaweed beds, sandy shores, and beaches in December 2022 through reef walking and gleaning or hand-picking. Live and dead bivalves and gastropod species were collected and considered in the study. The number of individuals of each species encountered was recorded. A voucher specimen from each encountered species was brought to the laboratory. The soft tissues were removed from live specimens, and the shells

of the live and dead specimens were cleaned and photographed to confirm the identification. Classification and description of each species were also conducted.

2.3. Species identification of collected samples

The species level of collected specimens was identified using various references, web searches, and previous studies. The study relied on reliable identification guides such as [17], Philippine Marine Molluscs Volume V [18], and Exceptional Shells from the Philippines Volume I and II [19]. Other supplementary websites visited for verification include www.gastropods.com, www.bily.com, indopacificseashells.com, conchylinet.com, okhaen.net/French-Polynesia-shells-iconography, and the World Register of Marine Species (WoRMS, www.marinespecies.org).

2.4. Data analysis

The diversity indices of macro molluscs for the entire intertidal region of Barangay Paniman were computed through the application of the Shannon-Weiner (H') index, serving as a quantitative measure to characterize the overall diversity of molluscs in the studied area.:

$$H' = \sum_{i=1}^{S} (pi)(lnpi) \quad (1)$$

Where "S" represents the total number of species collected and "pi" denotes the proportion of individuals in the sample attributed to species "I," Margalef's index was also computed, using the formula:

$$D = \frac{S-1}{lnN} \quad (2)$$

Where "S" represents the total number of species, and "N" denotes the overall number of samples.

3. Results and Discussion

3.1. Species richness of marine macro molluscan bivalves and gastropods

The current research was carried out to obtain baseline information on the biodiversity of marine macro molluscan bivalves and gastropods in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. There were 557 individual molluscs counted and attributed to 90 species, with 43 species of bivalves from 32 genera and 18 families and 47 species of gastropods from 34 genera and 20 families. The identified collection of bivalves and gastropods is shown in Figures 2 and 3.

Table 1 identifies the bivalves and gastropods observed in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. These observations could be attributed to the topography of the study site's intertidal zone, which ranged from sandy to muddy with patches of seaweed beds to rocky shorelines exposed during low tides and shallower water. The family Veneridae was the most abundant in terms of species richness in the current study, followed by Cardiidae and Arcidae among the bivalves, which was consistent with previous studies conducted by Picardal and Dolorosa [11] in Binunsalian and Turtle Bays, Palawan, Philippines. Moreover, in this study, however, the family Strombidae was the highest represented in terms of species richness, followed by Neritidae and Olividae among gastropods, which was also observed in the Sarangani study [15]. In contrast, in the study of Arabaca *et al*. [20], Muricidae is the best-represented family in Ajuy, Iloilo, Western Visayas. In contrast, in Palawan [11] and Padada, Davao del Sur [16], the family Costellariidae and Nassariidae were the best-represented, respectively. This study recorded an even species richness of marine macro molluscans' bivalves and gastropods, with 52 and 54 species, respectively. This can be compared to previous studies conducted on a few areas, such as the Tubbataha Reef in Palawan, the Kalayaan group of islands, Western Visayas, and parts of Mindanao, which found a significant difference in the species richness of bivalves and gastropods. Briefly, Masagca *et al*. [10] discovered 27 species of gastropods

and 30 species of bivalves. There were 89 gastropods and 19 bivalve species recorded in Binunsalian and Turtle Bays, Palawan [11], 50 gastropods and 15 bivalves recorded in Iwahig River-Estuary-Palawan [12], and 69 gastropods and nine bivalves recorded from Kalayaan Islands [9]. There were 43 gastropods and 29 species of bivalves recorded in Ajuy, Iloilo, Western Visayas [20].

Table 1. Taxonomic list of marine macro molluscan bivalves and gastropods species collected in the intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines.

Bivalves		Gastropods	
Family	**Species**	**Family**	**Species**
Arcidae	*Anadara ferruginea*	**Cerithiidae**	*Cerithium balteatum*
	Anadara trapezia		*Cerithium columna*
	Potiarca pilule		*Cerathium trailli*
	Cetomya sumatrana		*Rhinoclavis* sp.
	Barbatia lacerate		*Rhinoclavis vertagus*
	Barbatia fusca	**Pisaniidae**	*Engina fusimormis*
Veneridae	*Gafrarium pectinatum*	**Conidae**	*Conus figulinus*
Cardiidae	*Vasticardium sewelli*		*Conus magus*
	Vasticardium flavum subrugosum		*Conus marmoreus*
	Fragum unedo		*Conus miliaris*
	Acrosterigma discus	**Cymatiidae**	*Cymatium vespaceum*
	Vasticardium pectiniforme		*Cymatium lotorium*
	Acrosterigma simplex		*Cymatium gemmatum*
	Vasticardium mindanense	**Cypraeidae**	*Lecoricypraea mappa mappa*
Cyrenidae	*Polymesoda coaxans*		*Monetaria moneta*
Glycymeridae	*Tucetona pectunculus*		*Monetaria annulus*
Fissurelidae	*Diodora tanneri*		*Rapsoniella punctata punctata*
Lucinidae	*Lucina speciosa*	**Haminoeidae**	*Aliculastrum solidum*
Hemidonacidae	*Hemidonax donaciformis*		*Atys naucum*
Donacidae	*Latona cuneata*		*Haminoea fusca*
Mactridae	*Mactrotoma angulifera*	**Liotiidae**	*Angania delphinus*
	Mactra violacea	**Nassaridae**	*Nassarius bimaculosus*
Placunidae	*Placuna placenta*		*Nassarius livescens*
Pectinidae	*Comptopallium radula*	**Naticidae**	*Natica fasciata*
Pteriidae	*Pinctada nigra*		*Polinices melanostomus*
Chamidae	*Amphichama argentata*		*Mamilla sebae*
	Chama savignyl	**Muricidae**	*Murex spectabilis*
	Chama ambigua		*Murex pecten*
Spondylidae	*Spondylus ocellatus*		*Rapa rapa*
	Spondylus sinensis	**Littorinidae**	*Nodilittorina pyramidalis*
Tellinidae	*Cyclotellina remies*		*Littorina scabra scabra*
	Jactellina clathrata	**Neritidae**	*Nerita undata*
	Tellina staurella	**Olividae**	*Oliva concavospira*
	Tellina virgata	**Strombidae**	*Oliva reticulata*
Veneridae	*Pitar affinis*		*Strombus urceus urceus*
	Antigona puerpera		*Strombus* (Laevistrombus) *canarium*
	Anomalodiscus squamosus		*Euprotomus bulla*
	Gafrarium pectinatum	**Potamididae**	*Lambis lambis*
	Lioconcha tigrine		*Telescopium Telescopium*
	Periglypta chemnitzil	**Terebridae**	*Terebralia palustris*
	Gafrarium pectinatum forma *tumidum*	**Trochidae**	*Hatula Albula*
	Gafrarium divaricatum		*Monodonta canalifera*
	Antigona lacerata		*Tectus fenestratus*
		Tonnidae	*Trochus maculatus*
		Angariidae	*Tonna perdix*
		Turbinidae	*Angaria delphinus*
			Turbo intercostalis

Figure 2. Marine macro molluscans bivalves collected and identified in intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. **1**-*Anadara ferruginea*, **2**-*Anadara trapezia*, **3**-*Potiarca pilule*, **4**-*Cetomya sumatrana*, **5**-*Barbatia lacerata*, **6**-*Barbatia fusca*, **7**-*Gafrarium pectinatum*, **8&9**- *Vasticardium sewelli*, **10**-*Vasticardium flavum subrugosum*, **11**-*Fragum unedo*, **12**-*Acrosterigma discus*, **13**-*Vasticardium pectiniforme*, **14**-*Acrosterigma simplex*, **15**-*Vasticardium sewelli*, **16**- *Vasticardium flavum subrugosum*, **17&18**- *Acrosterigma simplex*, **19**-*Vasticardium mindanense*, **20**-*Vasticardium flavum subrugosum*, **21&22**- *Polymesoda coaxans*, **23**-*Tucetona pectunculus*, **24**-*Diodora tanneri*, **25**-*Lucina speciosa*, **26**-*Tucetona auriflua*, **27**-*Hemidonax donaciformis*, **28**-*Latona cuneata*, **29**-*Mactrotoma angulifera*, **30**-*Mactra violacea*, **31**-*Placuna placenta*, **32**-*Comptopallium radula*, **33**-*Pinctada nigra*, **34**-*Amphichama argentata*, **35**-*Chama savignyl*, **36**-*Chama ambigua*, **37**-*Spondylus ocellatus*, **38**-*Spondylus sinensis*, **39**-*Cyclotellina remies*, **40**-*Spondylus sinensis*, **41**- *Jactellina clathrata*, **42**-*Tellina staurella*, **43**-*Pitar affinis*, **44**-*Tellina virgata*, **45**-*Antigona puerpera*, **46**-*Anomalodiscus squamosus*, **47**-*Gafrarium pectinatum*, **48**-*Lioconcha tigrine*, **49**-*Periglypta chemnitzil*, **50**-*Gafrarium pectinatum* forma *tumidum*, **51**-*Gafrarium divaricatum*, **52**-*Antigona lacerate*.

Figure 3. Marine macro molluscans gastropods collected and identified in intertidal areas of Barangay Paniman, Caramoan, Camarines Sur, Philippines. **53**-*Cerithium columna,* **54**-*Cerithium balteatum*, **55**-*Rhinoclavis sp.*, **56&57**-*Cerithium traillii,* **58**-*Rhinoclavis vertagus*, **59**-*Engina fusiformis*, **60**-*Conus figulinus,* **61**-*Conus miliaris*, **62&63**-*Conus magus*, **64**-*Conus marmoreus*, **65**-*Conus miliaris*, **66**-*Conus magus*, **67**-*Cymatium vespaceum*, **68**-*Cymatium lotorium*, **69**-*Cymatium gemmatum*, **70**-*Leporicypraea mappa mappa*, **71**-*Monetaria moneta*, **72**-*Monetaria annulus*, **73**-*Rapsoniella punctata punctata*, **74**-*Aliculastrum solidum*, **75**-*Atys naucum*, **76**-*Haminoeia fusca*, **77**-*Angania delphinus*, **78**-*Nassarius bimaculosus,* **79**-*Nassarius livescens,* **80**-*Natica fasciata,* **81**-*Polinices melanostomus,* **82**-*Mamilla sebae*, **83**-*Murex spectabilis*, **84**-*Murex pecten*, **85**-*Murex spectabilis*, **86**-*Nodilittorina pyramidalis*, **87**-*Nerita undata*, **88**-*Oliva concavospira*, **89&90**-*Oliva reticulata*, **91**-*Strombus urceus urceus,* **92**-*Strombus* (Laevistrombus) *canarium* Linne, **93**-*Euprotomus bulla*, **94**-*Lambis lambis*, **95**-*Telescopium Telescopium*, **96**-*Terebralia palustris*, **97**-*Hastula albula*, **98**-*Monodonta canalifera*, **99**-*Tectus fenestratus*, **100**-*Trochus maculatus*, **101**-*Tonna perdix*, **102**-*Rapa rapa*, **103**-*Angaria delphinus*, **104**- *Littorina scabra scabra*, **105&106**-*Turbo intercostalis.*

Moreover, Tabugo *et al*. [14] discovered 15 gastropods and three bivalve species in Hadji Panglima Tahil, Province of Sulu, 57 gastropods and one bivalve species in Alabel and Maasim, Province of Sarangani [15], and 17 gastropod and 14 bivalve species in Padada, Davao del Sur [16]. However, this represents only a tiny proportion of the Philippines' 1,600 known gastropod and bivalve species [21]. Discrepancies observed between the findings of the present investigation and prior studies conducted in specific regions of the Philippines may be attributed to variances in substrates prevailing in each locale and environmental factors encompassing biological, physical, and chemical parameters. Furthermore, overexploitation can contribute to differences in every intertidal zone in the areas regarding species richness and abundance of marine macro molluscan bivalves and gastropods for residents in the study areas who rely on marine resources for a living. Finally, tourism-related recreational activities in the sampling area may contribute to the distribution and destruction of some areas of this marine habitat.

3.2. Shannon-Wiener diversity index of marine macro molluscan bivalves and gastropods

A community with an H' value greater than two is considered medium to high in terms of species diversity [20]. The H value of bivalves in this study was 3.44, and that of gastropods was 2.68, indicating a high species diversity in the study area. The high value of H' could be attributed to physical and biological factors that influence the abundance and diversity of marine macro molluscs. Many factors influence the abundance of marine macro molluscan bivalves and gastropods along the intertidal zones, which may be influenced by the continuous experience of large fluctuations in temperature, salinity, and wave action between the highest and lowest tides. This result may demonstrate significant differences in the diversity of bivalves and gastropods found in intertidal zones. However, the species diversity may experience a reduction, potentially influenced by anthropogenic activities, notably pollution and other disturbances within marine waters originating from coastal communities proximate to the shoreline and commercial zones frequented by a substantial influx of tourists annually. The persistence of such conditions poses the risk of further diminishing the species diversity over time. Finally, overexploitation and overfishing of some molluscan species for commercial purposes may also impact the decrease in species diversity in this area.

4. Conclusions

Out of 557 individual molluscs counted in the intertidal zones of Barangay Paniman, Caramoan, Camarines Sur, 43 species of bivalves and 47 species of gastropods were collected and identified. The most numerous species belonged to the Veneridae family of bivalves and the Strombidae family of gastropods. The Shannon-Weiner diversity index showed a high value among bivalves and gastropods. However, the overall value revealed that the area's species diversity was still high. This study contributes foundational data about the diversity of intertidal marine macro-molluscan bivalves and gastropods within Barangay Paniman, Caramoan, Camarines Sur, Philippines. The resultant dataset serves as a robust empirical foundation for formulating and implementing conservation and sustainability initiatives.

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