

Abundance and diversity of mollusks in the mangrove ecosystem of coastal barangay in Pasacao, Camarines Sur: Implications for local policy enhancement and sustainable management

Sibulo, Sunshine A. ✉

Central Bicol State University of Agriculture (Pasacao Campus), Philippines (sunshine.sibulo@cbsua.edu.ph)

Ilarde, Glency O.

Notario, Aira May

Salditos, Princess R.

Alcibor, Bencil E.

Barbosa, Daisyre B.

Bandola, Cristian Jay B.

Labilles, Rosechel C.

Nolasco, Michael N.

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Abstract

This study addresses the critical lack of baseline data on mollusk communities in the mangrove ecosystems of Pasacao, Camarines Sur, by assessing their abundance, diversity, and socioeconomic relevance. Using a descriptive-quantitative field design, the research investigated mollusk populations across three coastal barangays: Balogo, Sta. Rosa Del Sur, and Sarimao. The line-transect quadrat method was employed, establishing two 50- meter transects at each site with systematically placed 5m X 5m quadrats. All visible mollusks were collected, counted, and taxonomically identified. Environmental parameters salinity, temperature, and dissolved oxygen were measured in situ, while Shannon-Wiener and Simpson's indices quantified diversity. Concurrently, structured surveys (n = 45) assessed local reliance on mollusks for food security and livelihoods. A total of 18 mollusk species were recorded across the study sites. While Sta. Rosa Del Sur recorded the highest abundance (1,108 individuals of *Cerithidea cingulata*), Sarimao exhibited the highest diversity and the least environmental degradation. Conversely, Balogo and Sta. Rosa Del Sur displayed signs of pollution, including plastic waste and potential oil contamination, which reduced species diversity. Socioeconomically, the majority of coastal households, particularly in Balogo (86.67%), rely on mollusks as a primary food source, though commercial trade and craft usage remain minimal. To support conservation and sustainable management, the study recommends

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improving municipal solid waste management, establishing a seasonal harvesting ban in October to protect juvenile growth, restoring degraded mangroves near the local oil depot, implementing community-led conservation education modeled after Sarimao, and integrating mollusk diversity indicators into municipal coastal management plans.

Keywords: mollusks, abundance, species diversity, mangrove ecosystem, conservation policy

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1. Introduction

Coastal ecosystems play an essential role in maintaining global environmental balance and regulating climate. Among these, mangrove forests are particularly important due to their high productivity and resilience. Located at the interface of land and sea, these habitats are characterized by tidal changes, salty conditions, and nutrient-rich sediments. Coastal ecosystems are some of the most biologically rich and ecologically important environments on Earth. They provide essential services that support both environmental stability and human well-being, such as regulating climate, protecting shorelines, storing carbon, and providing homes for many marine and land species (Lisna et al., 2017). Mangrove forests are unique because they serve as transition zones between land and sea. With their regular tides, brackish water, and rich sediments, mangroves support complex food chains and act as important nursery areas for many aquatic animals especially mollusks (like snails and clams), which play key roles as waste eaters, water filters, and food for other animals in coastal food webs (Septiana et al., 2016).

Mollusks including gastropods (snails) and bivalves (clams and oysters) are not only ecologically integral but also socioeconomically valuable, especially in tropical coastal communities where they contribute significantly to food security, livelihoods, and cultural practices (Gallardo et al., 2018; Khan et al., 2017). In Southeast Asia, a region recognized for its exceptional mangrove biodiversity, mollusk assemblages are frequently employed as bioindicators of ecosystem health due to their sensitivity to anthropogenic stressors such as pollution, salinity shifts, sedimentation, and habitat degradation (Nóbrega et al., 2020; Ghosh et al., 2022). The conservation and sustainable use of marine biodiversity are emphasized in international environmental frameworks such as the United Nations Sustainable Development Goals (SDGs). These global commitments highlight the importance of protecting coastal ecosystems and marine resources to support ecological stability and human well-being. In particular, SDG 14 (Life Below Water) promotes the conservation and sustainable use of oceans, seas, and marine resources; SDG 2 (Zero Hunger) recognizes the role of marine organisms in sustaining food systems and livelihoods; and SDG 13 (Climate Action) underscores the need to protect natural ecosystems that enhance climate resilience. These international commitments encourage countries to strengthen national policies and local governance mechanisms for biodiversity conservation and sustainable resource management.

At the national level, the Philippines has enacted several policies that support the conservation and sustainable management of coastal and marine resources. National policy frameworks, including the Philippine Fisheries Code (Republic Act No. 8550, as amended by RA 10654), the Expanded National Integrated Protected Areas System (E-NIPAS) Act (RA 11038), and the Local Government Code (RA 7160), explicitly recognize the importance of conserving coastal and marine resources and delegate stewardship responsibilities to local government units (LGUs). Invertebrates are classified as wildlife resources under the control of the government and are shielded from harm caused by habitat destruction by Republic Act 9147 (Wildlife Resources Conservation and Protection Act). The Ecological Solid Waste Management Act (Republic Act 9003) and the Philippine Clean Water Act (Republic Act 9275) also empower local government units to combat plastic pollution and provide clean water quality in the mangrove areas. Together, these national laws provide a link between the national mandate for conservation and local enforcement to incorporate wildlife information (including invertebrates) into municipal coastal management plans. However, despite these strong laws, enforcing conservation measures at the local level remains inconsistent, largely because there is a lack of site-specific scientific data to help guide decision-making and enforcement.

The Philippines, home to an estimated 22,000 mollusk species representing approximately 10% of global

molluscan diversity, relies heavily on these invertebrates for subsistence fishing and small-scale commercial activities. Despite the country's significant molluscan diversity and dependence on these resources, the lack of localized ecological data limits the ability of local authorities to implement effective conservation and management strategies. This knowledge gap is particularly pronounced in Pasacao, Camarines Sur, a coastal municipality endowed with mangrove forests across barangays such as Balogo, Sta. Rosa del Sur, and Sarimao. While these mangroves sustain local mollusk harvesting for household consumption and limited trade, no systematic inventory exists regarding mollusk species composition, abundance, diversity, or the environmental drivers influencing their distribution. Moreover, emerging threats including plastic pollution, hydrocarbon contamination from a nearby oil depot, and unregulated harvesting pose increasing risks to both ecological integrity and community resilience. In the absence of actual baseline data, LGUs lack the necessary evidence to formulate targeted conservation strategies, enforce sustainable harvesting practices, or align local ordinances with national and international sustainability commitments, including the United Nations Sustainable Development Goals (SDGs), notably SDG 14 (Life Below Water), SDG 2 (Zero Hunger), and SDG 13 (Climate Action).

To address this gap, this study investigates the abundance, species diversity, and socioeconomic contributions of mollusks in the mangrove ecosystems of three coastal barangays in Pasacao, Camarines Sur. Using a combined approach of field surveys, analysis of environmental parameters (such as salinity, pH, sediment type, and organic matter), and household interviews, the research establishes the first comprehensive dataset on mollusk communities in the area. The findings aim to provide scientifically based insights that can inform policy recommendations, support community conservation initiatives, and help integrate biodiversity indicators into municipal coastal management plans. Ultimately, this study seeks to strengthen the connection between ecosystem health and human well-being in a rapidly changing coastal landscape.

Objectives of the Study - The primary aim of the research is to assess the role of the mangrove ecosystem in influencing the diversity and abundance of mollusks in Zone 1 Pongol, Balogo; Zone 6 Sta. Rosa Del Sur; and Sitio Sarimao, Caranan, Pasacao, Camarines Sur. Furthermore, this study aims to: identify the mollusk species present across the selected coastal sites; determine which among the three areas exhibits the highest mollusk diversity and abundance; examine the ecological and environmental factors that influence mollusk populations within these mangrove habitats; assess the potential economic contribution of mollusk resources, including their roles in food, trade, and crafts, to local household livelihoods; and identify sustainable conservation and protection mechanisms to preserve mollusk biodiversity in the mangrove ecosystems of Pasacao, Camarines Sur.

Significance of the Study - This study will significantly contribute to the understanding of mangrove ecosystems as vital habitats for mollusks across Zone 1 Pongol, Balogo, Zone 6 Sta. Rosa Del Sur, and Sitio Sarimao in Caranan, Pasacao, Camarines Sur, offering scientific insights essential for coastal resource management, conservation planning, and community education. For the local community, the research highlights the ecological and economic importance of mangroves, emphasizing that protecting these habitats directly safeguards their food security and livelihoods tied to mollusk harvesting. At the administrative level, the findings provide the Local Government Unit (LGU) of Pasacao with crucial, science-based baseline data on mollusk diversity and abundance, enabling more informed decision-making for local coastal policies. Furthermore, environmental groups can leverage these research outcomes to design targeted educational campaigns, habitat restoration projects, and collaborative initiatives with stakeholders. For the academic community, students and teachers can utilize this study as a practical learning tool to explore ecological connectivity and enrich school-based environmental projects, while future researchers can use it as a foundational guide and scientific reference for subsequent studies on marine life and environmental conservation in the region.

Scope and Delimitation - This study investigated the variety and quantity of mollusks, including clams and snails, found in the mangrove habitats of selected coastal barangays in Pasacao, Camarines Sur specifically Zone 1 Pongol and Zone 1 Balogo in Zone 6, Sta. Rosa del Sur, and Sitio Sarimao, Caranan, Pasacao, Camarines Sur. The research focused on identifying and studying different mollusk species, particularly gastropods (such as snails) and bivalves (like clams). Specific areas within these sites were divided into quadrats measuring five meters by

five meters. The research team manually collected and identified mollusks using field guides to better understand their relationship with the mangrove environment. The study did not extend beyond the identification and enumeration of mollusk species at these locations. It did not include detailed genetic analyses or in-depth investigations into the organisms' physiology. Practical constraints including time, accessibility to the sites, and available research resources served as realistic limitations. Additionally, the study was confined exclusively to the specified barangays: Sitio Sarimao and Balogo, as well as Zone 6 of Sta. Rosa del Sur; no other barangays in Pasacao or adjacent areas were included. This focused approach aimed to shed light on how mangrove ecosystems support mollusk diversity, with the hope that such insights could inform broader strategies for resource management and conservation in coastal regions.

The study was conducted over a one-month period in October 2025 within the designated coastal barangays of Pasacao, Camarines Sur. During this time, fieldwork was carried out to collect and identify mollusk species using transect and quadrat sampling methods. Following data collection, the results were organized and analyzed to assess mollusk diversity and abundance. In the final phase of the study, the findings were compiled into a comprehensive report that also included recommendations for the conservation and sustainable use of mollusk resources in the area.

Theoretical Framework - This study's theoretical framework uses several established ecological theories to explain the distribution and functions of mollusk communities within mangrove ecosystems. Hutchinson's Ecological Niche Theory (1957) and MacArthur and Wilson's Island Biogeography Theory (1967) explain how the complex physical structures of mangroves such as varied root systems and substrates along with the size and connectivity of these habitats, determine species richness. Furthermore, Tilman's Species Diversity-Productivity Relationship (1997) and Lindeman's Trophic Dynamics (1942) show how higher mollusk diversity maintains nutrient cycling and energy transfer as mollusks act as both consumers and prey. Finally, Connell's Intermediate Disturbance Hypothesis (1978) indicates that moderate natural and human disturbances prevent single-species dominance, allowing multiple species to coexist. Together, these theories demonstrate how habitat structure, energy flow, and disturbance levels regulate mollusk diversity and abundance.

2. Methodology

This section presented the Research design, area of study, sampling technique, data collection, and Data Gathering Procedure.

Research Design - This study used a descriptive, quantitative field research design to assess the diversity and abundance of mollusks in relation to the mangrove ecosystem in Zone 1 Pongol, Balogo, and Zone 6, Sta. Rosa del Sur; and Sitio Sarimao, Caranan, Pasacao, Camarines Sur. The research focused on identifying mollusc species and evaluating their distribution in mangrove areas.

Areas of the Study - This study was conducted in the ecologically significant mangrove forests of Pasacao, Camarines Sur, specifically across three selected coastal stations: Zone 1 Pongol in Barangay Balogo (13.5008° N, 123.0621° E), Zone 6 in Barangay Sta. Rosa del Sur (13.5086° N, 123.0412° E) and Sitio Sarimao in Barangay Caranan (13.5190° N, 123.0157° E). These sites were purposively selected due to their active mangrove stands, which serve as critical breeding, feeding, and sheltering grounds for various mollusk species, while simultaneously supporting local livelihoods through food security, small-scale trade, and raw materials for crafts. To ensure standardized ecological sampling across all three sites, a station was established at each location featuring two 50-meter transect lines placed 10 meters apart, along which (5m X 5m) quadrats were systematically placed to record species distribution and abundance. By analyzing these critical habitats, the study provides a vital baseline dataset necessary to align local biodiversity management with broader conservation goals and sustainable resource management practices.

Sampling Technique - To evaluate the community structure and distribution of mollusks, this study systematically utilized a stratified random sampling technique combined with a modified line-transect quadrat

method across the three coastal barangays. The sampling areas were first stratified into distinct zones based on mangrove density to capture varying ecological conditions. Within each station, 50-meter transect lines were laid across the mangrove forest during low tide, along which a transect walk was conducted to observe and document spatial patterns and microhabitats. Along these transects, (5m X 5m) quadrats were positioned at 5-meter intervals to ensure consistent and representative coverage while minimizing sampling bias. By breaking down the mangrove habitat into manageable sections, this quadrat sampling technique allowed for the precise recording of species diversity and population density, ensuring a highly structured approach to data collection.

Data Gathering Procedure - The study used a 5 m × 5 m quadrat frame to mark specific sampling areas in the mangrove sites. This ensured that sampling was conducted in equal and organized spaces across all study locations. Along transect lines, quadrats were placed systematically during low tide to facilitate easier and more accurate mollusk collection. Inside each quadrat, all visible mollusks were manually collected, counted, and identified using field guides such as *A Field Guide to the Marine Invertebrates* by Colin and Arneson. A measuring tape was used to lay out the transects accurately, while a camera documented the mollusks and their surrounding habitats to aid in species verification during post-fieldwork analysis. For data recording, notebooks and standardized data sheets were used to document the number of species, their abundance, and relevant environmental factors. Ultimately, these collected data were organized and analyzed using diversity indices to evaluate the distribution and abundance of mollusks within the mangrove ecosystem, following standard ecological survey methods to monitor biodiversity in a reliable and consistent manner. Concurrently, to determine the socioeconomic value of these resources to local households, face-to-face interviews were conducted across the study areas of Balogo, Sta. Rosa del Sur, and Sarimao during the October 2025 ecological sampling period. Following established Philippine coastal livelihood protocols, this semi-structured survey collected basic demographic data while focusing on four key dimensions: mollusk consumption patterns, sourcing methods, market access and trade involvement, and the use of shells for craft items. This dual approach minimized respondent burden while yielding contextually relevant, locally grounded data on these mangrove-dependent communities.

Data Collection - Mollusks within each quadrat were manually counted and identified using field guides and morphological characteristics.

Data Analysis - To analyze the collected species, all visible mollusks within each quadrat were manually counted and identified using field guides and distinct morphological characteristics. These counts were then evaluated through specific ecological formulas: species richness and diversity were assessed using both the Shannon-Wiener Diversity Index and the Simpson's Diversity Index, while tally counts and percentages were calculated to determine mollusk frequency and dominance within the habitat. Finally, the processed data were organized into structured tables to clearly present the spatial distribution of each mollusk species across the different sampling zones.

Frequency - Frequency referred to the proportion of sampling units (quadrats) in which a species occurred. It indicated the distribution or spread of a species within the study area.

Abundance - Abundance referred to the average number of individuals of a species per quadrat where that species was present. It reflected the concentration of a particular species within its occupied space.

Shannon-Wiener Diversity Index - The Shannon-Wiener Diversity Index was applied to evaluate overall species diversity by factoring in both the total number of species encountered and the proportion of the overall population that each species represents.

Simpson Index - The Simpson Index of Dominance was used to assess the probability that two randomly selected individuals belong to the same species, based on the number of individuals in a specific species relative to the total number of individuals across all species.

Density - Density referred to the number of individuals of a species per unit area, providing a snapshot of how crowded or sparsely distributed a species was within the habitat.

3. Results and Discussion

This chapter presented the results and discussed the data collected through the research methods employed in this study. The data were analyzed to infer findings needed to answer the specific problems identified in the study.

3.1 Mollusk species Distribution in Mangrove areas of Pasacao, Camarines Sur

The distribution of mollusk species collected across the three mangrove sampling areas; Station 1 at Zone 1 Pongol (Balogo), Station 2 at Zone 6 Sta. Rosa Del Sur, and Station 3 at Sitio Sarimao (Caranan) in Pasacao, Camarines Sur is presented in Table 1. Across all locations, a total of 18 species were identified, spanning a wide array of families including Neritidae, Potamididae, Littorinidae, Turbinidae, Conidae (*Conus spurius*), Muricidae, *Cerithidae sp.*, Pachychilidae, Melampidae, Assimineidae, Pleuroceridae, Pisaniidae, Ellobiidae (*Ellobium durisjudae*), the genus *Caraudus*, and Trochidae. Looking at the breakdown by site, Station 2 exhibited the highest species richness with 13 recorded mollusk families. This was followed by Station 3, which recorded 8 families, and Station 1, which had the lowest diversity with 7 identified mollusk families. The variation in the number of mollusk families across the three stations can be explained by the Ecological Niche Theory (Hutchinson, 1957), which states that species distribution is heavily influenced by localized environmental conditions and the availability of distinct ecological niches. This implies that stations with more favorable and diverse habitat characteristics such as variations in substrate type, salinity, and tidal exposure are able to support a greater number of mollusk families, whereas stations with limited or less suitable conditions support fewer groups. Ultimately, these differences in family composition highlight the crucial role that overall habitat complexity plays in shaping species survival and distribution within mangrove ecosystems.

Table 1
Mollusk species distribution in Mangrove areas of Pasacao, Camarines Sur

Mollusk Species	Zone 1 Pongol, Balogo	Zone 6 Sta. Rosa Del Sur	Sitio Sarimao
Neritidae	✓	✓	✓
Potamididae	✓	✓	✓
Littorinidae	✓	✓	✓
Turbinidae	✓	✓	✓
Conidae (<i>Conus spurius</i>)	✓	✓	
Muricidae	✓	✓	
<i>Cerithidae sp.</i>	✓	✓	✓
Pachychilidae		✓	
Melampidae		✓	
Assimineidae		✓	
Pleuroceridae		✓	
Pisaniidae			✓
Ellobiidae (<i>Ellobium durisjudae</i>)			✓
Genus <i>Caraudus</i>			✓
Trochidae		✓	



Figure 2. Image of the 18 mollusk species found in the 3 areas (a) Neritidae, (b) Littorinidae, (c) Melampidae, (d) Littorinidae, (e) Potamididae (*Cerithidea cingulate*), (f) Pisanidae, (g) Assiminae, (h) Trochidae, (i) Pachychilidae, (j) Pleroceridae, (k) Muricidae (*Nucella canaliculata*), (l) Muricidae, (m) Trochidae, (n) Turbinidae, (o) Potaminidae, (p) Ellobiidae (*Ellobium durisjudae*), (q) Conidae (*Conus spurius*), (r) Cerithidae

3.2 Frequency distribution of mollusks species in mangrove areas in Pasacao, Camarines Sur

In contrast, Station 2 at Zone 6 Sta. Rosa Del Sur displayed intermediate diversity characterized by the dual dominance of Neritidae and Cerithidea cingulata. The soft, organic-rich muddy substrate at this site heavily favored deposit-feeding and detritivorous species, while naturally limiting specialized or predatory taxa like Muricidae that require harder substrates. This structure aligns with the Species Diversity-Productivity Relationship, indicating that while the nutrient-rich environment functions productively and supports well-adapted generalists, it restricts specialists and lacks the ecological balance seen in more heterogeneous habitats (Tilman, 1997). Station 1 at Zone 1 Pongol Balogo recorded the lowest species diversity despite having the highest overall abundance of a single taxon. Here, the family Neritidae dominated overwhelmingly, reflecting competitive exclusion under uniform habitat conditions that offer limited niche availability. Secondary families occurred only at low frequencies, and specialized or predatory species were rare (Caril et al., 2023). Ultimately, this gradient across the three stations underscores the fundamental role of habitat complexity; varied substrates and moderate salinity promote species coexistence and biodiversity, whereas uniform environments allow a single, highly adaptive group to achieve complete dominance.

Table 2

Frequency distribution of mollusk in the three (3) sampling station

Mollusk species	Zone 1 Pongol, Balogo	Zone 6 Sta.Rosa Del Sur	Sitio Sarimao
Neritidae	95	100	60
Potamididae	65	45	35
Littorinidae	55	45	40
Turbinidae	30	0	30
Conidae(Conus spurius)	15	15	0
Muricidae	10	10	0
Cerithidae sp.	10	60	60
Pacychilidae	0	10	0
Melampidae	0	10	0
Assimineidae	0	10	0
Pleuroceridae	0	10	0
Ellobiidae(Ellobium durisjudae)	0	0	20
Genus Caraudus	0	0	10
Trochidae	0	10	0
isaniidae	0	0	25
Total families Recorded	7	13	8

Note. Values represent the number of quadrats (out of total sampled) in which each taxon was observed. Dash (0) indicates taxon not recorded at that station.

3.3 Abundance Distribution of mollusks species in mangrove areas in Pasacao, Camarines Sur

The results of the mollusk abundance distribution reveal distinct population patterns across the three sampling sites Zone 1 Pongol, Balogo; Zone 6 Sta. Rosa Del Sur; and Sitio Sarimao, Caranan, Pasacao, Camarines Sur as shown in Table 3. The three mangrove stations exhibited distinct mollusk assemblage patterns driven by habitat characteristics. Station 2 (Sta. Rosa Del Sur) recorded the highest abundance (1,108 individuals) but the lowest diversity, dominated by *Cerithidea cingulata* (Potamididae), reflecting adaptation to homogeneous, detritus-rich muddy sediments (Ando, 2015; Ma et al., 2018). This near-monoculture aligns with the Species Diversity–Productivity Relationship (Tilman, 1997), indicating that high abundance does not equate to ecosystem health or balance (Trianto et al., 2023). Station 1 (Pongol Balogo) showed moderate abundance (280 individuals) but the highest diversity, with balanced representation across Neritidae, Potamididae, Littorinidae, and Turbinidae. This pattern suggests a heterogeneous intertidal habitat with mixed substrates and brackish conditions that facilitate niche partitioning, supporting Hutchinson's (1957) Ecological Niche Theory (Ramos et al., 2021; Safitri et al., 2025). Station 3 (Sitio Sarimao) had the lowest abundance (256 individuals) and intermediate diversity, dominated by Potamididae (80.5%), consistent with adaptation to soft, organic-rich mud typical of mangrove ecosystems (Raw et al., 2017; Darmi & Yanti, 2017; Zvonareva et al., 2015). Collectively, these results demonstrate that habitat complexity not abundance alone drives mollusk diversity. Conservation efforts should prioritize structurally

diverse mangroves to sustain biodiversity and ecosystem function, in agreement with both the Species Diversity–Productivity Relationship and Ecological Niche Theory.

Table 3

Abundance and density of mollusk species across three mangrove sampling stations in Pasacao, Camarines Sur

MOLLUSK SPECIES	ZONE 1	PONGOL	ZONE 6	STA. ROSA DEL	SITIO	
	BALOGO		SUR		SARIMAO	
	Abundance	Density	Abundance	Density	Abundance	Density
Neritidae	38.00	1.49	40.15	1.61	17.76	0.70
Potamididae	43.79	1.10	56.38	1.03	74.59	1.06
Littorinidae	35.27	0.82	43.45	0.76	40.50	0.65
Turbinidae	3.20	0.04	—	—	3.88	0.05
Cerithiidae	2.00	0.01	—	—	17.76	0.40
Cerithidea cingulata	—	—	184.67	4.43	—	—
Conus spurius	2.50	0.01	1.25	0.01	—	—
Muricidae	1.00	0.01	3.00	0.01	—	—
Trochidae	—	—	11.00	0.04	—	—
Monodonta confusa	—	—	10.00	0.08	—	—
Nucella canaliculata	—	—	1.00	0.00	—	—
Pachychilidae	—	—	9.00	0.04	—	—
Melampidae	—	—	1.00	0.00	—	—
Assimineidae	—	—	2.00	0.01	—	—
Pleuroceridae	—	—	1.00	0.00	—	—
Pisaniidae	—	—	—	—	31.09	0.36
Ellobium durisjudae	—	—	—	—	42.50	0.34
Genus Caraudus	—	—	—	—	2.00	0.01

Note. Abundance = mean number of individuals per quadrat where species occurred; Density = individuals per m². Dash (—) indicates taxon not recorded at that station. Total sampled area per station = 250 m² (two 50-m transects × five 5×5 m quadrats).

3.4 Diversity index of mollusks species in mangrove areas in Pasacao, Camarines Sur

The diversity index results reveal distinct levels of mollusk diversity across the three sampling areas in Pasacao, Camarines Sur are shown in the table 4. Station 3 exhibited the highest diversity ($H' = 1.77$; $D = 5.24$), indicating high species richness and an equitable distribution facilitated by mixed muddy-sandy substrates, moderate salinity, and structural complexity. These conditions promote niche partitioning, aligning with the Ecological Niche Theory (Hutchinson, 1957), which posits that diverse environmental conditions create multiple microhabitats that allow species to utilize different resources and avoid direct competition. However, the presence of domestic debris introduces localized stressors that may favor opportunistic, pollution-tolerant species. This observation is consistent with the Intermediate Disturbance Hypothesis (Connell, 1978), suggesting that while some disturbance can influence composition, escalating pollution may eventually reduce overall diversity by favoring tolerant taxa over sensitive ones (Djohar et al., 2020; Widianarko & Hidayati, 2018).

Station 1 demonstrated moderate diversity, with balanced Shannon-Wiener and Simpson's values reflecting fair species richness and evenness without pronounced dominance. This equilibrium is attributable to the heterogeneous rocky-muddy substrate and stable tidal conditions that support the coexistence of algal-grazing Neritidae, mud-associated Potamididae, and trunk-dwelling Littorinidae. Such findings corroborate previous studies suggesting that mixed intertidal habitats promote resource partitioning (Baharuddin et al., 2019; Zvonareva et al., 2015). Conversely, Station 2 recorded the lowest diversity ($H' = 1.27$; $D = 2.7$), characterized by reduced species richness and increased dominance by pollution-tolerant taxa, likely driven by hydrocarbon contamination from a nearby oil depot. In accordance with the Intermediate Disturbance Hypothesis, high levels of disturbance alter physical and chemical habitat conditions, rendering them unsuitable for sensitive species. Furthermore, these results support the Species Diversity–Productivity Relationship (Tilman, 1997), which suggests that ecosystems with lower diversity and high species dominance are less stable due to an imbalance in energy and resource distribution (Hasidu et al., 2020; Gao et al., 2018).

Ultimately, the variation in mollusk diversity across these mangrove sites underscores the critical importance of habitat heterogeneity and water quality. Conservation efforts must be site-specific: low-diversity areas require immediate pollution mitigation and sediment restoration; moderate-diversity sites necessitate the protection of natural substrate mixes; and high-diversity areas require proactive waste prevention to maintain biodiversity. Aligning these strategies with the specific ecological needs of each site strengthens mangrove resilience, ensuring that these ecosystems continue to support the vital ecological roles played by mollusk assemblages. These findings reinforce fundamental ecological theories, demonstrating that habitat complexity provides the niches necessary for coexistence, while excessive disturbance significantly limits species survival and community stability.

Table 4

Diversity index of mollusks species in mangrove areas in Pasacao, Camarines Sur

SAMPLING STATION	SHANNON-WIENER INDEX (H')	SIMPSON'S INDEX (D)
Zone 1 Pongol, Balogo	1.39	2.94
Zone 6 Sta.Rosa Del Sur	1.27	2.70
Sitio Sarimao	1.77	5.24

Note. $H' < 1.5$ = low diversity; $H' = 1.5-2.0$ = moderate diversity; $H' > 2.0$ = high diversity. Higher D values indicate greater diversity and lower dominance by single species.

3.5 Factors influencing mollusk diversity and abundance in Mangrove areas

The composition and distribution of mangrove mollusk assemblages are dictated by a complex interplay of temporal, environmental, and anthropogenic factors. Research suggests that sampling duration and timing significantly influence observed biodiversity; specifically, surveys restricted to peak daylight hours may disproportionately represent heat-tolerant families like Neritidae while underestimating cryptic or burrowing taxa such as Potamididae and Muricidae. This temporal bias, rooted in Ecological Niche Theory, necessitates stratified sampling protocols to ensure ecological validity. Furthermore, environmental filters including tidal cycles, solar radiation, and the Intermediate Disturbance Hypothesis structure these communities by imposing physiological stressors that favor stress-tolerant species. Anthropogenic pressures, most notably plastic pollution, exacerbate habitat degradation by inducing hypoxic conditions and altering sediment composition, which ultimately simplifies community structures. Finally, seasonal fluctuations in rainfall and nutrient availability regulate reproductive cycles and energy flow, suggesting that single-period assessments may capture specific recruitment peaks while failing to represent the full scope of assemblage dynamics. Consequently, achieving a robust baseline for biodiversity requires integrated, multi-seasonal, and temporally diverse survey methodologies to account for the dynamic nature of mangrove ecosystems.

3.5.1 Environmental Parameters

As shown in Table 5, substantial variability in dissolved oxygen, temperature, salinity, and specific gravity was observed across the three mangrove locations: Zone 1 Pongol, Balogo; Zone 6 Sta. Rosa Del Sur; and Sitio Sarimao, Caranan, Pasacao, Camarines Sur. These physicochemical patterns are elucidated by the Ecological Niche Theory (Hutchinson, 1957), which posits that species possess specific tolerance ranges; consequently, mollusk assemblages are shaped by physiological filtering, where environmental conditions exceeding certain thresholds exclude sensitive taxa and favor adapted species. Dissolved oxygen (DO) values ranged from 1.4 mg/L to 14.3 mg/L, representing a spectrum from severe hypoxia to supersaturation. The hypoxic conditions (< 2 mg/L) recorded in Sitio Sarimao suggest localized respiratory stress potentially driven by organic decomposition and limited water exchange (Breitburg et al., 2018), while the peak DO in Zone 1 likely reflects robust photosynthetic activity in shallow, well-lit waters.

Thermal conditions varied from 29.2°C to 35.9°C, with the elevated temperatures in Balogo likely compounding physiological stress by reducing oxygen solubility while simultaneously increasing metabolic demands. Conversely, the lower temperatures in Sarimao and the moderate range in Sta. Rosa Del Sur represent more stable tropical estuarine conditions. Salinity displayed the most pronounced gradient, ranging from 0 ppt in Balogo to 32 ppt in Sarimao. This gradient serves as a primary regulator of biodiversity by dictating the

osmoregulatory limits of the biota (Telesh & Khlebovich, 2019); freshwater conditions in Balogo exclude strictly marine taxa, whereas the high salinity in Sarimao limits freshwater specialists. Sta. Rosa Del Sur exhibited intermediate salinity, reflecting a transitional estuarine system where brackish and marine species may coexist.

Specific gravity values (1.000 to 1.025) closely mirrored the salinity gradient, with lower values in Balogo confirming freshwater influence and higher values in Sarimao indicating strong marine connectivity. These variations in water density are critical for governing larval dispersal and nutrient transport (Whitfield, 2017). Ultimately, the environmental extremes recorded specifically the hypoxic DO and maximum salinity in Sarimao and the peak temperature in Balogo demonstrate the distinct physicochemical pressures acting upon these systems. These gradients likely dictate mollusk community composition, where extreme sites favor specialized, tolerant species, while the moderate and heterogeneous environment of Sta. Rosa Del Sur promotes greater species coexistence.

Table 6
Environmental parameters in mangrove areas in Pasacao, Camarines Sur

Station	Transect	Point	Dissolved oxygen (mg/l)	Temperature(°c)	Salinity(ppt%)	Specific gravity (sg)
Zone 1 Pongol, Balogo	1	1	5.0	31.2°C	0	1.000
		2	9.2	35.9°C	3	1.017
		3	9.5	31.8°C	29	1.022
	2	1	2.5	31.1°C	3	1.002
		2	8.5	32.1°C	4	1.003
		3	14.3	35.3°C	28	1.021
Zone 6 Sta. Rosa Del Sur	1	1	4.7	31.5°C	2	1.001
		2	6.3	31.2°C	3	1.002
		3	8.8	33°C	20	1.015
	2	1	3.2	30.2°C	2	1.001
		2	4.2	30.5°C	7	1.007
		3	12.7	34.3°C	26	1.020
Sitio Sarimao	1	1	1.4	29.3°C	2	1.001
		2	11.0	32.1°C	29	1.022
		3	10.3	31.6°C	30	1.023
	2	1	3.6	29.2°C	5	1.004
		2	5.0	30.7°C	30	1.023
		3	9.7	30.9°C	32	1.025

Note. Measurements taken during low tide, October 2025 (n = 6 sampling points per station: 2 transects × 3 points). SD = standard deviation.

3.6 Socioeconomic Contributions of Mollusk Resources to Coastal Households in the three (3) Sampling station in Pasacao, Camarines Sur

The socioeconomic assessment of mollusk resources in the coastal barangays of Balogo, Sta. Rosa del Sur, and Sitio Sarimao reveals that these organisms serve as a fundamental pillar of local food security rather than a primary source of commercial income. Guided by Trophic Dynamics and Energy Flow Theory, the study identifies a universal consumption rate across all communities, where mollusks facilitate critical protein and nutrient transfer from mangrove ecosystems to human households. Despite this high subsistence value particularly in Balogo, where food security dependence reaches 86.67% commercial engagement remains negligible due to institutional barriers such as inadequate market infrastructure and a lack of post-harvest expertise. This reliance on mollusks for immediate household needs aligns with the Species Diversity–Productivity Relationship, suggesting that while the ecosystem reliably supports local well-being, its economic potential in trade and craft industries remains largely untapped. To bridge the gap between subsistence and sustainable livelihood, the findings suggest that conservation strategies should be integrated with entrepreneurial training and institutional support, transforming mollusk resources into viable economic assets without compromising the ecological resilience of the mangrove habitat.

Table 7*Socioeconomic Contributions of Mollusk Resources to Coastal Households in Pasacao, Camarines Sur*

Indicator	Zone 1 Pongol Balogo	Zone 6 Sta.Rosa Del Sur	Sitio Sarimao
Food Security Contribution			
Mollusks as primary protein source	86.67	73.33	60.00
Household consumption (any frequency)	100.00	100.00	100.00
Frequent consumption (weekly/daily)	80.00	66.67	66.67
Sourcing Method			
Personally collected	93.33	66.67	66.67
Purchased from market	13.33	33.33	33.33
Livelihood Engagement			
Sale of mollusks/products	0.00	6.67	0.00
Shell-based craft production	0.00	6.67	0.00
Perceived Household Importance	73.33	80.00	46.67

Note. Percentages based on structured household surveys (n = 15 per barangay). Values may not sum to 100% due to multiple-response items.

3.7 Conservation Strategies for Mollusks in Pasacao's Mangrove Ecosystems

The findings reveal that plastic pollution and habitat degradation pose substantial threats to mollusk diversity within the mangrove ecosystems of Pasacao, particularly in Balogo and Del Sur. Accumulated plastic waste trapped in mangrove roots and sediments smothers pneumatophores and restricts oxygen exchange, effectively degrading habitat quality for burrowing mollusks. This phenomenon is consistent with the Intermediate Disturbance Hypothesis (Connell, 1978), which posits that high levels of disturbance reduce biodiversity by allowing only a few opportunistic, tolerant species to survive. Plastic waste alters sediment structure and oxygen availability, rendering the environment unsuitable for sensitive species and favoring pollution-tolerant organisms, resulting in a significantly reduced diversity index. In contrast, Sarimao exhibited cleaner environmental conditions and higher biodiversity ($H' = 1.77$), suggesting that improved waste management practices are directly associated with healthier ecosystems. This finding supports the Ecological Niche Theory (Hutchinson, 1957), as cleaner, more complex habitats provide a wider array of ecological niches that facilitate species coexistence and environmental stability (UNEP, 2021; IUCN, 2018).

The study further identified October as a critical recruitment period for *Cerithidea cingulata*, characterized by high juvenile counts in Del Sur. Unregulated harvesting during these peak recruitment months threatens population stability and long-term sustainability. Implementing seasonal closures during reproductive peaks is ecologically justified to protect breeding stocks and ensure recruitment success, a strategy supported by the FAO (2020) for small-scale coastal resources. This necessity is further underscored by the Trophic Dynamics and Energy Flow Theory (Lindeman, 1942), which emphasizes that maintaining population structure is vital for sustaining energy flow; the removal of juveniles disrupts replenishment, reduces future biomass, and weakens the energy transfer through the food chain, ultimately impacting both ecosystem balance and human food security. Additionally, the low biodiversity index in Del Sur ($H' = 1.27$) and the dominance of a single species suggest an ecological imbalance likely exacerbated by hydrocarbon contamination from a nearby oil depot. Oil pollution can damage mangrove roots and sediments, reducing habitat complexity and favoring specialized, tolerant species (Lewis et al., 2019). Restoration efforts, including sediment remediation and the replanting of native species such as *Rhizophora* and *Avicennia*, are essential for rebuilding microhabitats and enhancing coastal resilience (World Bank, 2021). Finally, establishing baseline diversity data provides a critical scientific foundation for policy development and long-term monitoring. Integrating biodiversity indices into municipal coastal management plans facilitates evidence-based decision-making and adaptive management (IPBES, 2019). Overall, an integrated approach combining strengthened waste management, seasonal harvest regulations, mangrove restoration, and institutionalized monitoring is vital for the conservation and sustainability of mollusk populations in Pasacao's mangrove ecosystems.

4. Summary, Findings, Conclusions, and Recommendations

Summary - The study titled Abundance and Diversity of Mollusks in Mangrove Ecosystems of Coastal

Barangays in Pasacao, Camarines Sur, provides a foundational baseline for the region by evaluating the ecological composition and socioeconomic significance of mollusk assemblages across three coastal sites. Findings identified 18 mollusk families, revealing that habitat complexity and minimal pollution at Sitio Sarimao facilitated the highest diversity ($H' = 1.77$), whereas industrial stressors and hydrocarbon presence at Sta. Rosa Del Sur resulted in lower diversity ($H' = 1.27$) and an ecological imbalance dominated by *Cerithidea cingulata*. Socioeconomically, while mollusks serve as an indispensable resource for local food security supporting up to 86.67% of households in Balogo their potential for commercial trade and craft production remains largely untapped. To ensure the long-term environmental and nutritional resilience of these mangrove ecosystems, the study advocates for an integrated management framework that includes community-based waste management, seasonal harvest closures to protect recruitment peaks, and the incorporation of biodiversity monitoring into municipal coastal planning.

Findings - The mollusk diversity study in Pasacao, Camarines Sur, identified 18 species across three coastal barangays, revealing that habitat complexity and environmental health are the primary drivers of local biodiversity. While Sta. Rosa Del Sur recorded the highest abundance of individuals, it suffered from the lowest species diversity ($H' = 1.27$) due to environmental stress from a nearby oil depot and a landscape dominated by a single species, *Cerithidea cingulata*. In contrast, Sitio Sarimao achieved the highest diversity ($H' = 1.77$) by leveraging a cleaner environment and varied substrates that support a wider range of ecological niches. These mollusks serve as a cornerstone for local food security, with up to 86.67% of households in Balogo relying on them as a primary protein source, yet the populations face growing threats from plastic pollution, hydrocarbon contamination, and habitat degradation. To ensure the longevity of these vital resources, researchers recommend implementing seasonal harvesting bans in October to protect juvenile recruitment, strengthening solid waste management to combat plastic debris, and prioritizing mangrove restoration in industrial zones.

Conclusions - The mangrove ecosystems of Pasacao, Camarines Sur, harbor a moderately rich mollusk community whose structural dynamics serve as a critical barometer for environmental health. The study reveals a distinct decoupling of abundance and diversity: while Sta. Rosa Del Sur exhibits the highest abundance due to the dominance of the pollution-tolerant *Cerithidea cingulata*, the superior diversity indices in Sitio Sarimao ($H' = 1.77$) signify a more resilient and ecologically balanced habitat. These variations are driven by a complex interplay of natural tidal regimes and escalating anthropogenic stressors, specifically plastic debris and hydrocarbon pollution. Beyond their ecological significance, these mollusks constitute a foundational component of local food security; however, their socio-economic potential remains largely latent due to a lack of market integration and value-addition initiatives. Consequently, the conservation of Pasacao's mangroves is imperative not only for maintaining regional biodiversity but also for sustaining the nutritional resilience of resource-dependent coastal communities.

Recommendations - To safeguard ecological integrity and sustain local livelihoods, it is strongly recommended that the Municipal Environment and Natural Resources Office (MENRO) and local barangay councils institutionalize evidence-based coastal management by enforcing stricter solid waste control and hydrocarbon mitigation measures, particularly near industrial zones and degraded mangrove stands. A seasonal harvesting moratorium should be implemented during October to protect peak juvenile recruitment, alongside targeted mangrove rehabilitation programs utilizing native species such as *Rhizophora* and *Avicennia*. Furthermore, local policymakers should formally integrate mollusk diversity indices into municipal coastal development ordinances, designate Sitio Sarimao as a model community-based ecological sanctuary, and launch environmental education and livelihood diversification initiatives to transition mollusk utilization from purely subsistence consumption toward sustainable, value-added economic enterprises.

AI Use Disclosure. We used Grammarly, December 2025, Quillbot, November 2025, ChatGPT, December 2025, Qwen, September 2025, Perplexity October 2025 and Google Gemini December 2025, for language editing/idea generation and fact-checking. All outputs were reviewed, verified, and edited by the author/s, including fact-checking sources, validating code/results, redrawing figures. No confidential or personally identifiable data were entered into AI tools. The author/s take full responsibility for the content.

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