

Species Diversity of Gastropods in the Intertidal Zones of Papuma Coastal, Jember Regency, East Java

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Abstract

Gastropods are a group of mollusks that have an important role in the intertidal zone, such as detritivores and grazers. Information on gastropod diversity in the intertidal ecosystem of Papuma Coastal is still limited, so research is needed to determine the condition of the gastropod community in the area. This study aims to determine the diversity, evenness, and richness of gastropod species in the intertidal ecosystem of Papuma Coastal. Data collection using plot transect method at three observation stations with a total of 45 plots. The data obtained were in the form of species, number of individuals, and habitat, then analyzed using the Shannon-Wiener, evenness, and richness index. The results showed that 19 gastropod species were found belonging to 16 genera and 12 families with a total of 2333 individuals. The diversity index value obtained was 2.677 which is included in the moderate category, followed by an evenness of 0.91 and richness of 2.32. The high number of individuals in certain species of the genus *Nerita* is related to the ability of this genus to adapt to the rocky substrate on Papuma Coastal, thus benefiting its population and reproduction. Substrate variations, such as rocks, sand, and rocky sand, influence the presence and abundance of gastropods in Papuma Coastal because they are related to habitat preferences for gastropods. This study indicates that the intertidal ecosystem of Papuma coastal has a fairly good gastropod diversity and can serve as a basis for scientific information to support coastal ecosystem management and conservation.

Keywords: Gastropods, Intertidal Zone, Papuma Coastal, Shannon-Wiener Index

INTRODUCTION

Intertidal zone is a transitional area between land and sea that is influenced by tidal cycles, resulting in a highly dynamic and fluctuating environment (Tomanek & Helmuth 2002; Brand *et al.*, 2020). This area experiences periodic changes in environmental conditions due to the influence of rising and falling sea levels, requiring the organisms within it to adapt to changes in the physical and chemical properties of the water. Factors such as temperature, salinity, humidity, light intensity, pH, and wave strength are key parameters that influence the lives of organisms in the intertidal zone (Ape *et al.*, 2018). These continuously changing environmental conditions make the intertidal zone a unique habitat, as only certain organisms with high adaptive capabilities can survive (Leeuwis & Gamperl, 2022). Despite its fluctuating conditions, the intertidal zone remains known as one of the coastal ecosystems with high levels of productivity and biodiversity. The high diversity of organisms in this area is influenced by variations in substrate types such as sand, rock, coral, and mud—which provide habitats and food sources for various marine organisms (Kon *et al.*, 2020). According to Haumahu *et al.*, (2024), the presence of rocky and sandy substrates in the intertidal zone supports high benthic organism diversity by providing shelter and foraging areas. These substrate characteristics are also commonly found in the southern coastal area of Jember Regency, particularly at Papuma Coastal, which features a combination of rocky and sandy substrates. These conditions suggest that the intertidal ecosystem of Papuma Coastal serves as a habitat supporting the presence of various benthic macroinvertebrates, especially gastropods, with a relatively high level of species diversity (Rizka *et al.*, 2025). In addition to serving as a critical habitat for various benthic organisms, the intertidal zone of Papuma Coastal holds significant ecological potential for further study regarding the community structure of its constituent organisms.

The presence of various benthic organisms in the intertidal zone is closely tied to their adaptive capabilities in response to fluctuating environmental conditions, with gastropods being a prime example (Moisez *et al.*, 2020). Gastropods are a group of animals within the phylum Mollusca that possess a very high ability to adapt to various changes in environmental conditions (Rumbatia *et al.*, 2023). These organisms belong to the invertebrate group animals without a backbone which generally have soft bodies protected by a single shell made of calcium carbonate. Gastropods from the subclass Prosobranchia exhibit a wide variety of shell shapes, sizes, patterns, and colors, making them one of the mollusk groups with the highest level of morphological variation (Arpani & Maulana, 2017). These body and shell structures help gastropods adapt to environmental stresses such as changes in temperature, salinity, drought, and the strength of currents and waves in intertidal habitats. Additionally, gastropods possess specific mobility and behavioral traits that enable them to survive in fluctuating environmental conditions (Stickle *et al.*, 2017). The habitat distribution of gastropods is also very extensive, as they can be found in various ecosystems, ranging from terrestrial environments, freshwater bodies, to marine waters (Lestari *et al.*, 2021). In intertidal ecosystems, gastropods typically inhabit substrates such as sand, rock, coral, or mud rich in organic matter and microalgae, which serve as food sources. The presence of gastropods plays a crucial ecological role in the food chain as they function as detritivores and herbivores (grazers), aiding in the decomposition of organic matter and controlling algal growth on substrates. This ecological role makes gastropods a key component in maintaining the stability of intertidal ecosystems.

The high level of gastropod diversity in intertidal areas is influenced by habitat conditions that can provide food sources, habitat, and protection for various species (Ebadzadeh *et al.*, 2024). Species diversity is the variation of organisms found in a community and can be determined based on the number of species (species richness) and the evenness of the number of individuals of each species found (Hasanah *et al.*, 2023). The level of diversity of a community is generally divided into three categories: high, medium, and low, which reflect the stability of the ecosystem in a habitat (Afnani & Rahayu, 2024). The higher the diversity value of an organism, the more stable the environmental conditions in that habitat tend to be and able to support the lives of various species. In intertidal ecosystems, gastropods are one group of organisms that play an important role, so their level of diversity can be used as an indicator of the ecological conditions of coastal areas. The high diversity of gastropods indicates that the habitat has good environmental quality and supports the life of benthic organisms (Kadim *et al.*, 2026). However, the presence of gastropods at Papuma Coastal is potentially under pressure due to increased human activity in coastal tourism areas. Activities such as harvesting gastropods during low tide, tourists stepping on the intertidal area, and increasing visitor numbers can cause habitat destruction and reduce species diversity (Nusantara *et al.*, 2023). Furthermore, changes in environmental conditions due to tourism activities can also disrupt the balance of the intertidal ecosystem. These conditions necessitate research on gastropod diversity to better understand the ecological conditions of the Papuma Coastal intertidal area.

Information on the ecological conditions of the Papuma Coastal intertidal area is becoming increasingly important because data related to the diversity of gastropod species in the area is still very limited and has not been widely reported. Gastropod research in the intertidal zone is important to determine the level of gastropod diversity in the southern coastal area of Java, which is dominated by rocky substrates with strong wave characteristics. Research by Mujiono (2016) explains that the southern coast is commonly found with hard-shelled gastropods that are tightly attached to the substrate, which is related to their behavior in dealing with high ocean waves. Previous studies by Yamazaki *et al.*, (2017) and Armiani *et al.*, (2025) showed that the number of gastropod species in the intertidal area is strongly influenced by habitat conditions and environmental factors such as substrate type, temperature, and human activities. However, studies on the structure of the gastropod community in the Papuma Coastal intertidal area have not been conducted comprehensively, especially those linking habitat conditions to the level of species diversity. These limited data mean that information on the ecological conditions of the Papuma coastal area is not yet fully available, thus requiring further research. This study was conducted to determine the level of gastropod species diversity in the Papuma Coastal intertidal ecosystem in Jember Regency as a

source of scientific information that can be used for further research and coastal area management. The research results are expected to contribute to the development of coastal ecology, particularly regarding the structure of gastropod communities in tropical intertidal areas. The data obtained can also be used as a basis for the management and conservation of the Papuma Coastal tourist area to ensure the sustainability of coastal biological resources.

MATERIAL AND METHODS

The study was conducted in January – February 2026. Data collection took place in the intertidal zone of Papuma Coastal, Jember Regency, in February 2026 when the sea reached its lowest tide. Papuma Coastal is geographically located between 8°25'45.50" – 8°26'11.59" South Latitude and 113°33'14.80" – 113°33'11.05" East Longitude (Figure 1). Data description, identification, and analysis were conducted at the Ecology Sublaboratory, Biology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Jember.

Gastropod data collection was conducted in the intertidal zone using the transect plot method with systematic placement. The plots used measured 1 × 1 m and were placed along a 10 meter transect line with a 2 meter spacing between transects (Figure 2). The study was conducted at three observation stations, each consisting of 15 plots, for a total of 45 plots. Sampling focused on the presence of gastropod individuals within the plots through a thorough search, both on the substrate surface and in the crevices of rocks, corals, and other substrates. The selection of research stations was based on purposive sampling, taking into account differences in substrate types between stations, the furthest low tide conditions, and most importantly, safety and security factors. Sampling was conducted directly using field equipment such as tweezers and gloves to avoid the risk of injury during specimen collection (Setiawan *et al.*, 2024). Data collection was carried out during low tide, making it easier for researchers to observe and collect specimens safely.

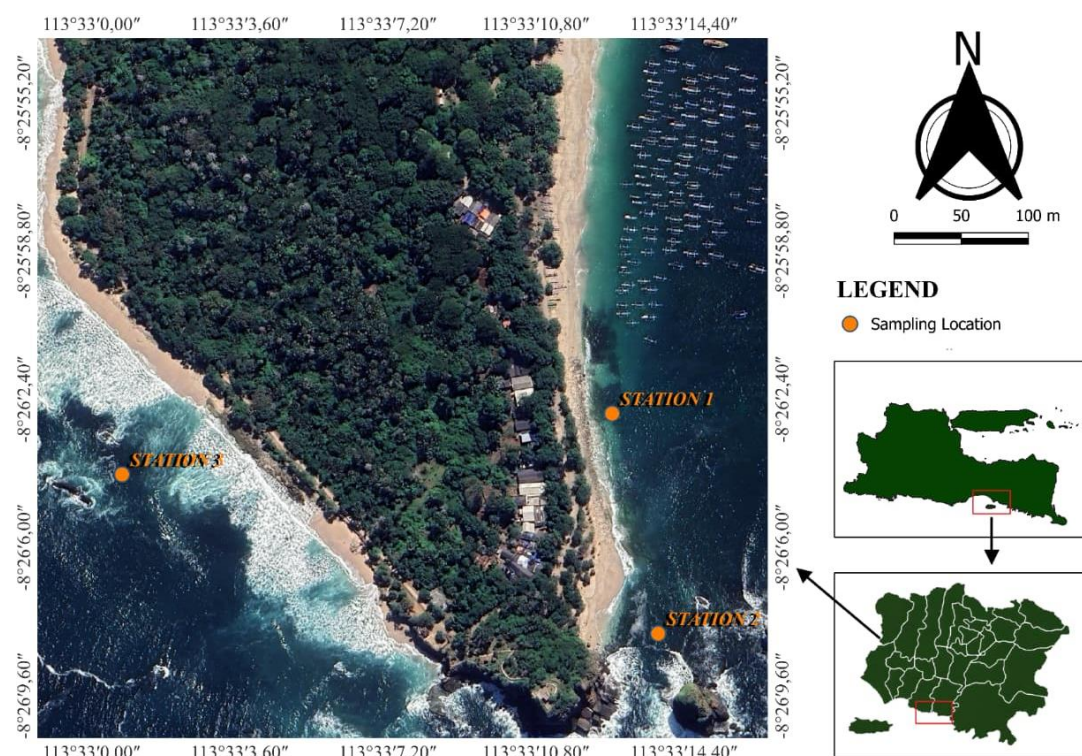


Figure 1. The Map of Sampling Location at Intertidal Zone, Papuma Coastal, Jember

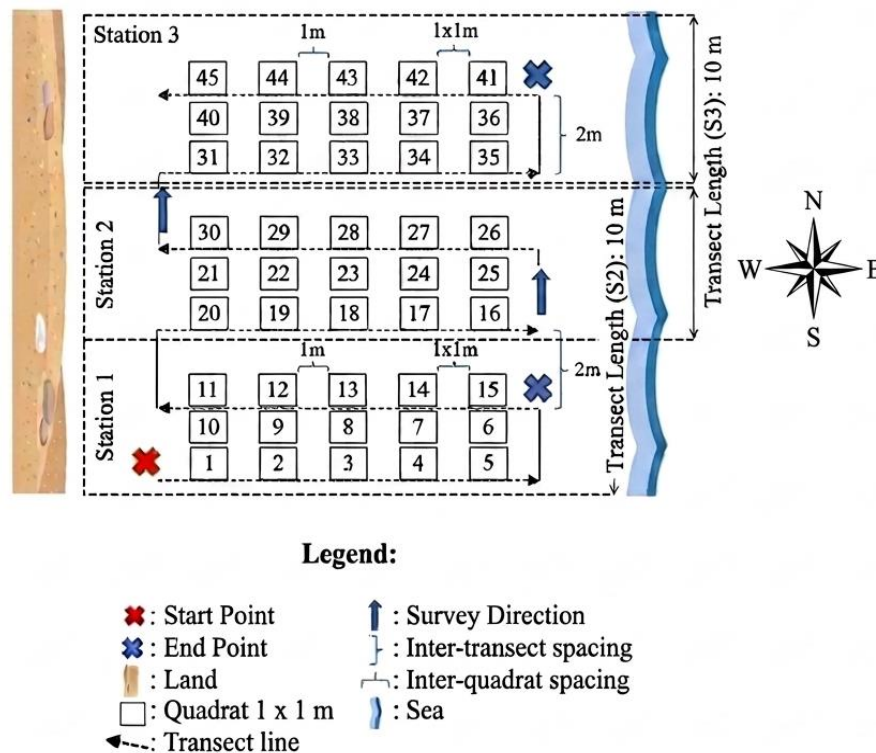


Figure 2. Technique of Schematic data collection in the Intertidal Zone of Papuma Coastal

The collected gastropods were then placed on a tray for data recording, including morphological characteristics, species codes, and the number of individuals per species (Padang *et al.*, 2025). For unidentified species, observations were made of morphological characteristics such as shape, size, color, and shell pattern, and a special code was assigned to facilitate the data collection process. Each specimen was documented by placing it on graph paper as a scale of measurement, then photographed using a cell phone camera. Specimens were collected selectively, with 1–2 individuals per species, taking into account representative size and distinct shell patterns.

The selected specimens were then placed in ziplock bags, cleaned of dirt and other organisms by brushing, and rinsed with water. Next, the specimens were preserved in jars containing a 70% alcohol solution to maintain their morphological condition prior to further identification at the Biology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Jember.

Analysis of gastropod species composition began with the description and identification of specimens. The description was conducted by directly observing the morphological characteristics of the gastropods found, including shape, size, color, and shell pattern, shell surface, direction of shell whorl, apex shape, aperture shape, and the presence of an operculum. These observations were then verified using identification literature, namely Recent & Fossil Indonesian Shells (Dharma, 2005), Collectible Shells of the Southeastern U.S., Bahamas & Caribbean (Abbott & Dance, 1982), and Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific (Carpenter & Niem, 1998). Subsequently, the identification data was verified using the World Register of Marine Species (WoRMS) database via the website <https://www.marinespecies.org/>.

Data on gastropods species that have been identified and verified are then tabulated based on their taxon including name of species, number of individuals, way of life, and number of individual types. The data on species composition and the number of individuals of each species were subsequently used as the basis for calculating the gastropod species diversity index (H'). Data that has been obtained is then entered into a table and the smallest to largest range value is determined.

Analysis of species diversity (H') uses the Shannon-Wiener Diversity Index, followed by species evenness (E), and species richness (R) with the following formula (Magurran & McGill, 2011). Community structure was assessed using three ecological indices: the Shannon-Wiener diversity index, the evenness index, and the richness index. The Shannon-Wiener diversity index (H') was calculated as the negative sum of the product of the proportional abundance of each species (p_i) and its natural logarithm, expressed as $H' = -\sum p_i \ln p_i$, where $p_i = n_i/N$. In this formula, H' represents the Shannon-Wiener diversity index, p_i is the proportional abundance of species i , n_i is the number of individuals of each species, and N is the total number of individuals across all species.

Species evenness (E) was calculated by dividing the Shannon-Wiener diversity index by the natural logarithm of the number of species ($E = H'/\ln S$), where S is the total number of species recorded. This index describes how evenly individuals are distributed among the species in a community. Finally, species richness (R) was calculated using the Margalef formula, $R = (S - 1)/\ln(N)$, in which S is the number of species and N is the total number of individuals. This index reflects the number of species present relative to the sampling effort represented by the total number of individuals.

RESULT AND DISCUSSION

The results showed that the species composition of gastropods in the intertidal zone of Papuma coastal, Jember Regency, consisted of 19 species of gastropods were identified, comprising 16 genera and 12 families (Table 1; Figure 3). The substrate characteristics in this coastal intertidal zone consist of rock and sand. The calculation of the gastropod species diversity index in the intertidal zone of Papuma Coastal, Jember Regency, yielded a value of 2.677 (Table 2), which falls into the moderate category. Species diversity is influenced by species richness and the distribution of individuals among species. This study identified 19 gastropod species, indicating a fairly good level of species richness for an intertidal ecosystem. However, the uneven distribution of individuals prevented the diversity value from reaching the high category. This value indicates that the gastropod community at the study site consists of a fairly diverse range of species, but the distribution of individuals among species is not yet even. This is evident from the significant difference in the number of individuals between dominant species and other species with relatively low numbers. An evenness index (E) value of 0.91 indicates that the gastropod community in the intertidal zone of Papuma Coastal exhibits a very high level of evenness. An evenness value close to 1 indicates that individuals of each species are distributed relatively evenly and that no single species exhibits particularly strong dominance (Setyaningsih, 2025). This high evenness value suggests that habitat conditions at Papuma Coastal are still capable of supporting the survival of various gastropod species in a balanced manner (Rizka *et al.*, 2025). Although there are several species with larger populations, such as *Nerita plicata* and *Strigatella zebra*, these differences do not lead to excessive dominance, so the community structure remains relatively stable. A high evenness value reflects a relatively balanced distribution of individuals and low ecological pressure on the habitat (Abdunnur & Kusumaningrum, 2023). Furthermore, communities with high evenness generally exhibit greater ecosystem stability and are better able to maintain their ecological functions in the face of environmental changes.

The Richness (R) index value of 2.32 falls into the moderate category, indicating that the intertidal zone of Papuma Coastal has a fairly diverse number of species, as evidenced by the discovery of 19 gastropod species. This suggests that the area provides habitat conditions and substrate variation capable of supporting species with different habitat preferences. This moderate species richness is believed to be influenced by the dynamic nature of the intertidal zone, meaning that only certain species are able to survive (Joloya & Pizon, 2026). In addition to natural factors, anthropogenic activities such as tourism and the harvesting of marine organisms also have the potential to reduce the presence of species that are sensitive to environmental changes (Karoumpali *et al.*, 2025). Substrate variation such as rock, sand, and mixtures of both plays a crucial role in increasing the number of gastropod species within a habitat. Therefore, the species richness value

obtained indicates that habitat conditions at Papuma Coastal are still sufficiently favorable to support the presence of various gastropod species; however, conservation efforts remain necessary to ensure the sustainability of this biodiversity.

Some of the dominant species include *Nerita plicata* (462 individuals), *Strigatella zebra* (415 individuals), *Nerita atramentosa* (327 individuals), and *Siphonaria javanica* (297 individuals), while species such as *Nebularia acuminata* and *Rhinoclavis sinensis* were found in only 12 individuals each, and *Engina mendicaria* in 13 individuals. These differences in the number of individuals among species result in suboptimal community evenness, placing the diversity value in the moderate category. The dominance of certain gastropod species such as those from the genus *Nerita* shows that this species is able to adapt to the extreme Papuma coastal environment through the behavior of attaching its body and hiding in rock crevices to avoid being hit by sea waves. Furthermore, the presence of this gastropod species also indicates the availability of food sources in the form of epilithic algae and macroalgae, which are important food sources for benthic gastropods (Sousa et al., 2018; Purnama et al., 2024).

Table 1. Species Composition of Gastropods in the Intertidal Zone of Papuma Coastal

Family	Genus	Species	Individual	Habitat
Muricidae	<i>Semiricinula</i>	<i>Semiricinula turbinoides</i> (Blainville, 1832)	102	Rocks
	<i>Menathais</i>	<i>Menathais tuberosa</i> (Röding, 1798)	43	Rocks and Sand
	<i>Morula</i>	<i>Morula granulata</i> (Duclos, 1832)	261	Rocks
Neritidae	<i>Nerita</i>	<i>Nerita lineata</i> (Gmelin, 1791)	271	Rocks
		<i>Nerita polita</i> (Linnaeus, 1758)	94	Rocks
		<i>Nerita atramentosa</i> (Reeve, 1855)	327	Rocks
		<i>Nerita plicata</i> (Linnaeus, 1758)	462	Rocks
		<i>Trochus radiatus</i> (Gmelin, 1791)	139	Rocks and Sand
Trochidae	<i>Clanculus</i>	<i>Clanculus atropurpureus</i> (Gould, 1849)	22	Rocks
Mitridae	<i>Strigatella</i>	<i>Strigatella zebra</i> (Lamarck, 1811)	415	Sand
	<i>Nebularia</i>	<i>Nebularia acuminata</i> (Swainson, 1824)	12	Rocks
Cypraeidae	<i>Cypraea</i>	<i>Cypraea annulus</i> (Linnaeus, 1758)	37	Rocks
Pisaniidae	<i>Engina</i>	<i>Engina mendicaria</i> (Linnaeus, 1758)	13	Rocks
Siphonariidae	<i>Siphonaria</i>	<i>Siphonaria javanica</i> (Lamarck, 1819)	297	Rocks
Costellariidae	<i>Vexillum</i>	<i>Zierliana woldemarii</i> (Kiener, 1838)	27	Rocks and Sand
Terebridae	<i>Hastula</i>	<i>Hastula raphanula</i> (Lamarck, 1822)	38	Sand
Cerithiidae	<i>Rhinoclavis</i>	<i>Rhinoclavis sinensis</i> (Gmelin, 1791)	12	Rocks and Sand
Conidae	<i>Conus</i>	<i>Conus ebraeus</i> (Linnaeus, 1758)	54	Rocks and Sand
Lottiidae	<i>Patelloida</i>	<i>Patelloida striata</i> (Quoy & Gaimard, 1834)	76	Rocks
		Individual Total	2333	

Table 2. Value of Diversity Index (H'), Evenness Index (E), and Richness Index (R) at the Intertidal Zone Papuma Coastal Jember Regency

Zonation	Index		
	Shannon-Wiener (H')	Evenness (E)	Richness (R)
Intertidal Papuma Coastal	2.677	0.91	2.32



Figure 3. Several Species of Gastropods Found on the Papuma Coastal

The differences in abundance among these species are related to the adaptive capabilities of each gastropod to the characteristics of the intertidal zone habitat (Miloslavich *et al.*, 2013). Species with better adaptive capabilities tend to be found in higher numbers than other species. One example is the genus *Nerita*, which belongs to the family Neritidae. This group possesses a morphological adaptation in the form of a hard operculum that functions to tightly seal the shell aperture when environmental conditions are unfavorable (Armiani *et al.*, 2025). This mechanism is effective in reducing water loss (desiccation) and protecting the body, allowing this species to survive better than other gastropods that lack similar protection (Páll-Gergely *et al.*, 2016). Additionally, gastropods of this genus possess strong muscular feet that enable them to cling firmly to rocky substrates, thereby preventing them from being dislodged by wave action.

The presence and abundance of gastropods are also influenced by substrate variation at the study site. The intertidal zone of Papuma Coastal features diverse substrate types, such as rocks, sand, and rocky-sandy substrates. Based on the gastropod species diversity index values obtained, substrate variation is believed to be one of the primary factors influencing this diversity (Pertika *et al.*, 2022). Rocky substrates tend to support a larger and more diverse population of gastropods because they provide a stable surface for attachment and serve as a habitat for algae growth, which is the primary food source for herbivorous (grazing) gastropods (Mardi *et al.*, 2019). This is evident from the dominance of species commonly found on rocky substrates, such as *Nerita* spp., *Siphonaria javanica*, and several members of the Muricidae family. According to Raiba *et al.*, (2022), substrate variation significantly influences the presence of gastropods because the substrate serves as a habitat, a place for adaptation, a refuge from predators, and a source of food. Conversely, sandy substrates are more unstable as they are easily displaced by currents, causing sand particles to become suspended and failing to provide an optimal surface for attachment. These conditions result in sandy substrates being inhabited only by specific species with adaptive capabilities, such as burrowing, for example, *Hastula raphanula*. This aligns with Maretta *et al.*, (2019), who stated that sandy substrates are less preferred by gastropods because they do not provide stable attachment sites, resulting in relatively fewer individuals being found. The substrate variations found on Papuma Coastal indicate that this area has considerable habitat potential for various gastropod species with different adaptive characteristics. Therefore, the rock and sand substrates in the intertidal zone of Papuma Coastal must be preserved to ensure they continue to support the sustainability of the gastropod community.

This study is expected to support coastal conservation efforts by providing scientific data on the relationship between habitat characteristics and gastropod diversity. This information can serve as a basis for managing the Papuma Coastal tourist area to ensure that ongoing tourist activities do

not cause damage to the intertidal habitat and continue to preserve the benthic organisms living within it. Additionally, the results of this study can serve as a basis for local governments and tourism managers in formulating sustainable coastal management policies grounded in environmental conservation.

CONCLUSION

Species diversity in the Intertidal Zone Papuma Coastal is classified as moderate, with a diversity index of 2.677, Evenness Index of 0.91, and Richness index of 2.32. This study identified 19 gastropod species with a total of 2333 individuals. The dominant species were *Nerita plicata*, *Strigatella zebra*, *Nerita atramentosa*, and *Siphonaria javanica*. This study indicates that the intertidal ecosystem of Papuma coastal has a fairly good gastropod diversity and can serve as a basis for scientific information to support coastal ecosystem management and conservation.

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