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Diversity of Gastropods in the Intertidal Zone of Tanjung Air Panas Beach, Tulehu Village, Central Maluku Regency, Indonesia

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ABSTRACT

Research on the diversity of gastropods in the intertidal area of Tanjung Air Panas Beach, Tulehu Village, Central Maluku Regency was conducted in November 2024. Gastropod samples were collected in 60 quadrants on 5 belt transects. All individuals obtained were identified to the species level and the number of individuals was counted. The results of the study showed that gastropods in the intertidal area of Tanjung Air Panas Beach, Tulehu Village consisted of 9 species belonging to 1 subclass i.e. Caenogastropoda, 3 orders, namely Caenogastropoda, Littorinimorpha and Neogastropoda, 7 families and 8 genera. *Nassarius globosus* had the highest occurrence frequency and was found in all transects and all quadrants (100%), followed by *Conus ebraeus* which was found in 6 quadrants (10%) and then *Canarium microurceus* which was found in 4 quadrants (6.67%). The highest density is owned by *N. globosus* with 2,633 ind./m^2 (87.78%) then followed by *C. ebraeus* with 0.117 ind./m^2 (3.89%) and *C. microurceus* with 0.100 ind./m^2 (3.33%). The Shannon diversity index (H'), Simpson dominance index (D) and Shannon uniformity index (E) are 0.59, 0.77 and 0.27, respectively. Based on the three indices, it can be concluded that the gastropod community in the intertidal area of Tanjung Air Panas Beach, Tulehu Village has low diversity and uniformity with high dominance.

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INTRODUCTION

The intertidal zone is a unique coastal ecosystem that is strongly influenced by tidal fluctuations, making it a dynamic habitat for various marine organisms. Among these organisms, gastropods play an important ecological role as grazers, detritivores, and prey for higher trophic levels. They are also considered good bioindicators because their diversity and abundance can reflect the health of coastal ecosystems. Previous studies in Maluku have reported the presence of diverse marine organisms, but specific information on gastropod diversity in the intertidal zones of Ambon Island remains limited. Therefore, studying gastropod diversity in this area is essential to provide baseline data for biodiversity conservation and sustainable management of coastal resources (Pattikawa & Ferdinandus, 2009; Tuapattinaja et al., 2014; Rijoly et al., 2016; Limmon et al., 2017; Haumahu & Uneputty, 2022; Hulopi et al., 2022; Haumahu et al., 2024).

The intertidal zone is a narrow area located between the highest tide and the lowest ebb, influenced by both terrestrial and marine ecosystems (Nybakken, 1992). Due to its limited width, this zone is characterized by extreme environmental conditions caused by tidal fluctuations, allowing only certain organisms with high adaptability to survive. One group of marine organisms with strong adaptation and tolerance to such extreme environmental changes is the gastropod. Gastropods play an important ecological role as grazers, detritivores, and prey for higher trophic levels, and their presence can be used as an indicator of ecosystem health. Gastropod is the class with the most species of the Mollusc phylum (Strong et al., 2008).

Gastropods have an important role both economically and ecologically (Siahainenia et al., 2024). Economically, gastropods are used as a source of income for the community. The body parts of gastropods that are used are their meat and shells. Gastropod meat is used as a source of animal protein and their shells are used as basic materials for souvenirs and jewelry (Uneputty et al., 2021). Ecologically, gastropod is one of the components that can support the life of organisms and control other organisms in the energy flow system or food chain in an ecosystem (Wahyuni, et al., 2017). In addition, gastropods are also often used to detect pollution (Uneputty et al., 2021).

The waters of Tanjung Air Panas Beach, which is located on the east coast of Tulehu Village, Central Maluku Regency, has the potential for fishery resources, especially gastropod resources, which are quite good with sandy and coral substrate conditions. Based on information, the utilization of gastropod resources has been carried out for years by the coastal communities of Tanjung Air Panas Beach in the morning or afternoon when low tide. The habit of collecting gastropod resources at low tide as food is still carried out today by the community (women and children) in the waters of Tanjung Air Panas Beach.

Research on gastropods in the coastal areas of Ambon Island has been carried out by several researchers, including studies in the intertidal zones of Suli, Hutumuri, Rutong, Hatu, and Hitu Villages (Haumahu & Uneputty, 2022), in Waiheru Village (Pietersz et al., 2022), in Negeri Passo (Hulopi et al., 2022), in Seri Village (Haumahu et al., 2023), and in Asillulu Village (Haumahu et al., 2024). These studies have provided valuable insights into the distribution and diversity of gastropods in several parts of Ambon Island. However, until now, there have been no published research findings on gastropods in the coastal waters of Tulehu, one of the important coastal areas on Ambon Island.

To fill this knowledge gap, the present study was conducted in the intertidal area of Tanjung Air Panas Beach, Tulehu Village. The study aimed to investigate the species composition, frequency of occurrence, density, and diversity of gastropods in this area. The results of this research are expected to contribute baseline data on gastropod biodiversity, which can be used for the sustainable management and conservation of coastal resources in Ambon Island. Furthermore, this study will complement previous research and provide a broader understanding of gastropod distribution across different coastal ecosystems of Ambon Island.

MATERIALS AND METHOD

Sampling Method. This study was conducted in the intertidal area of Tanjung Air Panas Beach, Tulehu Village, Salahutu District, Central Maluku Regency, Maluku Province **(Figure 1)** in November 2024.

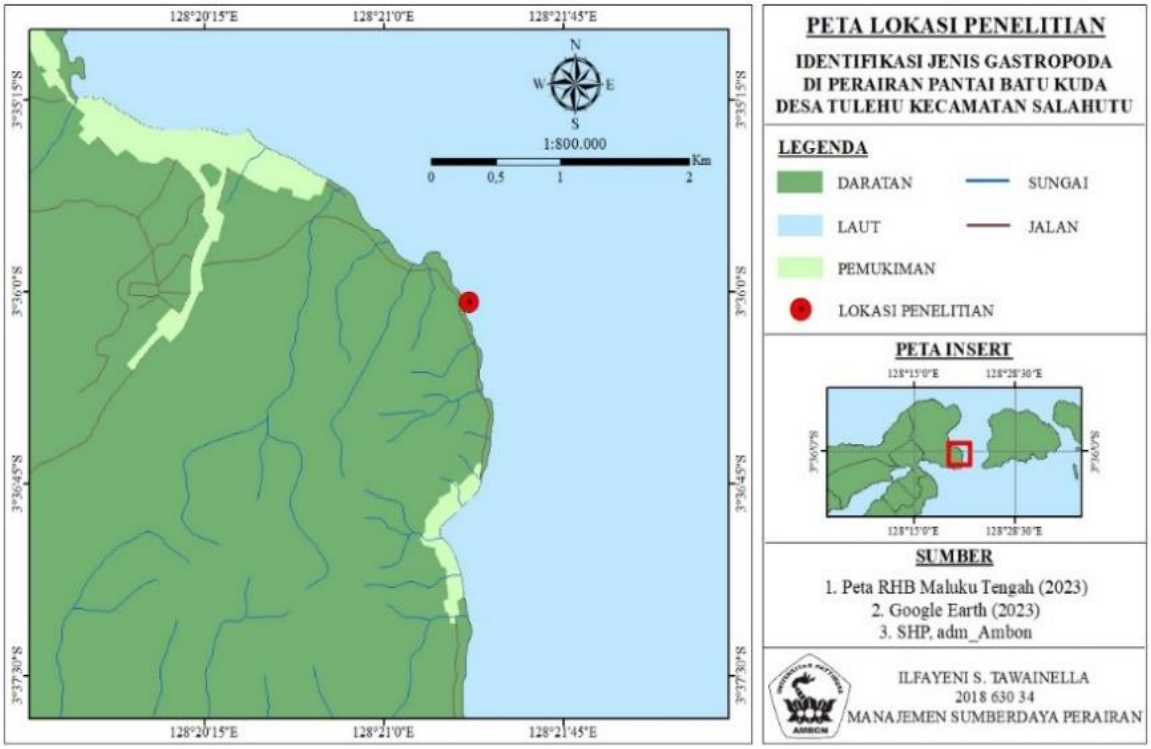

Figure 1. Map showing research location (red crcle)

Data was collected at low tide by using Belt Transect (Khouw, 2009) in which distance between transect is set at 50 meters. A total of 60 quadrates measuring 1x1m^2 were placed in 5 belt transects. All gastropods in each quadrate were collected then put into sample plastic and labeled. Samples collected were identified in the MSP laboratory, Faculty of Fisheries and Marine Sciences, Unpatti based on Wye (2000).

Data Analysis. Density (Di) and relative density (RDi) for each species was analysed based on Magurran (1991) as follows:

$Di = \_ni / a$
$RDi = Di / \sum Di$

Where: ni = number of individual of i^{th} species
a = sampling area

Ecological indexes namely Shannon diversity index (H'), Simpson dominance index (D) and Shannon evenness index (E) were calculated using following formula (Magurran, 1991):

$H' = -\sum pi \ln pi$
$D = \sum pi^2$
$E = H'/\ln S$

Where: $pi = ni / \sum n$
S = number of species
ln = natural logarithm

Criterion:
$H < 1$ = Low; $1 \leq H \leq 3$ = Moderate; $H > 3$ = High (Mason, 1981);
$D < 0.4$ = Low; $0.4 \leq D \leq 0.6$ = Moderate; $D > 0.6$ = High (Legendre & Legendre, 1983);
$E < 0.4$ = Low; $0.4 \leq E \leq 0.6$ = Moderate; $E > 0.6$ = High (Odum, 1975).

RESULTS AND DISCUSSION

Species Composition

Totally, there were 9 species of gastropod belonging to 1 subclass namely Caenogastropoda, 3 orders i.e. order Caenogastropoda, order Littorinimorpha and order Neogastropoda, 7 families and 8 genera (Table 1). Order Neogastropoda has the highest number of species i.e. 7 spesies which consist of 5 families and 6 genera, while order Caenogastropoda and order Littorinimorpha have only 1 family, 1 genus and 1 species.

Table 1. Species composition of gastropod in the intertidal area of Tulehu Village

Order	Family	Genus	Species
Caenogastropoda	Cerithiidae	Clypeomorus	*Clypeomorus moniliferus* (Kiener, 1841)
Littorinimorpha	Strombidae	Canarium	*Canarium microurceus* (Kira, 1959)
Neogastropoda	Conidae	Conus	*Conus ebraeus* (Linnaeus, 1758)
			Conus eburneus (Hwass, 1792)
	Mitridae	Strigatella	*Strigatella paupercula* (Linnaeus, 1758)
	Nassariidae	Nassarius	*Nassarius globosus* (Quoy & Gaimard, 1833)
	Olividae	*Oliva*	*Oliva reticulata* (Röding, 1798)
	Pisaniidae	Engina	*Engina mendicaria* (Linnaeus, 1758)
		Pollia	*Pollia fumosa* (Dillwyn, 1817)

The dominance of the order Neogastropoda with many families, genera and species has also been reported in several studies conducted on Ambon Island. Haumahu & Uneputty (2022) in their research in 5 villages in the intertidal zone of Ambon Island reported the dominance of the order Neogastropoda with 9 families and 25 species. Furthermore, Haumahu and Uneputty (2022a) also reported the dominance of the order Neogastropoda which has 6 families with 12 species in the intertidal zone of Rutong Village. A total of 5 families and 13 species from the order Neogastropoda were found in the waters of Latuhalat and Passo (Rumahlatu & Leiwakabessy, 2017). The presence of gastropods in the intertidal area is generally influenced by habitat conditions, especially the waters substrate. Haumahu & Uneputty (2022) stated that species from the order Neogastropoda prefer substrates dominated by sand and a few coral fragments.

The number of gastropod species found in this study (9 species) was fewer compared to previous studies in the waters of Ambon Island and in the waters of Maluku. Haumahu and Uneputty (2022) reported 78 gastropod species in the intertidal zone in 5 villages in the waters of Ambon Island. Furthermore, Haumahu and Uneputty (2022a) found 23 gastropod species in the intertidal zone of Rutong Village, while Rumahlatu and Leiwakabessy (2017) reported 65 gastropod species in the coastal waters of Passo and Latulahat. Furthermore, Kho et al. (2020) reported the presence of 33 gastropod species in mangrove forests on the coast of Ambon Island. Islami et al. (2018) found 85 gastropod species on the coast of Saparua Island.

The difference in the number of species obtained in this study and previous studies may be due to differences in the size of the sampling area and may also be due to habitat conditions, especially the aquatic substrate. Haumahu and Uneputty (2022) and Rumahlatu and Leiwakabessy (2017) conducted research at 5 locations and 2 different locations with a wider sampling area compared to this study and of course get a greater number of species. In addition, the substrate conditions in this study which are more homogeneous and dominated by fine sand affected the presence of gastropods.

In addition to the substrate, the hydrological conditions of the waters, especially temperature, can affect the presence of gastropods. Sokolova and Portner (2003) in Rumahlatu and Leiwakabessy (2017) stated that gastropods in the intertidal area of tropical waters prefer a temperature range of 28 - 30°C but their metabolism can take place at a wider temperature range, namely 25 - 40°C. The water temperature on the coast of Tanjung Air Panas during the study ranged from 29 - 37°C. The high temperature at the location of this study may have caused only a few gastropod species to be able to adapt and settle in the intertidal area of Tanjung Air Panas, Tulehu Village.

Occurrence Frequency and Density of Gastropods

Gastropod individuals were collected in 5 transects with a total of 60 quadrants. *Nassarius globosus* had the highest occurrence frequency and was found in all transects and all quadrants (100%), followed by *C. ebraeus* which was found in 6 quadrants (10%) in 3 transects and then *C. microurceus* which was found in 4 quadrants (6.67%) in 2 transects. Other gastropod species were only found in 1-3 quadrants (1.67-5%) in 1-2 transects **(Table 2)**. Apart from *N. globosus*, other gastropod species were generally found only in quadrants 1-5 in each transect.

Tabel 2. Occurrence, number of individul and density of gastropod

Species	Number of individual					Total	Density	
	I	II	III	IV	V		ind./m^2	%
C. moniliferus	-	-	1	-	-	1	0.017	0.56
C. microurceus	-	5	-	1	-	6	0.100	3.33
C. ebraeus	-	-	2	1	4	7	0.117	3.89
C. eburneus	-	-	1	1	-	2	0.033	1.11
S. paupercula	-	1	-	-	-	1	0.017	0.56
N. globosus	28	26	25	37	42	158	2.633	87.78
O. reticulata	-	-	-	1	-	1	0.017	0.56
E. mendicaria	-	-	3	-	-	3	0.050	1.67
P. fumosa	-	-	1	-	-	1	0.017	0.56
Total	28	32	33	41	46	180	3.000	100

Note: I, II, III, IV, V = transect
- = no individual

During the study, 180 individuals of gastropod were found in the intertidal area of Tanjung Air Panas, Tulehu Village. The largest number of individuals belonging to by *N. globosus* with 158 individuals, then followed by *C. ebraeus* and *C. microurceus* with the number of individuals as many as 7 individuals and 6 individuals, respectively, while the other species only had 1 - 3 individuals (Table 2). With the largest number of individuals, *N. globosus* has the highest density of 2.63 ind./m^2 with a relative density value of 87.78% while the lowest density is owned by 4 species, namely *C. moniliferus*, *S. paupercula*, *O. reticulata*, and *P. fumosa*, which is 0.017 ind./m^2 or a relative density of 0.56%. The results of this study indicate that there is a relationship between the occurrence frequency and density in which species with a high occurrence frequency will have a higher density.

The results of this study show that *N. globosus* of the Nassariidae family has a higher density than other families. This result is similar to the results of several other studies in the intertidal area of Maluku waters and especially in the waters of Ambon Island. Islami (2015) reported a high density of the Nassariidae family on the coast of Nusalaut Island; then Haumahu and Uneputty (2022) also reported a high density of the Nassariidae family at 5 research locations in the intertidal zone of Ambon Island. The similarity of these results may be due to the same habitat conditions, namely the substrate where this family was found is dominated by sandy substrate.

Diversity of Gastropod

In addition to species composition, gastropod diversity can also be studied using ecological indices such as the Shannon diversity index (H'), the Simpson dominance index (D) and the Shannon evenness index (E). The study of gastropod diversity using these indices not only uses the number of species found but also uses the number of individuals of each species. If the number of species found is large and the distribution of individuals in each species is even or not much different, it will increase the H' and E values and vice versa if the number of species is small and the distribution of individuals in each species is uneven or there is dominance of certain species, it will increase the D value (Magurran, 1991). The Simpson dominance value (D) and Shannon evenness value (E) range from 0 - 1 where if the value is close to 0 it indicates low dominance and evenness and vice versa if it is close to 1 it indicates high dominance and evenness (Magurran, 1991).

The results of the analysis of the gastropod community in the intertidal area of Tanjung Air Panas, Tulehu Village showed that the value of the Shannon diversity index H' = 0.59, the Simpson dominance index D = 0.77 and the Shannon evenness index E = 0.27. Based on the criteria for the Shannon diversity index from Mason (1981), the gastropod community in the intertidal area of Tanjung Air Panas, Tulehu Village has low diversity (H'<1) with low evenness (E<0.4) based on the criteria from Odum (1975). In contrast, the gastropod community at this research location has high dominance (D>0.6) based on the criteria from Legendre and Legendre (1983).

The high dominance and low diversity and evenness of the gastropod community at the research location are due to the small number of species and the uneven distribution of the number of individuals in each species. The data presented in Table 2 shows that only 9 species of gastropods were found in the intertidal area of Tanjung Air Panas, Tulehu Village with a high dominance of the *N. globosus*, which is 87.78% of the total gastropod individuals found at that location.

Several previous studies on gastropod communities in the intertidal area of Ambon Island reported much higher Shannon diversity index (H') and Shannon evenness index (E) (Rumahlatu & Leiwakabessy, 2017; Haumahu & Uneputty, 2022; Haumahu & Uneputty, 2022a) and lower Simpson dominance (D) compare to this

study (Haumahu & Uneputty, 2022; Haumahu & Uneputty, 2022a). The difference in the diversity index results of this study with previous studies is due to the greater number of species and perhaps also because of the distribution of the number of individuals for each species in previous studies which is more even compared to this study. In addition, this difference is also caused by different research locations in which each location may have different habitat conditions that affect the existence of gastropods.

CONCLUSION

A total of 9 species of gastropods belonging to 1 subclass, 3 orders, 7 families and 8 genera are found in the intertidal area of Tanjung Air Panas, Tulehu Village. Of those 9 species found, *Nassarius globosus* has the highest occurrence frequency and density. Based on ecological indices, the gastropod community in this intertidal area has low diversity and uniformity with high dominance due to the small number of species and the uneven distribution of the number of individuals of these species.

AUTHORS CONTRIBUTION

J. A. P. designed the research, analysed and interpretation the data, reviewed the draft of manuscript, and supervised all the process. I. S. T & M. H. designed and conducted the research, analysed and interpretation the data, and wrote the draft of manuscript. P. A. U & L. S. reviewed the draft of manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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