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Inventarization and Diversity Index of Gastropods in Meras Beach, Bunaken District, North Sulawesi

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ABSTRACT

Gastropods play an important role in maintaining the balance of coastal ecosystems, particularly as detritivores that support nutrient cycling. Pantai Meras, located in North Sulawesi, has a complex coastal ecosystem that includes mangrove forests, seagrass beds, and coral reefs, which support high biodiversity. However, information regarding gastropod diversity in this area remains limited. This study aims to identify gastropod species and analyze their diversity levels in the waters of Pantai Meras. A purposive sampling method was used for data collection, employing 0.5 m × 0.5 m plots placed randomly at 45 sampling points across three research stations with different substrate types, namely sandy substrate (Station 1), muddy sand substrate (Station 2), and sand mixed with coral fragments (Station 3). Data were analyzed using PAST software version 4.17 to calculate the Shannon diversity index (H'). The results showed a total of 243 gastropod individuals belonging to 89 species from six orders, with Neogastropoda being the dominant order, comprising 59 species. The most abundant species was *Nassarius globosus*, with a total of 26 individuals recorded. The overall Shannon diversity index (H') was 4.14, which falls into the high diversity category. The highest H' value was recorded at Station 1 (4.08), followed by Station 3 (4.02), and the lowest at Station 2 (3.43). The high gastropod diversity at Pantai Meras indicates that the coastal ecosystem in this area is still in good condition and capable of supporting sustainable gastropod populations. Environmental factors such as temperature, salinity, as well as the presence of mangroves, seagrass beds, and coral reefs contribute to the high species diversity of gastropods in the study area.
***Key words**: gastropods; species diversity; meras beach; seagrass beds.*

INTRODUCTION

Gastropods are a class of mollusks that move using abdominal muscles. In the process of development, they undergo torsion and generally have a twisted conical shell. Apart from their distinctive morphology, Gastropods have an important role in the ecosystem, especially as detritivores and herbivores that consume litter, detritus, and epiphytes on seagrass substrates and leaves.

This activity supports the recycling of organic matter and controls the growth of epiphytic algae, thereby assisting seagrass photosynthesis (Putra et al., 2015). Gastropods are often found in seagrass ecosystems, one of the coastal ecosystems that have high productivity. Seagrass beds act as habitat and refuge for various biota, and physically function as substrate stabilizers on the coastal bottom (Riniatsih et al., 2013). The interaction between Gastropods and seagrass beds is very close, where Gastropods utilize epiphytes attached to seagrass leaves as a food source, while supporting the photosynthesis process of seagrass (Sianu et al., 2014).

Gastropod diversity can be used as an indicator of the balance of seagrass ecosystems, one of which is through measuring the diversity index (Erika, 2018). Until now, there has been no research that specifically examines the diversity of Gastropods in Meras Beach. Therefore, this study aims to identify the level of Gastropod diversity in Meras Beach, Bunaken District, North Sulawesi. The results of this study are expected to provide basic data on Gastropod communities, as well

as provide new insights for the development of local conservation strategies and more effective coastal environmental management.

METHODS

The research was fielded at Meras Beach, Bunaken District, North Sulawesi. Sampling was conducted in November 2024. The research location was determined based on purposive sampling technique. By considering environmental conditions and variations in substrate types that reflect the characteristics of the area. Sampling was conducted at 3 stations: Station 1 on sandy substrate, station 2 with muddy sand substrate and station 3 on sand and coral fragments substrate. Each identified specimen was then counted and analyzed using the Shannon index, Simpson index, and Evennes index to measure the level of the Gastropoda species index. This analysis was conducted using PAST (PAleontological STatistics) software. The Shannon index is calculated by the following formula (Hammer, 1999-2024):

$$H = -\sum_i \frac{n_i}{n} \ln \frac{n_i}{n}$$

Description:

H	: Shannon index diversity
n_i	: Number of individuals of the i species
n	: Total number of individuals of all species present in the community
n_i/n	: Proportion of individuals of the i species
ln	: Natural logarithm

$$D = \sum_i \frac{n_i(n_i - 1)}{n(n-1)}$$

Description:

D	: Index simpson
n_i	: Number of individuals of the i species
n	: Total number of individuals of all species present in the community

$$E = \frac{H'}{\ln(S)}$$

Description:

E	: Index evenness
H'	: Shannon index diversity
$ln(s)$	: Number of species

The analysis was done using PAST software version 4.17, according to the reference guide provided in the user manual (Hammer, 1999-2024). diversity index is divided into 3 categories presented in **Table 1**.

Table 1. Diversity Index value ranges and criteria (Odum, 1993)

Criteria	H'
High	H'> 2.5
Medium	1.5<H' ≤ 2.5
Low	H'≤ 1.5

RESULTS AND DISCUSSION

Gastropod Species Inventarization

Research on Gastropod diversity in the coastal area of Meras Beach, Bunaken District, North Sulawesi, has identified 89 species of Gastropods spread in various orders and families, with a total of 243 individuals found. This study covers three observation sites with sandy substrate characteristics and slight differences in sand texture at each station. Station 1 had a sandy substrate, station 2 was in an area with muddy sand, while station 3 consisted of sand with coral fragments. The Shannon diversity index obtained in this study was 4.14, indicating that the level of Gastropod diversity in Meras Beach was high, reflecting a healthy and productive coastal ecosystem. The list of gastropod species and the number of individuals discovered during the study is presented in **Table 2**. As many as 89 species of gastropods were found with a total of 243 individuals.

Table 2. Classification of The Gastropod

	Classification				
No	**Order**	**Family**	**Genus**	**Spesies**	∑
1	Caenogastropoda	Potamididae	*Terebralia*	*Terebralia palustris*	1
2		Cerithiidae	*Cerithium*	*Cerithium columna*	1
3				*Cerithium dialeucum*	1
4				*Cerithium muscarum*	1
5				*Cerithium rostratum*	5
6	Cephalaspidea	Haminoeidae	*Atys*	*Atys naucum*	1
7			*Aliculastrum*	*Aliculastrum cylindricum*	2
8	Cycloneritida	Neritidae	*Neritina*	*Neritina labiosa*	1
9			*Nerita*	*Nerita plicata*	1
10	Littorinimorpha	Cypraeidae	*Monetaria*	*Monetaria annulus*	2
11				*Monetaria moneta*	1
12				*Monetaria* sp.	1
13		Cymatiidae	*Fusitriton*	*Fusitriton oregonensis*	2
14			*Monoplex*	*Monoplex parthenopeus*	2
15		Littorinidae	*Littoraria*	*Littoraria pallescens*	1
16				*Littoraria scabra*	5
17		Naticidae	*Notocochlis*	*Notocochlis cernica*	1
18			*Mammilla*	*Mammilla sebae*	1
19		Rissoinidae	*Phosinella*	*phosinella exasperata*	2
20		Triviidae	*Niveria*	*Niveria quadripunctata*	1
21			*Trivirostra*	*Trivirostra oryza*	2
22		Strombidae	*Canarium*	*Canarium sp.*	1
23				*Canarium mutabile*	2
24				*Canarium urceus*	3
25			*Gibberulus*	*Gibberulus gibbosus*	1
26			*Strombus*	*Strombus alatus*	1
27				*Strombus labiatus*	1
28				*Strombus luhuanus*	6

No	Classification				∑
	Order	**Family**	**Genus**	**Spesies**	
29			*Tricornis*	*Tricornis tricornis*	2
30	Neogastropoda	Clathurellidae	*Etrema*	*Etrema crassilabrum*	1
31		Drilliidae	*Clavus*	*Clavus canalicuralis*	1
32		Columbellidae	*Euplica*	*Euplica scripta*	8
33			*Mitrella*	*Mitrella nympha*	2
34		Conidae	*Conus*	*Conus arenatus*	2
35				*Conus aristophanes*	4
36				*Conus attenuatus*	3
37				*Conus balerensis*	1
38				*Conus catus*	3
39				*Conus eburneus*	1
40				*Conus eversoni*	2
41				*Conus floridulus*	2
42				*Conus fuscoflavus*	4
43				*Conus marmoreus*	1
44				*Conus nimbosus*	2
45				*Conus sponsalis*	1
46		Costellariidae	*Vexillum*	*Vexillum caveum*	1
47				*Vexillum discolorium*	2
48				*Vexillum epiphaneum*	1
49				*Vexillum exasperatum*	2
50				*Vexillum mica*	2
51				*Vexillum obeliscus*	1
52				*Vexillum plicarium*	1
53				*Vexillum semifasciatum*	1
54				*Vexillum virgo*	3
55		Eulimidae	*Melanella*	*Melanella acicula*	2
56		Mangeliidae	*Eucithara*	*Eucithara coronata*	1
57			*Gyrineum*	*Gyrineum lacunatum*	1
58			*Mangelia*	*Mangelia attenuata*	1
59			*Propebela*	*Propebela turricula*	1
60		Mitridae	*Imbricaria*	*Imbricaria flammigera*	5
61			*Mitra*	*Mitra mitra*	1
62			*Pseudonebularia*	*Pseudonebularia wareni*	1
63			*Subcancilla*	*Subcancilla fijiensis*	1
64		Muricidae	*Drupella*	*Drupella margariticola*	5
65			*Hexaplex*	*Hexaplex trunculus*	1
66			*Maculotriton*	*Maculotriton serriale*	1
67		Nassariidae	*Nassarius*	*Nasaarius jonasii*	7
68				*Nasaarius pullus*	17
69				*Nassarius distortus*	4
70				*Nassarius elegantissimus*	21

No	Classification				∑
	Order	Family	Genus	Spesies	
71				*Nassarius globosus*	26
72				*Nassarius graphiterus*	3
73				*Nassarius mutabilis*	1
74				*Nassarius olivaceus*	9
75				*Nassarius quadrasi*	3
76			*Phrontis*	*Phrontis vibex*	3
77			*Reticunassa*	*Reticunassa annabolteae*	1
78		Olividae	*Oliva*	*Oliva caerulea*	1
79				*Oliva maculata*	1
80				*Oliva samarensis*	6
81				*Oliva sp.*	1
82		Terebridae	*Clavus*	*Clavus unizonalis*	2
83			*Cinguloterebra*	*Cinguloterebra cumingii*	2
84			*Decorifer*	*Decorifer insignis*	3
85			*Hastula*	*Hastula lauta*	1
86			*Myurellopsis*	*Myurellopsis kilburni*	2
87		Tudiclidae	*Euthria*	*Euthria scepta*	1
88		Volutidae	*Longchaeus*	*Longchaeus acus*	2
89	Trochida	Tegulidae	*Tectus*	*Tectus mauritianus*	1
Total	6	26	49	89	243
		H'= 4.141	1-D= 0.96	e^H/S= 0.70	

Based on the results, the abundance of Gastropods varied at each observation station. Station 2, which has a muddy sand substrate, recorded the highest abundance, continued by Station 1 with a sandy substrate. However, the lowest abundance was found at Station 3, which was dominated by sand substrate mixed with coral fragments (**Table 3**).

Table 3. Abundance of species at three stations

No	Species	St. 1	St. 2	St. 3	∑
1	*Terebralia palustris*	1	0	0	1
2	*Cerithium columna*	0	1	0	1
3	*Cerithium dialeucum*	1	0	0	1
4	*Cerithium muscarum*	1	0	0	1
5	*Cerithium rostratum*	2	1	2	5
6	*Atys naucum*	1	0	0	1
7	*Aliculastrum cylindricum*	1	1	0	2
8	*Neritina labiosa*	1	0	0	1
9	*Nerita plicata*	0	0	1	1
10	*Monetaria annulus*	1	0	1	2
11	*Monetaria moneta*	0	0	1	1

No	Species	St. 1	St. 2	St. 3	∑
12	*Monetaria sp.*	0	0	1	1
13	*Fusitriton oregonensis*	1	0	1	2
14	*Monoplex parthenopeus*	1	0	1	2
15	*Littoraria pallescens*	0	1	0	1
16	*Littoraria scabra*	1	4	0	5
17	*Notocochlis cernica*	0	0	1	1
18	*Mammilla sebae*	0	1	0	1
19	*Phosinella exasperata*	0	1	1	2
20	*Niveria quadripunctata*	0	1	0	1
21	*Trivirostra oryza*	1	0	1	2
22	*Canarium sp.*	1	0	0	1
23	*Canarium mutabile*	1	0	1	2
24	*Canarium urceus*	1	0	2	3
25	*Gibberulus gibbosus*	0	0	1	1
26	*Strombus alatus*	1	0	0	1
27	*Strombus labiatus*	0	0	1	1
28	*Strombus luhuanus*	1	1	4	6
29	*Tricornis tricornis*	1	0	1	2
30	*Etrema crassilabrum*	0	0	1	1
31	*Clavus canalicuralis*	0	1	0	1
32	*Euplica scripta*	2	1	5	8
33	*Mitrella nympha*	1	0	1	2
34	*Conus arenatus*	0	1	1	2
35	*Conus aristophanes*	1	1	2	4
36	*Conus attenuatus*	1	0	2	3
37	*Conus balerensis*	0	1	0	1
38	*Conus catus*	2	0	1	3
39	*Conus eburneus*	1	0	0	1
40	*Conus eversoni*	0	1	1	2
41	*Conus floridulus*	1	1	0	2
42	*Conus fuscoflavus*	2	1	1	4
43	*Conus marmoreus*	0	0	1	1
44	*Conus nimbosus*	1	1	0	2
45	*Conus sponsalis*	0	0	1	1
46	*Vexillum caveum*	1	0	0	1
47	*Vexillum discolorium*	1	1	0	2
48	*Vexillum epiphaneum*	0	1	0	1
49	*Vexillum exasperatum*	1	1	0	2
50	*Vexillum mica*	1	0	1	2
51	*Vexillum obeliscus*	0	1	0	1
52	*Vexillum plicarium*	1	0	0	1
53	*Vexillum semifasciatum*	1	0	0	1
54	*Vexillum virgo*	0	1	2	3

No	Species	St. 1	St. 2	St. 3	∑
55	*Melanella acicula*	1	0	1	2
56	*Eucithara coronata*	0	1	0	1
57	*Gyrineum lacunatum*	1	0	0	1
58	*Mangelia attenuata*	0	1	0	1
59	*Propebela turricula*	0	0	1	1
60	*Imbricaria flammigera*	1	1	3	5
61	*Mitra mitra*	0	1	0	1
62	*Pseudonebularia wareni*	0	1	0	1
63	*Subcancilla fijiensis*	0	0	1	1
64	*Drupella margariticola*	2	0	3	5
65	*Hexaplex trunculus*	0	0	1	1
66	*Maculotriton serriale*	1	0	0	1
67	*Nassaarius jonasii*	2	4	1	7
68	*Nassaarius pullus*	4	10	3	17
69	*Nassarius distortus*	2	2	0	4
70	*Nassarius elegantissimus*	8	9	4	21
71	*Nassarius globosus*	7	15	4	26
72	*Nassarius graphiterus*	1	2	0	3
73	*Nassarius mutabilis*	0	1	0	1
74	*Nassarius olivaceus*	2	6	1	9
75	*Nassarius quadrasi*	2	1	0	3
76	*Phrontis vibex*	2	1	0	3
77	*Reticunassa annabolteae*	0	0	1	1
78	*Oliva caerulea*	1	0	0	1
79	*Oliva maculata*	0	1	0	1
80	*Oliva samarensis*	3	1	2	6
81	*Oliva sp.*	0	1	0	1
82	*Clavus unizonalis*	1	0	1	2
83	*Cinguloterebra cumingii*	1	1	0	2
84	*Decorifer insignis*	1	0	2	3
85	*Hastula lauta*	1	0	0	1
86	*Myurellopsis kilburni*	1	0	1	2
87	*Euthria scepta*	0	0	1	1
88	*Longchaeus acus*	0	0	2	2
89	*Tectus mauritianus*	0	0	1	1
Total		82	86	75	243

The high abundance of Gastropods at Station 2 is closely related to the characteristics of the muddy sand substrate. This substrate is known to have a higher organic matter content than other types of substrates, thus providing abundant food sources for benthic organisms, including Gastropods (Wibowo, 2009). The dominance of species from the Nassariidae family, such as *Nassarius globosus* (26 individuals), *Nassarius elegantissimus* (21 individuals), and *Nassarius pullus* (17 individuals), was one of the main contributors to the high abundance at Station 2.

These species are generally detritivores that rely heavily on the availability of organic matter at the bottom of the water, which is abundant in muddy substrates (Morton, 1990; Taylor & Lewis, 1970).

In comparison, Station 3 showed the lowest abundance of Gastropods despite its substrate consisting of sand and coral fragments, which tend to be more physically stable. However, this condition is less favorable for most detritivore species due to its low organic matter content. In addition, the coarser and harder texture of the substrate may inhibit foraging activities for Gastropods that depend on organic particles in the sediment (Alongi, 2002).

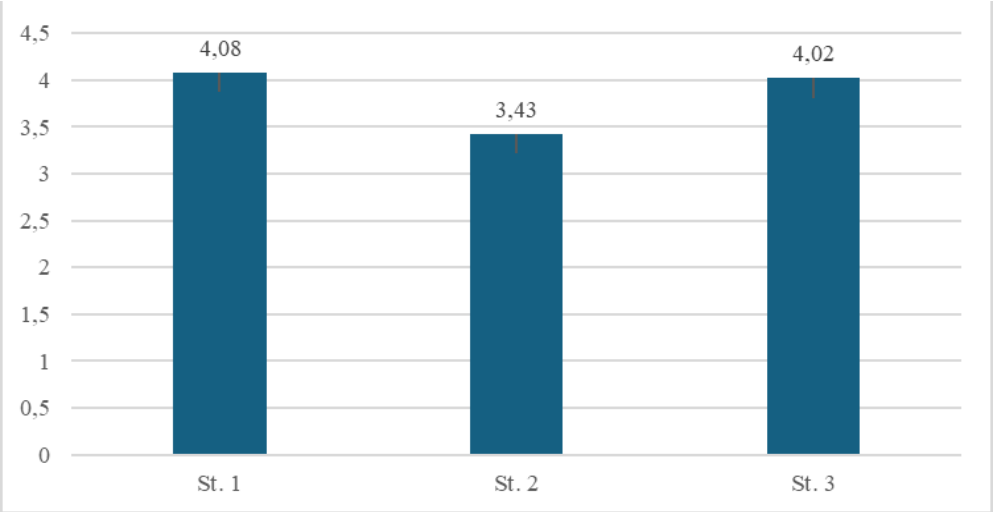

Figure 1. Diversity Index

Data analysis in **Figure 1** shows significant variation in the Gastropod diversity index across the three stations. Station 1 recorded the highest index value of 4.08, followed by Station 3 with 4.02, while Station 2 had the lowest value of 3.43. The high diversity index value at Station 1 indicates a balanced Gastropod community structure, with an even distribution of species and without dominance by one particular species.

These conditions are a direct result of the sand substrate characteristics at Station 1, which provides a stable habitat and supports a diversity of Gastropod species with different ecological requirements. The sand substrate present at this site creates a suitable environment for various species to coexist optimally. In contrast, the low diversity index value at Station 2 reflects high environmental pressure, resulting in a Gastropod community dominated by certain species. This is due to the homogeneous and unfavorable condition of the muddy sand substrate at Station 2 for most species, so that only species that are able to adapt to these conditions dominate.

This result is in line with Magurran's (1988) statement, which emphasizes that environmental variation directly determines the composition and structure of the aquatic bottom organism community. An environment with homogeneous conditions and low habitat quality causes a decrease in diversity and increases the dominance of certain species. Therefore, the Gastropod diversity index value at

each station in this study accurately reflects the habitat quality and stability of the aquatic ecosystem at Meras Beach.

The Gastropod diversity in Meras Beach can be compared with several other research locations in Indonesia. Based on the diversity index (H'), Meras Beach shows a very high value compared to other beaches in the tidal area. To see further comparison, the following **Table 4** summarizes the Gastropod diversity index values from various research locations.

Table 4. Comparison (H') of Gastropods in Selected Beaches in Indonesia

No	Lokasi	(H')	Category	Referensi
1	Pantai Meras Kec. Bunaken Sulawesi Utara	4,14	High	
2	Pantai Selatan, Kab. Pamekasan	3,075	High	Rahmasari *et al.,* (2015)
3	Pantai Seger, Lombok Tengah	2,96	High	Parorrongan *et al.,* (2018)
4	Pantai Ujong Kareung Kab. Aceh Besar	2,898	Medium	Rahmati (2021)
5	Pantai Pangi, Kab. Blitar	2,475	Medium	Nafi'ah (2019)
6	Pantai Desa Balukang, Kec. Sojol, Kab. Donggala	2,21	High	Rezkiana & Dhafir (2024)
7	Pantai Kadahang, Kab. Sumba Timur	2,168	Medium	Dai Waha (2023)
8	Pantai Nyang Nyang, Bali Selatan	2,19	Medium	Gildania (2018)
9	Pantai Kondang Merak, Kab. Malang	2,161	Medium	Sukiman (2023)
10	Ekosistem Mangrove di Kel. Meras, Kec Bunaken Kota Manado Sulawesi Utara	2,13	Medium	Tiranda (2024)
11	Pantai Kab. Kepulauan Aru Kec. Aru Selatan Utara	2,07	Medium	Bahar *et al.,* (2022)
12	Pantai Tambakrejo, Kab. Blitar	1,165	Low	Wardani (2023)
13	Pantai Wediombo, Gunungkidul. Yogyakarta	1,07	Low	Triastuti (2016)
14	Pantai Negeri Buano, Kab. Seram Bagian Barat	1,02	Low	Tuheitu (2020)
15	Pantai Kertosari, Kab. Pemalang	0,948	Low	Miftachudin (2014)

The results show that the diversity of Gastropods in Meras Beach has a diversity index (H') of 4.14, which is categorized as "high". This value places Meras Beach in the first rank compared to various other locations in Indonesia that have been studied previously. The high diversity of Gastropods in this area is closely related to the diversity of habitat characteristics, which include variations in substrate types and environmental conditions that support the abundance and distribution of species.

Environmental factors play an important role in supporting Gastropod survival at all stations. These environmental factors affect the fauna of animals including Gastropods, such as in the process of osmoregulation, shell formation, and reproduction. According to Wahyuni (2014), the ideal pH range for Gastropod life is 6.8 to 8.5. The optimal temperature range for Gastropod growth and development is 26°C to 32°C (Cahyanti, 2024). While the optimal salinity ranges from 31 to 33 ppt, within the optimal range of 28-34 ppt (Putra et al., 2015). The three parameters measured at the location are considered to be within the range of optimal values for

Gastropod habitat. The following table are the results of the measurement of physical factors at each station at Meras Beach, Bunaken Kec. North Sulawesi (**Table 5**).

Table 5. Aquatic environment parameters

Station	pH	Temp(°C)	Salinity (ppt)	Substrate
1	7,2	28,5	31	Sandy
2	7,8	29,5	33	Muddy sand
3	7,5	30	32	Sand and coral fragments
Mean	7,5	29,3	32	Sandy

The combination of maintained biotic (Gastropods and marine plants) and abiotic (environmental factors: temperature, salinity and pH) in this location is optimal in providing food sources, shelter, and environmental conditions that support the survival of many types of gastropods.

CONCLUSION

This study has been able to identify 89 species of Gastropoda from 243 individuals belonging to six orders and 26 families, which were spread across three observation stations in Meras Beach, Bunaken District, North Sulawesi. The three stations had different substrate characteristics, such as sand (Station 1), muddy sand (Station 2), and sand with coral fragments (Station 3). The results showed that the genus *Nassarius* was the most dominating group in the Gastropod community, with *Nassarius* globosus as the most common species found. The Shannon diversity index (H') value of 4.14 is included in the high category, which indicates that the coastal ecosystem at Meras Beach is in a healthy and stable condition, and is able to support the existence of various Gastropod species. The diversity of substrate types and the support of surrounding ecosystems such as mangrove forests, seagrass beds, and coral reefs contributed to the high level of diversity that was discovered. Thus, the results of this study not only provide basic data on the Gastropod community in Meras Beach, but also can be an initial reference in supporting conservation strategies and sustainable management of coastal ecosystems in the Bunaken National Park area.

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