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Diversity and density of marine intertidal gastropods in tropical seagrass beds at Oransbari Bay, South Manokwari - West Papua

Duaitd Kolibongso*, Frida A Loinenak, Agnestesya Manuputty

Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Papua, Manokwari, Indonesia

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ABSTRACT

Gastropod communities are one of the important components of the food chain in seagrass meadows. This study aims to investigate the diversity of gastropods in the distribution of the seagrass beds at Oransbari Bay. This study was carried out in November 2022, using the line transect method. Data collection is carried out at three stations, where each station is divided into three transects. A total of 36 species consisting of 16 families and 5 orders, were recorded in this study. The total density of gastropods found in the waters of Oransbari Bay ranged from 5.77-9.43 ind/m², with an average of 6.99 ± 2.10 ind/m². *Conus sp.* has the highest density value of any gastropod. Meanwhile, for seagrasses, five species from four clans and two families were obtained. The percent cover of seagrass ranges from 17.05 ± 3.30% – 58.90 ± 22.90% with an average of 40.18 ± 21.3%. *Halophila minor* and *Thallasia hempricii* showed a positive correlation with gastropod density. The value of the gastropod diversity index is in the medium category, the gastropod evenness index is in the stable category, and the gastropod dominance index is in the low category. The results of this study provide a base for a proper gastropod checklist at Oransbari Bay. Future research is recommended that involves a more detailed studies on the feeding ecology and habitat preference of the gastropods.

Introduction

Seagrass is a submerged marine flowering plant (Angiosperms) that grows in clusters to form clumps and is often the dominant component in coastal aquatic environments (Nontji, 2005; Unsworth *et al*., 2018). Seagrass beds are ecosystems with high organic productivity and a fairly high biota diversity. Many sedentary or transitory seagrass biota have a high economic value, particularly epibenthic types such as crabs, shrimp, snails, clams, squid, octopus, sea cucumbers, and various types of fish (Unsworth *et al*, 2018). The gastropods, which live as epifauna (creeping on the surface) and infauna (immersing themselves in sediments), are one group of fauna that is commonly found in coastal waters, particularly in seagrass meadow areas (Stephenson *et al*., 2013). In the food chain, epifauna gastropods are components that utilize epiphytic biomass in seagrass leaves. Meanwhile, gastropods are components that utilize litter on the surface of sediments (Kinch, 2003).

Gastropod communities are an important component of the food chain in seagrass meadows, where gastropods are detritus-eating base animals (detritus feeders) that collect litter from fallen seagrass leaves and circulate suspended substances in the water to obtain food (Hitalessy *et al*, 2015). The abundance and distribution of gastropods are influenced by local environmental factors, food availability, predation, and competition. Environmental pressures and changes can affect the number of types and differences in the structure of gastropod communities (Vian *et al*, 2022).

Research on the ecology and biodiversity of gastropods in seagrass beds has been widely conducted in Indonesia, including in Lampung (Sari *et al*., 2019), Bangka Belitung Island (Cappenberg & Wulandari, 2019), East Java (Hitalessy *et al*., 2015),

* Corresponding author.
Email address: d.kolibongso@unipa.ac.id

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South Sulawesi (Litaay *et al*., 2017), North Sulawesi (Arbi, 2012), Maluku Islands (Latuconsina & Buano, 2021; Uneputty *et al*., 2021), and Papua Island (Sari *et al*., 2017; Aji & Widyastuti, 2019; Souisa *et al*., 2019).

The amount of research on gastropod communities in tropical seagrass beds, especially in Indonesia, shows how important the role and potential of seagrass beds as habitats for gastropod communities. Oransbary Bay, which is located in South Manokwari Regency, West Papua, has seagrass potential with various types of seagrass vegetation in the intertidal zone. Seagrass beds in this area supports the fisheries activities of the local community. Oransbari Bay is directly adjacent to Cenderawasih Bay, and three-quarters of its territory is in the coastal area. People's livelihoods largely depend on fishing and agricultural activities. Therefore, seagrass beds in this area are under threat largely due to human activities. Scientific information on the ecology and diversity of gastropods associated with seagrass beds is lacking. This study is the first conducted in this area, where the condition and status of seagrass beds have not been published. So far, more research has focused on coral reefs and mangroves ecosystems (Parenden *et al*, 2019; Matani *et al*, 2021). Therefore, the results of this study can provide preliminary information and can be used as basic data for further monitoring, management, and conservation purposes. With this updated information, an understanding of mitigation strategies and priority management can be highlighted either for conservation purposes or to support local community activities without losing their functionality. The objective of the current study was to investigate the status of seagrass beds including information on the diversity of associated species (gastropods) in Oransbari Bay.

Materials and Methods

Study area and sampling stations

The current research was conducted in November 2022 in the waters of Oransbari Bay, South Manokwari (Figure 1).

Samples and data collections

Seagrass and gastropods data were collected using the line transect method (perpendicular to the coastline) and plot (quadrants) measuring 0.5 x 0.5 m (English *et al*, 1997; McKenzie *et al*, 2009). The seagrasses found in each plot were immediately identified, ranging from the shape of leaves, rhizomes, flowers, and fruits (Waycott *et al*, 2004; McKenzie *et al*, 2009; El Shaffai *et al*, 2011). Data collection was conducted at three stations where each station consisted of three transects, with a transect line length of 50 m and a distance of 25 m between transects. The distance between plots in the transect line was 5 m (Figure 1).

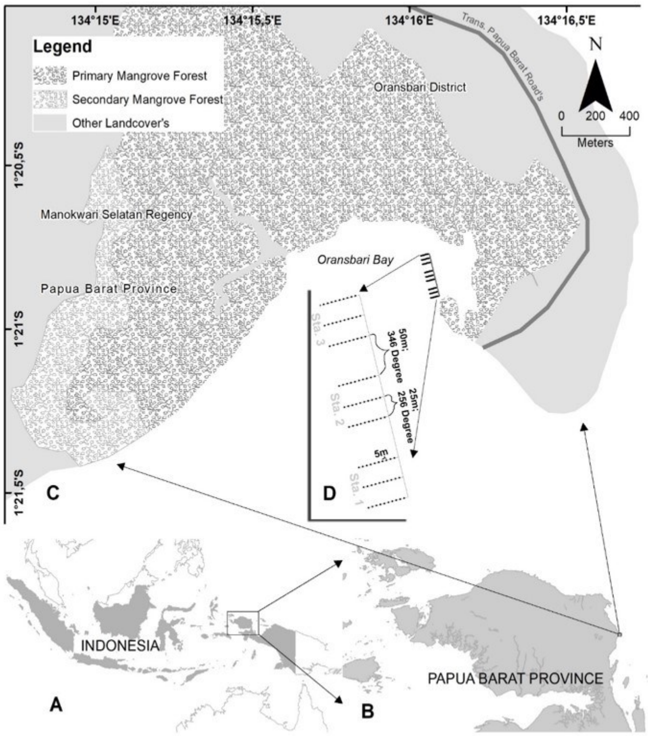

Figure 1. Map of research in Oransbari Bay, Manokwari West Papua.

The total number of plots at each transect was 10 plots, so the total number of plots at one station was 30 plots. Gastropod data collection is adapted to the conditions of the seagrass on site. Sampling was carried out in 0.5 x 0.5 m plots, and gastropods attached to seagrasses and those on the substrate were taken. All of the specimens found in the plots were identified, enumerated, and recorded in the field. They were collected, fixed with 10% formalin, placed in a labeled plastic bag, and brought to the Aquatic Resources Laboratory, Faculty of Fisheries and Marine Science, University of Papua Manokwari for further identification. The gastropods were identified to species level following keys by (Dharma, 1992; Poutiers, 1998). The World Register of Marine Species (WoRMS) was referred for the correct gastropod names. At each station, the substrate types were identified visually. Substrate collection and observation were carried out at each station, beginning, middle, and end of the transect. Meanwhile, seagrass identification was conducted according to McKenzie & Yoshida, (2016).

Seagrass coverage

Seagrass percentage cover measurements are used by the scientific literature based on (Rahmawati *et al*, 2014) with the percentage of seagrass covered categorized as rare (0–25%), moderate (25–50%), solid (51–75%), and very dense (76–100%). Seagrass health conditions are categorized based on the Minister's national regulation, Environmental Decree No. 200/2004, with a healthy category if seagrass cover in an area reaches >60%, unhealthy category if 30-59.9%, and a bad category if the percentage of coverage is between 0-29.9%.

Data analysis

The data obtained were described quantitatively. Density was calculated based on the number of animals per one square meter (no. ind. m-2). A univariate analysis is used to explain the conditions of gastropod communities. The indicators analyzed were diversity, evenness, and dominance (Odum, 1975). The Shapiro-Wilk test is used for normality and homogeneity of variance to ensure data distribution. The percent of seagrass cover and gastropod density at each station were compared to determine significant differences; the Kruskal-Wallis (non-parametric) test was used to analyze the data. A significant difference was obtained with a p-value < 0.05. Spearman's correlation analysis was used to see the relationship between percent covers and gastropod density, with a correlation at a significance level of 95% ($p < 0.05$).

Table 1. Seagrass community and type of habitats

Location	Ea	Th	Si	Ho	Hm	Substrate
Station 1	-	-	√	√	-	Muddy sand
Station 2	√	-	√	√	-	Muddy sand
Station 3	-	√	√	√	√	Gravel sand

Ea = *Enhalus acoroides*; Th = *Thalassia hempricii*; Si = *Syringodium isoetifolium*; Ho = *Halophila ovalis*; Hm = *Halophila minor*.

Results

Seagrass community and type of habitat

The results of observations show that seagrasses found in the waters of Oransbari Bay consist of 5 species from 2 families; these seagrass species include *Enhalus acoroides, Thalassia hempricii, Halophila minor, Halophila ovalis*, and *Syringodium isoetifolium*. *H. ovalis* and *S. isoetifolium* are two species found at all stations. Meanwhile, *T. hempricii* and *E. acoroides* were found at only one station each. The site's substrate is made up of gravel sand and muddy sand (Table 1).

Seagrass coverages

The percentage of seagrass cover found at all stations varied considerably from 17.05 ± 6.30% – 58.90 ± 28.10% with an average of 40.18 ± 21.3%.

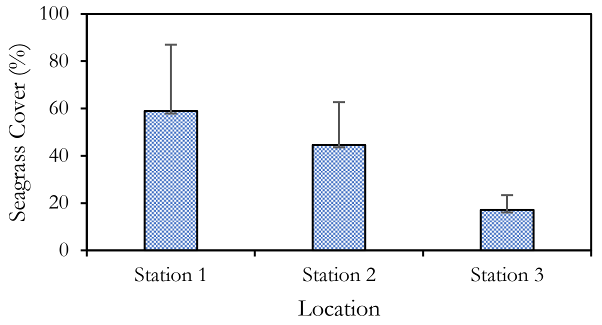

Figure 2. A total of seagrass coverage in each site

Table 2. Seagrass coverage at each species

Location	Ea (%)	Th (%)	Si (%)	Ho (%)	Hm (%)
Station 1	-	-	52.65	3.03	3.22
Station 2	15.06	-	27.27	2.27	-
Station 3	-	7.67	2.56	0.85	5.97

Ea = *Enhalus acoroides*; Th = *Thalassia hempricii*; Si = *Syringodium isoetifolium*; Ho = *Halophila ovalis*; Hm = *Halophila minor.*

Density and diversity gastropods

The composition of gastropods found in seagrass beds in Oransbari Bay consists of 36 species, 16 families, and 5 orders. There are five species whose distribution is found at two stations, namely *Canarium mutabile*, *Doxander vittatus*, *Ilyanassa obsoleta*, *Tritia reticulata*, and *Urosalpinx cinerea*. Meanwhile, *Conus* sp. and *Strombus giberrulus* are the species with the most individuals (Figure 3).

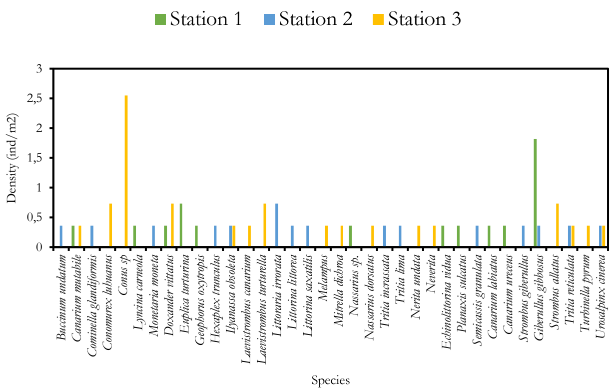

Figure 3. Density of gastropods on seagrass beds

The total density of gastropods found in the Oransbari Bay ranged from 5.77-9.43 ind/m^2, with an average of 6.99 ± 2.10 ind/m^2 (Figure 4). Statistical analysis showed there was no significant difference in density between stations ($p > 0.05$; Kruskal-Wallis $p = 0.996$).

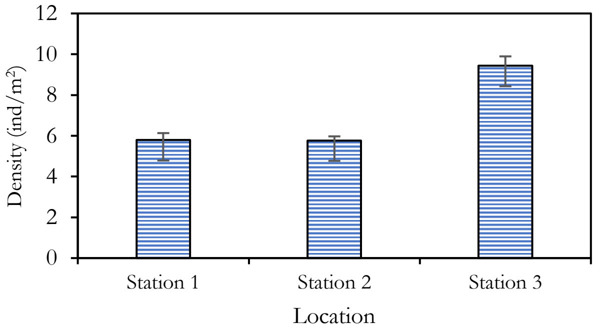

Figure 4. A total of gastropod density in each site

The diversity index ranges from 2,183 to 2,599, with the highest value found at station 2. Meanwhile, the uniformity index ranges from 0.777 to 0.961, where at station 3 it shows the lowest value. The dominance index ranges from 0.078 to 0.148 (Table 3).

Table 3. Ecological index of gastropod

Sample	S	H'	J'	D
Station 1	11	2.18	0.80	0.15
Station 2	14	2.59	0.96	0.07
Station 3	16	2.52	0.77	0.11

S = Species; H' = Shannon-wiener index, J' = Evenness index, D = Dominance index.

Relationship of seagrass and gastropods

Species *Thallassia hempricii* and *Halodule minor* showed a relationship with the density of gastropods in the bay of Oransbari with a correlation coefficient of r = 0.866 and r = 1.00, respectively, with a positive relationship direction.

Table 4. Association of seagrass and gastropods

	Ho	*Ea*	*Si*	*Hm*	*Th*	*Ga*
Ho		0.666	1,00	0.333	0.666	0.333
Ea	0.866		1,00	0.666	1,00	0.666
Si	0.500	0		1,00	0.666	1,00
Hm	-1,00	0.866	-0.5		0.666	0.333
Th	-0.866	-0.5	-0.866	0.866		0.666
Ga	-1,00	-0.866	-0.5	**1,00**	**0.866**	

Ea = *Enhalus acoroides*; Th = *Thalassia hempricii*; Si = *Syringodium isoetifolium*; Ho = *Halophila ovalis*; Hm = *Halophila minor*; Ga = gastropods.

Discussion

Condition and status of seagrass

The results showed that seagrasses found in the waters of Oransbari Bay consist of five species from two families; these seagrass species include *Enhalus acoroides, Thalassia hempricii, Halophila minor, Halophila ovalis*, and *Syringodium isoetifolium*. Eastern Indonesia has recorded ten seagrass species (Supriyadi *et al*, 2019). (Dewi *et al*, 2017) found eight seagrass species in Biak Island, Papua, and Supriyadi *et al.* (2018) found six species in Raja Ampat. The distribution and growth of seagrasses in a waters can be influenced by several parameters of the aquatic environment, including the level of brightness, the bottom substrate, salinity, and temperature (McKenzie *et al*, 2020) as well as the characteristics of the coastal waters. *H. ovalis* and *S. isoetifolium* are two species found at all stations. Meanwhile, *T. hempricii* and *E. acoroides* were found at only one station each. The site's substrate is made up of gravel sand and muddy sand (Table 1). The type of seagrass vegetation in the study area is mixed. At Station 1, three species of seagrasses, namely *H. minor*, *H. ovalis*, and *S. isoetifolium*, with the species of *S. isoetifolium* dominating where the substrate type found was muddy sand. *S. isoetifolium* is characterized by its cylindrical, smooth and beveled leaves with a length of up to 30 cm and a width of 0.1 - 0.2 cm. This species of seagrass is adapted to a muddy environment (Pranata *et al.*, 2018). Station 2 found three types of seagrasses, namely *H. ovalis, E. acoroides*, and *S. isoetifolium*, with *E. acoroides* being a species of seagrass found only at this station. This is thought to be related to the type of substrate found, which is muddy sand. According to Latuconsina *et al.* (2020), *E. acoroides* predominantly lives on sandy bottom substrates and slightly muddy sands and is sometimes found on a base consisting of a mixture of fragments of dead coral.

Station 3 found four species of seagrass, namely *H. ovalis*, *H. minor*, *S. isoetifolium*, and *T. hempricii*. The presence of *T. hempricii* is found only at this station. This is thought to be related to the substrate at this location, which dominates the gravel sand and the characteristics of *T. hempricii* which usually forms heterospecies with other species forming seagrass beds. According to Dewi *et al*, (2017); Sarinawaty *et al*, (2020); Sondak & Kaligis (2022), the species of *T. hempricii* which usually forms heterospecies on gravelly or muddy sand substrates, forming seagrass beds with other species such as *S. isoetifolium*, *H. ovalis*, *C. rotundata,* and *E. acoroides*. Seagrass communities are one of the most productive and dynamic ecosystems globally. Seagrasses may significantly influence the physical, chemical and biological environments in which they grow by acting as 'ecological engineers'. They provide habitat and nursery grounds for many marine animals and act as substrate stabilizers (McKenzie *et al*, 2016).

The condition of seagrasses in Oransbari Bay falls into the category of "unhealthy" referring to the Minister's national regulation of the Environment Decree No. 200/2004. Station 1 has the highest average cover percentage of 58.90 ± 22.90%, and station 3 has the lowest average cover percentage of 17.05 ± 3.30% (Figure 2). Statistical analysis showed there was no significant difference in the seagrass cover between the three stations ($p > 0.05$; Kruskal-Wallis $p = 0.998$). Station 1 shows that *S. isoetifolium* is the seagrass species that has the highest percentage of cover (52.65%), followed by *H. minor* (3.22%), and *H. ovalis* (3.03%). At station 2, seagrass *S. isoetifolium* was the species with the highest percentage of cover, followed by *E. acoroides* (15.06%) and *H. ovalis* (2.27%). Station 3, seagrass *T. hempricii* was the species with the highest percentage of cover, followed by *H. minor* (5.97%), *S. isoetifolium* (2.56%), and *H. ovalis* (0.85%), respectively. The percentage of seagrass cover at each station shows differences, implying that the loss and decline of seagrass cover are more influenced by local factors in each location. Seagrass cover is influenced by density and morphology, particularly leaf width, because the wider the seagrass leaf, the more covered the substrate area. Some factors that affect seagrass cover are seagrass density and tidal flows (Sarinawaty *et al*, 2020). However, it should be noted that many studies have shown a correlation between seagrass loss or degradation and the pressure exerted by human activities. In Indonesia, seagrass beds have decreased by around 30-40% due to various factors, especially anthropogenic pressures (Vo *et al*., 2013). Kawaroe *et al*. (2016) found seagrass cover in three ecoregions of Indonesia, namely in the waters of Riau Islands are 61%, Thousand Islands 37%, Talaud Islands 43%, and Tanimbar Islands 60%. Meanwhile, the status of seagrass beds in eastern Indonesia is categorized as good (43%), moderate (50%), and poor (7%) (Supriyadi *et al*, 2019).

When compared to the condition of seagrass beds in areas around Papua and West Papua, the condition of seagrass beds found in the study is classified as 'moderate to poor'. The low seagrass cover at the Oransbari bay is thought to come from local factors (direct and indirect factors). Direct factors are thought to be caused by the dominant seagrass species found to have small leaf size. Meanwhile, indirect factors are thought to be caused by pressure from activities around the site, namely the ferry port located around the area and land clearing for settlements, plantations, and so on, resulting in erosion and increased sediment transport in the waters. Damage to seagrass beds is caused by boat propellers or the laying of anchors of anchored ships. Next, South Manokwari is a developing district, so much land is cleared for economic development purposes. Unsworth *et al*. (2018) found that seagrass loss and/or degradation in Indonesia is mainly influenced by development (25%) and sedimentation (20%). Changes in the environment, primarily caused by coastal development, land reclamation, and deforestation, as well as seaweed farming, overfishing, and rubbish dumping, are the cause of declining seagrass health (Unsworth *et al*., 2016; Unsworth *et al*., 2018).

Diversity and density of gastropods

There are 36 species, 16 families, and 5 orders of gastropods found in Oransbari Bay's seagrass beds. The Strombidae (27.8%) was the most abundant family of all gastropods recorded. The Strombidae family is a group of gastropods that are usually found in colonies and abundant in shallow areas of seagrass ecosystems (Uneputty *et al*, 2021). Comparison of the number of gastropod species found in seagrass beds of Oransbari Bay is higher than in several locations in Indonesia. North Minahasa with 18 species, 11 families, dan 3 orders (Manaida *et al*., 2022), Belitung island with 12 species and 8 families (Cappenberg & Wulandari, 2019), East Java with 7 species, 5 families, and 3 orders (Hitalessy *et al*., 2015), South Sulawesi with 34 species and 14 families (Litaay *et al*., 2017), and Maluku island with 30 species, 13 families and 4 orders (Latuconsina & Buano, 2021). When compared within in Papua island found in this study, including "low", on Padaido Island-Papua, 115 species of gastropods were discovered (Aji *et al*, 2018); on Biak Island-Papua, 126 species gastropods were discovered (Aji & Widyastuti, 2019); and on Nabire, Papua discovered as many as 49 species and 12 families (Souisa *et al*., 2019). The high and low composition of gastropods found shows the high ability of gastropods to adapt to various environmental conditions. The different gastropod communities among the locations indicate that each site has a strong influence on the assemblage (Fong *et al*., 2018). As is known, gastropods are one of the species that have enormous adaptability, so they are able to survive in various places with a wide distribution. The distribution of organisms in relation to their habitat is critical in ecology (Schoepf *et al*, 2010). Many marine organisms' distribution and aggregation patterns can be influenced by physical and biological factors such as sediment characteristics, water movement, seasonality, competition, predation, reproduction, and recruitment (Shou *et al*., 2009). In addition, the utilization of gastropods by the community also influences the gastropod population in a location. Mollusks are a source of food and also for souvenirs or handicrafts for the people living in Oransbari Bay. When the weather at sea is extreme and fishermen cannot afford to go out, fisherman's families, such as wives and children, were to search for marine animals in shallow areas, and as a consequence, many shellfish are captured. If this is not properly managed, the gastropods population will decline, notably in the seagrass beds of Oransbari Bay. Some of the dominant species of gastropods and bivalves utilized by the local community are from the Strombidae and Veneridae families (Loinenak *et al*., 2023).

In general, the gastropods found were infaunal gastropods. This condition is thought to be related to the types of seagrasses that dominate, which morphologically have small leaf sizes. Seagrass beds provide a food source for gastropods. Gastropods will change their diet depending on the availability of food (Nakamoto *et al*, 2019). There are five species whose distribution is found at two stations, namely *Canarium mutabile*, *Doxander vittatus*, *Ilyanassa obsoleta*, *Tritia reticulata*, and *Urosalpinx cinerea*. The five species are infauna gastropods that live in intertidal areas by utilizing seagrass leaf litter on the surface of the substrate (sediment). However, specifically, the species *Ilyanassa obsoleta* is known to be one of the alien "invasive" species (Budi *et al*, 2014). This certainly deserves attention because the influence of alien invasive species on native species and ecosystems is very diverse. They can be competitors, predators, pathogens, and parasites. Meanwhile, *Conus* spp. and *Strombus giberrulus* are the species with the most individuals. Both species are gastropods whose distribution is in tropical and sub-tropical regions with habitat types such as sand and mud in the intertidal zone (Muttenthaler *et al*, 2012; Maxwell *et al*, 2021; Tebiary *et al*, 2022). In addition, these two species are also gastropods that have a large presence, especially in shallow areas of seagrass ecosystem (Tebiary *et al*, 2022). According to Cob *et al*, (2010), (2012), the genus Strombus is present as an indicator of the productivity of seagrass waters.

The density of gastropods found ranged between 5.77 ± 0.21 to 9.43 ± 0.46 ind/m^2. The density of gastropods found in this study compared to several reported locations, Souisa *et al.* (2019) found gastropod densities ranging between 0.14 - 10.7 ind/m^2 in seagrass beds of Nusi and Gersen islands, Nabire; Latuconsina & Buano (2021) gastropod densities ranging between 7.5 - 10.5 ind/m^2 in seagrass beds of East Seram, Maluku; and Litaay *et al*., (2017) found gastropod densities ranging between 1.93 to 5.86 ind/m^2 in South Sulawesi. The highest density was found at station 3 with a density of 9.43 ± 0.46 ind/m^2, and the lowest at station 2 with a density of 5.77 ± 0.21 ind/m^2. Statistical analysis showed no significant difference in density between stations ($p > 0.05$; Kruskal-Wallis $p = 0.996$) implying that species abundance among different stations with similar habitats. The high density of gastropods at station 3 is thought to be related to the number of seagrass species found at this station. Station 3 is the location where the most species of seagrasses are found, namely four species. Moreover, the predominantly gravelly (coarse) substrate at this station is thought to be associated with high gastropod densities. Vian *et al*, (2022) found that the high percentage of fine substrate reduced the presence of gastropods and bivalves. Gastropods and bivalves can hardly survive on fine substrates. Zaleha *et al*, (2009) reasoned that less compactness in coarser sediments offers more space for habitation. Hence, a higher abundance of common benthic fauna was found in the area. The density of gastropods at station 1 is dominated by the species *Strombus giberullus*, with a density of 1.82 ind/m^2. *Littoraria irrorata* at station 2 has the highest gastropod density, (0.73 ind/m^2), and *Conus sp.* at station 3 has the highest gastropod density, (2.55 ind/m^2) (Figure 3). In the food chain, epifauna gastropods are components that utilize epiphytic biomass in seagrass leaves. Meanwhile, gastropod infauna are components that utilize litter on the surface of sediments (Kinch, 2003).

The results of the ecological index analysis are shown in Table 3. The species diversity is influenced by two factors that are species number and species evenness (Long *et al*, 2014). The diversity index ranges from 2,18 to 2,59, with the highest value found at station 2. The high value of the gastropod diversity index at station 2 is probably due to the presence of the seagrass species *E. acoroides* which is only found at this station. This seagrass species has morphometric characteristics of long leaves and large rhizomes that can provide hiding place for gastropods. According to Ilias *et al.* (2021), *E. acoroides* plays an important role as providing areas for egg deposition and hiding place for the benthic organism. Cob *et al.* (2014) reported that gastropod composition will be higher in mixed seagrass beds with thick *Enhalus* beds. Since seagrasses provide security, and it is widely known that many species seek shelter within seagrass beds, especially among *E. acoroides*, we assume that this also applies to the high diversity of gastropods at this station. High diversity is an indicator of the stability of a gastropod community. Meanwhile, the evenness index ranges from 0.77 to 0.96, where at station 3 it shows the lowest value, indicating that the distribution of gastropods is uneven, and the dominance index ranges from 0.07 to 0.15. All three indices show that the structure of gastropod communities in seagrass beds on Oransbari Bay is generally in stable condition. Factors that influence gastropod community structure include the presence and absence of competitors, predators, and food sources. According to Cob *et al.* (2012); and Cob *et al.* (2014), the structure of the gastropod community is strongly influenced by the presence or absence of competitors or predators in utilizing space in the habitat which results in aggregation that will appear either by individuals moving towards, or moving away. Added by (Ilias *et al.*, 2021) the high density of gastropods is strongly influenced by the abundance of food found in seagrass beds.

Relationship between seagrass and gastropod communities

The coverage of seagrass has a correlation with the distribution and abundance of gastropod species Table 4. The species of *T. hempricii* and *H. minor* showed a relationship with gastropod density in Oransbari Bay with a positive correlation. This condition is then reinforced by the high-density distribution of gastropods found at Station 3 with dominating gastropod species *Conus* spp. As is known, this species is a type of gastropod that lives in gravel sand habitats among seagrass species that have a small size. The *Conus* spp. group are epifaunal gastropods that favor sandy habitats due to their tendency to bury themselves in the sand (Kohn, 2015). Therefore, it can be stated that the distribution and density of gastropods are more related to habitat (substrate) preference and specific food availability in both seagrass species favored by gastropods. The results of the study (Cob *et al.*, 2012) showed that seagrass *Halophilla* spp. is preferred by gastropods usually because it provides a lot of food in the form of detritus and microflora (epiphyte). Seagrass beds dominated by *Halophila* spp. and *Thallasia hempricii* usually have high sediment organic content, high sediment sorting, and fine sediment particle size – sandys substrate (Cob *et al.*, 2012; Sarinawaty *et al.*, 2020). Nugroho *et al.* (2012) stated sandy substrates have a relatively greater oxygen content compared to fine substrates because in sandy substrates there are air pores that function as a place for more intensive nutrient mixing with the water above. Ilias *et al.* (2021) also found a positive correlation between seagrass cover and gastropod distribution and density, where the presence of *Halophila* spp. seagrass was correlated with the high densities of certain gastropod species. According to Zhang *et al.* (2014) *T. hempricii* although has a short leaf size, it stores more nutrients followed by a high presence of epiphytic algae and detritus. In addition, the morphometric characteristics of these two types of seagrasses are also not too large or small, allowing gastropods to have space in motion. Latuconsina & Buano (2021) stated that the high density of seagrasses will inhibit the activity of basic organisms, namely macrozoobentos, especially in the mollusk phylum due to the dense root system, and it is suspected that there is no ideal space for movement for gastropods. Surprisingly, gastropod densities showed a negative correlation with *E. acoroides* coverage (indicated by large negative scores) in contrast to the common perception that gastropods are strongly associated with *E. acoroides* (Bay *et al.* 2011; Cob *et al.* 2009). However, the results suggest that dense seagrass beds may not be the main reason governing their spatial distribution patterns. The gastropod species found are generally those that can defend themselves from predators by burrowing fully into the sediment. Therefore, it is the preference for habitats with low sediment particle size that may have more influence. Thus, this is an indication that the actual density and distribution of gastropods are not determined by high or low seagrass cover but rather by each species' preference for certain seagrass species and substrates. However, the feeding ecology and habitat preference of the gastropods need further investigation, especially in uncovering gastropod dispersal patterns in seagrass beds.

The results of this study can be used for future research for an updated checklist of gastropods in Oransbari Bay. Limited information and lack of knowledge in taxonomic identification are also potential limitations of this study. An overestimate or underestimate of species diversity may occur because some gastropod species are not easy to distinguish because they have similar shell characteristics (Ran *et al*, 2020). In addition, some of the same species may display diverse shell characteristics because they may be in different growth and environmental settings, which may contribute to their misidentification as different species (Glover *et al*, 2016; Ran *et al*, 2020).

Conclusion

In summary, there are 36 gastropod species with densities ranging between 5.77 ± 0.21 to 9.43 ± 0.46 ind/m^2 on seagrass beds. Five species of seagrass found are *Enhalus acoroides, Thalassia hempricii, Halophila minor, Halophila ovalis*, and *Syringodium isoetifolium*. Our study suggests that individuals' preferences for distinct microhabitats within the seagrass bed appear to be related to their eating and habitat specificity. This study also revealed that they favored mixed seagrass beds dominated by *Halophila* spp and *Thallasia hempricii*, with fine sediment particle size. Understanding habitat preferences will help improve the management of gastropod populations and enable more precise stock assessments. We recommend more detailed studies on the feeding ecology and habitat preference of the gastropods in the future.

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