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Gastropoda community structure in the mangrove forest of Ketapang Coastal Waters, Rupat District

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Abstract
Gastropod community structure is a concept or study that studies the arrangement or composition of species in an ecosystem. Changes influence the structure of this gastropod community in terms of environmental factors such as temperature, salinity, substrate type, and organic matter content. Rupat District is geographically located in a cluster of islands directly adjacent to the Strait of Malacca, strongly influenced by coastal environmental conditions. Rupat sub-district has one of three tropical marine ecosystems, namely mangroves. This study aims to determine the structure of gastropod communities in mangrove forests in Ketapang Beach, Rupat District waters. The study was conducted in April 2023 using the technique of random sampling with a total of three stations. There are 8 (eight) species of gastropods found, with the species *Cerithidea obtusa* the dominant one. The abundance of gastropods is 130,000 ind/ha. The value of the diversity index (H') is 1.24, the uniformity index (E) is 0.33, and the dominance index value (C) is 0.40. The distribution pattern (Id) is grouping. The similarity index (Ss) of gastropods between each station in Ketapang Beach is almost the same type and has similarities that are classified as high category. Test results Oneway ANOVA < 0.05. The LSD (Least Significance Difference) test states that the abundance between stations I and III is significant, just as stations II and III are markedly different. The abundance between station I and station II does not differ markedly.

1. INTRODUCTION

Rupat District is geographically located in a cluster of islands directly adjacent to the Strait of Malacca, strongly influenced by coastal environmental conditions. Rupat sub-district has one of three tropical marine ecosystems, namely mangroves. Mangrove forests dominate the coastal ecosystem in the Rupat District. The mangrove forest area is spread over several places which generally have a geographical location directly opposite the territorial waters of the country (Pertika et al., 2022)

Mangrove forests are forest vegetation that grows between tidal lines but can also grow on coral beaches and dead coral plains filled with a thin layer of sand, mud, and muddy beaches. Mangrove ecosystems are habitats for living things, especially those that live around stagnant areas under mangrove stands. One group of invertebrate fauna in mangrove ecosystems is Mollusks, dominated by the Gastropoda class. Gastropods are soft-bodied animals that walk with their stomachs and can live in various places on land, rivers, seas, and estuaries, which are transitional areas between land and sea. Very widely distributed gastropods are found in sandy, rocky, and muddy substrates (Sari et al., 2010).

In terms of science, studying the structure of gastropod communities is a concept or study that studies the arrangement or composition of species in an ecosystem. Changes influence the structure of this gastropod community in terms of environmental factors such as temperature, salinity, substrate type, and organic matter content (Oriza et al., 2022).

Based on the above problems, the formulation of the problem in this study is: what are the types and abundance of gastropods, how are the diversity, uniformity, and dominance of gastropods, then how is the distribution pattern of gastropods, and how the similarities of gastropod communities in the mangrove ecosystem waters of Ketapang Beach, Rupat District. The purpose of the following research is to know the type and abundance of gastropods, diversity, uniformity, and dominance of gastropods, gastropod distribution patterns, and similarities of gastropod communities in the mangrove ecosystem waters of Ketapang Beach, Rupat District.

2. RESEARCH METHODS

Time and Place

The study will be conducted from April 2023. The study was conducted in mangrove forests in Ketapang Beach, Rapat District, Bengkalis Regency, Riau Province. Samples were analyzed at the Marine Biology and Marine Chemistry Laboratory, Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Universitas Riau.

Materials and Tools

The parameters measured in this study determine the structure of the gastropod community (type, abundance, diversity, uniformity, dominance index, distribution pattern, and similarity index). The main variables are gastropods and sedimentary substrates (sediment fractions, organic matter). The supporting variables are water's physical and chemical parameters, including temperature, acidity (pH), and salinity. The tools used in this study are a hand-refractometer, pH meter, filter, ice box, plastic sample, digital scale, multilevel sieve, 1000 mL measuring tube, furnace, oven, drip pipette, and aluminum foil.

Research method

The method used in this study is a survey method with sampling using the random sampling method. Sampling was carried out at three stations with different characteristics between stations: station I, the condition of mangrove forests that are undergoing abrasion processes; station II, the condition of mangrove forests that are still well maintained but close to settlements, the condition of mangrove forests whose conditions are still very good and far from residential areas (Figure 1).

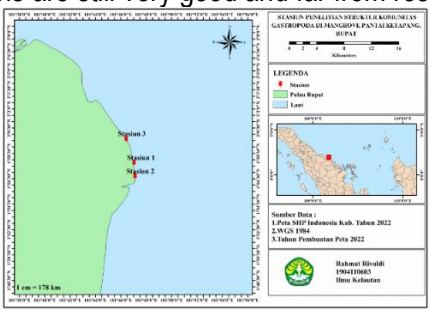

Figure 1. Location of sampling station

Gastropod and sediment sampling was conducted at the lowest low tide, using random samples to determine the number of 5 plots studied with a plot area of 1m^2. At the same time, those in the substrate were dug ±5 cm deep. Sediment sampling is carried out at the same point, and sampling is carried out at the lowest low tide using a paralon pipe with a diameter of 10 cm. Sediment samples are taken by plugging a paralon pipe into the substrate to a depth of 5 cm. Sediment sampling was carried out 3 times at each station.

The sample was put in a plastic bag, dripped with 4% formalin, put into an ice box, and taken to the Laboratory of Marine Physics, Marine Chemistry, and Marine Biology, Department of Marine Sciences, Faculty of Fisheries and Marine Universitas Riau. Physical and chemical water quality parameter measurements are carried out in situ, including pH and salinity temperature measurements using pH meters and hand-refractometer measurements.

Parameters Measurement

The Abundance of Gastropods

The abundance of gastropods describes the density in a community so that a density value is obtained that includes the number of individual unity areas. In the study results, the abundance value is converted and presented in the number of individual hectares in the union (Krebs, 1985).

$$K=\frac{ni}{a}$$

Information:

K = Abundance of individual types (ind/ha)
Ni = Number of i-th type individuals found
A = Area of i-th type plot found (m^2)

Relative Abundance

Relative abundance is the proportion represented by each species of all individuals in a community (Algifari & Junardi, 1985)

$$Di = \frac{ni}{N} x100\%$$

Information:

At : Relative abundance
Ni : Number of I-type individuals obtained
N : Total number of individuals of all types

Gastropod Diversity Index

The diversity index describes the state of gastropod populations mathematically to make it easier to analyze the level of population diversity in a community using the Shanon-Wienner index (Krebs, 1985).

$$H'=-\sum_{i-1}^{s} pi\ (\ln pi)$$

Information:

H' = Species diversity index
Pi = ni/N (Proportion of i-th type)
Ni = Number of individuals in the i-th type
N = Total number of individuals
s = Number of types successfully captured

Gastropod Uniformity Index

The uniformity index is a balance, which is the individual composition of each species contained in a community. The uniformity index can be calculated using the Shanon-Wiener formula (Krebs, 1985) as follows:

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

Information:

E = Uniformity index
H' = Shannon-Wieners diversity index

S = Number of species

Dominance Index Gastropoda

The dominance index is used to determine the presence or absence of dominance of a particular species, so the Simpson dominance index formula is used (Krebs, 1985).

$$C = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Information:
C = Dominance Index
i = Number of individuals of each type
N = Total number of individuals of all species
s = Number of species

Distribution Pattern

A dispersion index or distribution pattern is a way to determine how a member of a population spreads out in its habitat. The distribution pattern of gastropods is calculated by the calculation method with the Morisita index formula (Krebs, 1985) as follows:

$$Id = N\frac{\sum X^2 - N}{N\,(N-1)}$$

Information:
Id = Morisita Dispersion Index
N = Total number of individuals contained in the plot
n = Total number of sampling units

Gastropod Community Similarity Index

Community similarity between stations is calculated by the community similarity index based on Sorensen's formula (Odum et al., 1993) as follows:

$$S = \left(\frac{2c}{A+B}\right) x100\%$$

Information:
A = Number of types at location 1
B = Number of types at location 2
S = Index of similarity between two communities

Total Organic Matter Sediment

Analysis of organic matter content is carried out using the Loss On Ignition (LOI) method (Heiri et al., 2001). The formula calculates the rate of organic matter present in the sediment:

$$BOT = \frac{(Wt-C)-(Wa-C)}{Wt-C} x100\%$$

Information:
Wt = Total weight (aluminum foil + sample) before burning (g)
Wa = Total weight (aluminum foil + sample) after burning (g)
C = Weight of empty aluminum foil (g)

Sediment Type

The determination of sediment type in the laboratory follows the procedure referring to Rifardi (2008), namely the analysis of sediment grain size for sand and gravel fractions using the wet sieving method, for sludge fractions analyzed by pipette method, as for the procedure by drying samples on

aluminum foil containing wet samples dried in a 105°C oven (one day). The sample is weighed and then given a 3-5% solution of hydrogen peroxide to taste. The determination of the sediment type is carried out using the calculation method of the Sheppard triangle. The calculation is based on the proportion of gravel, sand, and mud particle size content.

3. RESULTS AND DISCUSSION

General Conditions of the Study Site

Rupat District is one of the sub-districts included in the administrative area of Bengkalis Regency. Geographically, Rupat District is bordered by Rupat District to the north, Dumai City to the west, Bengkalis District to the south, and Malacca Strait to the east. The area of Rupat District is 896.35 km², with the most prominent village being Makeruh Village, with an area of 151 km² or 16.85% of the total area of Rupat District. Rupat District has the potential for diverse coastal and marine resources, ranging from mangrove forests, seagrass beds, and other aquatic biota.

Water Quality

Water quality parameters were measured to see how the condition of the waters in Rupat District at the time of the research.

Table 1. Average water quality measurement of Ketapang Beach, Rupat District

Station	Temperature (°C)	Salinity (ppt)	pH
I	27	30	7
II	28	31	7
III	28	30	6
Average	27,6	30,6	6,6

The pH value is in the range of 6-7. Satria (2014) states gastropods generally require a water pH between 6.5 and 8.5 for survival and reproduction. The results of temperature measurements in Ketapang coastal waters are included in the range that can still provide tolerance, and it can be said that the temperature at each research station is included in the optimum conditions for gastropods. Dewiyanti (2004) stated that the existence of a species and the state of a community's entire life tend to vary with changing temperatures. From the measurement results, temperature values are obtained in the range of 27-28°C. The range of average temperature values is still relatively good for the life of gastropods.

The salinity obtained at the study site is in the range of 30-31‰. The salinity is still in a state that supports the life and sustainability of gastropod animals. Water salinity is suitable for gastropod life. In general, gastropods live in the average category of water salinity of 15-45‰. Low water salinity can cause organisms to die because most organisms show limited tolerance to decreased water salinity (Rangan, 2010).

Sediment Organic Matter

Based on the analysis of all sediment samples, the organic matter content in the coastal waters of Rupat District ranged from 3.33 -4.63%. The results of the study of sediment organic matter content in mangrove forests in Ketapang Beach waters can be seen in Table 2.

Table 2. Sediment organic matter at each observation station in the coastal waters of Rupat District

Station	Plot I	Plot II	Average
I	2.71	3.94	333 ± 0.61
II	3.21	6.05	4.63 ± 1.42
III	4.55	3.73	4.14 ± 0.41

The percentage of sediment organic matter content in the mangrove forest waters of Ketapang Beach obtained the average value at station I, which was 3.33%; station II, which was 4.63%; and station III, which was 4.14%. The highest sediment organic matter content was found at station II at 4.63%, while the lowest was at station I at 3.33%. The type of substrate at the research site located at station I is sand, allowing good oxidation due to the presence of more extensive pore water. Sandy sediments are generally poor in nutrients, and vice versa; stations II and III have an average that falls on high criteria, so finer substrates are rich in nutrients. The amount of organic matter present in the waters can determine the fertility level of the waters themselves.

Low organic matter is affected by the base substrate or the particles of the substrate itself. Basic substrates with coarse particles have a low organic matter content. According to Prihatin et al. (2021), *a* minimal organic matter content in the substrate will significantly affect the spread and abundance of macrozoobenthos in it. Azham et al. (2016) state that gastropods adapt well to hard shells, making them more likely to survive in fluctuating environments.

Sediment type

Based on the results of sediment fraction analysis at each observation station in the mangrove forest waters of Ketapang Beach, 4 (four) types of sediment fractions were obtained: sandy, muddy sand, mud, and sandy mud. The weight percentage, fraction, and type of sediment are presented in Table 3.

Table 3. Percentage of sediment fraction and sediment type at each observation station in the coastal waters Rupat District

Station	Plot	Gravel	Sand	Mud	Sediment type
I	1	4.72	82.50	12.69	Sand
	2	13.67	78.15	8.18	Sand
	3	15.21	80.40	4.39	Sand
II	1	14.36	61.76	23.88	Muddy sand
	2	14,00	10.15	75.85	Mud
	3	9.02	17.35	73.63	Mud
III	1	5.40	40.32	54.28	Sandy mud
	2	2.40	40.22	57.38	Sandy mud
	3	3.50	43.70	52.80	Sandy mud

The type of sediment in the mangrove forest waters of Ketapang Beach is dominated by two kinds of muddy and sandy sediments; for the type of mud sediment, the highest percentage is found in station II plot 2, which is 75.85% mud, and the lowest rate is found in station I plot 3 which is 4.39%. As for the type of sandy sediment, the highest percentage was found at station I plot 1, 82.5%, and the lowest percentage at station 2 plot 2, 10%.

The high number of species of the gastropod class is thought to be due to the substrate type in all three zones dominated by muddy sand. According to Heiri et al. (2001), gastropods choose muddy sand substrates because it makes shifting and moving to other places easier. At the same time, Febrita et al. (2015) stated that gastropods prefer mud substrates because of their smooth texture and higher levels of organic matter than coarse-textured substrates. Organic matter settles in fine particles, which is suitable for gastropod survival.

Gastropod Species

The Gastropoda species obtained consist of 6 (six) families, 8 (eight) genera, and 8 (eight) species. The gastropods at all research stations comprise Potamididae, Buccinidae, Fasciolariidae, Littorinidae, Muricidae, and Ellobidae.

Table 4. Gastropod species found in mangrove forests in the waters of Ketapang Beach, Rupat District

Family	Genus	Species
Potamididae	Cerithidea	*Cerithidea obtusa*
	Telescopium	*Telescopium telescopium*
Muricidae	Bolinus	*Bolinus brandaris*
	Murex	*Murex Trapa*
Buccinidae	Buccinum	*Buccinum undatum*
Fasciolariidae	Fusinus	*Fusinus aurinodatus*
Littorinidae	Littoraria	*Sprayed coastline*
Ellobidae	Melampus	*Melampus bidentatus*

The most common species is Cerithidea obtusa of the family Potamididae. Factors that cause the abundance of *C. Obtusa* were found allegedly caused by around the study site there is a mangrove ecosystem where there is a lot of organic matter produced by mangrove tree litter, and substrate types around the research site are muddy. Muddy substrates are nutrient-rich substrates. Standard conditions of the aquatic environment at the study site are also suspected to be the cause of the many found *C. obtusa.* According to Muzzamil et al. (2021), benthos animals are closely related to the availability of organic matter in the substrate because organic matter is a source of biota nutrients generally found in base substrates.

Muddy substrate conditions are the habitat of snails because, at low tide, these snails will immerse themselves in mud to avoid the heat of the sun and drought, as stated by Silaen et al. (2013), who suggested that Cerithidea is found in mangrove forest areas overgrown by Rhizophora, because of Rhizophora can provide a muddy substrate that is the habitat of Cerithidea.

Gastropod Abundance

Based on the results of the analysis, the abundance value ranges from 20,000-340,000 ind/ha. The highest abundance is found at station III, which is 340,000 ind/ha, while the lowest is found at station I, which is 20,000 ind/ha. The results of the calculation of gastropod abundance are tabulated in Figure 2.

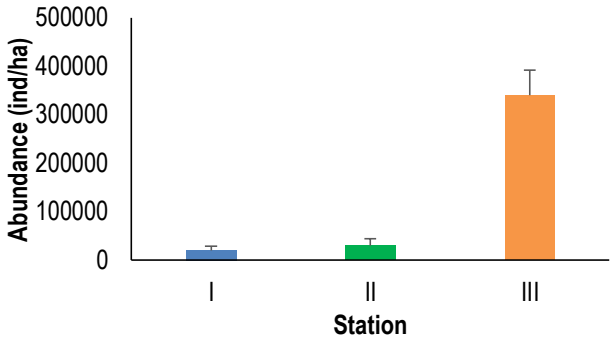

Figure 2. The abundance of gastropods in the mangrove forest waters of Ketapang Beach

The high abundance value at station III is thought to be due to the physical-chemical factors of the waters, namely the type of muddy sand substrate preferred by gastropods, and the temperature, pH, and salinity are still in normal circumstances to support gastropod life. In addition, environmental factors also strongly affect the high abundance value at station III because it is far from settlements and the condition of mangrove forests that are still maintained sustainably. Reasonably good conditions and a high content of sedimentary organic matter and substrate types support the growth of gastropods. The low abundance of gastropods at station I is thought to be due to social factors, namely the activities of tourists who take gastropods for private collections of the physical environment, as well as

environmental factors, namely the condition of mangrove forests that are undergoing abrasion and close to settlements and become tourist attractions by tourists who come. Other factors, such as the dominant substrate condition in the form of sand, inhibit the number of gastropod species present there. Based on available food factors such as residue, gastropods tend to live in an area where they can quickly obtain food.

Gastropods generally live on the ground's surface and tend to move downward at low tide and rise again at high tide. According to Silaen et al. (2013), the abundance and distribution of gastropods are influenced by their habitat environment, food availability, predation, and competition. Various factors, including the physical chemistry of water, temperature, salinity, currents, pH, water depth, and base substrate, influence an organism's high and low abundance. According to Zarkasyi et al. (2016), environmental conditions significantly affect the distribution pattern and abundance of species residing in the intertidal zone. According to Nybakken (1992), the movement of waves can affect the organisms there, but some organisms cannot live other than in areas of solid waves.

Relative Abundance of Gastropods

Based on the analysis results, a value was obtained from the percentage of species abundance at each station. The highest abundance is in the *species C.obtusa* at 28.83%, and then the lowest species is in the species *T.telescopium* with a percentage of 2.73%.

Table 6. Relative abundance of gastropods in mangrove forest Ketapang Beach Waters

Species	Relative abundance (%)
Cerithidea obtusa	28.83
Telescopium telescopium	2.73
Bolinus brandaris	12.63
Murex Trapa	11.30
Buccinum undatum	17.97
Fusinus aurinodatus	8.17
Sprayed coastline	9.50
Melampus bidentatus	8.90
Total	100

The abundance of gastropods in the mangrove forest waters of Ketapang Beach is dominated by *C.obtusa,* a relatively high abundance of 28.3% compared to other species found in the mangrove forest waters of Ketapang Beach. This is thought to be due to this species being able to adapt to various types of substrates and have good adaptation to changes in environmental conditions, one of which is water quality. Prabandini et al. (2021) stated that *C.obtusa has a* wide distribution in aquatic ecosystems, relatively high abundance, and high body resistance. It is also widely found on mud substrates. The lowest species is the species *T.telescopium.* Various factors influence an organism's high and low abundance, including physicochemical waters, temperature, salinity, pH, currents, and base substrates.

Gastropod Community Index

The gastropod community index, which consists of diversity, uniformity, dominance, and distribution patterns, can be seen in Table 7. Influenced by various factors, including the number of species obtained and some species found in more significant numbers than others. According to Apriyani et al. (2018), the diversity of a species is strongly influenced by the number of species and the total number of individuals of each species found; otherwise, if the number of species is small and the total number of individuals of each species is small, the species diversity is low. According to Persulessy & Arini (2018), the diversity of a species is greatly influenced by the number of species and

the total number of individuals of each species found; otherwise, if the number of species is small and the total number of individuals of each species is small, the species diversity is low.

Table 7. Gastropod community index

Station	Diversity index (H')	Uniformity index (E)	Dominance index (C)	Distribution Patterns
Station I	1,47	0,70	0,26	0,9
Station II	1,69	0,21	0,20	0,7
Station III	0,57	0,07	0,75	3,8
Research Location	1,24	0,33	0,40	1,8

The uniformity index at station I was the highest, with a value of 0.70. At station II, the value was 0.21, and the lowest uniformity value was at station III, which had a value of 0.07. Table 7 shows that the uniformity index at the study site was 0.33. The uniformity index of gastropods in mangrove forests in the waters of Ketapang Rupat Beach is 0≤ E< 0.4, which shows that uniformity is low. The value of the gastropod uniformity index ranges from 0.6–1, meaning the species' evenness is almost evenly distributed. Odum et al. (1993) stated that the distribution of fauna can be evenly distributed if the species' evenness value ranges from 0.60-0.80. According to Browner & Zar (1990), uniformity index values range from 0 to 1. The uniformity index is close to the value of 0; it can be said that the tendency to have one type dominates, while the uniformity index value close to 1 can be said that in the ecosystem, there is a tendency for relatively good conditions, namely the number of individuals of each type who are relatively the same. According to Fachrul (2007), uniformity is a balance, namely the individual composition of each species contained in a community. The uniformity of benthos animals in a body of water can be known from its uniformity index.

Table 7 shows that the highest dominance index is found at station III, which is 1.21, and the lowest is found at station I, with a value of 0.26. At station II, the dominance index value is 0.75. The criteria for the dominance index ranged from 0-1. From Table 7, it can be seen that the gastropod dominance index at the study site was 0.40. The gastropod dominance index in mangrove forests in Ketapang Beach waters is C<0.5, which shows that no type of gastropod dominates. The value of species diversity obtained influences the dominance value obtained. According to Odum et al. (1993), the species diversity index is inversely proportional to the dominance index. If the species diversity index is high in a place, then there are no dominant species in that place, and vice versa. If species diversity is low then there are species that dominate.

Table 7 shows that the dispersion index values at stations I, II, III, and the study location were 0.9, 0.7, 3.8, and 1.8 for the overall average of the study site. The distribution pattern of gastropods in Ketapang Beach Id> 1's mangrove forest waters shows a clumped pattern. According to Odum et al. (1993), light intensity affects the pattern of spread of organisms. Some organisms like light with a significant intensity, but some microorganisms prefer dim light. Apriyani et al. (2021) stated that the pattern with clustered distribution is the pattern of organisms or biota in a habitat that live in groups in specific numbers.

Gastropod Type Similarity Index

Different community similarity index values were obtained between research stations based on the analysis conducted. The similarity index of gastropod communities found in mangrove forests in the waters of Ketapang Beach can be seen in Table 8.

Table 8. Index of similarity of gastropod communities in coastal waters of Rupat District

Station	Community similarity index (%)	Similarities
I to II	90	Tall
I to III	66	Tall
II to III	77	Tall

Table 8 shows that the highest gastropod community similarity index is found at stations I to II, which is 90% with almost the same type, and the lowest at stations I to III, which is 66% with unequal types. The similarity of values on the community similarity index between stations is thought to be due to proximity and similarity of aquatic environmental factors. Environmental conditions are relatively extreme and relatively close together, so the number of gastropods that can survive is minimal, so there is only one community (Haryoardyantoro et al., 2013).

4. CONCLUSIONS

The average abundance of gastropods is 25,533 ind/ha. Oneway ANOVA test results of gastropod abundance between p stations < 0.05 LSD (Least Significance Difference) follow-up test the abundance between stations I and III is significant (significantly different), as well as station II and station III are significantly different. The abundance between stations I and II did not differ markedly, with the most common species being *C.obtusa*. The diversity index (H') value at the study site was moderate. The uniformity index value (E) is low, and the dominance index value (C) no species dominates. The distribution pattern (Id) belongs to the grouping category. The similarity index (Ss) of gastropods between each station on Ketapang Beach is almost the same type and has similarities that are classified as high category.

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