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Morphometric Analysis Of Gastropods In Jenggalu Mangrove Forest Tourist Park, Bengkulu Province

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Abstract
Gastropods are one of the groups of mollusks that have an important role in the mangrove ecosystem as a detritivor and part of the food chain. The existence and variation of gastropod body shape can be studied through a morphometric approach to determine the growth patterns and morphological characteristics of each species. This study aims to analyze the morphometrics of gastropods found in the Jenggalu Mangrove Forest Tourism Park, Bengkulu City and identify the types of gastropods found in the area. The method used in this study is Visual Encounter Survey (VES) combined with the transect line method. Sampling was carried out directly using hand picking techniques in the mangrove zone during tidal conditions. Morphometric measurements include shell diameter, shell length, shell height, opening height, spiral height, opening width, and shell weight using calipers and digital scales. The results of the study showed that 8 species of gastropods were found from 7 families with a total of 46 individuals. The most commonly found species is Littoraria scabra. The relationship between length and weight of the shell shows a negative allometric growth pattern, where the increase in length is faster than the increase in weight. Based on the results of the study, it can be concluded that gastropods in the Jenggalu Mangrove Forest Tourism Park area have a diversity of species and morphometric variations influenced by the environmental conditions of mangrove habitats.

Keywords: Gastropoda; Mangrove Forest; Jenggalu; Bengkulu province; Morphometrics; Visual Encounter Survey (VES).

INTRODUCTION

Indonesia is an archipelagic country consisting of 13,667 islands and has a coastal area of 54,716 kilometers (Adyasari et al., 2021; Andréfouët et al., 2022; Rochwulaningsih et al., 2019). One of the main potentials of Indonesia's coast is the mangrove ecosystem (Analuddin et al., 2025; Chadda-Harmer et al., 2025) . Mangrove forests can grow on coral beaches, namely on dead coral reefs overgrown with thin layers of sand or overgrown with mud or muddy beaches (Stewart *et al*. 2022). Mangrove forests are found in coastal areas that are continuously or successively submerged in seawater and exposed to tides, the soil consists of mud and sand (Wintah & Kiswanto, 2024). Mangrove ecosystems are transitional ecosystems between land and sea that are known to have a very large role and function, such as maintaining ecological balance (Wei et al., 2024). Gastropods are animals that can live in various habitats, such as land, freshwater, brackish, and sea. Gastropods are mostly found in the littoral zone, which is the area between the tides and the tides or the sea-land border (Baharuddin *et al.* 2019). Gastropods are a class of molluscs that live in the coastal intertidal zone and generally have shells, but there are also snails without shells (Lestari *et al.* 2021). Gastropod shells have different carvings and motifs, so that the difference in carvings and shell motifs can be used in the characteristics of a certain species (Johnson *et al.* 2019). Gastropods have the characteristic of moving bodies using abdominal muscles (leg muscles) with muscle contractions that make their bodies move.

Gastropods produce mucus (mucus) from glands found in their muscular legs. The function of the mucus is to reduce friction between the gastropod's body and the surface, so that its body can move more easily and not get hurt when crawling on rough surfaces (Usman, 2022).

Gastropods are one of the key organisms in the food chain in aquatic ecosystems. In addition to being prey for other biota, gastropods also act as detritivores in the food chain (Ndukang *et al.* 2024). In the food chain, detritivores act as a converter of detritus that has low energy levels into trophic with higher energy levels. The physical characteristics and shape variations of gastropods related to their ecological functions require a morphometric approach for more precise analysis. This approach quantitatively measures and analyzes size and shape, thereby revealing morphological patterns influenced by environmental factors and ecological adaptations (Verhaegen et al., 2019).

Morphometrics, which is the study of variation, changes in shape and size of organisms, including the measurement of weight length and analysis of the skeleton of an organism (Klingenberg, 2022; Rummel et al., 2024; Theska et al., 2020). The morphometric characteristics of gastropods in mangrove forests include measurements and descriptions of shell shape, shell weight, shell length and width, operculum type, and shell color and pattern that vary between species. The shell of a gastropod generally has a single twisted shell forming a spiral, which is formed from the embryo (Altomari et al., 2021) 0. In addition, There are also types that do not have a shell, called naked snails.

This Mangrove Tourism Park is located on Jenggalu Street, West Ring Road Gading Cempaka, Bengkulu City. This area has natural mangrove debt. This study is to examine the morphometry of gastropods in mangrove forest tourism parks and identify the types of gastropods in mangrove forest tourism parks. These mangroves have a high biodiversity, including gastropods which are one of the most diverse and important groups of animals in the mangrove ecosystem. In addition, the strategic and easy location of the Jenggalu mangrove tourism park is also a consideration in the selection of a research location. Researchers will collect relevant data and make direct observations on the diversity of gastropods in the Jenggalu mangrove tourism forest park. As well as increasing understanding of the important role of gastropods in mangrove ecosystems. Considering the lack of data and information about gastropods in the Mangrove Tourism Park area, this is one of the main reasons for conducting research in this area.

METHODS

Research Time and Location

This research was carried out in November-December 2025 in the area of the Mangrove Forest Tourism Park on Jenggalu Street No.1 West Lingkar, Gading Cempaka District, Bengkulu province. This location was chosen because it has a mangrove ecosystem that is still well maintained. The research process will involve direct observation, field data collection

Tools and Materials

Tools used in the research of salinometers, calipers, water thermometers, pH meters, gloves, stationery, digital scales, buckets, cameras, boots, sample bottles, tweezers, lups, steropsomes, tissues. The materials used consist of 50% and 70% alcohol solutions as a gradual preservation medium to keep the sample in good condition for morphometric analysis in the laboratory.

Data Collection

Gastropod sampling was carried out in the jenggalu mangrove forest tourism park in Bengkulu province during tidal beach conditions to facilitate direct data collection. The main methods used are Visual Encounter Survey (VES) (Baharuddin & Satyanarayana, 2024; Nugroho et al., 2019). Where researchers actively observe and search for gastropods in a predetermined area. In addition, this VES method is also combined with the transect method, which is a transect line along the mangrove zone that has been determined as a sampling route. Along the transect, researchers observed and recorded the presence of any gastropods found within the transect line .

Observation and Sampling

Gastropod sampling was carried out at the Mangrove Forest Tourism Park on Jenggalu street No.1, Lingkar Barat, Gading Cempaka District, Bengkulu Province, which has an area of 214.62 hectares. The sampling process is carried out in the morning and evening, when seawater conditions experience tides and recedes so that the intertidal zone is easily accessible. Gastropods that stick to the substrate are taken by hand directly (Hand picking) (Wintah & Kiswanto, 2024). This method involves visual observation and physical sampling in the field with simple techniques without automated tools. Researchers used hands or gloves to carefully pick up gastropods so as not to damage the organism. Each individual gastropod found is recorded and put in a bucket, After sample collection, the gastropods are cleaned with clean water then the gastropods are soaked in 50% alcohol for the initial preservation process. After some time, the sample is then transferred to 70% alcohol for long-term preservation. The preserved specimen is then stored in a tightly sealed specimen bottle and placed in a laboratory storage cabinet at room temperature and avoided direct sunlight exposure This multi-stage preservation is to keep the physical condition and morphology of the gastropod intact and representative for further morphometric analysis (Baharuddin & Satyanarayana, 2024; Klingenberg, 2022; Nugroho et al., 2019). Conducted in the laboratory of the University of Muhammadiyah Bengkulu Ecological measurements are important in understanding the condition of a habitat, especially such as gastropods in mangrove ecosystems. Ecological measurement involves determining salt levels, air temperature, alkaline levels, oxygen levels in a habitat.

Body morphology measurements

Shell diameter

The measurement of the diameter of the shell is carried out on the width of the gastropod shell, the tool used is the caliper (Amini-Yekta et al., 2019).

Shell height

The height of the shell is measured from the base of the shell to the highest peak of the shell This measurement uses the appropriate measuring instrument, namely the caliper (Amini-Yekta et al., 2019).

Shell length

The length of the shell is measured from the anterior end (the front of the shell) to the posterior (the back of the shell) measurement using the appropriate measuring instrument (Kalesaran & Lumenta, 2021).

Shell Width

The width of the shell is measured from the furthest point on the shoulder of the shell (the protruding curved part) to the outer lip of the shell (Amini-Yekta et al., 2019).

Shell weight

Measurement of the weight of the shell is carried out by separating the shell from the body of the gastropod so that only the weight of the shell is measured. The shell is then cleaned of dirt and dried, then weighed using an accurate digital scale (Amini-Yekta et al., 2019).

Colors and patterns

In addition to the physical size, the color and pattern of the shell are also noted to aid in the process of identifying gastropod species. The difference in color and pattern can be a clue in distinguishing each species, then each species is documented using a camera (Amini-Yekta et al., 2019).

Data analysis

The relationship between length and weight

According to (Bariddah *et al.* 2020) The relationship between length and weight is analyzed based on an allometric model in which the growth of gastropods shows a negative allometric pattern with a faster increase in length than weight.

$$W = a L^b$$

Remarks :
W = Total weight
L = Shell length (mm)
A,b = The constant obtained from the equation data is then transformed into logarithms, tomen Get the linear regression equation of the heavy length category.
If b = 3, then the growth is isometrical, i.e. the growth rate of the length and weight of the gastropods is the same.

If b > 3 (the increase in the length of the gastropod is not as rapid as the increase in weight if b < 3 (the increase in the length of the gastropod is faster than the increase in weight.

RESULT AND DISCUSSION

Based on the results of research conducted in the Jenggalu Mangrove forest tourism park, Bengkulu Province, there are 7 families and 8 species with a total of 46 gastropod individuals found in November-December *2025. The Gastropod species found are Littoraria scabra, Cerithidea quadrata, Oxychilus draparnaudi, Neritodryas dubai, Telescopium, Stramonita heamastoma, Neritina paralella and Faunus ater* (Islamy & Hasan, 2020).

Table 1. Types of gastropods in mangrove forest Jenggalu Bengkulu city

No	Family	Spesies	Number of individuals
1.	Littoraria	*Littoraria scabra*	13
2.	Muricidae	*Stramonita heamastoma*	1
3.	Neritidae	*Neritina paralella*	10
		Neritodryas dubai	5
4.	Oxychilidae	*Oxychilus draparnaudi*	1
5.	Pachychilidae	*Faunus ater*	3
6.	Potamididae	*Cerithidea quardata*	12
7.	Pachychilidae	*Telescopium*	1
		Total	46

Based on table I, the most commonly found gastropods are the type of Littoraria scabra compared to other types of gastropods, because of the role of Litoraria scabra in mangrove ecosystems as a control of microalgae and a contributor to the balance of the ecosystem through grazer activities (Wei et al., 2024). L. scabra species are reported to occupy a variety of habitat types, ranging from substrates and parts of mangrove vegetation (roots, stems, and leaves). Meanwhile, gastropods of other types are found in mangrove trunks. Their frequent presence in various mangrove substrates demonstrates their adaptability and important ecological role in the food chain and the overall mangrove ecosystem (Ayzah *et al,* 2024). Gastropods and mangrove plants have properties that need each other, gastropods not only utilize mangroves as a habitat and food source but also play a role in the fertility of the area with their ability to decompose parts of plants that fall off. This mangrove forest area has a muddy substrate that is used as a protector from threats and also as a breeding ground to support the life of gastropods (Lubis, 2023).

Table 2 Morphometrics of Gastropods in Mangrove Forest Tourism Park

No	Character	Spesies							
		Litoraria scabra	*Cerithide aquardata*	*Oxychilus draparnaudi*	*Neritina paralella*	*Neritodryas dubai*	*Faunus ater*	*Telescopium*	*Stramonita hoamastoma*
1	Dc	7,34 ± 1,085	29,84 ± 19,035	12,2 mm	9,71 ± 2,057	5,96 ± 1,852	89,93 ± 208,303	82,8 ± 36,511	10 mm
2	Pc	12,37 ± 1,532	29,78 ± 1,554	13,3 mm	18,76 ± 1,857	14,55 ± 8,962	81,5 ± 28,50	68,5 cm	24,5 mm
3	Tc	6,03 ± 1,093	15,63 ± 0,905	0,65 mm	9,35 ± 1,104	5,79 ± 1,717	27,17 ± 0,57	3,5 cm	12,15 mm
4	Tb	0,90 ± 2,175	26,63 ± 1,404	10,5 mm	16,78 ± 1,995	8,1 ± 1, 425	48,1 ± 1,155	51,4 mm	11,4 mm
6	Lb	9,33 ± 1,297	13,64 ± 0,813	8,2 mm	10,65 ±1,0 97	11, 38 ± 1,583	2,04 ±15,94	25, 7 mm	14,3 mm
7	Bb	0,02 ± 0,086	0,30 ± 0,506	0,2 gr	3,77 ± 1,982	0,03 ± 0,433	25,33 ± 14,25	0,50 gr	0,05 gr
8	Bk	0,02 ± 0,030	0,28 ± 0,66	0,01 gr	2,32 ±1,110	0,02 ± 251	0,17 ± 3,01	0,47 gr	0,04 gr

Based on the results of the above morphometric measurements, it is carried out using several parameters (Jamili ,2025). Littoraria scabra has the shortest shell length (6.8–18.2 mm), compared to Cerithidea quadrata (37.3 mm), Oxychilus draparnaudi (13.3 mm), Neritina parallela (24.3 mm), Neritodryas dubia (18.4 mm), Faunus ater (57.02 mm), Telescopium telescopium (68.5 mm), Stramonita haemastoma (24.5 mm). Shell width is one of the measures that support the length of the shell (Leiwakabessy & Latupeirissa, 2023). The telescope has the highest width (25.7 mm), the lowest Littoraria scabra (7.4 mm). The telescopium telescopium also has the highest shell height, the lowest Oxychilus draparnaudi (0.65 mm). The height of the highest aperture of the Telescopium telescopium, the lowest of the Littoraria scabra (4.2 mm). The highest spiral height is Telescopium telescopium, the lowest is Littoraria scabra. Shell length longer than peak height (Leiwakabessy & Latupeirissa, 2023). Overall, the length of the shell is three times longer than the peak length of each species (Leiwakabessy & Latupeirissa, 2023). Because the size of the shell is influenced by the condition of the substrate (Ningsih *et al.* 2024). In addition to substrate conditions, the size of the gastropod shell is also affected by temperature, dissolved oxygen, ammonia levels, salinity, and human activities (Alka, 2020). Selain faktor lingkungan itu, perbedaan ukuran juga dipengaruhi faktor biologis seperti umur, pertumbuhan individu, dan perbedaan spesies (Béguinot, 2021). Perbedaan ukuran ini terlihat pada setiap spesies karena habitat dan bentuknya berbeda. Gastropoda seperti *Littoraria scabra* dan *Neritodryas dubia* punya ukuran cangkang kecil karena hidup di batang dan akar mangrove, sehingga butuh cangkang ringan untuk pergerakan dan menempel di pohon (Beguinot 2021). Berbeda dengan *Cerithidea quadrata*, *Telescopium telescopium*, dan *Faunus ater* yang hidup di substrat lumpur atau sedimen mangrove, sehingga punya ukuran cangkang lebih besar dan memanjang untuk memudahkan pergerakan dan mencari detritus (Adamu et al., 2024). Sementara itu, *Neritina parallela* mempunyai bentuk cangkang bulat dan kuat karena hidup di batu atau akar mangrove yang terkena arus, sehingga tahan tekanan air (Isroni et al., 2023). Gastropoda *Stramonita haemastoma* punya cangkang tebal karena hidup di daerah berbatu dengan ombak kuat, butuh perlindungan dari benturan dan predator (Nugroho *et al.* 2024). Oxychilus draparnaudi memiliki cangkang yang lebih kecil dan tipis karena hidup di lingkungan darat yang lembap sehingga tidak memerlukan cangkang yang tebal (Federico *et al.* 2023).

Table 3. Male and female characteristics

No	Spesies	Morphometric Characteristics	Male	Female
1.	*Littoraria scabra*	Dc	7,05 ± 1,49	12,05 ± 4,34
		Pc	11 ± 5,5	17,7 ± 1,58
		Tc	5,5 ± 1,76	9,07 ± 1,63

		Tb	7,75 ± 1,61	4,4 ± 4,29
		Ts	0,8 ± 1,41	0,13 ± 0,1
		Lb	9,4 ±2,83	14,0 ± 2,88
		Bb	0,25 ± 0,52	0,04 ± 0,14
		Bk	0,02 ± 0,1	0,35 ± 7,9
		Dc	2,93 ± 64,19	5,10 ± 1,03
		Pc	26,5 ± 2,88	30,45 ± 2,83
		Tc	13,2 ± 0,85	15,4 ± 3,10
2.	*Cerithidea quardata*	Tb	23,45 ± 1,43	25,85 ± 4,29
		Ts	15,03 ±1,42	14,85 ± 2,87
		Lb	11,85 ± 1, 55	13,6 ± 2,99
		Bb	0,045 ± 4,47	0,065 ± 0,35
		Bk	0,35 ± 3,8	0,045 ± 7
		Dc	6,35 ± 3,07	13,1 ± 2,9
		Pc	11,3 ± 4,31	23,6 ± 1,47
		Tc	5,6 ± 3,02	11,8 ± 1,68
3.	*Neritina paralella*	Tb	8,4 ± 4,39	20,6 ± 2,95
		Ts	7,32 ± 3,54	14,5 ± 1,48
		Lb	7,4 ± 1,41	13,6 ± 2,99
		Bb	0,4 ± 1,41	9,0 ± 1,41
		Bk	0,2 ± 0,70	6,25 ± 5,3
4.	*Oxychilus draparnaudi*	Dc	12,2 mm	-
		Pc	13,3 mm	-
		Tc	0,65 mm	-
		Tb	10,5 mm	-
		Ts	10,4 mm	-
		Lb	8,2 mm	-
		Bb	0,2 gr	-
		Bk	0,01 gr	-
	Neritodryas dubai	Dc	-	5,96 ± 1,852
		Pc	-	14,55 ± 8,962
		Tc	-	5,79 ± 1,717
		Tb	-	8,1 ± 1, 425
		Ts	-	7,19 ± 2,624
		Lb	-	11, 38 ± 1,583
		Bb	-	0,03 ± 0,433
		Bk	-	0,02 ± 251
	Faunus ater	Dc	-	89,93 ± 208,303
		Pc	-	81,5 ± 28,50
		Tc	-	27,17 ± 0,57
		Tb	-	48,1 ± 1,155
		Ts	-	18,4 ± 0,05
		Lb	-	2,04 ±15,94
		Bb	-	25,33 ± 14,25
		Bk	-	0,17 ± 3,01
	Telescopium	Dc	23,5 mm	-
		Pc	68,5 cm	-
		Tc	3,5 cm	-
		Tb	51,4 mm	-
		Ts	23,4 mm	-
		Lb	25, 7 mm	-
		Bb	0,50 gr	-
		Bk	0,47 gr	-
	Stramonita hoamastoma	Dc	-	10 mm
		Pc	-	24,5 mm
		Tc	-	12,15 mm

Tb	-	11,4 mm
Ts	-	4,06 mm
Lb	-	14,3 mm
Bb	-	0,05 gr
Bk	-	0,04 gr

Based on the results of table 3 above, it can be seen that the morphometric measurements of female gastropods Littoraria scabra, Cerithidea quardata, Neritina parallela have higher average values than males, especially in Dc, Pc, Tc, and Lb. Gastropod differences are due to allometric growth patterns, in which females allocate more energy to somatic growth than early reproduction, resulting in non-isometric size variations in intertidal gastropods in mangroves (Kusuma *et al.* 2022). High population density triggers competition for resources such as microalgae, so dominant individuals (such as females) survive and grow larger via survival selection, reflecting population age structure rather than innate differences (Baiti *et al.* 2025). In addition, environmental factors such as salinity, tides, and nutrients cause adaptation, where females are more resilient and have a larger size in response to habitat (Alcaraz *et al.* 2025). In mangrove gastropods, it is shown that female individuals tend to have larger shell sizes due to internal needs and egg production needs. In the species Oxychilus draparnaudi, Neritodryas dubai, Faunus ater, Telesopium and Stramonita hoamastoma there was no sex separation, because during the identification process in the laboratory no differences were found between males and females.

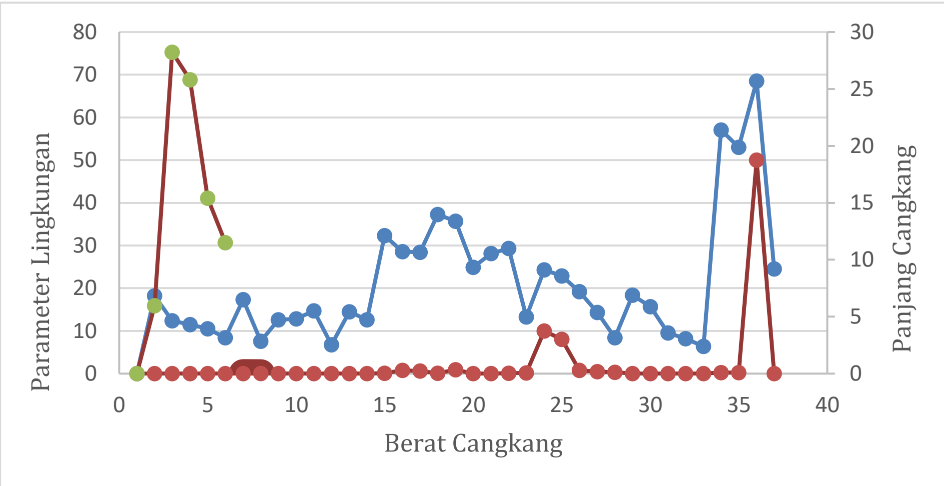

Figure 1. The relationship between length, weight, and environmental parameters

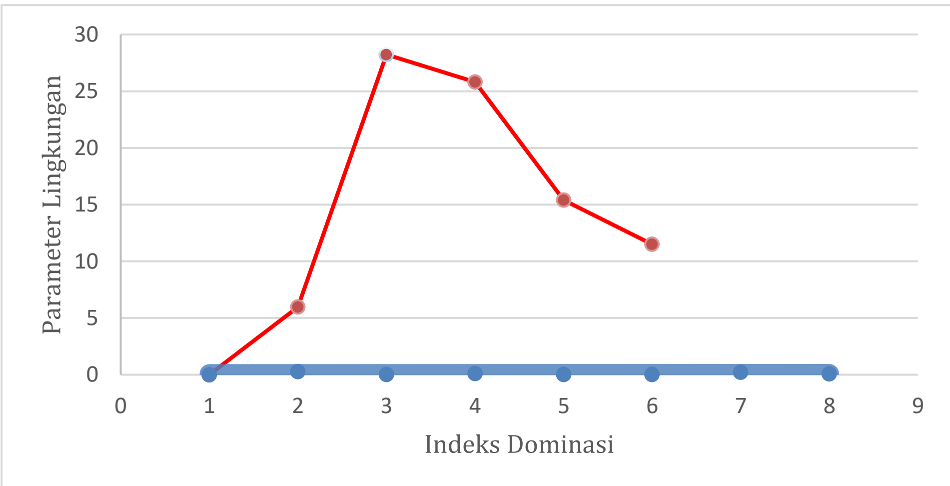

Figure 1. Dominance Index and Environmental Parameters

Based on figure 1, there is a tendency to relate to the weight and length of the gastropod shell (Litaay, 2025). In addition, analysis of the relationship between the length and weight of the shell, the gastropod pattern showed negative allometric growth (b < 3) (Merly, 2025). Negative allometric growth pattern is a pattern of rapid increase in the length of gastropods than in weight gain (Ningsih *et al*. 2024). Negative allometric growth in gastropods is influenced by environmental factors such as food availability, substrate conditions, salinity, and the adaptation of organisms to mangrove habitats (Ernawati et al., 2024).

Figure 2 shows the relationship between the gastropod dominance index and environmental parameters. It can be seen that most of the dominance index values are in the low to medium category (Wintah & Kiswanto, 2024). This shows that the gastropod community in mangroves is not dominated by one species. Because the structure of the gastropod community in the mangrove forest tourism park remains stable and balanced. The relatively high environmental parameter values in the image show that environmental conditions can affect the existence and abundance of gatsropods. Factors such as the type of muddy substrate, salinity, water temperature, and the presence of mangroves can provide suitable conditions for gastropods to live, eat, and reproduce. For example, it provides a source of organic matter from leaf litter which is a food source for some types of gastropods, while also providing protection from currents and predators (Baharuddin & Satyanarayana, 2024).

The data distribution pattern in the image suggests that the relationship between the dominance index and environmental parameters is not very strong. This suggests that the level of gastropod dominance is not influenced by environmental factors alone, but by several factors that interact with each other in the mangrove ecosystem. Such as biological factors, the adaptability of each species, and the availability of food sources can also affect the level of dominance in a community. The relationship between gastropod growth and environmental conditions in mangrove areas shows that the ecosystem is still able to support gastropod life, both in terms of individual growth and community structure. The presence of gastropods can be an indicator of relatively good environmental conditions in mangrove ecosystems.

CONCLUSION

This study examined the gastropod diversity and abundance within the Rajolelo Grand Forest Park, comparing two distinct habitats: the artificial lake and the secondary forest. The results revealed a clear distinction between the two habitats in terms of gastropod community structure. The artificial lake habitat showed a higher abundance of gastropods, with a total of 205 individuals, while the secondary forest habitat recorded 75 individuals. The Shannon-Wiener diversity index indicated a low diversity in the artificial lake (H’ = 0.6175), suggesting a less diverse but abundant gastropod population dominated by species such as *Filopaludina javanica*. In contrast, the secondary forest exhibited a moderate diversity (H’ = 1.44), with a more balanced distribution of species across different families. The Simpson's dominance index further highlighted the disparity in species dominance, with the artificial lake exhibiting a higher dominance value (C = 0.6893), indicating the prevalence of certain species in that habitat. Conversely, the secondary forest had a more balanced community with a low dominance index (C = 0.2635). The absence of community similarity between the two habitats (0%) suggests that habitat type plays a significant role in determining gastropod species distribution, likely influenced by distinct environmental conditions such as substrate type, water quality, and moisture availability. These findings underscore the importance of habitat-specific factors in shaping gastropod communities and their ecological roles within different ecosystems. However, the study’s limited scope and sampling, as well as unaccounted factors like microhabitat variation and human disturbance, restrict its generalizability. Future research should examine gastropod diversity across broader habitats, explore seasonal and environmental fluctuations, and investigate the impacts of anthropogenic activities on gastropod communities to deepen our understanding of their ecological roles and sustainability.

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