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Judul Artikel Sebelum Revisi : ***Gastropod Abundance For Mangrove Crab (Scylla Spp.) Silvofishery Patterns At Kaliwlingi Village, Brebes District***

Jurnal : Heliyon, Volume 11 Issue 2

Penulis : Suyono, Alin Fithor

No.	Perihal	Tanggal
1	Bukti *submit* artikel, artikel yang di*submit* dan *submission acknowledgement*	20 Juni 2023
2	Bukti konfirmasi *review* dan hasil *review* pertama	20 November 2024
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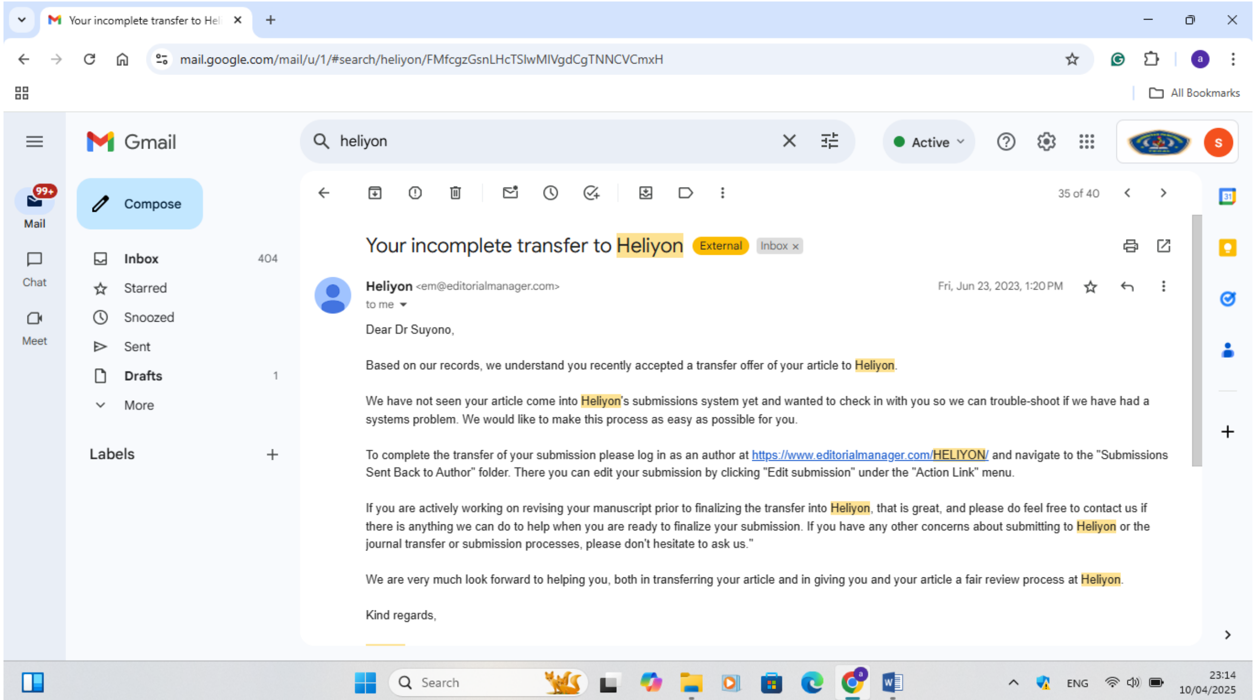

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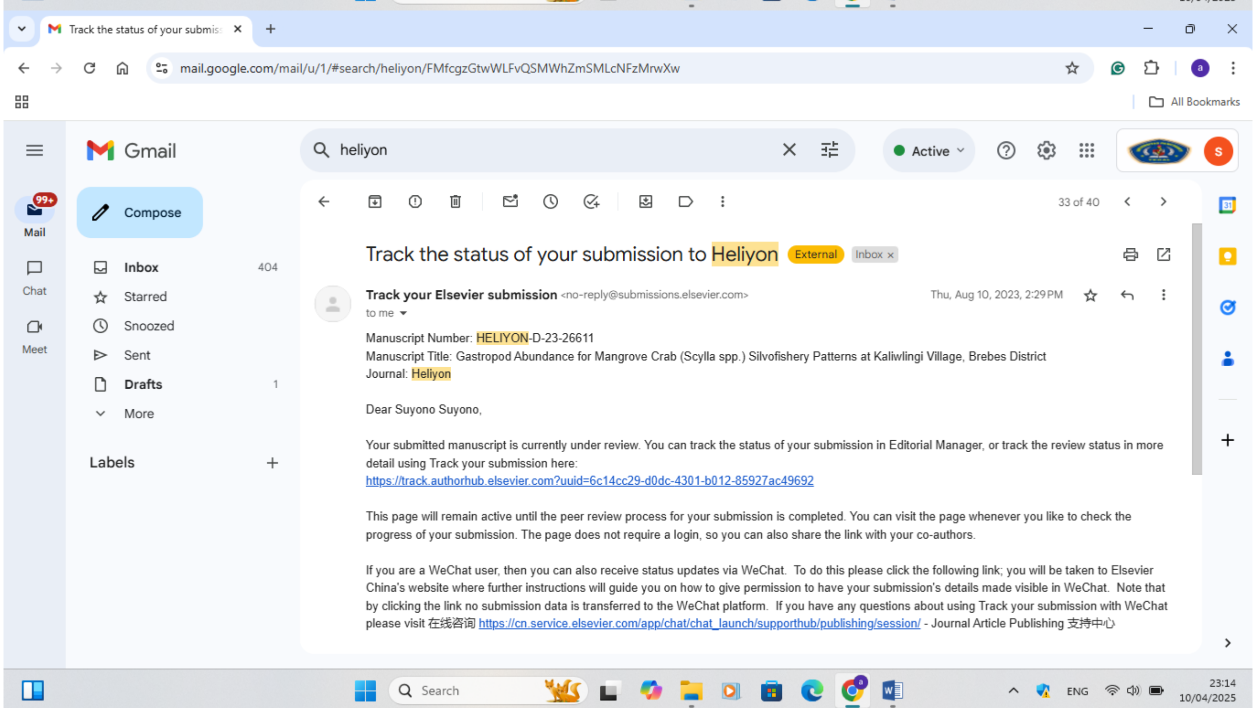

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Gastropod Abundance for Mangrove Crab (*Scylla* spp.) Silvofishery Patterns at Kaliwlingi Village, Brebes District,Cental Java, Indonesia

--Manuscript Draft--

Manuscript Number:	HELIYON-D-23-26611
Article Type:	Original Research Article
Section/Category:	Life Sciences
Keywords:	mangrove; 10-year-old stands; gastropod; Kaliwlingi; Silviofishery,

Abstract:

The novelty of this study is related to silvofishery investigations in 10-year-old mangrove forests in former abrasive shrimp ponds with different sedimentation depths from the forest area in the core mangrove forest stand zone as a fishing area. This study aimed to describe the relationship between mangrove conditions, the abundance of gastropods, and mud crabs (Scylla spp.) in Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. The mangrove tourist area of Station I is a muddy substrate located in the mangrove tourism area; Station II is a sandy substrate located in a mangrove forest bordering the sea with a length of 15 m; and Station III which has a muddy sand substrate in the mangrove forest near the Pemali River which is 8 m away. The involvement of local communities is essential in efforts to manage mangroves sustainably. Silvofishery is the utilization of mangrove forests combined with fishery commodities to protect mangrove plants by providing more results from the fisheries sector. This system can increase people's income while still paying attention to the sustainability of mangrove forests. Based on these conditions, the mangrove forest area can be declared feasible as the best silvofishery area in Indonesia.

Gastropod Abundance for Mangrove Crab (*Scylla* spp.) Silvofishery Patterns at Kaliwlingi Village, Brebes District

Suyono*, Alin Fithor
Aquaculture Department, Faculty of Fisheries and Marine Science,
Pancasakti University, Tegal, 52121, Indonesia

*Corresponding author: suyono@upstegal.ac.id

Abstract

The novelty of this study is related to silvofishery investigations in 10-year-old mangrove forests in former abrasive shrimp ponds with different sedimentation depths from the forest area in the core mangrove forest stand zone as a fishing area. This study aimed to describe the relationship between mangrove conditions, the abundance of gastropods, and mud crabs (Scylla spp.) in Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. The mangrove tourist area of Station I is a muddy substrate located in the mangrove tourism area; Station II is a sandy substrate located in a mangrove forest bordering the sea with a length of 15 m; and Station III which has a muddy sand substrate in the mangrove forest near the Pemali River which is 8 m away. The involvement of local communities is essential in efforts to manage mangroves sustainably. Silvofishery is the utilization of mangrove forests combined with fishery commodities to protect mangrove plants by providing more results from the fisheries sector. This system can increase people's income while still paying attention to the sustainability of mangrove forests. Based on these conditions, the mangrove forest area can be declared feasible as the best silvofishery area in Indonesia.

Keywords: Mangrove, 10-year-old stands, Gastropod, Kaliwlingi, Silviofishery,

Introduction

The mangrove forest area of Dukuh Pandansari in Kaliwlingi Village, Brebes District, Brebes Regency, is geographically located at 109° 01' 07" East Longitude and 6° 48' 18" South Latitude. The soil has a sand-silt-clay texture with 34.00% sand, 44.89% silt, and 21.11% clay. Mangrove forests are typical for muddy, sandy, or muddy sandy beach areas, and the water is calm. Mangrove vegetation can grow optimally in coastal areas, river estuaries, and deltas, where the flow contains much mud (Putri *et al.*, 2022).

The Kaliwlingi mangrove area has the Pemali Delta on the Pemali River. This area is a fertile one for the existence of mangrove forests. The mangrove vegetation in Pandansari Kaliwlingi is a 10- to 25-year-old mangrove stand. The mangrove vegetation is the result of reforestation to reduce the risk of coastal abrasion that hit the Kaliwlingi coast in the early 2000s, along with developments in the opening of mangrove areas for shrimp farming activities. Mangrove forests are an ecosystem that has a reasonably high productivity value because they allow litter decomposition to occur. Mangrove forests significantly contribute to organic detritus, which is very important as food for the biota that lives in them (Irwansyah et al., 2022) related to its ecological function as a place to live, find food, spawn, nurture, grow aquatic biota, and protect the coast from abrasion and pressure from sea waves. Mangrove forests are complex ecosystems consisting of flora and fauna in coastal areas, both on land and at sea, and are usually affected by sea tides (Bagarinao, 2020). Mangroves as a place to find food for biota contribute to the complexity of the habitat and the diversity of macrofauna associated with this ecosystem, such as mollusks and crabs, which are the most dominant macrofauna in this ecosystem. The density, diversity, and distribution of biota life in an ecosystem are affected by environmental factors concerning its community structure (Anunciado & Budiongan, 2021).

Growth of mangrove vegetation resulting from reforestation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency, other biota associated with mangrove forests are present, including gastropods and mangrove crabs (*Scylla* spp.). Gastropods, the largest class of the mollusk phylum, are biota important in ecological functions in mangrove forest ecosystems. Gastropods have reasonably high adaptability to various habitats and can accumulate heavy metals without dying, so they can be used as indicators of the coastal environment. Gastropods can respond to water conditions sustainably so that they master a variety of varied habitats (Nurfadillah *et al.*, 2021). Mwaluma & Kaunda-Arara (2021) state that around 75% of mollusk species fall into the gastropod class. Gastropods, slugs, or snails have very varied body shapes and sizes. The majority of gastropods like to live in sandy mud substrates because of the availability of organic matter in them (Junaidi & Agustina, 2021). Ecologically, gastropods are essential in the circulation of nutrients in waters; economically, they have a selling value for their shells and meat (Retnaningdyah *et al.,* 2022). Gastropods in the water are generally found as detritivores and prey for other biota, including herbivores, carnivores, scavengers, deposit feeders, suspension feeders, and parasites. Gastropods are vital organisms in the food chain in coastal ecosystems and can affect the existence and life of other biotas, including mangrove crabs (Karlina & Pratiwi, 2021).

Mud crab (*Scylla spp.*) is a coastal fishery commodity with high economic value. Mud crab has become a vital fishery commodity in Indonesia since the early 1990s. Mud crabs are macrobenthic fauna that belongs to the Crustaceae family and are commonly found in mangrove and estuarine waters. Mud crabs play an essential role in mangrove ecosystems related to their activities, which include making holes in the substrate in search of food to affect the decomposition process of organic matter content in mangrove ecosystems (Hilmi *et al.,* 2022). Naturally, mangrove crabs are cannibals and eat the carrion of fish and other biota, including gastropods. Thus, the presence of gastropods, which is influenced by the condition of the mangrove forest, will also determine the abundance of mangrove crabs in that location.

This pattern can increase people's income while still paying attention to the sustainability of mangrove forests (Ginantra *et al.,* 2021). The study's novelty is related to investigating silvofishery in 10-year-old standing mangrove forests in formerly abrasive shrimp ponds with different sedimentation depths than forest areas. The purpose of this study was to examine the density of mangrove forests and the abundance of gastropods and mud crabs (*Scylla* spp.) in the core zone of 10-year-old mangrove forests in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency, as well as the carrying capacity of the core zone of mangrove forests in Pandansari Hamlet, Kaliwlingi Village, District, and Brebes Regency as a salvo-fishery area for mangrove crabs (*Scylla* spp) in the district.

Meeting the needs of mud crabs is obtained from catches, which can affect their abundance in the zoning of the core of the mangrove forest. For this reason, mangrove crab cultivation is in demand to maintain the balance of the mangrove ecosystem. One of the mud crab cultivation techniques worth developing is mud crab cultivation with a silvofishery pattern due to the nature, which utilizes mangrove forests in a sustainable manner combined with fishery commodities. The basic principle of silvofishery is the protection of mangrove plants by providing yields from the fisheries sector.

Research Method

This research was conducted in April–July 2022 in the mangrove forest area of Dukuh Pandansari, Kaliwlingi Village, Brebes District, and Brebes Regency. This study describes the relationship between mangrove conditions, the abundance of gastropods and mud crabs (Scylla spp.), and mud crab cultivation locations in the core zone of 10-year-old mangrove forests in

Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency. The determination of the locations of the stations was carried out randomly at selected locations with specific considerations (purposive-random sampling): Station I is a muddy substrate located in a mangrove tourism area; Station II is a sandy substrate located in a mangrove forest adjacent to the sea 15 m away; and Station III, a muddy sand substrate, is in a mangrove forest near the Pemali River 8 m away. Sampling used a 2 m x 2 m transect equipped with three mud crab traps with a distance of 0.5 m at each station. The location of each station is presented in **Figure 1**.

Figure 1. Research Locations in the Core Zone of the Pandansari Mangrove Forest.

Preparation

The preparation stage included the preparation of transects measuring 2 m by 2 m and traps for mud crabs (*Scylla spp*.) measuring 60 cm by 20 cm by 22 cm in the amount of 3 pieces per observation station for the three selected observation stations.

Identification of Soil Sediment and Substrate

Organic matter sediments in standing mangrove forests aged ten years were measured for depth. Soil substrate samples were taken from inside the observation transect by filtering and pipetting (Utaminingsih, 1994). The results of the analysis of sediment grains were carried out to determine the grain size and type of sediment. Grain size analysis was carried out using the dry sieving (sieving) and wet sieving (piping) methods, as was done by Buchanan (1971).

Mangrove Vegetation Density Check

Checking the mangrove vegetation was carried out using the tracing method and observing the density and condition of the mangrove vegetation that was ten years old. Measure mangrove vegetation density using transects measuring 2 m by 2 m at each station The size of a 10-year-old mangrove tree trunk was measured using a length meter.

Identification of Gastropod Samples

Gastropod samples were taken from 9 points, 3 points each for each station. Gastropod sampling was carried out at low tide. Gastropod samples were preserved as evidence of research results by immersing them in a 96% alcohol solution (Eka et al., 2020). Soaking and draining of the gastropod samples were carried out two times. The first step is soaking in 0.5 liters of 96% alcohol mixed with distilled water in a 1: 1 ratio for 7-8 hours. In the second stage, the samples were soaked in 96% alcohol without mixing with water for a week and drained and dried. Gastropod identification and calculations were carried out using the Gastropod Class Mollusc Identification Book, including the morphology and structure of the musty shell, spire, body whorl, suture, aperture, axial ribs, spiral cord, columella, posterior canal, anterior siphonal canal, and operculum (Widianingsih *et al.*, 2019).

Gastropod and Mud Crab (*Scylla spp*.) Abundance Calculations

The abundance of gastropods and mud crabs (*Scylla spp*.) was calculated based on the samples found in three plots on each station's transect. The abundance of gastropods and mud crabs (*Scylla spp*.) was calculated by dividing the number of individual samples of gastropods or mud crabs caught in traps by the area of the sampling area (Setyadi *et al.*, 2021). The catching of gastropods and mud crabs was carried out on the second day of the 2-day study period for several arrests. In addition to the data on the density of mangrove vegetation and the abundance of gastropods and mud crabs, measurements of water quality (variable temperature, variable pH, and variable salinity) were also carried out.

Data Analysis

The obtained data on mangrove vegetation, gastropods, and mud crabs (Scylla spp.) were analyzed using several formulas as stated by Krebs (1989), Odum (1993), and Bengen (2000), including absolute and relative density, absolute and relative frequency, absolute dominance and relative dominance, the Important Value Index, as well as diversity and uniformity.

Water Quality Observation

The water quality parameters measured in this study were the key parameters of water chemistry and physics: temperature, salinity, pH, and dissolved oxygen (DO). These parameters support the life of gastropods and mangrove crabs in the mangrove ecosystem. Parameter measurements were carried out with three repetitions at each station. Measure the temperature using a thermometer dipped in water for about 1 minute. They dropped a sample of water on the hand refractometer lens to measure salinity. Measure the pH by immersing the pH meter in 3 cm of deep water for about 1 minute.

Results and Discussion

Sediment and Soil Substrate Research Location

The sediments in the study area are derived from mangrove forest organic matter and silt deposited due to the hydrodynamics of the coastal area. The average thickness of the sediment at the three observation stations has a value of 52.80 cm to 69.07 cm. Station 1 area has the highest sediment depth value of 69.07 cm, Station 2 has a sediment depth of 52.80 cm, and Station 3 area is 65.20 cm deep. The location of the observation station is a pond affected by abrasion that is then used as a mangrove reforestation area. Hence, the depth of the mud in the area is relatively deep. The results of observing the soil substrate at each study location are presented in **Table 1** and **Figure 2.**

Table 1. Sediment and Soil Substrate Research Location

Station	Substrate	Plot	Sediment type	Information
1	Muddy	A1	Muddy silt	Soft and dense
1	Muddy	A1	Muddy silt	Soft and dense
1	Muddy	A1	Muddy silt	Soft and dense
2	Sandy	A2	Sandy silt	Soft Particle
2	Sandy	A2	Sandy silt	Soft Particle
2	Sandy	A2	Sandy silt	Soft Particle
3	Muddy sand	A3	Mix	Dull
3	Muddy sand	A3	Mix	Dull
3	Muddy sand	A3	Mix	Dull

Source: Result analysis (2022).

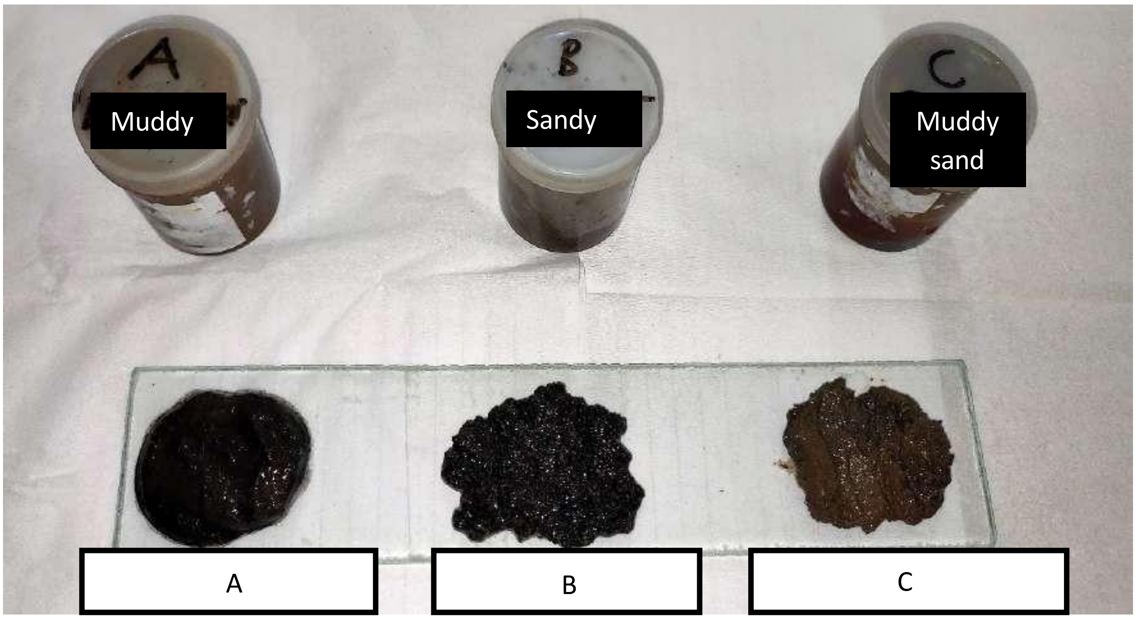


Figure 2. Muddy, sandy, and muddy sand substrates.

berlumpur

Figure 2. The results of observing the soil substrate at each study location
(A. Muddy substrate station; B. Sandy substrate station; C. Muddy sand substrate station)

Mangrove Forest Density

Based on the research results on the density of mangrove forests in the 10-year-old core zone, presented in **Table 2** and **Figure 3**.

Table 2. Mangrove Forest Density Data Based on Research Results.

Mangrove type	Tree density (tree/hectare)								
	Station 1 Muddy			Station 2 Sandy			Station 3 Muddy Sand		
	1st Transect	2nd Transect	3rd Transect	1 st Transect	2nd Transect	3rd Transect	1 st Transect	2nd Transect	3rd transect
Rhizophora mucronata	2	1	3	2	2	0	3	1	1
Avicennia marina	0	0	0	0	1	0	0	0	1

Source: Result analysis (2022)

The average number of mangrove trees at each station is 5, with a density of 5 individuals/m2 or 4,166 ind/ha. The results of the statistical analysis showed that there was no difference in the density of mangrove forests at each station.

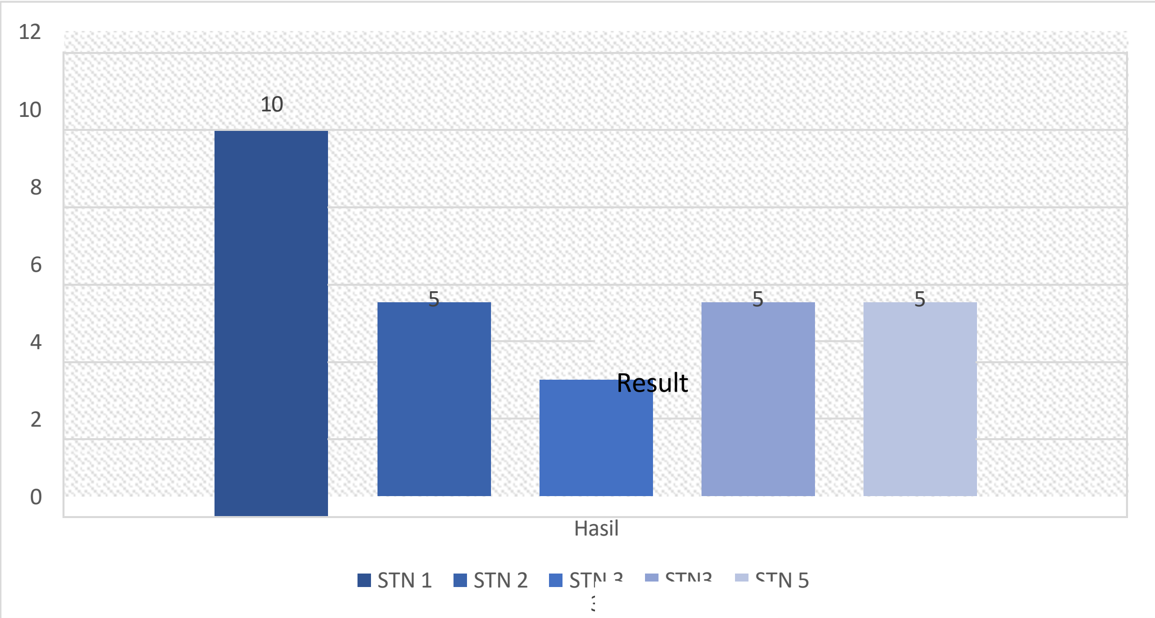


Figure 3. Graph of Mangrove Tree Density at 5 Stations

Mangrove

The size of the mangrove trees at each observation station has a size range of 5.00–13.50 cm, as presented in **Table 3** and **Figure 4**.

Table 3. Differences in the Size of the Rhizophora Mangrove Vegetation Stems (cm)

Sta	Sediment Texture	Mangrove tree size (cm)					Average	SD
		1	2	3	4	5		
1	Substrate Muddy	8,30	8,50	10,40	9,50	8,00	8,94	0,99
2	Substrate Sandy	8,50	10,00	10,00	5,00	8,00	8,30	2,05
3	Substrate Muddy sand	7,00	8,00	11,00	11,00	13,50	9,50	2,60

Source: Result analysis (2022)

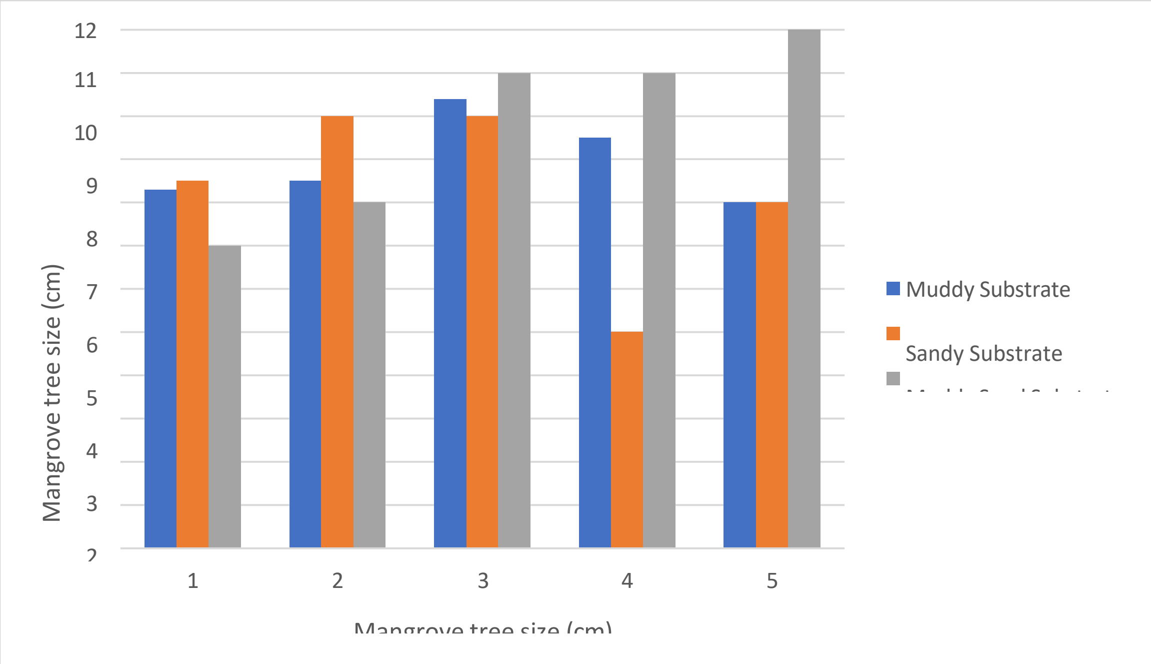


Figure 4. Graph of Mangrove Tree Magnitude at 3 Observation Stations

Gastropda Composition

At the study site was a Gastropod Class with two sub-classes, Pulmonata and Prosobranchia, and four families, Ellobidae and Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found: *Cassudula auriferous* and *Cassidula nucleus*. From the Littorinidae family, one species was found: Littoraria articulate, and from the Neritidae family, one species was found: *Neritidae violacea*. Three species were found in the Potamidae family: *Cerebralia obtuse*, *Telescopium Telescopium*, and

Terebralia palustris. These gastropods were found when the waters were receding. The most common species found were gastropod species from the Pulmonata subclass of the Ellobidae family, namely *Cassudula auriferous* and *Cassidula nucleus*, according to Nhuong *et al*. research results (2021). Gastropods found at the study site are presented in **Table 4** and **Figure 5.**

Table 4. Composition of gastropods found at the study site at each observation station

		Composition/type of substrate									
No	**Species**	**Muddy**			**Sandy**			**Muddy sand**			**Amount**
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	
1	*C. aurisfelis*	50	53	46	15	8	9	30	33	29	273
2	*C. nucleus*	55	45	59	25	17	8	28	27	23	287
3	*L. articulata*	8	4	6	0	1	0	5	3	0	27
4	*N. violacea*	26	30	33	14	16	10	20	18	25	192
5	*C. obtusa*	2	0	0	0	0	1	3	2	0	8
6	*T. telescopium*	7	12	9	2	5	0	5	3	6	49
7	*T. palustris*	30	26	39	15	17	14	25	33	29	238
	Amount	178	171	192	72	64	42	116	119	112	
	Amount (ind)		541			178			347		

Amount (%)		51			17			32	
Average/station (ind)	25,5	25,7	27,4	10	9,1	5,6	23,7	17	16

Source: Result analysis (2022)

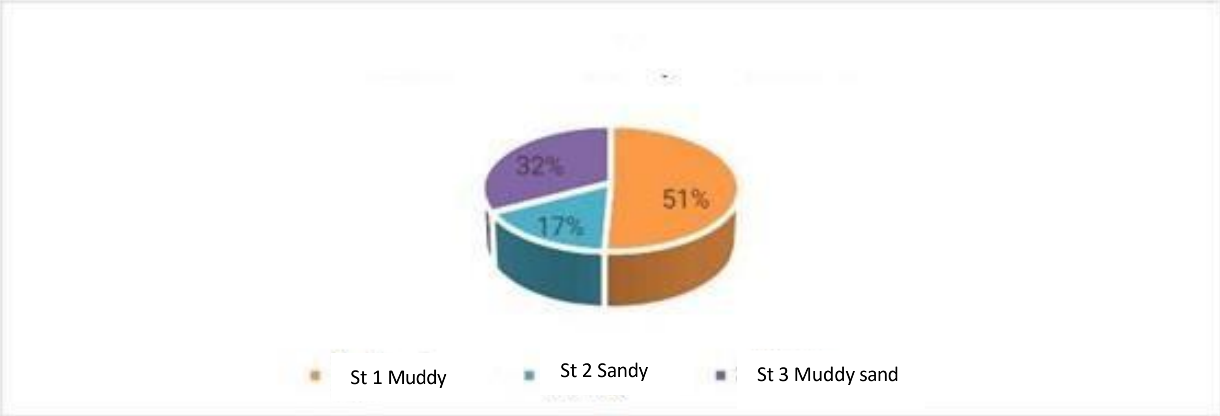


Figure 5. Graph of Gastropod Composition Results found per station.

Gastropod Density

Gastropod Density values at each station are presented in **Table 5** and **Figure 6**.

Table 5. Results from Average Density for Gastropods found at the study site.

No	Station	Gastropod Density (ind/m^2)
1	Muddy	7,20
2	Sandy	2,36

3	Muddy sand	4,62
	Summary	14,18
	Average	4,72

Source: Result analysis (2022)

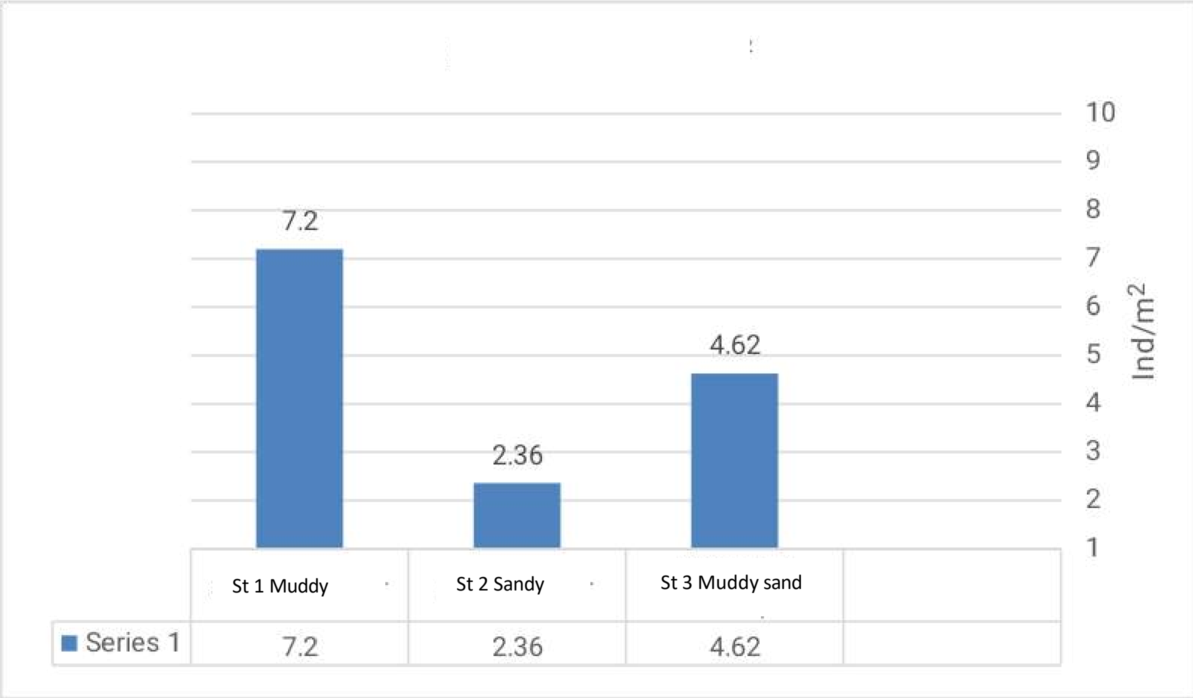


Figure 6. Graph of Density Results for Gastropods found at the study site

Statistical test results showed that the density of gastropods between stations was typically distributed, homogeneous, and significantly different from each other (Sig 0.002 <0.01 with F hit = 82,965 > F tab 2.6; 0.01 = 2.305).

Gastropod Diversity, Uniformity, and Dominance Index

The analysis results of the diversity index, uniformity index, and gastropod dominance index at the study site are presented in Table 6 and Figure 7.

Table 6. The average results of Diversity Index (H'), Uniformity (E), and Dominance (C).

No	**Station**	**Indicator**					
		Diversity		**Uniformity**		**Dominance**	
		H'	**Category H'**	**E**	**Category E**	**C**	**Category C**
1	Muddy	1,59	Medium	0,81	High to medium	0,227	ND
2	Sandy	1,49	Medium	0,76	High to medium	0,243	ND
3	Muddy sand	1,59	Medium	0,81	High to medium	0,221	ND

Source: Result analysis (2022)

Information : H' = Wilhm (1975), E = Krebs (1985), C = Odum (1993),ND = No Domination

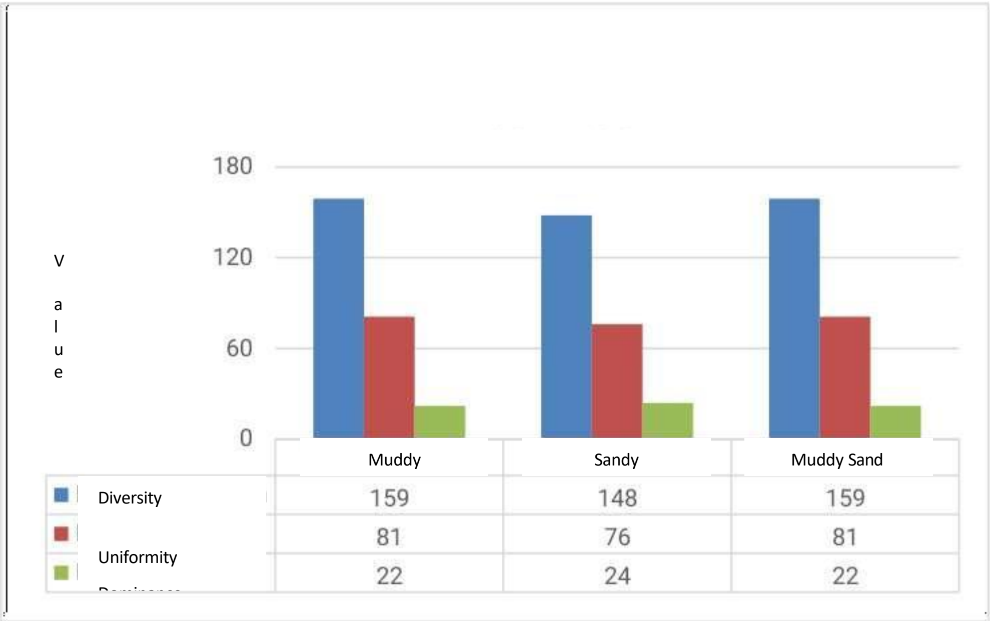


Figure 7. Graph of Diversity Index (H'), Uniformity (E), and Dominance (C).

The diversity index (H') of muddy I station (A) is (A1) = 1.61, (A2) = 1.58, (A3) = 1.58 with an average value of 1.59; sandy station II (B) is (B1) = 1.44, (B2) = 1.57, (B3) = 1.44 with an average value of 1.48; and station III muddy sand (C1) = 1.69, (C2) = 1.58, (C3) = 1.51 with an average value of 1.59. Diversity Index values are included in the moderate category of 1-3 (Wilhm, 1975). From a series of statistical tests and ANOVA test results, the Diversity Index values were normally distributed and homogeneous, and the diversity between observation stations was not significantly different from each other (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143), so that it can be concluded that the Gastropod Diversity Index between stations is relatively the same as the Medium value category.

Uniformity Index (E) for station I muddy (A) is (A1) = 0.83, (A2) = 0.81, (A3) = 0.81 with an average value of 0.81; sandy station II (B) is (B1) = 0.74, (B2) = 0.80, (B3) = 0.74 with an average value of 0.76; and station III muddy sand (C) is (C1) = 0.86, (C2) = 0.81, (C3) = 0.77 with an average value of 0.81; Uniformity Index (E) values generally show varying values but are still in the high-to-medium category with a category value of 0.61–1.49 (Wilhm, 1975). The results of related statistical tests and the ANOVA test showed that the data is usually distributed and homogeneous, but the uniformity between observation stations is relatively different (sig value = 0.153 > 0.05 or F hit = 2.604 F tab 2.6; 0.05 = 5.143) so that it can be concluded that the uniformity index between stations is relatively different in the high to medium category range.

Dominance Index (C) for the station I muddy (A) for (A1) = 0.228, (A2) = 0.227, (A3) = 0.226 with an average value of 0.227; sandy station II (B) for (B1) = 0.253, (B2) = 0.226, (B3) = 0.251 with an average value of 0.243; and station III muddy sand (C) for (C1) = 0.206, (C2) = 0.230, (C) = 0.229 with an average value of 0.221; The Dominance Index value is included in the category where no species dominates. A low dominance index indicates low concentration (nothing dominates). The results of related statistical tests and the ANOVA test revealed that the data were normally distributed and homogeneous and that the differences between stations were insignificant (sig value = 0.164 > 0.05 with F hit = 2.478 F tab = 2.6; 0.05 = 5.143). As a result, the dominance index between stations is relatively equal, implying that no one station dominates.

The abundance of mud crabs (*Scylla* spp.)

The number of mangrove crabs (*Scylla* spp.) found at each observation station was the same, i.e., 2 for each observation station. The abundance of crabs (*Scylla* spp.) at the study sites is presented in **Table 7** and **Figure 8**.

Table 7. The abundance of Research Results at various Stations

No	Bubu	The abundance of mud crabs (ind/bubu)		
		Station 1	Station 2	Station 3
1	1	2	1	0
2	2	1	1	0
3	3	0	0	2
	Average	1,00	0,66	0,66

Source: Result analysis (2022)

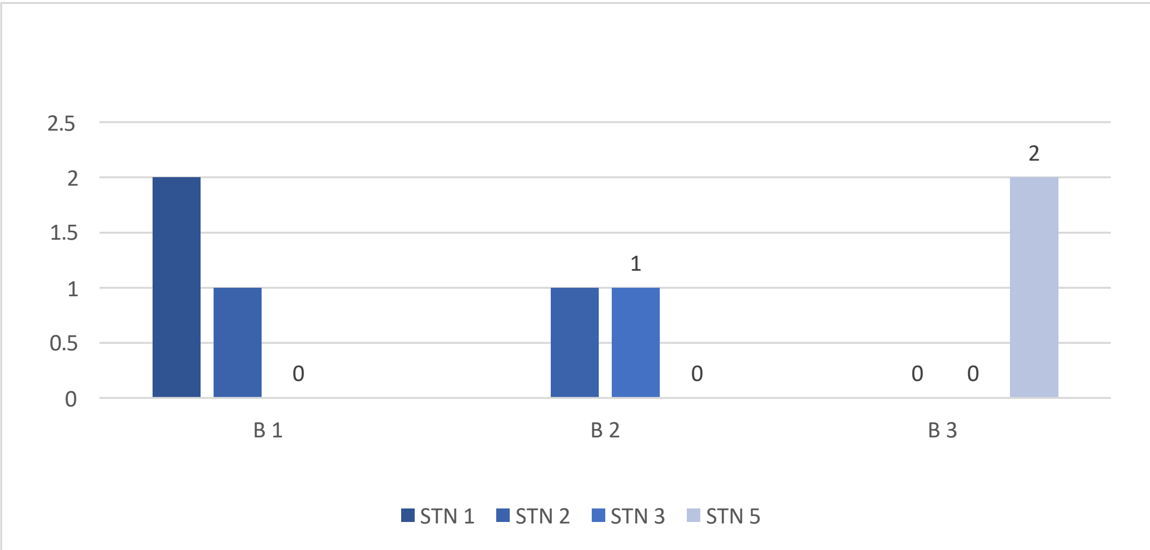


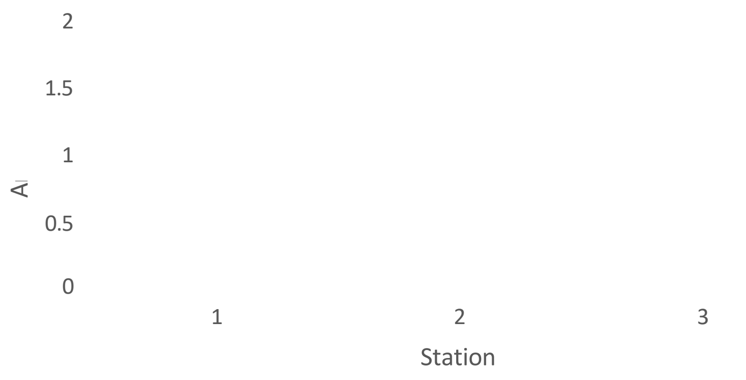
Figure 8. Graph of Mud Crab (*Scylla spp*.) Abundance at 5 Stations

The gender of mangrove crabs caught during the study is presented in **Table 8** and **Figure 9**.

Table 8. Data of Male and Female Mud Crab *Scylla* spp.

Station		Gender		Amount
		Male	**Female**	
1	1	2	1	3
2	2	2	0	2
3	3	1	1	2
Amount		5	2	7

Source: Result analysis (2022)



The mud crabs (*Scylla* spp.) found at the study site consisted of 5 males and only two females, possibly because female crabs spend part of their life cycle not in the mangrove forest but in the sea. After spawning with the male crabs in the mangrove forest area, the female mangrove crabs migrate to deep sea waters to lay their eggs. On the other hand, male crabs remain in the mangrove forest area, so there are more of them in the mangrove forest area than female crabs.

Carapace Growth and Individual Weight of Mangrove Crab (*Scylla* spp.)

The size of the carapace length and individual weight of mud crabs (*Scylla* spp.) found at the study site ranged from 6.5 – 8.5 cm, with individual weight sizes ranging from 48.2 – 117.9 grams presented in **Table 9.**

Table 9. Data on Carapace Size and Weight of Mud Crab (*Scylla* spp.)

No	Station	Carapace length, cm (Individual weight, grams)		
		Bubu 1	**Bubu 2**	**Bubu 3**
1	1	0	0	6,4 and 7,5 (48,2 and 73,5)
2	2	8,5 and 7,3 (117,9 and 63,0)	0	0
3	3	0	6,5 and 7,5 (76,8 and 50,5)	0

Source: Result analysis (2022)

Waters Quality Parameters

The importance of water quality is measured based on the parameters used in **Table 10**; this is also an essential part of the research, as explained in the following table :

Table 10. Results of water quality measurements during the study

No	Parameters	Observation Station 1 Muddy			2 Sandy			3 Muddy sand			Optimum value (Reference)
											2022)
	(°C0										
2	Salinity (ppt)	26-27	25-27	25-27	27-28	27-28	27-28	29-30	29-31	29-31	15-32 (Hewitt et al., 2022)

2019)

Source: Result analysis (2022)

In general, the water quality parameters at the study site support the existence of a mangrove ecosystem with associated biota, especially gastropods and mangrove crabs (*Scylla* spp.).

Substrate Conditions

The condition of the substrate in the research location of the Pandansari mangrove forest is one of the important ecological factors that affect community structure and life for mollusks; the substrate also plays an essential role as a habitat for foraging, reproducing, and shelter (Deng *et al.,* 2020). Substrate texture is a place for gastropods' sticking, crawling, and walking. The substrate contains oxygen and increases nutrient availability in the sediment.

The primary substrate is one of the main ecological factors affecting macrobenthos' community structure and distribution. Macrobenthos, which have the nature of being deposit-feeding diggers, tend to exist around where they live, either on sandy, muddy, or a mixture of the two substrates. Good substrate conditions affect the development of the gastropod community because a substrate composed of sand and silt with a small quantity of clay is a very suitable place for gastropods. The distribution and its abundance are directly related to the size of the sediment grains under or above the gastropods (Raniah, 2022). This type of silty sand substrate has a high oxygen supply due to the pores in the sand texture, which allow oxygen to enter the substrate. Gastropods can survive in muddy sand. Apart from being a place to live, the substrate is also a food source for some macrobenthos animals, including several types of gastropod species such as *C. aurisfelis, C. nucleus, L. articulata, N. violacea, C. obtusa, T. telescopium*, and *T. palustris*. With the conditions and role of the muddy sand sediments and organic matter, the land is conducive to mangrove forests.

Mangrove Forest Density

According to Harefa et al. (2022), the area of mangrove forest in Kaliwlingi Village, Brebes District, and Brebes Regency in 2003 was 48.42 ha, then increased in 2013 to 149.9 ha, and in 2018 to 333.9 ha. Mangrove reforestation activities influenced this increase. The density of mangrove forests is essential in mud crab (*Scylla* spp.) habitat. The results showed the highest tree density at station 1, with a muddy texture of 10 trees with a distance of less than 0.5 m, while the lowest density was at station 3, with a texture of sandy, muddy soil and many three trees with a distance of more than 0.5 m possible because the salinity at Station 1 is lower and optimal for the existence of mangrove vegetation. Furthermore, direct wave influence on mangrove vegetation at station 3 can cause eroding of mangrove vegetation at station 3. However, statistical test results show that the density of mangrove vegetation between stations is relatively the same possible because the texture of sand, silt, and a mixture of both at each observation station provides adequate and relatively the same carrying capacity for the existence and growth of mangrove vegetation.

In this study, two types of mangrove vegetation were found, namely *Rhizophora mucronata* and *Avicennia marina,* following previous research by Boulanger et al. (2019), which stated that in the mangrove forest area of Kaliwlingi Village and Sawojajar Village, Brebes District, Brebes Regency, 11 types of mangrove vegetation were found, namely: *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, *Avicennia marina*, *Avicennia alba*, *Sonneratia caseolaris*, *Xylocarpus granatum*, *Sesuvium*, and *Ipomea.*

The density of mangrove vegetation at the study site is still quite good, as shown by the results of calculating the absolute density of *Rhizophora* and *Avicennia* mangrove vegetation, which totals around 7,000 is also the same as the Boulanger et al. opinion (2019) that the density of mangrove vegetation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency is classified as good with a distance of 1 meter and 0.5 meters. The density of mangrove vegetation affects the abundance of mangrove crabs. The size of the mangrove vegetation ranges from 5.0 to 13.7 cm. With the condition of the mangrove vegetation, the mangrove forest in the research location can be stated in the "good" category to allow the biota in the research location to live well in association with the mangrove forest, including gastropods and mangrove crabs (*Scylla spp*.)

Gastropod Composition

At the study site, there was a class of gastropods with two sub-classes, namely Pulmonata and Prosobranchia, consisting of 4 families, namely Ellobidae, Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found, namely Cassudula auriferous and Cassidula nucleus. One species was found from the Littorinidae family, namely Littoraria articulata; from the Neritidae family, one species was found, namely Neritidae violacea. Three species were found in the Potamidae family: Cerebralia obtusa, Telescopium telescopium, and Terebralia palustris. These gastropods were found when the waters were receding.

The most common gastropods found were Cassudula aurifelis and Cassidula nucleus, both from the subclass Pulmonata family Ellobidae to have something to do with the type of mangrove vegetation in the Pandansari mangrove forest. The distribution of gastropods is evenly distributed in a clustered pattern in the Pandansari mangrove area. This species likes Rhizophora and Avicennia mangrove vegetation. This family often lives on or attaches to mangrove vegetation's stems, roots, and branches. Species tend to be able to win the competition to get the desired food and living space compared to other gastropod species (Vorsatz *et al.,* 2021).

The fewest gastropods found were the species Cerebralia obtuse and Telescopium Telescopium. The difference between the density of mangroves and organic matter at each station, be it muddy, sandy, or muddy sand, is thought to influence the presence of the species Cerebralia obtuse and Telescopium Telescopium so that they are only found in a few plots where the density of mangrove vegetation is sparse. The rarer the density of mangrove vegetation, the less organic matter is produced to support the lives of existing gastropods. Terebralia palustris, a member of the Potamididae family, was found more frequently in stations with brackish, muddy, or mangrove waters.

Gastropod density index

Places and habitats for gastropods tend to favor coastal areas with mangroves and a relatively high density of mangrove vegetation, such as the Pandasari mangrove forest area, a Mangrove rehabilitation and reforestation area. Gastropod density index values varied significantly (Sig 0.001) between stations, with gastropod density index values at station I muddy substrate averaging 7.20 ind/m2, Station II sandy substrate averaging 2.36 ind/m2, and Station III silty sand averaging 4.62 ind/m2. The cause of the highest density index value of 7.20 individuals/m2 at station I (muddy substrate) is possible because the station I has mangrove vegetation with better density, which is one of the producers of organic matter derived from mangrove leaf litter, which is then used as a food source for gastropods (Salim *et al.*, 2020). In addition, the minimal human activity in the area due to its entry into a protected forest zone also helps maintain the presence of gastropods on Station I. Likewise, at Station III (sand-muddy substrate), several species of gastropods were found with an average individual density index value of 4.62 individuals/m2, more than Station II (sandy substrate), with an average density index of 2.36 individuals/m2 possible because the mud substrate has a fine texture and a higher nutrient content than a coarse-textured or sandy substrate because organic matter settles more easily on fine particles and is very good for the survival of gastropods.

Gastropod Diversity Index

The value of the Gastropod Diversity Index (H) at the study site was 1.49–1.59, included in the medium category as stated by Wilhm (1975), who stated that the Diversity Index value level of 1–3 was included in the moderate category. The Gastropod diversity index was not significantly different (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143), so it can be stated that the gastropod diversity index between stations was relatively the same. The diversity index is influenced by the number and average density of each type of gastropod at each observation station. A community with a diversity value in the moderate category has competitive biota-life interactions, adequate productivity, fairly balanced ecosystem conditions, and moderate ecological pressure (Chowdhury *et al.*, 2020). Likewise, the types of gastropods found at each station are relatively related to the ability of gastropods to adapt to their environment, especially the mud and sand substrates at each observation station.

Uniformity Index

The Uniformity Index values between stations vary but fall into the high-to-medium category. The Gastropod diversity index between stations was not significantly different (Sig = 0.153 > 0.05 or F hit = 2.604 F tab 2, 6; 0.05 = 5.143), so it can be interpreted that the Gastropod Uniformity Index between stations is relatively the same. The cause of the high to moderate uniformity index values is likely due to the relatively small number of gastropods at each observation station can be caused by the limited adaptability of gastropods to their environment (Maxemilie et al., 2021)

Gastropod Dominance Index

Each observation station's average Dominance Index value ranges from 0.221 to 0.243. Based on the Simpson dominance index, which has a value close to 0, it is said that there are almost no dominant gastropod species possible because sufficient food and favorable environmental conditions can support the lives of existing gastropod species. The presence of non-dominant species will result in moderate to high species diversity. The Gatropda Dominance Index was not significantly different (Sig = 0.164 > 0.05 or F hit = 2.478 F tab 2, 6; 0.05 = 5.143), meaning the dominance index between stations was relatively the same possible because each gastropod species' adaptability to its environmental conditions is relatively similar.

Abundance and Body Size of Mud Crab (*Scylla* spp*.)*

The mud crabs (*Scylla spp.*) caught in the study were five males and two females, possibly because the male mud crabs spend more of their lives in the waters of the mangrove forests, which have more abundant food for the mud crabs than the open sea. In addition, mangrove vegetation is a haven from various environmental factors, such as sea waves. Female mangrove crabs in mangrove forests are less significant than male mangrove crabs because female mud crabs do not spend their entire life in the mangrove forest. Female mangrove crabs migrate to deep sea waters to lay their eggs after mating with male crabs in the mangrove forest area. Furthermore, the female mangrove crabs return to the forest area again to take shelter after laying their eggs until their egg-laying time (Durairaj *et al.,* 2020).

The mangrove crab (*Scylla spp.)* is a marine biota whose life depends on the presence of mangroves. This research was conducted at the core zone of 10-year-old stands. Mangrove forests have at least two zones: the core and outer zones. The core zone is generally located close to the sea and river mouths and has relatively dense mangrove vegetation compared to the outer zone, around ponds. This zone division is quite influential in the survival of mangrove crabs following the opinion (Huang *et al.,* 2019), which states that the division of mangrove zones dramatically affects the survival of the mangrove association biota, and one of them is mangrove crabs in each zone.

The research location is in a mangrove forest area resulting from reforestation with an old age of 10 years. It allows dense mangrove vegetation, supported by sedimentation and organic matter from the sea and the Pemali River at its estuary. This organic material becomes a food supply for mud crabs and existing gastropods. The river mouth is also one of the doors for the entry of young crabs from the sea that enter the mangrove forest to continue their lives, allowing the mangrove crabs to live in it and fulfill their needs.

On the other hand, the number of mud crabs obtained from the three observation stations was only seven individual mud crabs with a transect area of 2 m x 2 m per station, made possible because the environmental conditions at the study site were disrupted by high tides entering the research location area. Hence, the mangrove crabs moved to another safer location. Thus, the existence of mangrove crabs is also partly located in the outer zone, around the pond area, which has also grown quite a lot of mangrove vegetation due to reforestation, especially in the pond bunds following the opinion (Bagarinao, 2020) that mud crabs prefer to be in the outer zone of ponds, which are continuously exposed to water and lots of food and are places of refuge for crabs from all threats, such as environmental hazards. The relatively small number of mud crabs has resulted in statistical test results that show that the abundance of mud crabs is relatively the same.

The carapace length of the mud crabs in this study ranged from 6.4–8.5 cm, with an individual weight of 48.2–117 grams. Mud crab carapace length and individual weights were not significantly different between stations possible because the condition of the mangroves at each station is also relatively the same. Hence, the growth of the mangrove crab carapace is also relatively the same. When mature, mangrove crabs of Scylla spp. have a relatively large body size with a carapace length of up to 8.5 cm (Putri *et al.,* 2022).

Water Quality Parameters

In general, the value of each water quality parameter for all stations shows promising results in supporting gastropod life. The water temperature at all research stations ranged from 260°C to 290°C. Differences in the intensity of sunlight penetration, tides, and the presence or absence of mangrove plants cause this temperature difference. The temperature that can be tolerated for the development and reproduction of gastropods is 0°–480°C (Anunciado & Budiongan, 2021), while mud crabs can tolerate a temperature range of 12–35°C.

The water salinity at all observation stations ranged from 25 to 31 ppt. Low salinity was obtained at the first station on a muddy substrate, and higher salinity was obtained at station III on a muddy sand substrate because the existence of Station I in the ecotourism area is closer to the upstream area. Hence, the salinity level is slightly lower compared to other stations. The location of Station III is closer to the sea, so the salinity level is high. The range of water salinity values for gastropod life in mangrove forests ranges from 5–75 ppt (Anunciado & Budiongan, 2021). Mud crabs (Scylla spp.) can survive at a 10–30 ppt salinity, but mud crabs can grow and develop well in the 15–35 ppt range.

The pH value of the water obtained at all observation stations ranged from 7.6 to 8.0. The pH range of the water is included in the optimum category, namely 7-8 for gastropod life (Nurfadillah *et al.,* 2021). Gastropods do not like too acidic areas because it will damage their shell structure. The mangrove crabs can survive at pH 7–9.

Dissolved oxygen in the Pandansari mangrove forest area ranges from 2.4–2.7 mg/l following the statement of Kusuma et al. (2020), which states that a dissolved oxygen content of 2.4–4 ml/l is sufficient to support macrobenthos life, such as gastropods. NO2, NH3, and H2S at the study site are still within the permissible limits for aquaculture activities. The maximum tolerance limits for N2, NH3, and H2S concentrations for aquaculture activities are 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively (Mwaluma & Kaunda-Arara, 2021).

Feasibility of Silvo-Fishery System Mangrove Crab Cultivation Activities

The existence of communities around the mangrove forest is very influential on the sustainability of the ecosystem. For this reason, it is necessary to involve local communities in efforts to manage mangroves sustainably, and one form is the mud crab silvofishery system (Retnaningdyah *et al.*, 2022). Silvofishery is the utilization of mangrove forests combined with fishery commodities. The basic principle of silvofishery is the protection of mangrove plants by providing yields from the fisheries sector. This system can increase people's income while still paying attention to the sustainability of mangrove forests.

The primary substrate in the Pandansari mangrove forest area (Kaliwlingi et al. District, Brebes Regency), with a mangrove stand age of 10 years, is in the form of sand and clay sediments. In addition, the sediment is also enriched by the presence of organic matter from mangrove forests and precipitated mud due to the hydrodynamics of the coastal area. The thickness of the sediment is relatively large, namely 52.80–69.07 cm, because it is in a pond location affected by abrasion, which is then used as a mangrove reforestation area. The substrate condition allows for gastropods and natural foods for mud crabs. Besides that, the sand sediment, muddy clay, and presence of organic matter in the soil make the land conducive to the growth and development of mangrove forests. Mangrove vegetation at the study site results from reforestation with a spacing of 0.5–1 meter, and the size of the mangrove vegetation is 5.0–13.7 cm. With the condition of the mangrove vegetation, the mangrove forest in the research location can be stated in the "good" category to allow the biota in the research location to live well in association with the mangrove forest, including gastropods and mangrove crabs (*Scylla spp.).*

In general, the value of each water quality parameter for all observation stations shows good results to support the life of mangrove vegetation, gastropods, and mangrove crabs. The water temperature ranges from 260°C to 290°C, within the optimal temperature range for the life of gastropods, namely 0°C to 480°C and for the life of mud crabs, namely 12°C to 35°C (Hilmi *et al.*, 2022). Water salinity ranges from 25–31 ppt, which is in the range of water salinity for gastropod life, namely 5-75 ppt, and mud crabs (*Scylla spp*., 10–30 ppm. The pH value of the water ranges from 7.6 to 8.0, which is within the optimum range for the life of gastropods, namely 7-8, and mangrove crabs, namely 7 to 9. Dissolved oxygen ranges from 2.4–2.7 mg/l, within the range that supports the life of gastropods, namely 2.4–4 ml/l and crabs. NO2, NH3, and H2S at the study site were still within the allowable limits for aquaculture activities. The maximum concentration limits of N2, NH3, and H2S that could still be tolerated for aquaculture activities were 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively (Karlina & Pratiwi, 2021).

Conclusion

Based on these conditions, the Pandansari mangrove forest area, Kaliwlingi Village, Brebes District, Brebes Regency, with a mangrove stand age of 10 years, can be declared adequate as a Mangrove crab silvofishery area. This effort is an unforgettable part of human efforts in addressing the environment but can also increase income; this area is adequate in silvioforestry surveys and is the forerunner of nature management policies and increasing income in Indonesia.

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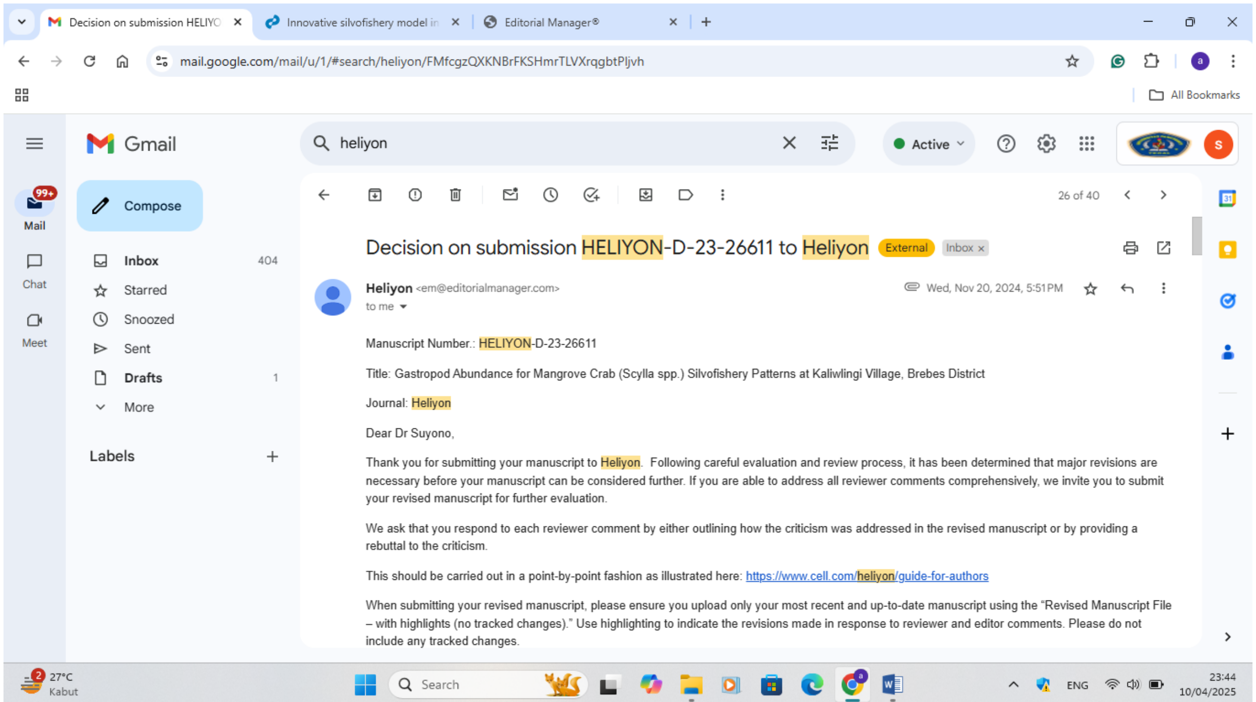
Supplementary Material

2 Bukti konfirmasi *review* dan hasil *review* pertama, 20 November 2024



3 Bukti respon hasil *review* pertama, 8 Desember 2024

[00.08, 11/6/2023] Dewi: Komentar Editor dan Reviewer:

Reviewer #1: Makalah ini membahas struktur komunitas gastropoda dan kepiting di area mangrove yang telah direhabilitasi selama 10 tahun. Namun, struktur tulisan ini masih jauh dari memadai terutama dalam hal struktur dan alur cerita. Masalah utama tentang makalah ini antara lain adalah bahasa Inggrisnya yang perlu ditingkatkan secara signifikan, kehilangan beberapa isi penting seperti pertanyaan penelitian, hipotesis penelitian, metode detail pengumpulan dan analisis data dan kinerja hasil (tabel dan grafik). Beberapa kalimat masih menggunakan bahasa non-Inggris (menggunakan Bahasa Indonesia) dan ini menunjukkan bahwa tulisan ini ditulis dengan tergesa-gesa. Referensi yang digunakan dalam makalah ini tidak tersedia dalam daftar referensi di bagian akhir makalah ini.

Komentar yang sangat penting adalah makalah ini tidak memiliki gagasan yang jelas tentang pesan utama yang ingin diungkapkan oleh penulis. Salah ketik yang mendasar dan masalah bahasa Inggris adalah prinsipnya. Seperti halnya struktur komunitas gastropoda dan kepiting di kawasan mangrove. Judul tentang daya dukung tidak ditampilkan di koran dan tidak dibahas sama sekali di MS.

Berikut di bawah ini adalah komentar saya:

Abstrak : Mohon ditambahkan informasi tentang tujuan penelitian secara singkat, hipotesis penelitian, hasil dan kesimpulan. Masukkan beberapa data dan hasil penelitian dalam abstrak.

Perkenalan :

Makalah ini perlu dirumuskan kembali terutama cerita tentang latar belakang dan topik utama yang diteliti: gastropoda dan hubungannya dengan kepiting Scylla.

Mohon rumuskan : mengapa penelitian ini penting baik dari segi ilmu pengetahuan maupun pengelolaan mangrove.

Apa pertanyaan penelitian utama dan karenanya hipotesis dari penelitian ini? apakah ini tentang korelasi antara gastropoda dan kepiting? atau dengan kondisi ekosistem mangrove ?

Apa peran mangrove yang direhabilitasi selama 10 tahun dalam penelitian ini? apakah ada yang tertarik untuk dieksplorasi dalam hal gastropoda dan kepiting?

Hipotesis penting dalam menentukan strategi penelitian, yang meliputi strategi pengumpulan data dan analisisnya.

Semua pengumpulan data dan strategi analisisnya harus dirancang agar dapat menjawab semua tujuan penelitian.

Metode

Ini harus diungkapkan lebih sistematis dan jelas dalam pendahuluan makalah ini sebagai pertanyaan penelitian dan hipotesis.

Tolong tambahkan kalimat tentang desain penelitian dan hubungannya dengan pertanyaan penelitian. Tambahkan juga alasan dalam menentukan stasiun-stasiun tersebut. Itu harus sesuai dengan hipotesis penelitian dan pertanyaan penelitian.

Plot transek 2 x 2 m terlalu kecil untuk analisis kerapatan mangrove.

Pengumpulan Data Gastropoda dan Kepiting : Mohon diperjelas :

- berapa banyak transek
- bagaimana Anda mengumpulkan hewan selama pengambilan sampel
- bagaimana Anda menangani sampel
- Berapa banyak replikasi yang Anda miliki selama masa studi? Apakah Anda membuat replikasi berdasarkan musim?

Analisis data

Mohon ditambahkan informasi rinci pada masing-masing analisis data dalam hubungannya dengan tujuan penelitian. Misalnya, mengapa Anda melakukan analisis Indeks Nilai Penting? di mana tujuan penelitian itu berkorelasi? Mengapa Anda menganalisis data dengan Krebs (1989) dan Odum (1993)? analisis apa dan apa tujuan melakukan ini?

Kualitas air

Karena sebagian besar hewan merupakan hewan yang berafiliasi dengan habitat bentik, maka perlu dilakukan pengukuran kualitas parameter sedimen, seperti kandungan organik, pH dan oksigen dalam sedimen. Perlu diketahui apakah habitat tersebut cocok untuk kehidupan hewan tersebut.

Metode bagaimana mengukur kedalaman sedimen tidak disajikan secara jelas dalam Metode.

HASIL

Tabel 1: Apakah data ini berdasarkan pengukuran Anda? Atau itu data sekunder yang dilakukan oleh Kusuma (2020) ?

Referensi ini tidak tersedia dalam daftar referensi.

Tabel 2. Kerapatan pohon mangrove terlalu kecil…mohon diubah menjadi pohon/ha.

-Tidak ada spesies bakau bernama Rhizophora marina. Harap berhati-hati dengan masalah ini. Pengarang terkesan terburu-buru dalam bekerja dan tidak menerapkan prinsip penulisan yang cermat dan benar.

P6. L 46. Tolong jelaskan analisis statistik apa yang Anda lakukan? Spesies mana yang Anda perhitungkan untuk perbedaan statistik?

Gambar 3 Grafik ini tidak lengkap. Sumbu Y perlu ditambahkan : Unit. Apa singkatan dari Axes X? Ada banyak karya yang salah seperti ini di seluruh manuskrip.

Fi 4. Tampaknya grafik ini membingungkan. Sumbu X salah.

Tidak perlu menambahkan judul grafik dalam grafik.

P 8. L59. Harap sebelum mengirimkan ke jurnal, harap periksa semua kesalahan ketik.

Tabel 4. Harap perbaiki judul tabel dengan benar. Maksudnya kepadatan? harap spesifik

Gambar 5. Grafik ini tidak jelas. Apa yang ingin Anda tampilkan dalam grafik ini?

Tabel 5.

-Dalam metode, nama stasiun adalah 1, 2 dan 3. Dalam tabel ini, diubah menjadi Muddy Sandy dan Muddy Sandy

-Apakah nilai-nilai ini berarti nilai? jika iya, dihitung dari berapa data? Apakah mereka berbeda secara signifikan antara stasiun?

Gambar 6. Kualitas grafik perlu ditingkatkan. Legenda "seri 1" sepertinya tidak perlu

[00.08, 11/6/2023] Dewi: ary.

Tabel 6. Mewakili Kemerataan bukan Keseragaman. Itu sebabnya disebut (E).

P 10. L45. Tolong tunjukkan nilai p dari hasil tes. Jika dibawah 0,05 maka berbeda nyata.

Tabel 7. Data hasil tangkapan terlalu kecil. Artinya replikasi ctach perlu ditingkatkan.

Gambar Halaman 12. Gambar di atas tidak memiliki judul Gambar.

Halaman 12 L 42. Masih ada bahasa non Inggris.

Hewitt et al (2022) dan Kurkutte et al (2019) tidak tercantum dalam daftar referensi, serta banyak kutipan lainnya. Jaminan kualitas kertas ini buruk. Harap berhati-hati dalam menulis karya ilmiah. Silakan periksa dengan seksama sebelum mengirimkan ke jurnal yang dimaksud.

P 14. L 37. Tidak ada Indeks kepadatan Gastropoda yang Anda hitung sebelumnya. Tolong hati-hati. Namun, indeks tidak dapat dibandingkan dan dianalisis secara statistik.

Saya menyarankan untuk menambah bab Pembahasan dimana penulis dapat mendiskusikan semua hasil dan membandingkannya dengan referensi yang tersedia dan membahas semua hal yang berkaitan dengan kelemahan penelitian serta aspek masa depan yang berkaitan dengan konservasi kawasan mangrove terutama yang terkait dengan biota terkait. Daya dukung yang secara khusus disebutkan dalam judul naskah sama sekali tidak dibahas.

Kesimpulan

Judul makalah ini adalah tentang daya dukung, tetapi tidak ada hasil atau analisis yang menyebutkannya.

Referensi : banyak artikel yang hilang dan harus diperiksa dengan teliti sebelum penulis menyerahkan ke jurnal.

4 Bukti artikel yang di *resubmit* pertama, 10 Desember 2024

Innovative Silvofishery Model in Restored Mangrove Forests: A 10-Year Assessment

Suyono[1]*, Alin Fithor[2]
Aquaculture Department, Faculty of Fisheries and Marine Science,
Pancasakti University, Tegal, 52121, Indonesia

Coastal Resources Management, National Research and Innovation
Agency-BRIN, Yogyakarta, 55284, Indonesia

*Corresponding author: suyono@upstegal.ac.id

Abstract
Novelty of study is related to silvofishery investigations in 10-year-old mangrove forests in former abrasive shrimp ponds with different sedimentation depths from the forest area in the core mangrove forest stand zone as a fishing area. Study aimed to describe the relationship between mangrove conditions, the abundance of gastropods, and mud crabs (Scylla spp.) in Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. Mangrove tourist area of Station I is a muddy substrate located in the mangrove tourism area; Station II is a sandy substrate located in a mangrove forest bordering the sea with a length of 15 m; and Station III which has a muddy sand substrate in the mangrove forest near the Pemali River which is 8 m away. The involvement of local communities is essential in efforts to manage mangroves sustainably. Silvofishery is the utilization of mangrove forests combined with fishery commodities to protect mangrove plants by providing more results from the fisheries. System can increase people's income while still paying attention to the sustainability of mangrove forests. Based on these conditions, the mangrove forest area can be declared feasible as the best silvofishery area in Indonesia.

Keywords: Mangrove, 10-year-old stands, Gastropod, Kaliwlingi, Silviofishery,

Introduction

The mangrove forest area of Dukuh Pandansari in Kaliwlingi Village, Brebes District, Brebes Regency, is geographically located at 109º 01' 07" East Longitude and 6º 48' 18" South Latitude. The soil has a sand-silt-clay texture with 34.00% sand, 44.89% silt, and 21.11% clay. The Kaliwlingi mangrove area has the Pemali Delta on the Pemali River. Area is a fertile one for the existence of mangrove forests. The mangrove vegetation in Pandansari Kaliwlingi is a 10- to 25-year-old mangrove stand. The mangrove vegetation is the result of reforestation to reduce the risk of coastal abrasion that hit the Kaliwlingi coast in the early 2000s, along with developments in the opening of mangrove areas for shrimp farming activities. Mangrove forests are typical for muddy, sandy, or muddy sandy beach areas, and the water is calm. Mangrove vegetation can grow optimally in coastal areas, river estuaries, and deltas, where the flow contains much mud (Putri *et al.*, 2022). Mangrove forests are an ecosystem that has a reasonably high productivity value because they allow litter decomposition to occur. Mangrove forests significantly contribute to organic detritus, which is very important as food for the biota that lives in them (Irwansyah et al., 2022) related to its ecological function as a place to live, find food, spawn, nurture, grow aquatic biota, and protect the coast from abrasion and pressure from sea waves. Mangrove forests are complex ecosystems consisting of flora and fauna in coastal areas, both on land and at sea, and are usually affected by sea tides (Bagarinao, 2020).

Mangroves as a place to find food for biota contribute to the complexity of the habitat and the diversity of macrofauna associated with ecosystem, such as mollusks and crabs, which are the most dominant macrofauna in ecosystem. Density, diversity, and distribution of biota life in an ecosystem are affected by environmental factors concerning its community structure (Anunciado & Budiongan, 2021).

Growth of mangrove vegetation resulting from reforestation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency, other biota associated with mangrove forests are present, including gastropods and mangrove crabs (*Scylla spp*.). Gastropods, the largest class of the mollusk phylum, are biota important in ecological functions in mangrove forest ecosystems. Gastropods have reasonably high adaptability to various habitats and can accumulate heavy metals without dying, so they can be used as indicators of the coastal environment. Gastropods can respond to water conditions sustainably so that they master a variety of varied habitats (Nurfadillah *et al.*, 2021). Mwaluma & Kaunda-Arara (2021) state that around 75% of mollusk species fall into the gastropod class. Gastropods, slugs, or snails have very varied body shapes and sizes. The majority of gastropods like to live in sandy mud substrates because of the availability of organic matter in them (Junaidi & Agustina, 2021). Ecologically, gastropods are essential in the circulation of nutrients in waters; economically, they have a selling value for their shells and meat (Retnaningdyah *et al.*, 2022). Gastropods in the water are generally found as detritivores and prey for other biota, including herbivores, carnivores, scavengers, deposit feeders, suspension feeders, and parasites. Gastropods are vital organisms in the food chain in coastal ecosystems and can affect the existence and life of other biotas, including mangrove crabs (Karlina & Pratiwi, 2021).

Mud crab (*Scylla spp.*) is a coastal fishery commodity with high economic value. Mud crab has become a vital fishery commodity in Indonesia since the early 1990s. Mud crabs are macrobenthic fauna that belongs to the Crustaceae family and are commonly found in mangrove and estuarine waters. Mud crabs play an essential role in mangrove ecosystems related to their activities, which include making holes in the substrate in search of food to affect the decomposition process of organic matter content in mangrove ecosystems (Hilmi *et al.*, 2022). Naturally, mangrove crabs are cannibals and eat the carrion of fish and other biota, including gastropods. Thus, the presence of gastropods, which is influenced by the condition of the mangrove forest, will also determine the abundance of mangrove crabs in that location with pattern can increase people's income while still paying attention to the sustainability of mangrove forests (Ginantra *et al.*, 2021).

Meeting the needs of mud crabs is obtained from catches, which can affect their abundance in the zoning of the core of the mangrove forest. Mangrove crab cultivation is in demand to maintain the balance of the mangrove ecosystem. One of the mud crab cultivation techniques worth developing is mud crab cultivation with a silvofishery pattern due to the nature, which utilizes mangrove forests in a sustainable manner combined with fishery commodities. Basic principle of silvofishery is the protection of mangrove plants by providing yields from the fisheries sector. The study's novelty is related to investigating silvofishery in 10-year-old standing mangrove forests in formerly abrasive shrimp ponds with different sedimentation depths than forest areas. Purpose of study was to examine the density of mangrove forests and the abundance of gastropods and mud crabs (*Scylla spp*.) in the core zone of 10-year-old mangrove forests in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency, as well as the carrying capacity of the core zone of mangrove forests in Pandansari Hamlet, Kaliwlingi Village, District, and Brebes Regency as a salvo-fishery area for mangrove crabs (Scylla spp) in the district.

Research Method

Research was conducted in April–July 2022 in the mangrove forest area with relationship between mangrove conditions, the abundance of gastropods and mud crabs (Scylla spp.), and mud crab cultivation locations in the core zone of 10-year-old mangrove forests in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency. The determination of the locations of the stations was carried out randomly at selected locations with specific considerations (purposive-random sampling). Sampling used a 2 m x 2 m transect equipped with three mud crab traps with a distance of 0.5 m at each station, research has just been carried out. The location of each station is presented in **Figure 1**.

Figure 1. Research Locations in the Core Zone of the Pandansari Mangrove Forest.

Preparation

The preparation stage included the preparation of transects measuring 2 m by 2 m and traps for mud crabs (*Scylla spp*.) measuring 60 cm by 20 cm by 22 cm in the amount of 3 pieces per observation station for the three selected observation stations. Sampling was carried out using the number of mangroves in the area over the last 10 years, and also only represented locations where there were mangroves

Identification of Soil Sediment and Substrate

Organic matter sediments in standing mangrove forests aged ten years were measured for depth. Soil substrate samples were taken from inside the observation transect by filtering and pipetting (Utaminingsih, 1994). The results of the analysis of sediment grains were carried out to determine the grain size and type of sediment. Grain size analysis was carried out using the dry sieving (sieving) and wet sieving (piping) methods, as was done by Buchanan (1971). Identification of sediment and soil substrate is a complex process and involves a variety of methods, depending on the type of sediment to be identified, the level of accuracy required, and the equipment available. Commonly used identification methods with visual observation such as colour, texture and structure.

Mangrove Vegetation Density Check

Checking the mangrove vegetation was carried out using the tracing method and observing the density and condition of the mangrove vegetation that was ten years old. Measure mangrove vegetation density using transects measuring 5 m x 5 m at each station (Sapling) The size of a 10-year-old mangrove tree trunk was measured using a length meter to ensure that the observation area becomes more narrow so that he can see the richness

Identification of Gastropod Samples

Gastropod samples were taken from 9 points, 3 points each for each station. Gastropod sampling was carried out at low tide. Gastropod samples were preserved as evidence of research results by immersing them in a 96% alcohol solution (Eka et al., 2020). Soaking and draining of the gastropod samples were carried out two times. The first step is soaking in 0.5 liters of 96% alcohol mixed with distilled water in a 1: 1 ratio for 7-8 hours. In the second stage, the samples were soaked in 96% alcohol without mixing with water for a week and drained and dried. Gastropod identification and calculations were carried out using the Gastropod Class Mollusc Identification Book, including the morphology and structure of the musty shell, spire, body whorl, suture, aperture, axial ribs, spiral cord, columella, posterior canal, anterior siphonal canal, and operculum (Widianingsih et al., 2019) with ethical clearance number 50/KEPMEN-KP/2017.

Gastropod and Mud Crab (*Scylla spp.*) Abundance Calculations

The abundance of gastropods and mud crabs (*Scylla spp.*) was calculated based on the samples found in three plots on each station's transect. The abundance of gastropods and mud crabs (*Scylla spp.*) was calculated by dividing the number of individual samples area of 5 x 5 of gastropods or mud crabs caught in traps by the area of the sampling area (Setyadi *et al.*, 2021). Research location only took a few samples of mud crabs from the location, not cultivated by the community catching of gastropods and mud crabs was carried out on the second day of the 2-day study period for several arrests. In addition to the data on the density of mangrove vegetation and the abundance of gastropods and mud crabs, measurements of water quality (variable temperature, variable pH, and variable salinity) were also carried out.

Data Analysis

The obtained data on mangrove vegetation, gastropods, and mud crabs (Scylla spp.) were analyzed using several formulas as stated by Krebs (1989), Odum (1993), and Bengen (2000), including absolute and relative density, absolute and relative frequency, absolute dominance and relative dominance, visual observation, as well as diversity and uniformity. The correlation is that when one part of the plant or animal experiences a problem and must be solved, adjustments must be made. The research also looks at how the challenges of 10 years of development of mangrove vegetation and other animals which have important elements in life have advantages.

The diversity index (H') of muddy I station (A); sandy station II (B); and station III muddy sand (C1). Diversity Index values are included in the moderate category of 1-3 (Wilhm, 1975). From a series of statistical tests and ANOVA with SPSS test results, the Diversity Index values were normally distributed and homogeneous, and the diversity between observation stations was not significantly different from each other, so that it can be concluded that the Gastropod Diversity Index between stations is relatively the same as the Medium value category.

Uniformity Index (E) for station I muddy (A); sandy station II (B); and station III muddy sand (C); Uniformity Index (E) values generally show varying values but are still in the high-to-medium category with a category value of 0.61–1.49 (Wilhm, 1975). The results of related statistical tests and the ANOVA with SPSS test showed, so that it can be concluded that the uniformity index between stations is relatively different in the high to medium category range.

Dominance Index (C) for the station I muddy (A); sandy station II (B); and station III muddy sand (C); The Dominance Index value is included in the category where no species dominates. A low dominance index indicates low concentration (nothing dominates). The results of related statistical tests and the ANOVA with SPSS test revealed that the data were normally distributed and homogeneous and that the differences between stations were insignificant.

Water Quality Observation

The water quality parameters measured were the key parameters of water chemistry and physics: temperature, salinity, pH, and dissolved oxygen (DO). These parameters support the life of gastropods and mangrove crabs in the mangrove ecosystem. Parameter measurements were carried out with three repetitions at each station. Measure the temperature using a thermometer dipped in water for about 1 minute. They dropped a sample of water on the hand refractometer lens to measure salinity. Measure the pH by immersing the pH meter in 3 cm of deep water for about 1 minute.

Results and Discussion

Sediment and Soil Substrate Research Location

The sediments in the study area are derived from mangrove forest organic matter and silt deposited due to the hydrodynamics of the coastal area. The average thickness of the sediment at the three observation stations has a value of 52.80 cm to 69.07 cm. Station 1 area has the highest sediment depth value of 69.07 cm, Station 2 has a sediment depth of 52.80 cm, and Station 3 area is 65.20 cm deep. The location of the observation station is a pond affected by abrasion that is then used as a mangrove reforestation area. Hence, the depth of the mud in the area is relatively deep. The results of observing the soil substrate at each study location are presented in **Table 1** and **Figure 2.**

Table 1. Sediment and Soil Substrate Research Location

Station	Substrate	Plot	Sediment type	Information
1	Muddy	A1	Muddy silt	Soft and dense
1	Muddy	A1	Muddy silt	Soft and dense
1	Muddy	A1	Muddy silt	Soft and dense
2	Sandy	A2	Sandy silt	Soft Particle
2	Sandy	A2	Sandy silt	Soft Particle
2	Sandy	A2	Sandy silt	Soft Particle
3	Muddy sand	A3	Mix	Dull
3	Muddy sand	A3	Mix	Dull
3	Muddy sand	A3	Mix	Dull

Source: Result analysis (2022).

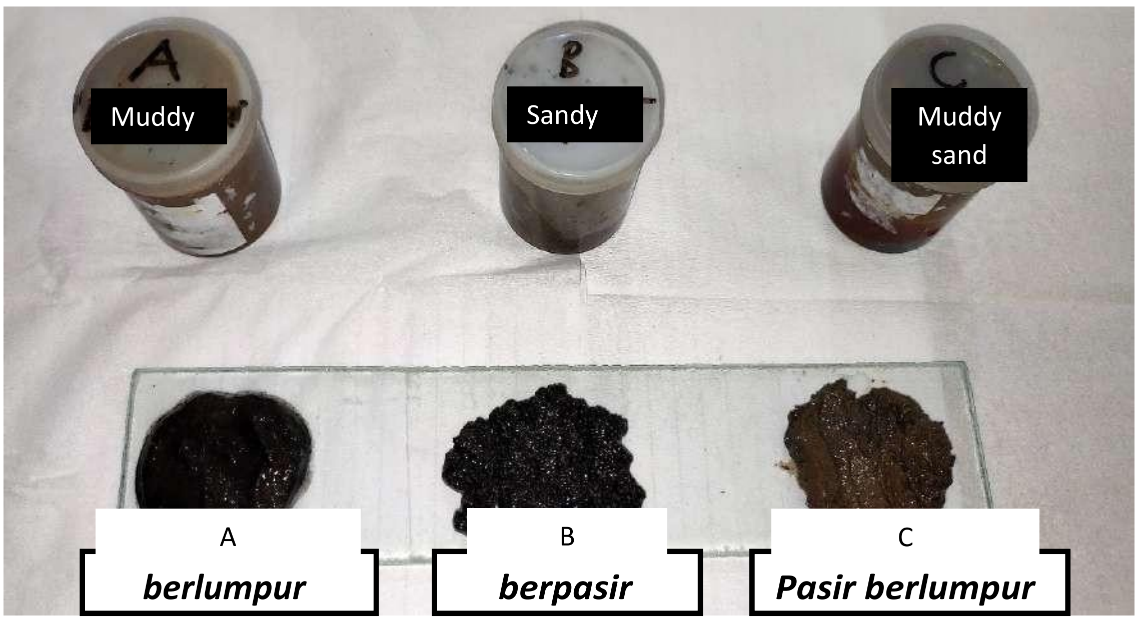


Figure 2. Muddy, sandy, and muddy sand substrates.

Figure 2. The results of observing the soil substrate at each study location (A. Muddy substrate station; B. Sandy substrate station; C. Muddy sand substrate station)

Mangrove Forest Density

Based on the research results on the density of mangrove forests in the 10-year-old core zone, presented in **Table 2** and **Figure 3**.

Table 2. Mangrove Forest Density Data Based on Research Results.

Mangrove type	Density (sampling/5 x 5)								
	Station 1 Muddy			Station 2 Sandy			Station 3 Muddy Sand		
	1st Transect	2nd Transect	3rd Transect	1 st Transect	2nd Transect	3rd Transect	1 st Transect	2nd Transect	3rd transect
Rhizophora	2	1	3	2	2	0	3	1	1

mucronata									
Avicennia marina	0	0	0	0	1	0	0	0	1

Source: Result analysis (2022)

The average number of mangrove trees at each station is 5, with a density of 5 individuals/m2 or 4,166 ind/ha. The results of the statistical analysis showed that there was no difference in the density of mangrove forests at each station.

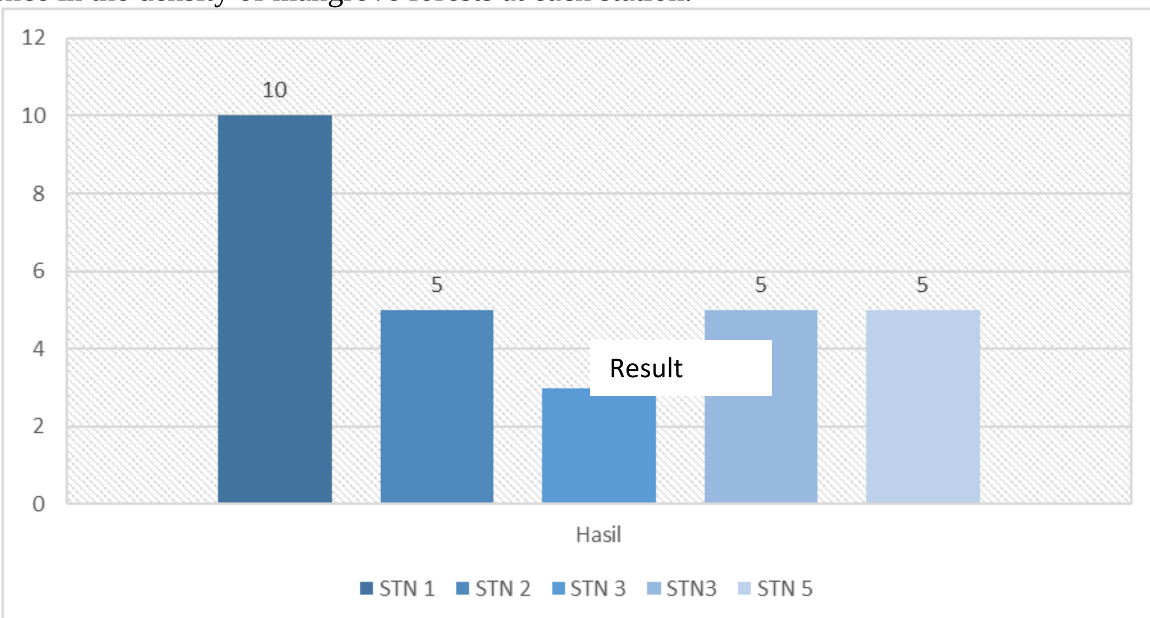


Figure 3. Graph of Mangrove Tree Density at 5 Stations

Mangrove

The size of the mangrove trees at each observation station has a size range of 5.00–13.50 cm, as presented in **Table 3** and **Figure 4**.

Table 3. Differences in the Size of the Rhizophora Mangrove Vegetation Stems (cm)

Sta	**Sediment Texture**	**Mangrove tree size (cm)**					**Average**	**SD**
		1	**2**	**3**	**4**	**5**		
1	Substrate Muddy	8,30	8,50	10,40	9,50	8,00	8,94	0,99
2	Substrate Sandy	8,50	10,00	10,00	5,00	8,00	8,30	2,05
3	Substrate Muddy sand	7,00	8,00	11,00	11,00	13,50	9,50	2,60

Source: Result analysis (2022) asse

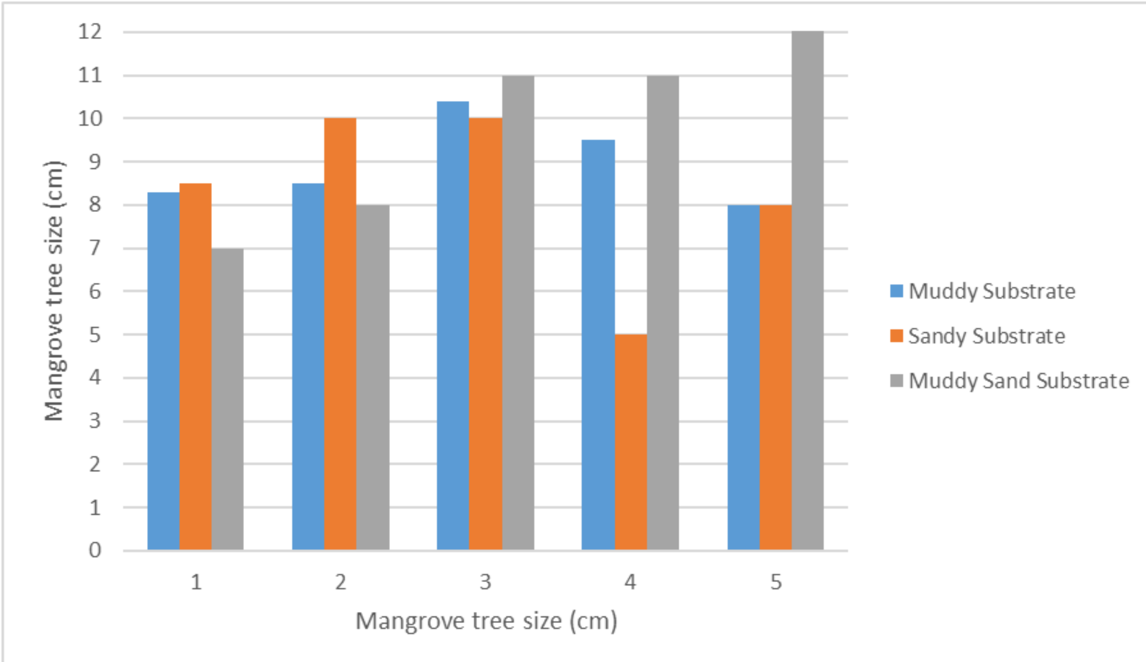


Figure 4. Graph of Mangrove Tree Magnitude at 3 Observation Stations

Gastropda Composition

At the study site was a Gastropod Class with two sub-classes, Pulmonata and Prosobranchia, and four families, Ellobidae and Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found: Cassudula auriferous and Cassidula nucleus. From the Littorinidae family, one species was found: Littoraria articulate, and from the Neritidae family, one species was found: Neritidae violacea. Three species were found in the Potamidae family: Cerebralia obtuse, Telescopium Telescopium, and Terebralia palustris. These gastropods were found when the waters were receding. The most common species found were gastropod species from the Pulmonata subclass of the Ellobidae family, namely Cassudula auriferous and Cassidula nucleus, according to Nhuong et al. research results (2021). Gastropods found at the study site are presented in **Table 4** and **Figure 5.**

Table 4. Composition of gastropods found at the study site at each observation station

No	**Species**	**Composition/type of substrate**									**Amount**
		Muddy			**Sandy**			**Muddy sand**			
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	
1	C. aurisfelis	50	53	46	15	8	9	30	33	29	273
2	C. nucleus	55	45	59	25	17	8	28	27	23	287

3	L. articulata					1					27
		8	4	6	0		0	5	3	0	
4	N. violacea	2	3	3	1	1	1	2	1	2	19
		6	0	3	4	6	0	0	8	5	2
5	C. obtusa					0					8
		2	0	0	0		1	3	2	0	
6	T. telescopium		1			5					49
		7	2	9	2		0	5	3	6	
7	T. palustris	3	2	3	1	1	1	2	3	2	23
		0	6	9	5	7	4	5	3	9	8
	Amount	178	171	192	7	6	4	1	119	112	
	Amount (ind)				2	4	2	1			

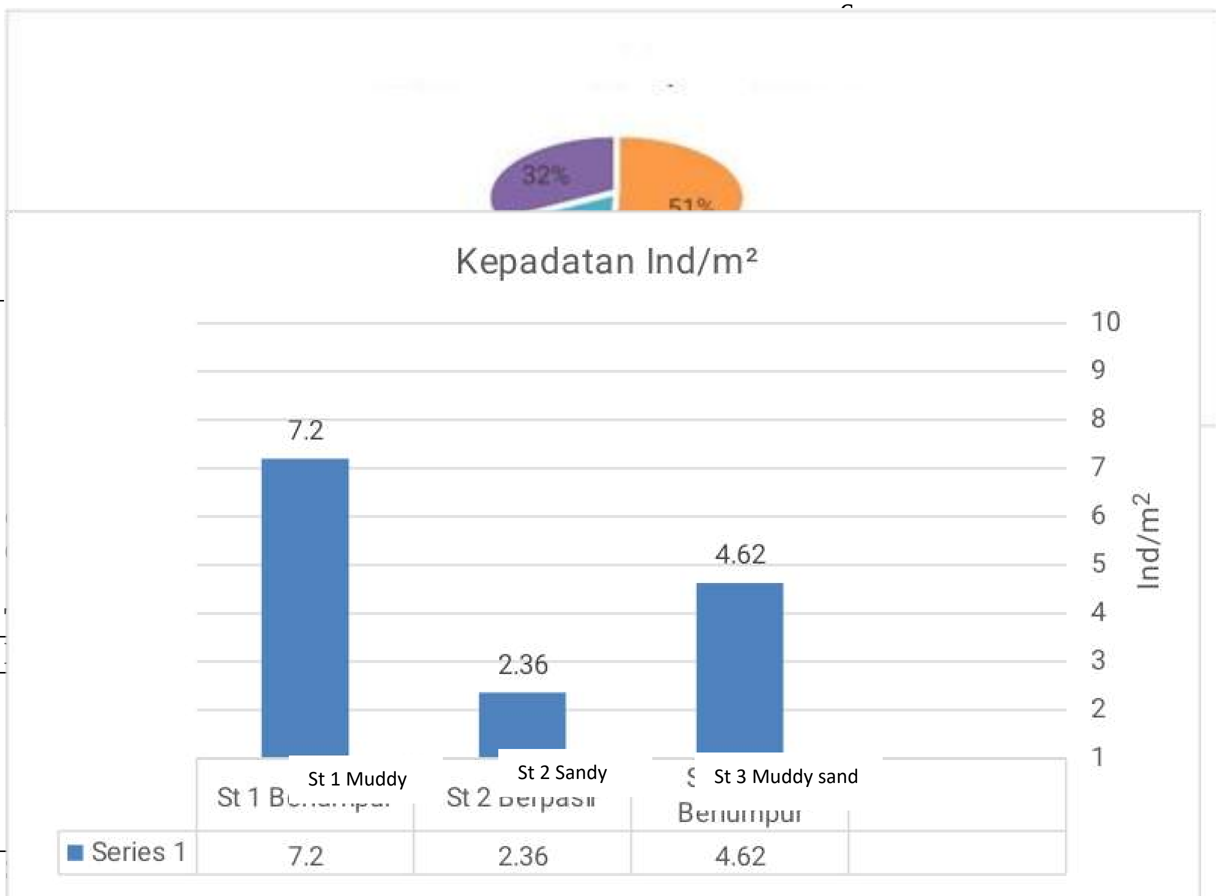


Figure 6. Graph of Density Results for Gastropods found at the study site

Statistical test results showed that the density of gastropods between stations was typically distributed, homogeneous, and significantly different from each other (Sig 0.002 <0.01 with F hit = 82,965 > F tab 2.6; 0.01 = 2.305).

Gastropod Diversity, Uniformity, and Dominance Index

The analysis results of the diversity index, uniformity index, and gastropod dominance index at the study site are presented in Table 6 and Figure 7.

Table 6. The average results of Diversity Index (H'), Uniformity (E), and Dominance

St 1 Muddy St 2 Sandy St 3 Muddy sand

(C).

No	Station	Indicator					
		Diversity		Uniformity		Dominance	
		H’	Category H’	E	Category E	C	Category C
1	Muddy	1,59	Medium	0,81	High to medium	0,227	ND
2	Sandy	1,49	Medium	0,76	High to medium	0,243	ND
3	Muddy sand	1,59	Medium	0,81	High to medium	0,221	ND

Source: Result analysis (2022)
Information : H’ = Wilhm (1975), E = Krebs (1985), C = Odum (1993), ND = No Density

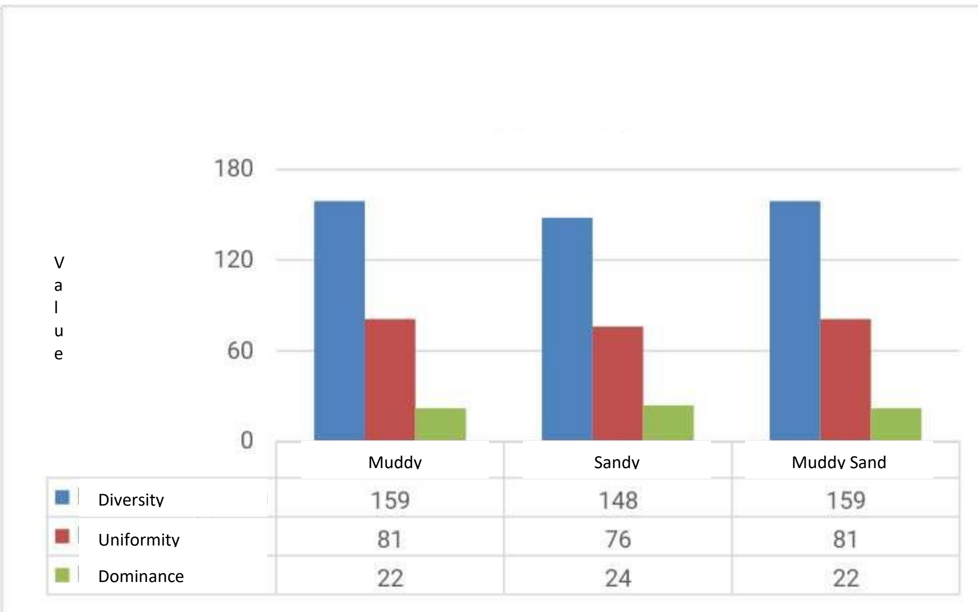


Figure 7. Graph of Diversity Index (H'), Uniformity (E), and Dominance (C).

The diversity index (H') of muddy I station (A) is (A1) = 1.61, (A2) = 1.58, (A3) = 1.58 with an average value of 1.59; sandy station II (B) is (B1) = 1.44, (B2) = 1.57, (B3) = 1.44 with an average value of 1.48; and station III muddy sand (C1) = 1.69, (C2) = 1.58, (C3) = 1.51 with an average value of 1.59. Diversity Index values are included in the moderate category of 1-3 (Wilhm, 1975). From a series of statistical tests and ANOVA test results, the Diversity Index values were normally distributed and homogeneous, and the diversity between observation stations was not significantly different from each other (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143), so that it can be concluded that the Gastropod Diversity Index between stations is relatively the same as the Medium value category.

Uniformity Index (E) for station I muddy (A) is (A1) = 0.83, (A2) = 0.81, (A3) = 0.81 with an average value of 0.81; sandy station II (B) is (B1) = 0.74, (B2) = 0.80, (B3) = 0.74 with an average value of 0.76; and station III muddy sand (C) is (C1) = 0.86, (C2) = 0.81, (C3) = 0.77 with an average value of 0.81; Uniformity Index (E) values generally show varying values but are still in the high-to-medium category with a category value of 0.61–1.49 (Wilhm, 1975). The results of related statistical tests and the ANOVA test showed that the data is usually distributed and homogeneous, but the uniformity between observation stations is relatively different (sig value = 0.153 > 0.05 or F hit = 2.604 F tab 2.6; 0.05 = 5.143) so that it can be concluded that the uniformity index between stations is relatively different in the high to medium category range.

Dominance Index (C) for the station I muddy (A) for (A1) = 0.228, (A2) = 0.227, (A3) = 0.226 with an average value of 0.227; sandy station II (B) for (B1) = 0.253, (B2) = 0.226, (B3) = 0.251 with an average value of 0.243; and station III muddy sand (C) for (C1) = 0.206, (C2) = 0.230, (C) = 0.229 with an average value of 0.221; The Dominance Index value is included in the category where no species dominates. A low dominance index indicates low concentration (nothing dominates). The results of related statistical tests and the ANOVA test revealed that the data were normally distributed and homogeneous and that the differences between stations were insignificant (sig value = 0.164 > 0.05 with F hit = 2.478 F tab = 2.6; 0.05 = 5.143). As a result, the dominance index between stations is relatively equal, implying that no one station dominates.

The abundance of mud crabs (*Scylla* spp.)

The number of mangrove crabs (Scylla spp.) found at each observation station was the same, i.e., 2 for each observation station. The abundance of crabs (Scylla spp.) at the study sites is presented in **Table 7** and **Figure 8**.

Table 7. The abundance of Research Results at various Stations

No	Passive gear	The abundance of mud crabs (individu/passive gear)		
		Station 1	Station 2	Station 3
1	1	2	1	0
2	2	1	1	0
3	3	0	0	2
	Average	1,00	0,66	0,66

Source: Result analysis (2022)

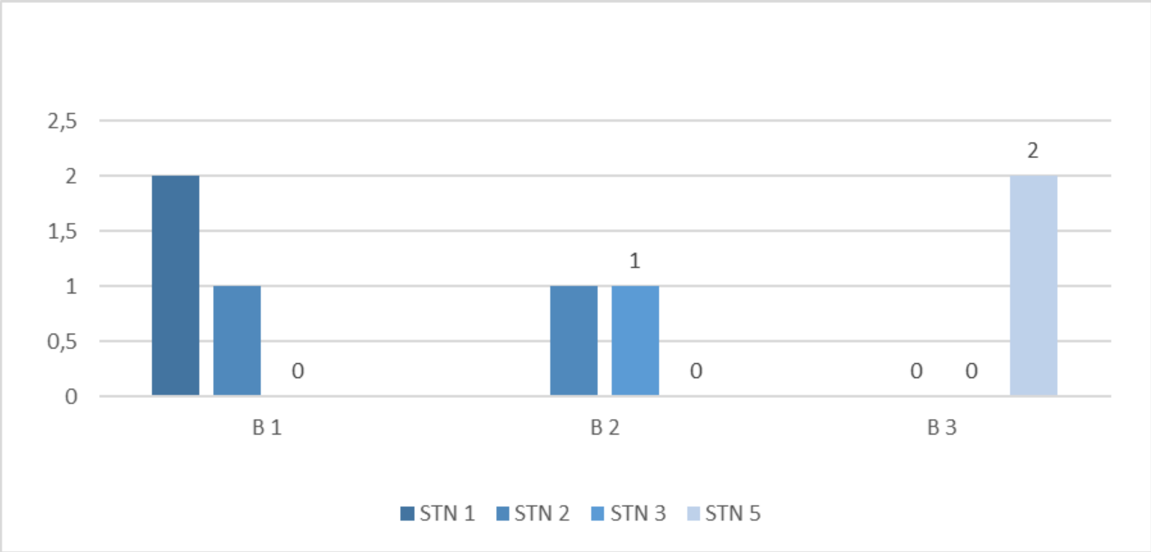


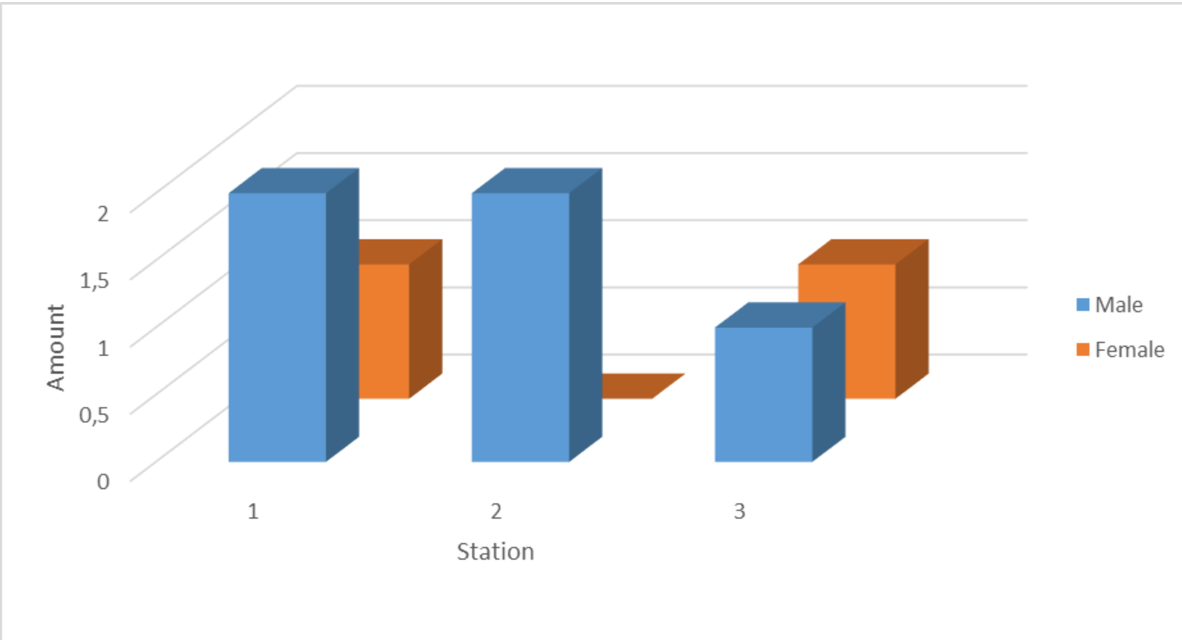
Figure 8. Graph of Mud Crab (*Scylla spp.*) Abundance at 5 Stations

The gender of mangrove crabs caught during the study is presented in **Table 8** and **Figure 9**.

Table 8. Data of Male and Female Mud Crab *Scylla* spp.

	Station	**Gender**		**Amount**
		Male	**Female**	
1	1	2	1	3
2	2	2	0	2
3	3	1	1	2
	Amount	5	2	7

Source: Result analysis (2022)



The mud crabs (Scylla spp.) found at the study site consisted of 5 males and only two females, possibly because female crabs spend part of their life cycle not in the mangrove forest but in the sea. After spawning with the male crabs in the mangrove forest area, the female mangrove crabs migrate to deep sea waters to lay their eggs. On the other hand, male crabs remain in the mangrove forest area, so there are more of them in the mangrove forest area than female crabs.

Carapace Growth and Individual Weight of Mangrove Crab (*Scylla* spp.)

The size of the carapace length and individual weight of mud crabs (Scylla spp.) found at the study site ranged from 6.5 – 8.5 cm, with individual weight sizes ranging from 48.2 – 117.9 grams presented in **Table 9.**

Table 9. Data on Carapace Size and Weight of Mud Crab (Scylla spp.)

No	**Station**	**Carapace length, cm (Individual weight, grams)**		
		Passive Gear 1	**Passive Gear 2**	**Passive Gear 3**
1	1	0	0	6,4 and 7,5 (48,2 and 73,5)
2	2	8,5 and 7,3 (117,9 and	0	0

		63,0)		
3	3	0	6,5 and 7,5 (76,8 and 50,5)	0

Source: Result analysis (2022)

Waters Quality Parameters

The importance of water quality is measured based on the parameters used in **Table 10**; also an essential part of the research, as explained in the following table :

Table 10. Results of water quality measurements during the study

No	Variable	Observation Station 1 Muddy			2 Sandy			3 Muddy sand			Optimum value (Reference)
		1	2	3	1	2	3	1	2	3	
1	Temperature (ºC0	28-29	28-29	27-29	28-29	27-29	27-29	28-29	28-29	28-29	26-32 (Hewitt et al., 2022)
2	Salinity (ppt)	26-27	25-27	25-27	27-28	27-28	27-28	29-30	29-31	29-31	15-32 (Hewitt et al., 2022)
3	pH	8,0-8,2	7,8-8,0	7,9-8,1	7,8-7,9	7,6-7,8	7,6-7,7	7,6-7,7	7,7-7,8	7,7-7,8	7,5-8,7 (Hewitt et al., 2022)
4	DO (ppm)	2,3-2,5	2,2-2,5	2,3-2,4	2,4-2,5	2,4-2,6	2,6-2,7	2,5-2,7	2,5-2,7	2,4-2,7	1,0-6,0 (Kurkute et al. 2019)
5	NO_2 (ppm)	0,08	0,08	0,07	0,07	0,07	0,08	0,09	0,08	0,08	< 0,1 (Kurkute et al., 2019)
6	NH_3 (ppm)	0,16	0,14	0,13	0,14	0,14	0,16	0,16	0,15	0,16	0,06-0,2 (Kurkute et al., 2019)
7	H_2S (ppm)	0,001	0,001	0,002	0,001	0,002	0,002	0,001	0,002	0,001	< 0,002 (Kurkute et al. 2019)

Source: Result analysis (2022)

In general, the water quality parameters at the study site support the existence of a mangrove ecosystem with associated biota, especially gastropods and mangrove crabs (Scylla spp.).

Substrate Conditions

The condition of the substrate in the research location of the Pandansari mangrove forest is one of the important ecological factors that affect community structure and life for mollusks; the substrate also plays an essential role as a habitat for foraging, reproducing, and shelter (Deng et al., 2020). Substrate texture is a place for gastropods' sticking, crawling, and walking. The substrate contains oxygen and increases nutrient availability in the sediment.

The primary substrate is one of the main ecological factors affecting macrobenthos' community structure and distribution. Macrobenthos, which have the nature of being deposit-feeding diggers, tend to exist around where they live, either on sandy, muddy, or a mixture of the two substrates. Good substrate conditions affect the development of the gastropod community because a substrate composed of sand and silt with a small quantity of clay is a very suitable place for gastropods. The distribution and its abundance are directly related to the size of the sediment grains under or above the gastropods (Raniah, 2022). Type of silty sand substrate has a high oxygen supply due to the pores in the sand texture, which allow oxygen to enter the substrate. Gastropods can survive in muddy sand. Apart from being a place to live, the substrate is also a food source for some macrobenthos animals, including several types of gastropod species such as C. aurisfelis, C. nucleus, L. articulata, N. violacea, C. obtusa, T. telescopium, and T. palustris. With the conditions and role of the muddy sand sediments and organic matter, the land is conducive to mangrove forests.

Mangrove Forest Density

According to Harefa et al. (2022), the area of mangrove forest in Kaliwlingi Village, Brebes District, and Brebes Regency in 2003 was 48.42 ha, then increased in 2013 to 149.9 ha, and in 2018 to 333.9 ha. Mangrove reforestation activities influenced increase. The density of mangrove forests is essential in mud crab (*Scylla spp*.) habitat. The results showed the highest tree density at station 1, with a muddy texture of 10 trees with a distance of less than 0.5 m, while the lowest density was at station 3, with a texture of sandy, muddy soil and many three trees with a distance of more than 0.5 m possible because the salinity at Station 1 is lower and optimal for the existence of mangrove vegetation. Furthermore, direct wave influence on mangrove vegetation at station 3 can cause eroding of mangrove vegetation at station 3. However, statistical test results show that the density of mangrove vegetation between stations is relatively the same possible because the texture of sand, silt, and a mixture of both at each observation station provides adequate and relatively the same carrying capacity for the existence and growth of mangrove vegetation.

The density of mangrove vegetation at the study site is still quite good, as shown by the results of calculating the absolute density of *Rhizophora* and *Avicennia* mangrove vegetation, which totals around 7,000 is also the same as the Boulanger et al. opinion (2019) that the density of mangrove vegetation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency is classified as good with a distance of 1 meter and 0.5 meters. The density of mangrove vegetation affects the abundance of mangrove crabs. The size of the mangrove vegetation ranges from 5.0 to 13.7 cm. With the condition of the mangrove vegetation, the mangrove forest in the research location can be stated in the "good" category(explain with a good condition ecosystem) to allow the biota in the research location to live well in association with the mangrove forest, including gastropods and mangrove crabs (*Scylla spp*.)

Gastropod Composition

At the study site, there was a class of gastropods with two sub-classes, namely Pulmonata and Prosobranchia, consisting of 4 families, namely Ellobidae, Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found, namely C. auriferous and C. nucleus. One species was found from the Littorinidae family, namely Littoraria articulata; from the Neritidae family, one species was found, namely Neritidae violacea. Three species were found in the Potamidae family: C. obtusa, T. telescopium, and T. palustris. These gastropods were found when the waters were receding.

The most common gastropods found were C. aurifelis and C. nucleus, both from the subclass Pulmonata family Ellobidae to have something to do with the type of mangrove vegetation in the Pandansari mangrove forest. The distribution of gastropods is evenly distributed in a clustered pattern in the Pandansari mangrove area. Species likes Rhizophora and Avicennia mangrove vegetation with family often lives on or attaches to mangrove vegetation's stems, roots, and branches. Species tend to be able to win the competition to get the desired food and living space compared to other gastropod species (Vorsatz et al., 2021).

The fewest gastropods found were the species Cerebralia obtuse and Telescopium Telescopium. The difference between the density of mangroves and organic matter at each station, be it muddy, sandy, or muddy sand, is thought to influence the presence of the species C. obtuse and T. telescopium so that they are only found in a few plots where the density of mangrove vegetation is sparse. The rarer the density of mangrove vegetation, the less organic matter is produced to support the lives of existing gastropods. Terebralia palustris, a member of the Potamididae family, was found more frequently in stations with brackish, muddy, or mangrove waters.

Gastropod density index

Places and habitats for gastropods tend to favor coastal areas with mangroves and a relatively high density of mangrove vegetation, such as the Pandasari mangrove forest area, a Mangrove rehabilitation and reforestation area. Gastropod density index values varied significantly (Sig 0.001) between stations, with gastropod density index values at station I muddy substrate averaging 7.20 ind/m2, Station II sandy substrate averaging 2.36 ind/m2, and Station III silty sand averaging 4.62 ind/m2. The cause of the highest density index value of 7.20 individuals/m2 at station I (muddy substrate) is possible because the station I has mangrove vegetation with better density, which is one of the producers of organic matter derived from mangrove leaf litter, which is then used as a food source for gastropods (Salim et al., 2020). In addition, the minimal human activity in the area due to its entry into a protected forest zone also helps maintain the presence of gastropods on Station I. Likewise, at Station III (sand-muddy substrate), several species of gastropods were found with an average individual density index value of 4.62 individuals/m2, more than Station II (sandy substrate), with an average density index of 2.36 individuals/m2 possible because the mud substrate has a fine texture and a higher nutrient content than a coarse-textured or sandy substrate because organic matter settles more easily on fine particles and is very good for the survival of gastropods.

Gastropod Diversity Index

The value of the Gastropod Diversity Index (H) at the study site was 1.49–1.59, included in the medium category as stated by Wilhm (1975), who stated that the Diversity Index value level of 1–3 was included in the moderate category. The Gastropod diversity index was not significantly different (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143), so it can be stated that the gastropod diversity index between stations was relatively the same. The diversity index is influenced by the number and average density of each type of gastropod at each observation station. A community with a diversity value in the moderate category has competitive biota-life interactions, adequate productivity, fairly balanced ecosystem conditions, and moderate ecological pressure (Chowdhury et al., 2020). Likewise, the types of gastropods found at each station are relatively related to the ability of gastropods to adapt to their environment, especially the mud and sand substrates at each observation station.

Uniformity Index

The Uniformity Index values between stations vary but fall into the high-to-medium category. The Gastropod diversity index between stations was not significantly different (Sig = 0.153 > 0.05 or F hit = 2.604 F tab 2, 6; 0.05 = 5.143), so it can be interpreted that the Gastropod Uniformity Index between stations is relatively the same. The cause of the high to moderate uniformity index values is likely due to the relatively small number of gastropods at each observation station can be caused by the limited adaptability of gastropods to their environment (Maxemilie et al., 2021)

Gastropod Dominance Index

Each observation station's average Dominance Index value ranges from 0.221 to 0.243. Based on the Simpson dominance index, which has a value close to 0, it is said that there are almost no dominant gastropod species possible because sufficient food and favorable environmental conditions can support the lives of existing gastropod species. The presence of non-dominant species will result in moderate to high species diversity. The Gatropda Dominance Index was not significantly different (Sig = 0.164 > 0.05 or F hit = 2.478 F tab 2, 6; 0.05 = 5.143), meaning the dominance index between stations was relatively the same possible because each gastropod species' adaptability to its environmental conditions is relatively similar.

Abundance and Body Size of Mud Crab (*Scylla* spp.*)*

The mud crabs (Scylla spp.) caught in the study were five males and two females, possibly because the male mud crabs spend more of their lives in the waters of the mangrove forests, which have more abundant food for the mud crabs than the open sea. In addition, mangrove vegetation is a haven from various environmental factors, such as sea waves. Female mangrove crabs in mangrove forests are less significant than male mangrove crabs because female mud crabs do not spend their entire life in the mangrove forest. Female mangrove crabs migrate to deep sea waters to lay their eggs after mating with male crabs in the mangrove forest area. Furthermore, the female mangrove crabs return to the forest area again to take shelter after laying their eggs until their egg-laying time (Durairaj et al., 2020).

The mangrove crab (Scylla spp.) is a marine biota whose life depends on the presence of mangroves. Research was conducted at the core zone of 10-year-old stands. Mangrove forests have at least two zones: the core and outer zones. The core zone is generally located close to the sea and river mouths and has relatively dense mangrove vegetation compared to the outer zone, around ponds. Zone division is quite influential in the survival of mangrove crabs following the opinion (Huang et al., 2019), which states that the division of mangrove zones dramatically affects the survival of the mangrove association biota, and one of them is mangrove crabs in each zone.

The research location is in a mangrove forest area resulting from reforestation with an old age of 10 years. It allows dense mangrove vegetation, supported by sedimentation and organic matter from the sea and the Pemali River at its estuary. Organic material becomes a food supply for mud crabs and existing gastropods. The river mouth is also one of the doors for the entry of young crabs from the sea that enter the mangrove forest to continue their lives, allowing the mangrove crabs to live in it and fulfill their needs of mud crabs obtained from the three observation stations was only seven individual mud crabs with a transect area of 2 m x 2 m per station, made possible because the environmental conditions at the study site were disrupted by high tides entering the research location area. Hence, the mangrove crabs moved to another safer location. Thus, the existence of mangrove crabs is also partly located in the outer zone, around the pond area, which has also grown quite a lot of mangrove vegetation due to reforestation, especially in the pond bunds following the opinion (Bagarinao, 2020) that mud crabs prefer to be in the outer zone of ponds, which are continuously exposed to water and lots of food and are places of refuge for crabs from all threats, such as environmental hazards. The relatively small number of mud crabs has resulted in statistical test results that show that the abundance of mud crabs is relatively the same.

The carapace length of the mud crabs in ranged from 6.4–8.5 cm, with an individual weight of 48.2–117 grams. Mud crab carapace length and individual weights were not significantly different between stations possible because the condition of the mangroves at each station is also relatively the same. Hence, the growth of the mangrove crab carapace is also relatively the same. When mature, mangrove crabs of Scylla spp. have a relatively large body size with a carapace length of up to 8.5 cm (Putri et al., 2022).

Water Quality Parameters

In general, the value of each water quality parameter for all stations shows promising results in supporting gastropod life. The water temperature at all research stations ranged from 260°C to 290°C. Differences in the intensity of sunlight penetration, tides, and the presence or absence of mangrove plants cause by temperature difference. The temperature that can be tolerated for the development and reproduction of gastropods is 0°–480°C (Anunciado & Budiongan, 2021), while mud crabs can tolerate a temperature range of 12–35°C.

The water salinity at all observation stations ranged from 25 to 31 ppt. Low salinity was obtained at the first station on a muddy substrate, and higher salinity was obtained at station III on a muddy sand substrate because the existence of Station I in the ecotourism area is closer to the upstream area. Hence, the salinity level is slightly lower compared to other stations. The location of Station III is closer to the sea, so the salinity level is high. The range of water salinity values for gastropod life in mangrove forests ranges from 5–75 ppt (Anunciado & Budiongan, 2021). Mud crabs (Scylla spp.) can survive at a 10–30 ppt salinity, but mud crabs can grow and develop well in the 15–35 ppt range.

The pH value of the water obtained at all observation stations ranged from 7.6 to 8.0. The pH range of the water is included in the optimum category, namely 7-8 for gastropod life (Nurfadillah *et al.*, 2021). Gastropods do not like too acidic areas because it will damage their shell structure. The mangrove crabs can survive at pH 7–9.

Dissolved oxygen in the Pandansari mangrove forest area ranges from 2.4–2.7 mg/l following the statement of Kusuma et al. (2020), which states that a dissolved oxygen content of 2.4–4 ml/l is sufficient to support macrobenthos life, such as gastropods. NO2, NH3, and H2S at the study site are still within the permissible limits for aquaculture activities. The maximum tolerance limits for N2, NH3, and H2S concentrations for aquaculture activities are 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively (Mwaluma & Kaunda-Arara, 2021).

Feasibility of Silvo-Fishery System Mangrove Crab Cultivation Activities

The existence of communities around the mangrove forest is very influential on the sustainability of the ecosystem. Necessary to involve local communities in efforts to manage mangroves sustainably, and one form is the mud crab silvofishery system (Retnaningdyah *et al.*, 2022). Silvofishery is the utilization of mangrove forests combined with fishery commodities. The basic principle of silvofishery is the protection of mangrove plants by providing yields from the fisheries sector. System can increase people's income while still paying attention to the sustainability of mangrove forests.

The primary substrate in the Pandansari mangrove forest area (Kaliwlingi et al. District, Brebes Regency), with a mangrove stand age of 10 years, is in the form of sand and clay sediments. In addition, the sediment is also enriched by the presence of organic matter from mangrove forests and precipitated mud due to the hydrodynamics of the coastal area. The thickness of the sediment is relatively large, namely 52.80–69.07 cm, because it is in a pond location affected by abrasion, which is then used as a mangrove reforestation area. The substrate condition allows for gastropods and natural foods for mud crabs. Besides that, the sand sediment, muddy clay, and presence of organic matter in the soil make the land conducive to the growth and development of mangrove forests. Mangrove vegetation at the study site results from reforestation with a spacing of 0.5–1 meter, and the size of the mangrove vegetation is 5.0–13.7 cm. With the condition of the mangrove vegetation, the mangrove forest in the research location can be stated in the "good" category to allow the biota in the research location to live well in association with the mangrove forest, including gastropods and mangrove crabs (*Scylla spp.)*.

In general, the value of each water quality parameter for all observation stations shows good results to support the life of mangrove vegetation, gastropods, and mangrove crabs. The water temperature ranges from 260°C to 290°C, within the optimal temperature range for the life of gastropods, namely 0°C to 480°C and for the life of mud crabs, namely 12°C to 35°C (Hilmi *et al.*, 2022). Water salinity ranges from 25–31 ppt, which is in the range of water salinity for gastropod life, namely 5-75 ppt, and mud crabs (*Scylla spp.*, 10–30 ppm. The pH value of the water ranges from 7.6 to 8.0, which is within the optimum range for the life of gastropods, namely 7-8, and mangrove crabs, namely 7 to 9. Dissolved oxygen ranges from 2.4–2.7 mg/l, within the range that supports the life of gastropods, namely 2.4–4 ml/l and crabs. NO_2, NH_3, and H_2S at the study site were still within the allowable limits for aquaculture activities. The maximum concentration limits of N_2, NH_3, and H_2S that could still be tolerated for aquaculture activities were 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively (Karlina & Pratiwi, 2021).

Conclusion

Study investigated the silvofishery potential of a 10-year-old restored mangrove forest in Brebes, Indonesia. Research focused on the relationship between mangrove conditions, gastropod abundance, and mud crab populations in different sedimentation zones. Results demonstrate that restored mangrove forests can support diverse marine life and provide significant ecological and economic benefits. By integrating silvofishery practices, local communities can sustainably utilize mangrove resources while preserving the ecosystem. Study highlights the feasibility of restoring degraded mangrove ecosystems for both ecological and socio-economic purposes.

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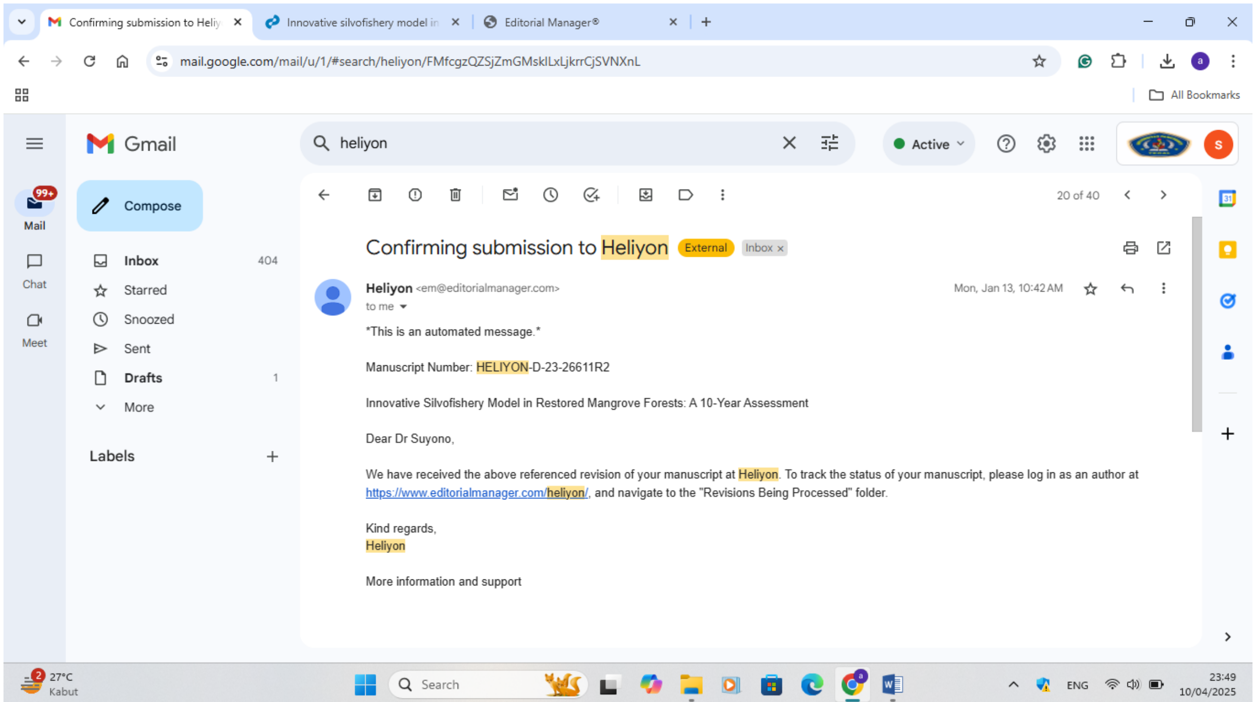
5 Bukti konfirmasi *review* dan hasil *review* kedua, 6 Januari 2025



6 Bukti artikel yang di *resubmit* kedua, 13 Januari 2025

Innovative Silvofishery Model in Restored Mangrove Forests: A 10-Year Assessment

Suyono[1*], Alin Fithor[1,2]
[1]Aquaculture Department, Faculty of Fisheries and Marine Science, Pancasakti University, Tegal, 52121, Indonesia

[2]Coastal Resources Management, National Research and Innovation Agency-BRIN, Yogyakarta, 55284, Indonesia

*Corresponding author: suyono@upstegal.ac.id

Abstract
The novelty of this study lies in the investigations of silvofishery in 10-year-old mangrove forest in former abrasive shrimp ponds. The sedimentation depths of this mangrove forest are different from the forest area in the core mangrove forest stand zone as a fishing area. This study aims to describe the relationship between mangrove conditions, the abundance of gastropods, and mud crabs (Scylla spp.) in Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. The different sedimentation depths of the Mangrove tourist area resulted from the different locations, which were divided into 3 stations. Station I was a muddy substrate located within the mangrove tourism area. Station II was a sandy substrate located in the mangrove forest area bordering the sea, which was only 15 m away. Finally, Station III had a muddy sand substrate in the mangrove forest near the Pemali River, which was 8 m away. For sustainability management purpose, local communities needed to be involved . Utilizing mangrove forests in combination with fishery commodities, silvofishery could protect mangrove plants while providing more yields from the fisheries. Thus, the system could increase people’s income while still maintaining the sustainability of mangrove forests. Based on these findings, it could be said that mangrove forest areas were feasible to be used as the best silvofishery area in Indonesia.

Keywords: Mangrove, 10-year-old stands, Gastropod, Kaliwlingi, Silviofishery,

Introduction

The Kaliwlingi mangrove forest is geographically located at 109º 01' 07" East Longitude and 6º 48' 18" South Latitude or at Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. Its soil has a sand-silt-clay texture consisting of 34.00% sand, 44.89% silt, and 21.11% clay. Within the Kaliwlingi mangrove area, there is the Pemali Delta on the Pemali River. The soil is fertile for mangrove to grow, hence forming a mangrove forest. The mangrove vegetation in Pandansari, Kaliwlingi ranges from 10- to 25-years-old stand. This vegetation is the result of reforestation to reduce the risk of coastal abrasion that hit Kaliwlingi coast in the early 2000s, along with developments in the opening of mangrove areas for shrimp farming. Mangrove forests are typically found on muddy, sandy, or muddy sandy beach areas where the water is calm. Its vegetation can grow optimally in coastal areas, river estuaries, and deltas, where the flow contains much mud [1]–[3]. They are an ecosystem that has a reasonably high productivity value because they allow litter to decompose. They significantly contribute to organic detritus, which is very important as food for the biota that lives in them [4]–[7]. This is related to its ecological function as a place to live, find food, spawn, nurture, grow aquatic biota, and protect the coast from abrasion and pressure from the sea waves with primary and secondary data. Mangrove forests are complex ecosystems consisting of flora and fauna in coastal areas, both on land and at sea, and are usually affected by sea tides[8]–[11].

As a place to find food for biota, mangrove forests contribute to the complexity of the habitat and the diversity of macrofauna associated with the ecosystem, such as molluscs and crabs, which are the most dominant macrofauna in the ecosystem. The density, diversity, and distribution of biota life in an ecosystem are affected by environmental factors which have something to do with its community structure [9], [12], [13].

The mangrove vegetation in the area grow as a result of reforestation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, Brebes Regency. Some other biota associated with mangrove forests are also present, including gastropods and mangrove crabs (Scylla spp.). Gastropods, the largest class of the mollusk phylum, are important biota in the mangrove forest ecosystems' ecological functions. They have reasonably high adaptability to various habitats and can accumulate heavy metals without dying. For this reason, they can be used as indicators of the coastal environment. Having the ability to respond to water conditions sustainably, gastropods survive a variety of habitats [14]. [3], [15], [16] state that around 75% of mollusc species belong to the gastropod class. Gastropods, slugs, or snails come in highly varied body shapes and sizes. Most gastropods like to live in sandy mud substrates since organic matters are available in them [17], [18]. Ecologically, gastropods are essential in the circulation of nutrients in waters. And economically, they have a selling point for their shells and meat [19]. In the water, they are generally found as detritivores and prey for other biota, including herbivores, carnivores, scavengers, deposit feeders, suspension feeders, and parasites. As vital organisms in the food chain in coastal ecosystems, gastropods can affect the existence and life of other biotas, including mangrove crabs [12].

Mud crab (Scylla spp.) is a coastal fishery commodity of high economic value. It has become a vital fishery commodity in Indonesia since the early 1990s. It is a macrobenthic fauna that belongs to the Crustaceae family and are commonly found in mangrove and estuarine waters. In addition to its high economic value, mud crabs play an essential role in mangrove ecosystems as their activities, such as making holes in the substrate in search of food, affect the decomposition process of organic matter content in mangrove ecosystems [20]. Naturally, mangrove crabs are cannibals and eat the carrion of fish and other biota, including gastropods. Thus, the presence of gastropods, which is influenced by the condition of the mangrove forest, will also determine the abundance of mangrove crabs in that location. In turn, this can increase people's income while still maintaining the sustainability of mangrove forests [10].

The needs for mud crabs can be met from catches, which can affect their abundance in the core zone of the mangrove forest. Therefore, to maintain the balance of the mangrove ecosystem a cultivation of mud crab is needed. One mud crab cultivation technique worth developing is mud crab cultivation with a silvofishery. Its worthiness for development comes from the fact that it utilizes mangrove forests sustainably in combination with fishery commodities. The basic principle of silvofishery is protecting mangrove plants while providing yields from the fisheries sector. The study's novelty lies in the investigation of silvofishery in 10-year-old standing mangrove forests in formerly abrasive shrimp ponds with different sedimentation depths from that of forest areas. The study aims to examine the density of the mangrove forest and the

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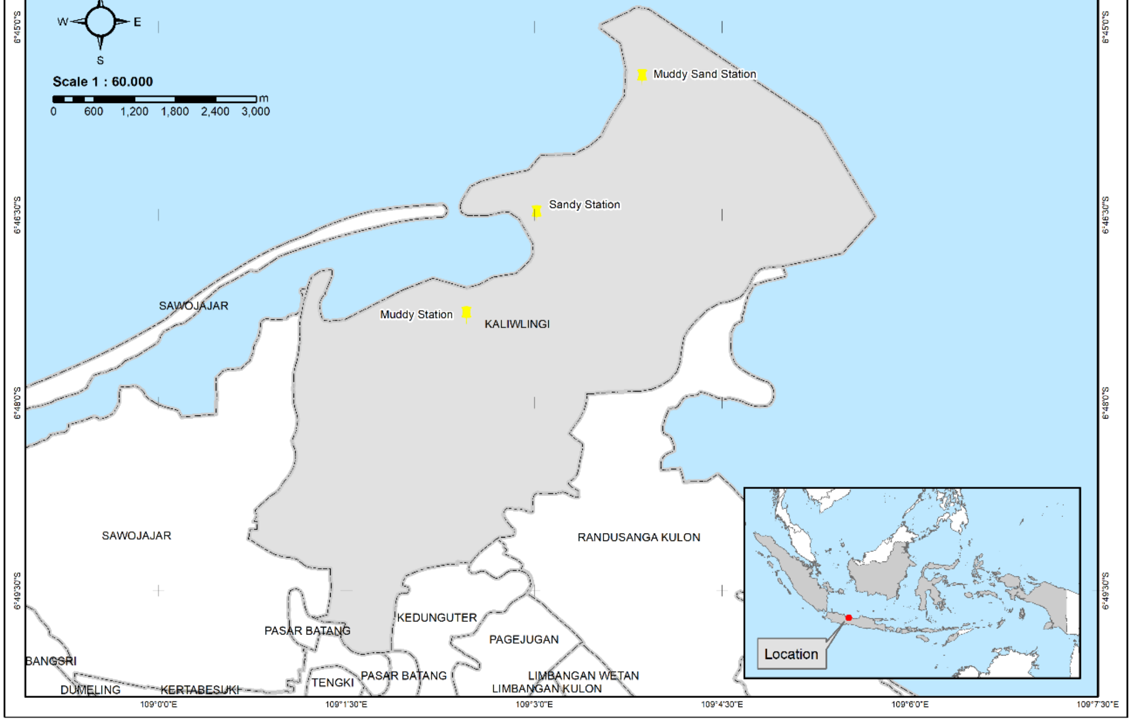

Figure 1. Research Locations in the Core Zone of the Pandansari Mangrove Forest.

Preparation

This stage began with preparing 2m x 2m transects and 60cm x 20cm x 22cm traps for mud crabs. Each observation station had 3 pieces of these tools. The number of mangroves in the area over the last 10 years was used for sampling and only locations where mangroves grew were represented.

Identification of Soil Sediment and Substrate

The organic matter sediments in the 10-year standing mangrove forest were measured for their depth. The soil substrate samples were taken from inside the observation transect by filtering and pipetting [6], [22]. The obtained sediment grains were analyzed to determine the grain size and type of sediment. The grain size was analyzed further using dry sieving and wet sieving (piping), as was done by [6], [23]. Identifying the sediment and soil substrate is a complex process and involves a variety of methods, depending on the type of sediment to be identified, the level of accuracy required, and the equipment available. The commonly used identification method was visual observation focusing on their color, texture and structure.

Mangrove Vegetation Density Check

The mangrove vegetation was checked for its density by tracing and observing the density and condition of the mangrove vegetation that was ten years old. The mangrove vegetation density was measured using the 5m x 5cm transects at each station (Sapling). The size of the 10-year-old mangrove tree trunks was measured using a length meter to ensure that the observation area became narrower to allowed the researchers to see their richness [24].

Identification of Gastropod Samples

Gastropod samples were taken from 9 points, where 3 points were taken from each station. The gastropods were sampled at low tide. Gastropod samples were preserved as evidence of research results by immersing them in a 96% alcohol solution[9], [25]. The gastropod samples were then soaked and drained twice. The first step was soaking tjem in 0.5 liters of 96% alcohol mixed with distilled water in a 1: 1 ratio for 7-8 hours. In the second stage, the samples were soaked in 96% alcohol without water for a week and then drained and dried. The gastropods were identified and calculated based on the Gastropod Class Mollusc Identification Book, including the morphology and structure of the musty shell, spire, body whorl, suture, aperture, axial ribs, spiral cord, columella, posterior canal, anterior siphonal canal, and operculum [26], under an ethical clearance number 50/KEPMEN-KP/2017.

Calculation of Gastropod and Mud Crab Abundance

The abundance of gastropods and mud crabs was calculated based on the samples found in three plots on each station's transect. The abundance of gastropods and mud crabs was calculated by dividing the number of individual gastropods or mud crabs caught in traps by the area of the sampling area [27], [28]. Only a few non-cultivated samples of mud crabs were taken from the research location. The gastropods and mud crabs were caught on the second day of the 2-day study period for several catches. In addition to the data on the density of mangrove vegetation and the abundance of gastropods and mud crabs, the water quality was also measured for its temperature, pH, and salinity.

Data Analysis

The obtained data on mangrove vegetation, gastropods, and mud crabs were analyzed using several formulas as stated by [22], [29]. The analyses covered their absolute and relative density, their absolute and relative frequency, their absolute dominance and relative dominance, and their diversity and uniformity. Included in the analyses was a visual observation. When one part of the plant or animal experienced a problem and must be solved, adjustments would be made. The research also looks at the advantages resulting from the challenges of 10 years of developing mangrove vegetation and other animals which had important elements in life.

The diversity index (H') was measured for the muddy Station I (A), the sandy Station II (B), and muddy and sandy Station III (C1). The diversity index for the three stations was classified as moderate since their values were 1-3 [27]. From a series of statistical tests and ANOVA test with SPSS, these diversity index values were normally distributed and homogeneous. Furthermore, the diversity between the observation stations was not significantly different from each other. Hence, it could be concluded that the gastropod diversity index between these stations was relatively the same and classified as medium.

Just like the diversity index, the uniformity index (E) was also measured for the muddy Station I (A), the sandy Station II (B), and the muddy and sandy Station III (C). The uniformity index (E) values generally showed varying values, yet they were still classified as high to medium at a value of 0.61–1.49 [27]. Therefore, it could be concluded that the uniformity index between stations was relatively different within a high to medium range.

Finally, the dominance index (C) was measured for the muddy Station I (A), the sandy Station II (B), and the muddy and sandy Station III (C). The dominance index was classified as low where no species dominated other species. A low dominance index indicated low concentration (nothing dominated). The results of related statistical tests and the ANOVA test with SPSS revealed that the data were normally distributed and homogeneous and that the differences between stations were insignificant.

Water Quality Observation

The water quality parameters measured were the chemical and physical key parameters of water such as: temperature, salinity, pH, and dissolved oxygen (DO). These parameters supported the life of gastropods and mangrove crabs in the mangrove ecosystem. These parameters were measured in three repetitions at each station. The temperature was measured using a thermometer dipped in water for about 1 minute. A drop of water sample was put on the hand refractometer lens to measure its salinity. Finally, the pH was measured by immersing the pH meter in the water at 3 cm depth for about 1 minute.

Results and Discussion

The Sediment and Soil Substrate at Research Locations

The sediments in the research area were derived from the organic matter and silt at the mangrove forest deposited as a result of the hydrodynamics of the coastal area. The average thickness value of the sediment at the three observation stations ranged from 52.80 cm to 69.07 cm. Station I area had the highest sediment depth value at 69.07 cm. The sediment depth of Station II was 52.80 cm, and Station III was 65.20 cm deep. The stations where the observation was done used to be ponds affected by abrasion which was then turned into a mangrove reforestation area. Hence, the mud in the area was relatively deep. The results of observation of soil substrate at each research location are presented in **Table 1** and **Figure 2.**

Table 1. Sediment and Soil Substrate at Research Location

Station	Substrate	Plot	Sediment type	Information
I	Muddy	A1	Muddy silt	Soft and dense
I	Muddy	A1	Muddy silt	Soft and dense
I	Muddy	A1	Muddy silt	Soft and dense
II	Sandy	A2	Sandy silt	Soft Particle
II	Sandy	A2	Sandy silt	Soft Particle
II	Sandy	A2	Sandy silt	Soft Particle
III	Muddy and sandy	A3	Mix	Dull
III	Muddy and sandy	A3	Mix	Dull
III	Muddy and sandy	A3	Mix	Dull

Source: Result analysis (2022).

A B C

Figure 2. Muddy, sandy, and muddy & sandy substrates.

Figure 2. The results of observation of soil substrate at each research location (A. Muddy substrate station; B. Sandy substrate station; C. Muddy & sandy substrate station)

Mangrove Forest Density

The research results on the density of mangrove forests in the 10-year-old core zone are presented in **Table 2** and **Figure 3**.

Table 2. Mangrove Forest Density Data Based on Research Results.

Mangrove type	**Density (sampling/5 x 5)**								
	Station I Muddy			**Station II Sandy**			**Station III Muddy and Sandy**		
	1st Transect	2nd Transect	3rd Transect	1st Transect	2nd Transect	3rd Transect	1st Transect	2nd Transect	3rd transect
Rhizophora mucronata	2	1	3	2	2	0	3	1	1
Avicennia marina	0	0	0	0	1	0	0	0	1

Source: Result analysis (2022)

The average number of mangrove trees at each station is 5, at 5 individuals/m2 or 4.166 ind/ha density. The results of the statistical analysis showed that no significant difference was found in the density of mangrove forests at each station.

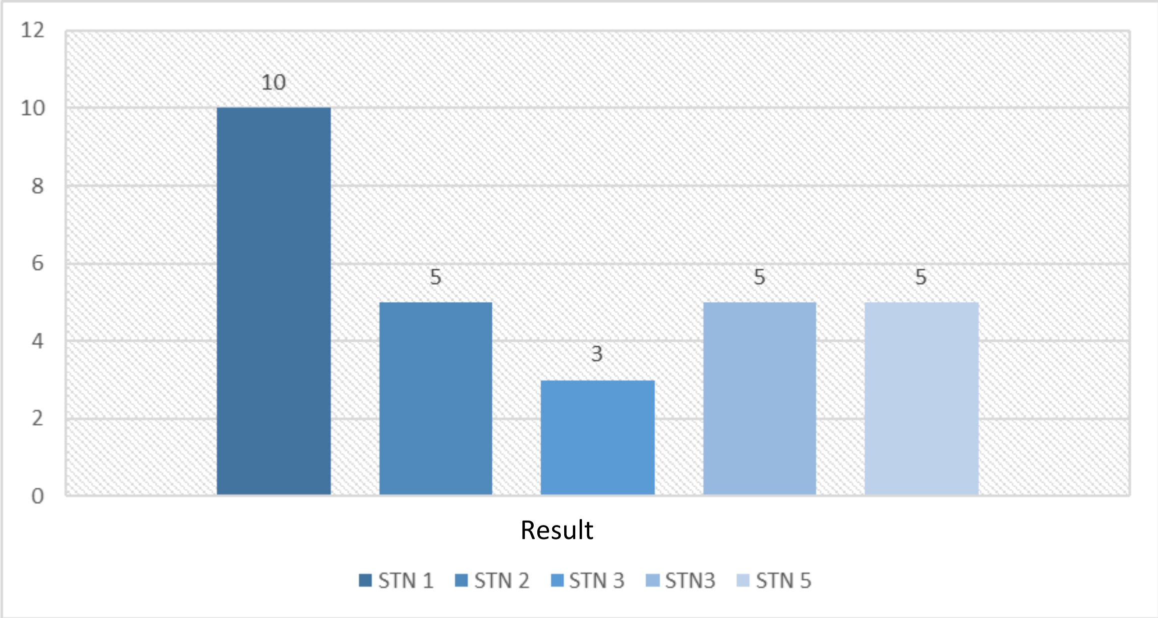

Figure 3. Mangrove Tree Density Chart at 5 Stations

The size of mangrove trees at each observation station ranged from 5.00 to 13.50 cm, as presented in **Table 3** and **Figure 4**.

Table 3. Differences in Size of Rhizophora Mangrove Vegetation Stems (cm)

Sta	**Sediment Texture**	**Mangrove tree size (cm)**					**Average**	**SD**
		1	**2**	**3**	**4**	**5**		
1	Muddy substrate	8.30	8.50	10.40	9.50	8.00	8.94	0.99
2	Sandy substrate	8.50	10.00	10.00	5.00	8.00	8.30	2.05
3	Muddy & sandy substrate	7.00	8.00	11.00	11.00	13.50	9.50	2.60

Source: Result analysis (2022)

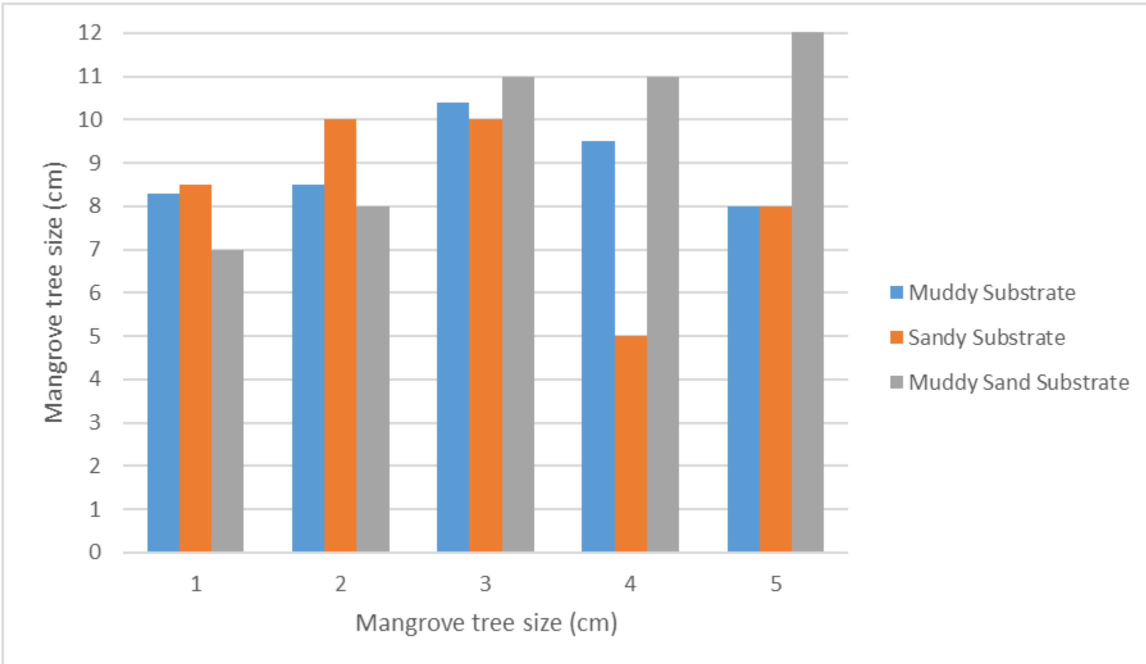

Figure 4. Mangrove Tree Size Chart at 3 Observation Stations

Gastropode Composition

The research location had two sub-classes of gastropods, i.e., Pulmonata and Prosobranchia, and four families, i.e., Ellobidae and Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found: C. auriferous and C. nucleus. From both the Littorinidae and Neritidae families, each only had one species, namely L. articulate and N violacea, respectively. Three species were found in the Potamidae family, namely C. obtuse, T. Telescopium, and T. palustris. These gastropods were found when the waters were receding. In general, the most commonly found species were from the Pulmonata sub-class of the Ellobidae family, namely C. auriferous and C. nucleus. The gastropods found at the research locatuon are presented in **Table 4** and **Figure 5.**

Table 4. Composition of gastropods found in the research location at each observation station(7 species)

No	Species	Composition/type of substrate									Amount
		Muddy			Sandy			Muddy & sandy			
		1	2	3	1	2	3	1	2	3	
1	C. aurisfelis	50	53	46	15	8	9	30	33	29	273
2	C. nucleus	55	45	59	25	17	8	28	27	23	287
3	L. articulata	8	4	6	0	1	0	5	3	0	27

4	N. violacea	2	3	3	1	1	1	2	1	2	19
		6	0	3	4	6	0	0	8	5	2
5	C. obtusa					0					8
		2	0	0	0		1	3	2	0	
6	T. telescopium		1			5					49
		7	2	9	2		0	5	3	6	
7	T. pal										23
											8
	Amount										
	Amount (										
	Amount (										
	Average/										
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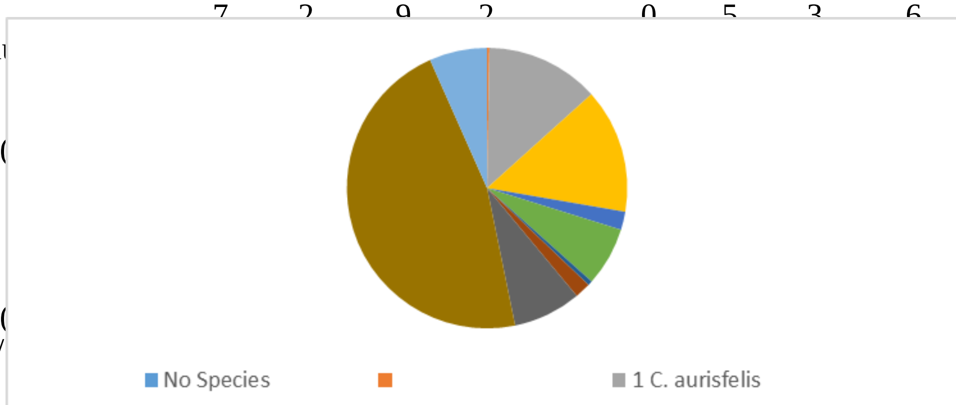

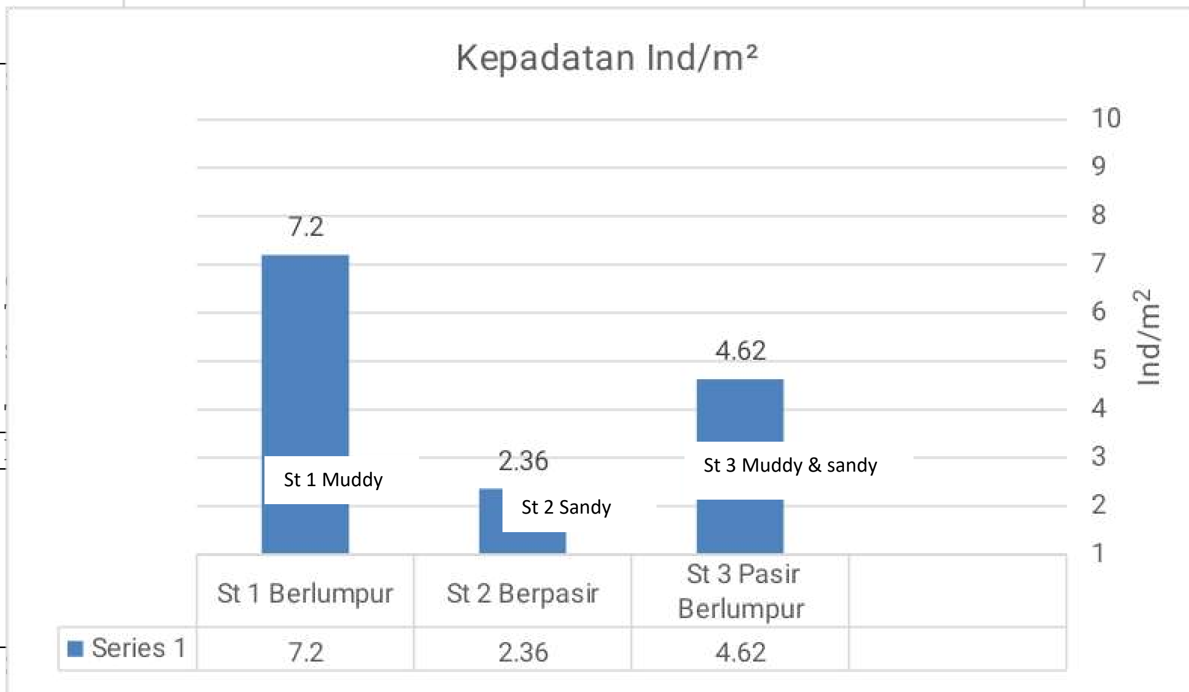

Figure 6. Density Chart for Gastropods found at the Research Location

The statistical test results showed that the density of gastropods between stations was typically distributed, homogeneous, and significantly different from each other (Sig 0.002 <0.01 with F hit = 82,965 > F tab 2.6; 0.01 = 2.305).

Gastropod Diversity, Uniformity, and Dominance Indices

The analysis results of the gastropod diversity, uniformity, and dominance indices at the research location are presented in Table 6 and Figure 7.

Table 6. The Average Diversity (H'), Uniformity (E), and Dominance (C) Indices

St 1 Muddy St 2 Sandy St 3 Muddy & sandy

No	Station	Indicator					
		Diversity		Uniformity		Dominance	
		H’	Category H’	E	Category E	C	Category C
1	Muddy	1.59	Medium	0.81	High to medium	0.227	ND
2	Sandy	1.49	Medium	0.76	High to medium	0.243	ND
3	Muddy & sandy	1.59	Medium	0.81	High to medium	0.221	ND

Source: Result analysis (2022)
Information : H’ = Wilhm (1975), E = Krebs (1985), C = Odum (1993), ND = No Density

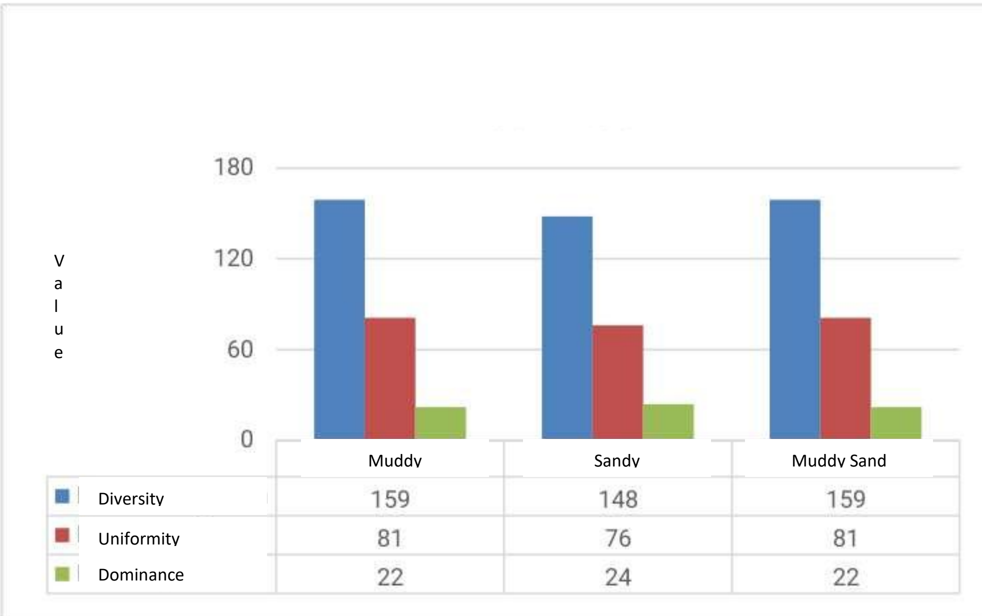

Figure 7. Chart of Diversity (H'), Uniformity (E), and Dominance (C) Indices, with value 1.0 just high value

The diversity index (H') of muddy Station I (A) was (A1) = 1.61, (A2) = 1.58, (A3) = 1.58 at an average value of 1.59. The diversity index of sandy Station II (B) was (B1) = 1.44, (B2) = 1.57, (B3) = 1.44 at an average value of 1.48. Finally, the diversity index of muddy & sandy Station III (C) was (C1) = 1.69, (C2) = 1.58, (C3) = 1.51 at an average value of 1.59. These diversity index values were classified as moderate since the values ranged from 1 to 3 (Wilhm, 1975). From a series of statistical tests and ANOVA test, the Diversity Index values were found to be normally distributed and homogeneous, and the diversity between observation stations was not significantly different from each other (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143). Thus, it could be concluded that the gastropod diversity index between stations was relatively the same as the Medium category.

The uniformity index (E) for the muddy Station I (A) was (A1) = 0.83, (A2) = 0.81, and (A3) = 0.81 at an average value of 0.81. The uniformity index for the sandy Station II (B) was (B1) = 0.74, (B2) = 0.80, and (B3) = 0.74 at an average value of 0.76. Finally, the uniformity index for the muddy and sandy Station III (C) was (C1) = 0.86, (C2) = 0.81, and (C3) = 0.77 at an average value of 0.81. The uniformity index (E) values generally showed varying values. However, they were still within the high-to-medium range at a value of 0.61–1.49 (Wilhm, 1975). The results of related statistical tests and the ANOVA test showed that the data are normally distributed and homogeneous, yet the uniformity between observation stations was relatively different (sig value = 0.153 > 0.05 or F hit = 2.604 F tab 2.6; 0.05 = 5.143). Therefore, it could be concluded that the uniformity index between stations was relatively different in the high-to-medium range.

The dominance index (C) for the muddy Station I (A) was (A1) = 0.228, (A2) = 0.227, and (A3) = 0.226 at an average value of 0.227. For the sandy Station II (B), it was (B1) = 0.253, (B2) = 0.226, (B3) = 0.251 at an average value of 0.243. And for the muddy and sandy Station III (C), it was (C1) = 0.206, (C2) = 0.230, (C) = 0.229 at an average value of 0.221. The dominance index value is classified as low where no species dominated. A low dominance index indicated low concentration (nothing dominates). The results of relevant statistical tests and ANOVA test revealed that the data were normally distributed and homogeneous and that the differences between stations were insignificant (sig value = 0.164 > 0.05 with F hit = 2.478 F tab = 2.6; 0.05 = 5.143). As a result, the dominance index between stations was relatively equal, implying that no one station had one dominant species [30], [31].

The Abundance of Mud Crabs

The number of mangrove crabs found at each observation station was the same, i.e., 2 for each observation station. The abundance of mud crabs at the research location is presented in **Table 7** and **Figure 8**.

Table 7. The Abundance of Mud Crabs at Observation Stations

No	Passive gear	The abundance of mud crabs (individuals/passive gear)		
		Station I	Station II	Station III
1	1	2	1	0
2	2	1	1	0
3	3	0	0	2
	Average	1.00	0.66	0.66

Source: Analysis result (2022)

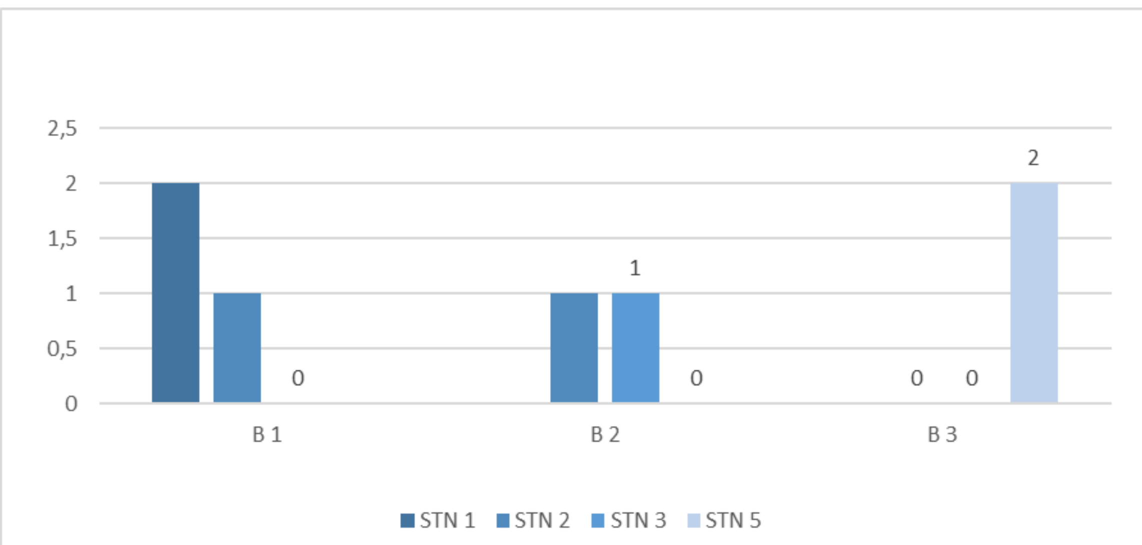

Figure 8. Mud Crab (Scylla spp.) Abundance Chart at 5 Stations

The gender of mangrove crabs caught during the study is presented in **Table 8** and **Figure 9**.

Table 8. Data of Male and Female Mud Crabs (Scylla spp.)

	Station	Gender		Amount
		Male	**Female**	
1	I	2	1	3
2	II	2	0	2
3	III	1	1	2
	Amount	5	2	7

Source: Analysis result (2022)

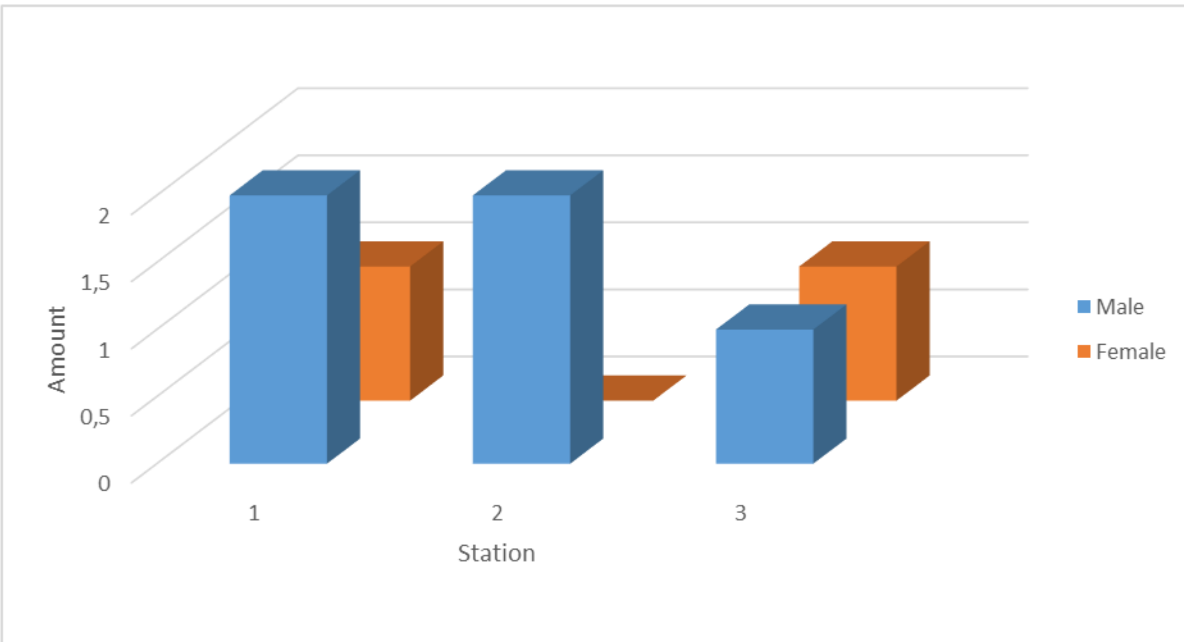

Figure 9. Mud Crab (Scylla spp.) gender found at 5 Stations

The mud crabs found at the research locations consisted of 5 male crabs and only two female crabs [32]. It was possible that this was because female crabs spent part of their life cycle in the sea, rather than in the mangrove forest [33]–[35]. After spawning with the male crabs in the mangrove forest area, they migrated to deep sea waters to lay their eggs. On the other hand, male crabs remained in the mangrove forest area, thus there were more of them in the mangrove forest area than their female counterparts [33], [36].

Carapace Growth and Individual Weight of Mangrove Crab

The carapace length and individual weight of mud crabs (Scylla spp.) found at the study site ranged from 6.5 to 8.5 cm, with individual weight sizes ranging from 48.2 grams to 117.9 grams as presented in **Table 9.**

Table 9. Data on Carapace Length and Weight of Mud Crab (Scylla spp.)

No Station	Carapace length, cm (Individual weight, grams)		
	Passive Gear 1	**Passive Gear 2**	**Passive Gear 3**

1	1	0	0	6.4 and 7.5 (48.2 and 73.5)
2	2	8.5 and 7.3 (117.9 and 63.0)	0	0
3	3	0	6.5 and 7.5 (76.8 and 50.5)	0

Source: Analysis result (2022)

Waters Quality Parameters

The water quality, which was also an essential part of the research, was measured based on the parameters used in **Table 10**.

Table 10. Results of Water Quality Measurements during the Study

No	Variable	Observation Station 1 Muddy			Observation Station 2 Sandy			Observation Station 3 Muddy sand			Optimum value (Reference)
		1	2	3	1	2	3	1	2	3	
1	Temperature (ºC0	28-29	28-29	27-29	28-29	27-29	27-29	28-29	28-29	28-29	26-32 (Hewitt et al., 2022)
2	Salinity (ppt)	26-27	25-27	25-27	27-28	27-28	27-28	29-30	29-31	29-31	15-32 (Hewitt et al., 2022)
3	pH	8.0-8.2	.8-8.0	7.9-8.1	7.8-7.9	7.6-7.8	.6-7.7	7.6-7.7	7.7-7.8	7.7-7.8	7.5-8.7 (Hewitt et al., 2022)
4	DO (ppm)	2.3-2.5	.2-2.5	2.3-2.4	2.4-2.5	2.4-2.6	.6-2.7	2.5-2.7	2.5-2.7	2.4-2.7	1.0-6.0 (Kurkute et al., 2019)
5	NO_2 (ppm)	0.08	0.08	0.07	0.07	0.07	0.08	0.09	0.08	0.08	< 0.1 (Kurkute et al., 2019)
6	NH_3 (ppm)	0.16	0.14	0.13	0.14	0.14	0.16	0.16	0.15	0.16	0.06-0.2 (Kurkute et al., 2019)
7	H_2S (ppm)	0.001	.001	0.002	0.001	0.002	0.002	0.001	0.002	0.001	< 0.002 (Kurkute et al., 2019)

Source: Analysis result (2022)

In general, the water quality parameters at the research location supported the existence of a mangrove ecosystem with associated biota, especially gastropods and mangrove crabs (Scylla spp.).

Substrate Conditions

The condition of substrate in Pandansari mangrove forest constituted one of the important ecological factors that affected the community structure and life for mollusks. This substrate also played an essential role as a habitat for foraging, reproducing, and shelter [37]. The substrate texture was a place for gastropods to stick to, crawl and walk on. The substrate contained oxygen and increased the availability of nutrients in the sediment[38], [39].

As one of the main ecological factors, the primary substrate affected macrobenthos' community structure and distribution. Macrobenthos, which had the nature of being deposit-feeding diggers, tended to exist around where they lived, either on sandy, muddy, or a mixture of the two substrates[38]. Good substrate conditions affected the development of the gastropod community because a substrate composed of sand and silt with a small quantity of clay could serve as a very suitable place for gastropods to live.

Its distribution and abundance were directly related to the size of the sediment grains under or above the gastropods [40]. Muddy sand substrate had a high oxygen supply due to the pores in the sand texture, which allowed oxygen to enter the substrate. This allowed gastropods to survive in muddy sand. Apart from being a place to live, the substrate was also a food source for some macrobenthos animals, including several types of gastropod species such as C. aurisfelis, C. nucleus, L. articulata, N. violacea, C. obtusa, T. telescopium, and T. palustris. Thanks to these conditions and the role that the muddy sand sediments and organic matter played, the land was conducive for mangrove forests to grow.

Mangrove Forest Density

According to [41], the area of mangrove forest in Kaliwlingi Village, Brebes District, and Brebes Regency in 2003 was 48.42 ha wide, then it increased in 2013 to 149.9 ha wide, and increased further in 2018 to 333.9 ha wide. This increase was the result of the mangrove reforestation. Considering its importance for mud crab habitat, this research also investigated the mangrove forest density. The results showed that the highest tree density was found at Station I, with a muddy texture of 10 trees at less than 0.5 m distance. Meanwhile, the lowest density was found at Station III, with a sandy, muddy soil texture and three trees at more than 0.5 m distance. This was possibly because the salinity at Station I was lower and optimal for mangrove vegetation to exist. Furthermore, the direct influence of waves on mangrove vegetation at Station III could erode its mangrove vegetation. However, the statistical test results showed that the density of mangrove vegetation between stations was relatively the same. This was possible since the texture of sand, mud, and a mixture of both at each observation station provided adequate and relatively the same carrying capacity for the existence and growth of mangrove vegetation [40].

The density of mangrove vegetation at the research location was still fairly good, as shown by the results of absolute density of *Rhizophora* and *Avicennia* mangrove vegetation, which made up a total of around 7,000. This was consistent [42], [43] who argued that the density of mangrove vegetation in Pandansari Hamlet, Kaliwlingi Village, Brebes District, and Brebes Regency was classified as good at 1 meter and 0.5-meter distance. The density of mangrove vegetation affected the abundance of mangrove crabs. The size of the mangrove vegetation ranged from 5.0 to 13.7 cm. Considering such condition of the mangrove vegetation, the mangrove forest in the research location could be considered "good" (as explained by the good condition ecosystem). This allowed the biota in the research location to live well in the mangrove forest, including gastropods and mangrove crabs [44].

Gastropod Composition

At the research location, there lived a class of gastropods with two sub-classes, namely Pulmonata and Prosobranchia, consisting of 4 families, namely Ellobidae, Littorinidae, Neritidae, and Potamididae. From the Ellobidae family, two species were found, namely C. auriferous and C. nucleus. One species from both the Littorinidae and Neritidae family were found, namely L. articulata and N. violacea, respectively. Three species were found in the Potamidae family,i.e., C. obtusa, T. telescopium, and T. palustris. These gastropods were found when the waters were receding.

The most commonly found gastropods were C. aurifelis and C. nucleus, both from the subclass Pulmonata family Ellobidae. This had something to do with the mangrove vegetation in Pandansari mangrove forest. The gastropods were evenly distributed in a clustered pattern in the Pandansari mangrove forest. Species likes Rhizophora and Avicennia mangrove vegetation with their family often lived on or attached to mangrove vegetation's stems, roots, and branches. These species had the tendency to be able to win the competition to get the desired food and living space compared to other gastropod species [45].

The fewest gastropods found were the Cerebralia obtuse and Telescopium Telescopium species. The difference in the density of mangroves and organic matter at each station, be it muddy, sandy, or muddy and sandy, was thought to influence the presence of these C. obtuse and T. Telescopium. As a result, they could only be found in a few plots where the density of mangrove vegetation was sparse. The rarer the density of mangrove vegetation, the less organic matter was produced to support the lives of existing gastropods. Terebralia palustris, a member of the Potamididae family, was found more frequently in stations with brackish, muddy, or mangrove waters.

Gastropod Density Index

Gastropods had the tendency of favoring coastal areas with mangroves and a relatively high density of mangrove vegetation for their habitat and place to live, just like the Pandasari mangrove forest area, which was a Mangrove rehabilitation and reforestation area. The gastropod density index values varied significantly (Sig 0.001) between stations, with gastropod density index values at the muddy subtrate of Station I averaging 7.20 ind/m2, the sandy substrate of Station II averaging 2.36 ind/m2, and the muddy and sandy substrate of Station III averaging 4.62 ind/m2. It was a possibility that the highest density index value of 7.20 individuals/m2 at Station I (muddy substrate) was because it had mangrove vegetation with better density, which was one of the producers of organic matter derived from mangrove leaf litter before being used as a food source for gastropods [21], [46], [47]. In addition, the minimum human activity in the area due to the tight rules for entering it as a protected forest zone also helped maintain the presence of gastropods on Station I. Likewise, at Station III (muddy-sandy substrate), several species of gastropods were found at an average individual density index value of 4.62 individuals/m2, which was greater than that in Station II (sandy substrate), at an average density index of 2.36 individuals/m2. It was possible that this was because the mud substrate had a fine texture and a higher nutrient content than a coarse-textured or sandy substrate since organic matter settled more easily on fine particles and was very good for the survival of gastropods[48].

Gastropod Diversity Index

The value of the Gastropod Diversity Index (H) at the research location ranged from 1.49 to 1.59, which according to [46], [47], [49] was classified as medium. The gastropod diversity index was not significantly different between the three stations (Sig = 0.163 > 0.05 or F hit = 2.491 F tab 2, 6; 0.05 = 5.143). In other words, the gastropod diversity index was relatively the same. The diversity index was influenced by the number and average density of each species of gastropod at each observation station. A community with a moderate diversity value had competitive biota-life interactions, adequate productivity, fairly balanced ecosystem conditions, and moderate ecological pressure [47]. Likewise, the species of gastropods found at each station were relatively related to the ability of gastropods to adapt to their environment, especially the muddy and sandy substrates at each observation station.

Uniformity Index

The uniformity index values between stations varied, yet they still fell into the high-to-medium range. The gastropod diversity index between stations was not significantly different (Sig = 0.153 > 0.05 or F hit = 2.604 F tab 2, 6; 0.05 = 5.143), thus it could be said that the gastropod uniformity index between stations was relatively the same. The high-to-medium uniformity index values was likely because of the relatively small number of gastropods at each observation station. Furthermore, this might be because the gastropods had limited adaptability to their environment [17].

Gastropod Dominance Index

Each observation station's average dominance index value ranged from 0.221 to 0.243. Based on the Simpson’s dominance index, any value close to 0 meant that almost no gastropod species dominated the area. This was possibly because the food availability was sufficient and the environmental condition was favorable to support the lives of existing gastropod species. This non-dominance of any species in the area would result in moderate to high species diversity. The gatropod dominance index was not significantly different (Sig = 0.164 > 0.05 or F hit = 2.478 F tab 2, 6; 0.05 = 5.143), meaning the dominance index between stations was relatively the same. A possible cause was that the each gastropod species had relatively similar adaptability to its environmental conditions.

Abundance and Body Size of Mud Crab (Scylla spp.*)*

The mud crabs caught in the study were five male and two female mud crabs possibly because the male ones spent more of their lives in the waters of the mangrove forest, which had more abundant food for them than the open sea. In addition, mangrove vegetation was a haven from various environmental factors, such as sea waves [50], [51]. The less significant number of female mangrove crabs in mangrove forests was because they did not spend their entire life in the mangrove forest. They migrated to deep sea waters to lay their eggs after mating with the male crabs in the mangrove forest area. Furthermore, the female mud crabs returned to the forest area again to take shelter after laying their eggs until their egg-laying time [18], [52].

The mud crab was a marine biota whose life depended on the presence of mangroves. The research was conducted at the core zone of 10-year-old stands. Mangrove forests had at least two zones: the core and outer zones. The former was generally located close to the sea and river mouths and had relatively dense mangrove vegetation compared to the outer one, around ponds. This zone division was quite influential in the survival of mangrove crabs. According to [44], [49], the division of mangrove zones dramatically affected the survival of the mangrove association biota, including mangrove crabs in each zone.

The research was conducted in a 10-years old mangrove forest area resulting from a reforestation activity. This reforestation allowed a dense mangrove vegetation, supported by sedimentation and organic matter from the sea and the Pemali River at its estuary. Organic matters became a food supply for mud crabs and existing gastropods. The river mouth was also one of the doors for the entry of young crabs from the sea to reach the mangrove forest to continue their lives. This allowed the mangrove crabs to live in it and fulfil their needs. Only seven individual mud crabs were obtained from the three observation stations with a 2m x 2m transect area per station. It was possibly because the environmental conditions at the research location were disrupted by high tides that entered the research location area. This made the mangrove crabs move to another safer location. Thus, some mangrove crabs also partly found in the outer zone, around the pond area, which had also grown quite a lot of mangrove vegetation due to the reforestation, especially in the pond bunds. According to [5] mud crabs preferred to be in the outer zone of ponds, where they could continuously be exposed to water and lots of food and which served as places of refuge for crabs from all threats, such as environmental hazards. Due to the relatively small number of mud crabs, the statistical test results showed that the abundance of mud crabs is relatively the same.

The carapace length of the mud crabs ranged from 6.4 cm to 8.5 cm, with an individual weight of 48.2–117 grams. The mud crab carapace length and individual weights were not significantly different between stations, possibly because the condition of the mangroves at each station was also relatively the same. Hence, the growth of the mangrove crab carapace was also relatively the same. When matured, mangrove crabs had a relatively large body size with a carapace length of up to 8.5 cm [46].

Water Quality Parameters

In general, the value of each water quality parameter for all stations showed promising results in supporting gastropod life. The water temperature at all research stations ranged from 26°C to 29°C. Differences in the intensity of sunlight penetration, tides, and the presence or absence of mangrove plants were caused by temperature difference. The tolerable temperature for the development and reproduction of gastropods was 0°–480°C [24], [37], [53], while mud crabs could tolerate a temperature range of 12–35°C.

The water salinity at all observation stations ranged from 25 to 31 ppt. Low salinity was found at Station I on a muddy substrate, and higher salinity was found at Station III on a muddy and sandy substrate. This was because Station I was located in the ecotourism area closer to the upstream area. Hence, its salinity level was slightly lower than other stations. Station III was located closer to the sea, thus its salinity level was high [24]. Mud crabs could survive at a 10–30 ppt salinity, but they could grow and develop well in the 15–35 ppt range.

The pH value of the water at all observation stations ranged from 7.6 to 8.0. This pH range of the water was classified as optimum, namely 7-8 for gastropod to live [54]. Gastropods did not like too acidic areas because it would damage their shell structure.

Meanwhile, the dissolved oxygen in Pandansari mangrove forest area ranged from 2.4–2.7 mg/l. According to [53], a dissolved oxygen content of 2.4–4 ml/l was sufficient to support macrobenthos life, such as gastropods. NO2, NH3, and H2S at the research location were still within the permissible limits for aquaculture activities. The maximum tolerance limits for N2, NH3, and H2S concentrations for aquaculture activities were 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively [53].

Feasibility of Silvofishery System for Mangrove Crab Cultivation Activities

The communities around the mangrove forest played an important role to make the ecosystem sustainable. It was, therefore, necessary to involve local communities to manage mangroves sustainably. And one attempt to do this was using the silvofishery system for mud crab cultivation [32]. Silvofishery was the utilization of mangrove forests combined with fishery commodities. The basic principle of silvofishery was to protect mangrove plants while providing yields for the community from the fishery commodity. This system could increase people's income while still taking care of the sustainability of mangrove forests[52], [55], [56].

The primary substrate in Pandansari mangrove forest area (Kaliwlingi Village. Brebes District, Brebes Regency), with 10-years old mangrove stand, was sand and clay sediments. In addition, the sediment was also enriched by the presence of organic matter from the mangrove forest and precipitated mud due to the hydrodynamics of the coastal area. The thickness of the sediment was relatively large at 52.80–69.07 cm. This was because it was in what used to a pond location affected by abrasion. The former pond was then used as a mangrove reforestation area. The substrate condition allowed gastropods to live and provided natural foods for mud crabs. Other than that, the sand sediment, muddy clay, and the presence of organic matter in the soil made the land conducive for the mangrove forest to grow and develop. The mangrove vegetation at the research location resulted from the reforestation at 0.5–1 meter distance between trees. Meanwhile, the size of the mangrove vegetation was 5.0–13.7 cm. Considering this condition of mangrove vegetation, the mangrove forest in the research location could be considered good to allow the biota in the research location to live well, including gastropods and mangrove crabs.

In general, the value of each water quality parameter for all observation stations showed good results to support the life of mangrove vegetation, gastropods, and mangrove crabs. The water temperature ranged from 260°C to 290°C. This range of temperature was still within the optimal range for the life of gastropods, namely 0°C to 480°C, and for the life of mud crabs, namely 12°C to 35°C [24]. The water salinity ranged from 25 to 31 ppt. The pH value of the water ranged from 7.6 to 8.0, which was still within the optimum range for gastropod life, namely 7-8, and mangrove crabs, namely 7 to 9. The dissolved oxygen ranged from 2.4 to 2.7 mg/l.Again, this was still within the range that could support gastropod, namely 2.4–4 ml/l and crabs. The values of NO_2, NH_3, and H_2S at the research location were still all within the allowable limits for aquaculture activities. The maximum concentration limits of N_2, NH_3, and H_2S that could still be tolerated for aquaculture activities were 0.1 ppm, 0.06-0.2 ppm, and 0.002 ppm, respectively [36].

Conclusion

This study investigated the silvofishery potential of a 10-year-old restored mangrove forest in Brebes, Indonesia. The research focused on the relationship between mangrove conditions, gastropod abundance, and mud crab populations in different sedimentation zones. The results demonstrated that the mangrove forest could support diverse marine life and provide significant ecological and economic benefits. By integrating silvofishery practices, local communities could sustainably utilize mangrove resources while preserving the ecosystem. The study highlighted the feasibility of restoring degraded mangrove ecosystems for both ecological and socio-economic purposes.

CRediT authorship contribution statement

Suyono: Conceptualization, Formal analysis, Investigation, Project administration, Software, Validation, Writing – original draft. **Alin Fithor**: Data curation, Funding acquisition, Methodology, Resources, Supervision, Visualization, Writing – review & editing.

Data availability statement

[Standardized datatype] data have been deposited at [datatype-specific repository (http://repository.upstegal.ac.id/id/eprint/10037)] with accession numbers [10037]

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by (Directorate of Research, Technology, and Community Service, Ministry of Higher Education, Science, and Technology Republic of Indonesia) and (Pancasakti University, Tegal) with ID Research fund - 0557/E5.5/AL.04/2023. Authors would also like to thank the editor and respected reviewers for their valuable comments.

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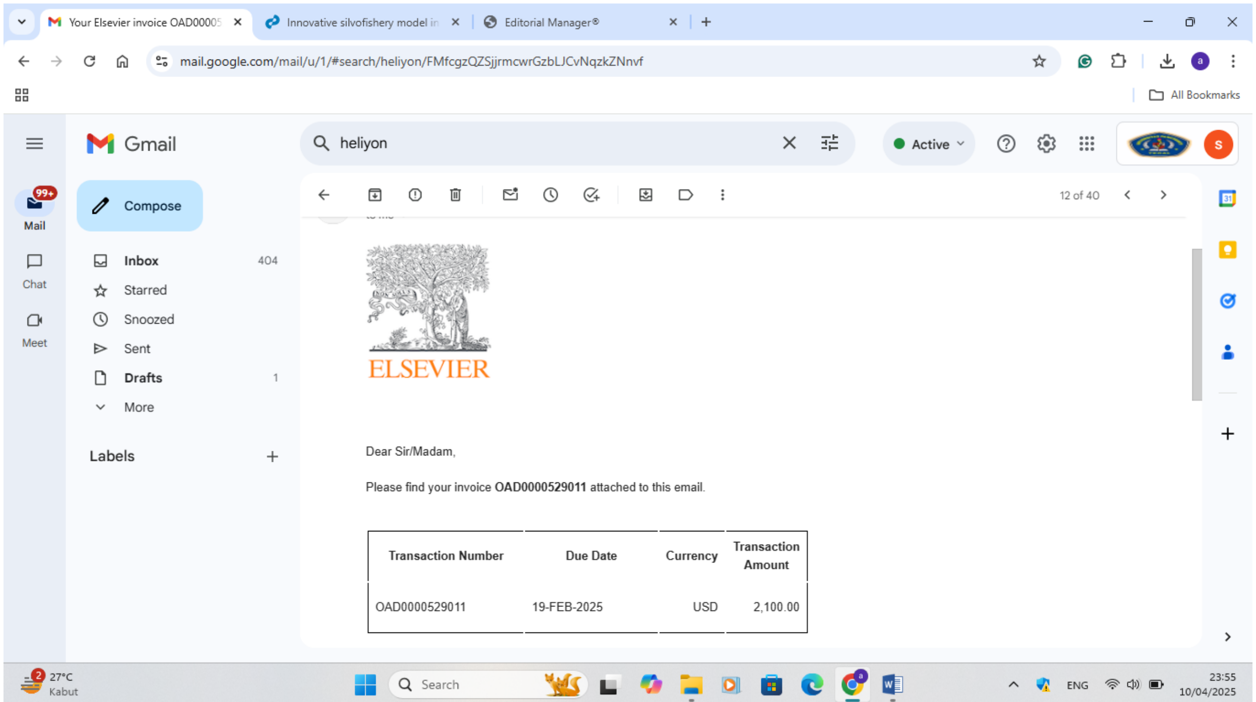

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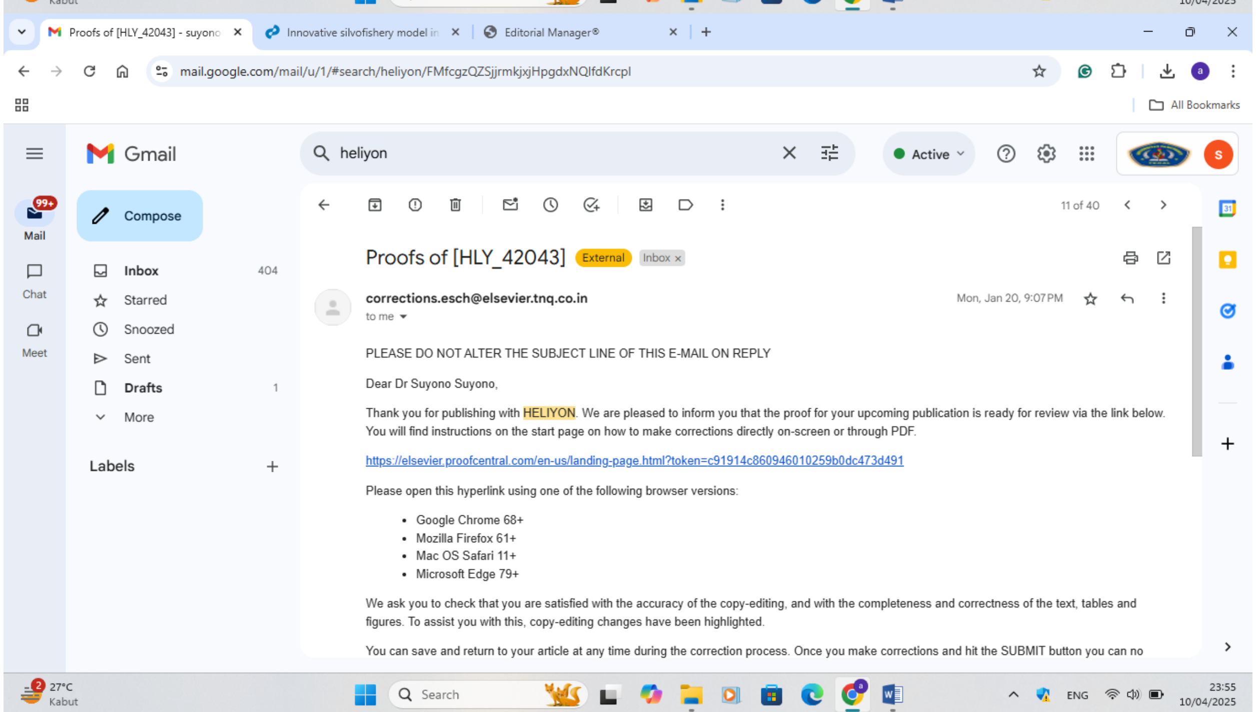

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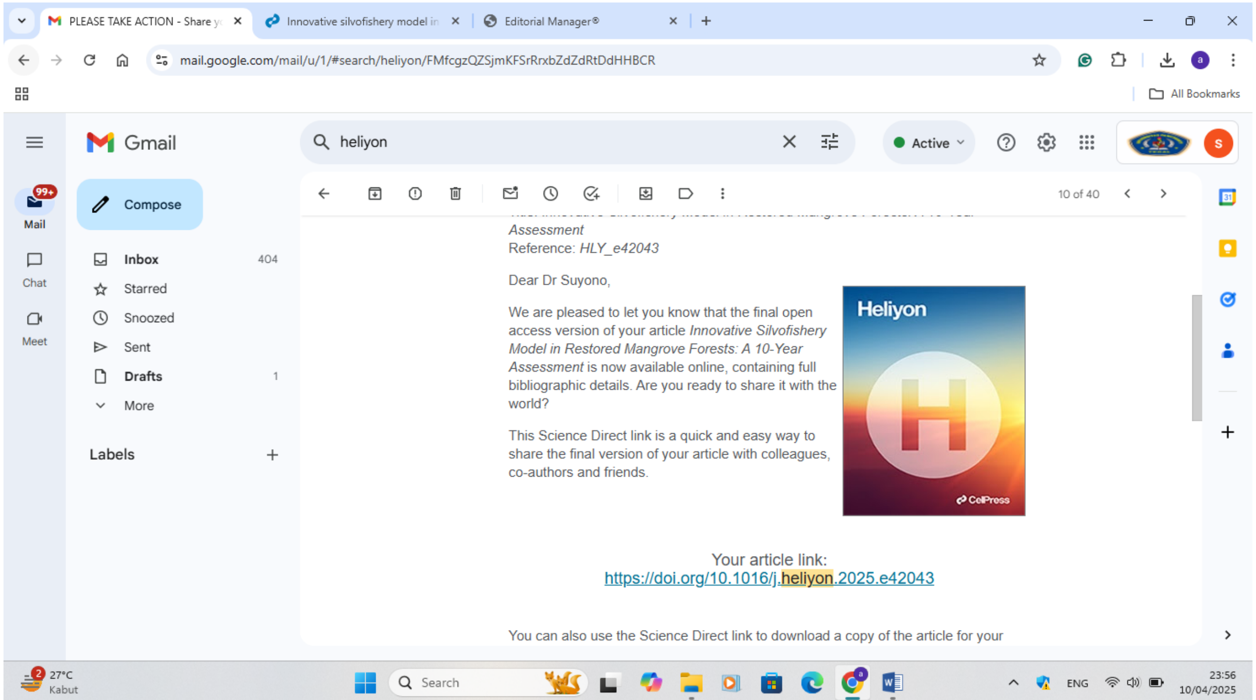

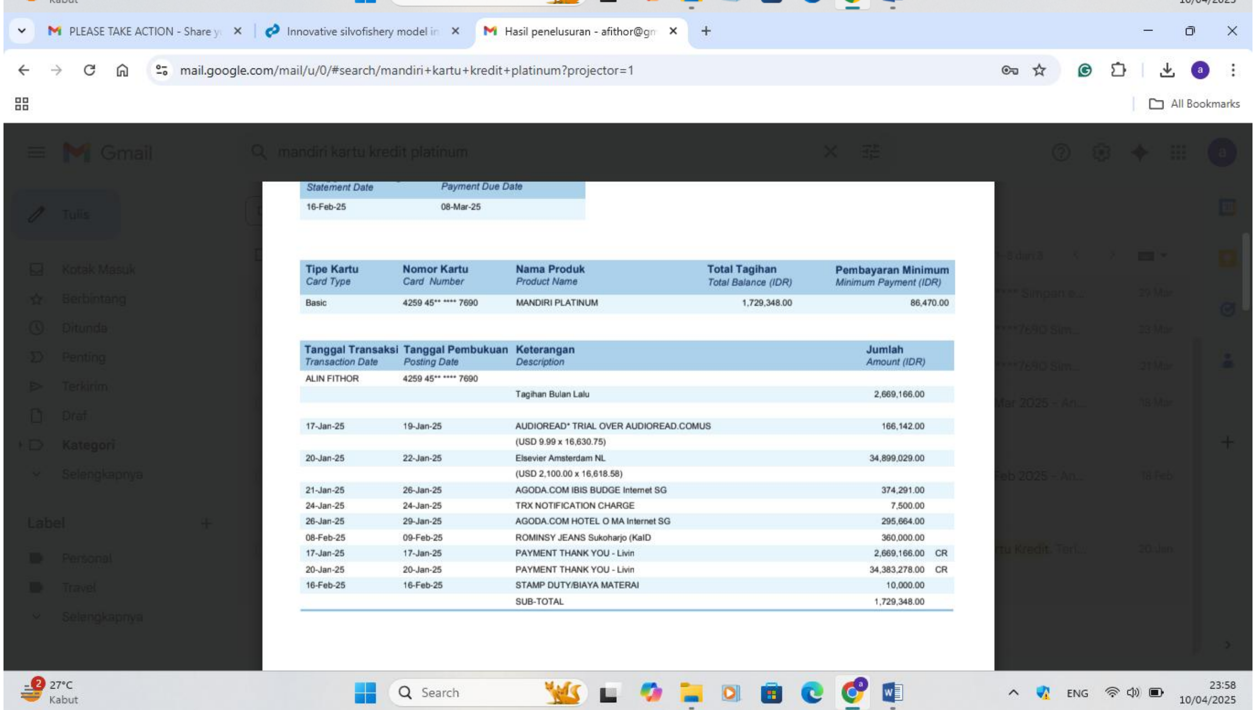

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