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Association between Mangrove Types and Some Mangrove Crab Species in West Lombok Sheet Mangrove Ecosystem

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Abstract: One of the ecosystems found in coastal areas is the mangrove ecosystem. Mangroves have many functions including as a shelter, a place to find food, a breeding ground for aquatic biota. Damage to mangrove areas can cause a decrease in the quality of mangrove ecosystems, especially for the life of mangrove crabs. Mud crab is one of the aquatic biota associated with mangroves and its life is influenced by the presence of mangrove forests. Therefore, the purpose of this study was to determine the diversity of mud crabs that live in mangrove ecosystems and the association of mangrove species with several species of mud crabs in the coastal mangrove ecosystem of Lembar, West Lombok. Mud crab samples were taken using purposive sampling by looking at the density of mangroves in each observation plot. The collected data were analyzed by diversity index, ecological index, association and Pearson's correlation coefficient. Then a simple linear regression analysis was performed with the variable (x) density of mangroves and (y) density of mangrove crabs. The results of this study were found to be 10 species of mud crabs consisting of 2 families of Ovalipidae and 8 families of Portunidae which belong to the moderate diversity index. There were 2 species of mud crabs that were positively associated with 2 species of mangroves out of 10 species of mud crabs found. Linear regression equation y = 0.2482x + 0.0004 with a pearson correlation coefficient (r^2) (0.58). The conclusion of this study is that there is a relationship between mangrove density and mangrove crab density.

Keywords: Mud crab density; Diversity; Association

Introduction

Mangroves are a community of plants that grow in tropical and subtropical regions around the world (Subur & Sarni, 2018). In addition, mangroves live in coastal areas around river mouths which are affected by tidal currents (Sipahelut et al., 2020). Therefore, mangroves are considered as one of the ecologies that are unique to the ebb and flow (Karimah, 2017). Furthermore, the pH tolerance limit to support mangrove growth ranges from 6 to 7 (Dewi & Herawatiningsih, 2017). Meanwhile, the optimal temperature for mangrove ecosystems ranges from 28-31°C (Imamsyah et al., 2020). This temperature affects the increase in mangrove leaf production, the optimal temperature for leaf production in Rhizopora sp species is 28-32°C (Aini et al., 2016), whereas, Avicennia sp species grows optimally at temperatures of 18-20°C (Alwidakdo et al.,2014).

The diversity of mud crabs can be associated with mangroves as their habitat (Yonvitner et al., 2019). This is because mangroves have a biological function as a place of refuge, spawning, and a place to find food (Saputri & Muammar, 2019). Mud crab is one of the animals that live in mangroves. Furthermore, the types of food for mangrove crabs are algae, rotting leaves, animal carcasses, fish, plankton, and other animals and they eat everything (Adila et al., 2020). Mud crabs utilize mangrove substrates for spawning, as well as for changing their skin (Septiani et al., 2019). Thus, mangrove crabs are associated with mangroves (Syahrera et al., 2016).

The number of mud crab species is caused by mangrove vegetation (Tarumasely et al., 2022). In

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addition, the low diversity index of mangrove crabs is also caused by the tidal factor (Kusuma et al., 2021). And most of the damage to mangroves is caused by human activities (Ritohardoyo & Ardi, 2014). Efforts to improve mangrove recovery are carried out namely conservation and restoration activities (Utomo et al., 2018). In addition, restoration activities can restore the condition of mangroves naturally to meet the food needs of mangrove crabs (Eddy et al., 2019). For example, restoration results may increase the mangrove crab species. However, mangroves are not a factor that can affect the diversity of mud crabs. However, the distribution and species richness of restored mangroves is very favorable for mud crab species (Ismail et al., 2019).

Other evidence of the increase in mangrove species can affect the increase in mangrove crab species (Sulistiono et al., 2021). In addition, the results of mangrove conservation in the Bagek Kembar mangrove ecotourism area, West Nusa Tenggara are habitat for mangrove crabs (Dyani & Citra, 2021). However, research on the Association between Mangrove Types and Several Mud Crab Species in the West Lombok Sheet Coastal Mangrove Ecosystem needs to be carried out. Therefore, the aims of this research are to describe the diversity of mud crab species that live in the coastal mangrove area of Lembar, West Lombok, and to describe the association of mangrove species with several species of mud crabs in the coastal mangrove ecosystem of Sheet, West Lombok.

Method

This research was conducted in the coastal mangrove area of West Lombok Sheet in May 2023 Figure 1.

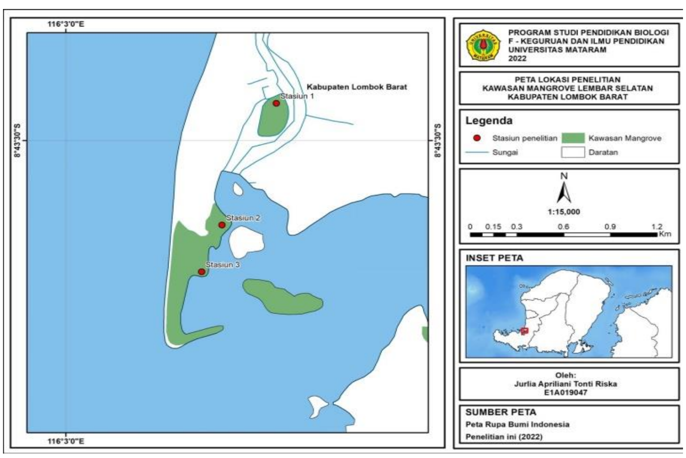

Figure 1. Research Location

The tools and materials used in this study were as follows: 1 x 1 m plot, thermometer, GPS, pH meter, salinometer, soil meter, digital camera, folding container, plastic ziplock, label paper, gloves, raffia rope, 70% alcohol, blackboard. The population in this study was the mangrove crab community found in the coastal mangrove area of Lembar, West Lombok, and the sample used was mud crabs which were in an observation plot located on the coast of Lembar, West Lombok. There are 3 stations used. Furthermore, the determination of the transect in this study used the Purposive Sampling method. Purposive sampling is a technique that has certain considerations in using it (Hartoko et al., 2013). The considerations used are the dominant mangrove groups, namely the genera *Rhizophora, Sonneratia, and Avicennia* (Zamroni & Rohyani, 2008). Furthermore, each location consists of 3 transect lines placed perpendicular to the shoreline 100 m long with a distance of 50 m between adjacent transects (Figure 2) (Ruru et al., 2023).

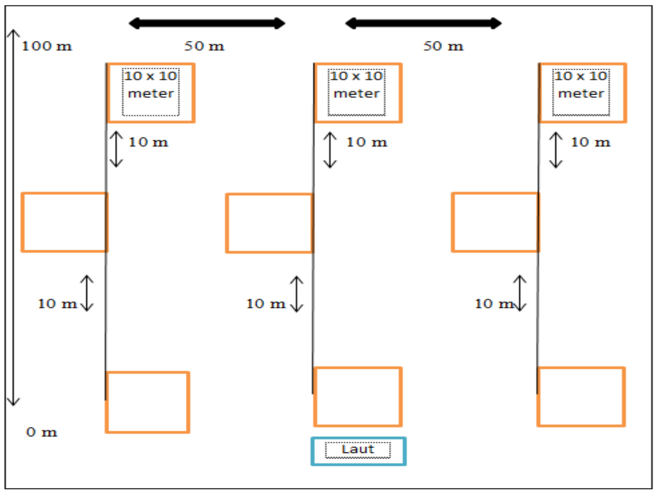

Figure 2. Transect Line Drawing

Data collection on mangrove vegetation was taken at each transect with a distance of 50m between transects consisting of 3 plots with a size of 10 x 10 m. Furthermore, the distance between plots is 10 m, each plot records mangrove vegetation data based on the name of the species, the number of individuals/species and the diameter of the trunk (Wintak, 2018). Furthermore, the environmental parameters measured were water pH, DO, water salinity, phosphate and nitrate.

Mud crab samples were taken from each transect in each plot. Meanwhile, sampling used fishing gear, namely folding traps measuring 45 x 30 x 15 cm (Zulkarnain et al., 2019). And mangrove crabs were collected from 08.00 to 16.00 WITA using chicken meat as bait. Next, the mud crabs obtained were put into ziplock plastic to be identified. Meanwhile, all species found are documented or photos taken to be observed in detail. Folding trap fishing gear in Figure 3.

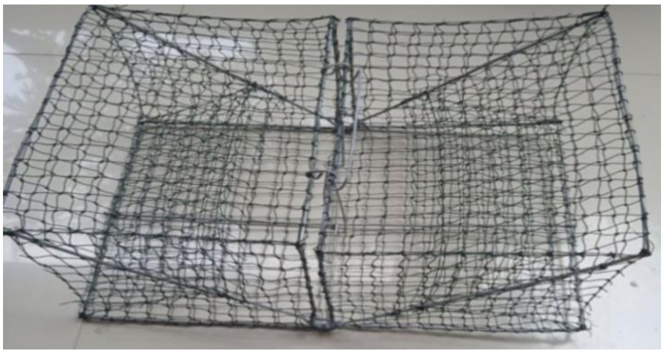

Figure 3. Folding Trap Fishing Gear

The analysis of the data used in this study that is:

1. Density

Mangrove density is measured using the Formula 1 (English et al., 1994):

$$K=\frac{number\ of\ individuals\ of\ a\ species}{sample\ area} \quad (1)$$

2. Shanon-Wienner Diversity Index

The diversity index is used to measure the biodiversity of the biota studied. The species diversity index is calculated based on the Shanon & Wienner Formula 2 (Krebs, 1994):

$$H' = -\sum pi \ln pi \quad (2)$$

$$pi = ni/N$$

Description:

H'= species diversity index

ni = the number of individuals of the i-th species

N = total number of all individuals

3. Uniformity Index

The species uniformity index is calculated using the Formula 3 (Odum, 1994):

$$E= \frac{H'}{\ln S} \quad (3)$$

Description :

E = uniformity index

H'= species diversity index

S = number of species

4. Simpson's Dominance Index

The dominance index is used to determine the level of dominance of a species in a community using the Formula 4 (Odum, 1994):

$$C= \sum (ni/N)^2 \quad (4)$$

Description :

C = dominance index

ni = number of individuals of each species

N = total number of individuals

5. Association

Determining the tendency of association of two species refers to Ludwig & Reynolds (1998) using the 2x2 contingency table method which can be seen in Table 1.

Table 1. 2 x 2 Contingency Table

		Species b		
		Ada	tidak ada	
Species a	Ada	a	b	m = a + b
	tidak ada	c	d	n = c + d
		r = a + c	s = b + d	N = a + b + c + d

Description:

a = number of sample units containing species a and species b

b = number of sample units containing species a only, b is not present

c = number of sample units containing species b only, a is not present

d = number of sample units that do not contain species a and species b

N = number of observation sample units (N=a+b+c+d)

Result and Discussion

Mangrove Species Composition

The results showed that the composition of the mangrove species found in Cemare hamlet, Lembar District, West Lombok Regency consisted of 4 families, namely *Mirsinaceae, Acanthaceae, Rhizophoraceae, and Sonneratiaceae* (Figure 4). The family *Rhizophoraceae* consists of the genus *Rhizophoracea (R. apiculata, R. mucronata, R. stylosa),* the family *Acanthaceae* consists of the genus *Avicennia (A. marina, A. lanata),* and the family of *Sonneratiacea* consists of the genus *Sonneratia (S. alba)*, the family of *Mirsinaceae* consists of the genus *Aegiceras (A. corniculatum).*

The mangrove species that had the highest number of individuals was the genus *Rhizophora* species *(Rhizophora mucronata)* (47%). Furthermore, from the genus *Avicennia* species *(A. marina)* as much (15%). Meanwhile, species from the genus *Sonneratia (S. alba)* have the lowest number of species (4%). These results are in line with the opinion (Candri et al., 2018) indicating that the mangrove vegetation in Cemare West Lombok has the dominant species on Lombok Island, namely mangrove species from the genera *Rhizophora, Avicennia, Sonneratia.* mangroves from the genera *Rhizophora, Avicennia, Sonneratia.*

The mangrove species composition of *Rhizophora mucronata* is in the high category because areas with suitable substrates for this species grow and develop in areas that are more tolerant of muddy sand substrates. Optimal growth of this species occurs in deep waterlogged areas. As for the composition of mangrove species which are in the low category in species *(A. marina)* and *(S. alba*) it is suspected that these pioneer species grow in the surrounding area on a type of substrate that is not often inundated with water or affected by sea tides.

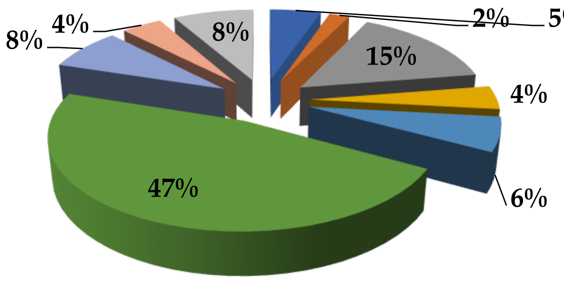

Figure 4. Mangrove Species Composition

Diagram on the West Lombok Sheet coast

Description :Dark blue color species *(Aegiceras corniculatum*); species carmine (*Avicennia lanata*); species dark green (Avicennia marina); species purple *(Ceriops tagal*); light blue species *(Rhizophora apiculata*); species orange color *(Rhizophora mucronata*); species gray (*Rhizophora stylosa*); species pink (*Sonneratia alba*); light green species (*Sonneratia caseolaris)*

Density, Frequency and Significant Value Index
a. Mangrove Tree

The relative density values of mangrove trees in the study area are presented in (Figure 5). It can be seen that the highest relative density was *Rhizophora mucronata*, which was 58.3%, while the lowest relative density was *Sonneratia alba,* which was 4.16%. The relatively high density of mangroves in a large area to live so that they can develop well up to areas close to the coast as long as they still get a food supply such as water from the sea.

The highest relative frequency value of mangrove trees was *Rhizophora mucronata* with 36.36% (Figure 5). Meanwhile, the lowest frequency at the tree level was Rhizophora stylosa and *Sonneratia alba* as much as 9.09%. The large number of species of *Rhizophora mucronata* is caused by the condition of the substrate in the study site in the form of muddy sand.

The same research was conducted on tree-level mangrove vegetation in the Sereweh bay area of East Lombok, where 2 families were found, namely *Rhizophoraceae* and *Sonneratiaceae*, among these families there was an even distribution of *Rhizophoraceae* species (Rahman et al., 2019). In particular, many species of *R. apiculata, R. mucronata, R. stylosa* were found because they were on muddy substrates.

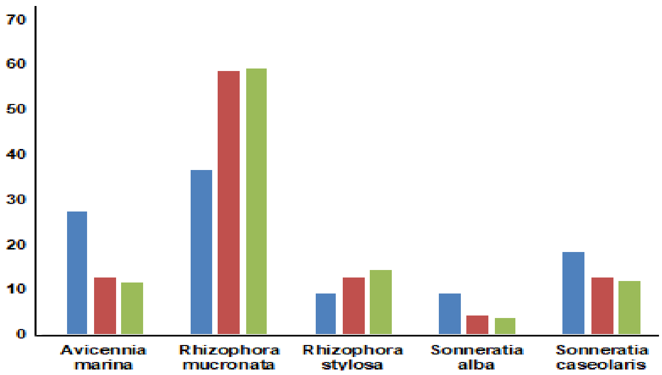

Figure 5. Density and Dominance Frequency on the Sheet coast of West Lombok

Description: Blue beam (frequency (F); red beam (Density (E)); green block (dominance (C))

The importance value index is calculated based on the dominance level of mangrove species in the study area (Figure 6). The high importance value index was observed from the tree level of the species *Rhizophora mucronata* 153.7%. While the lowest importance value index is owned by the mangrove species Sonneratia alba 16.72%. The high importance value index is caused by the soil substrate, namely silt and sand. The difference in the important value index is caused by the presence of sunlight and nutrients from the soil at each station.

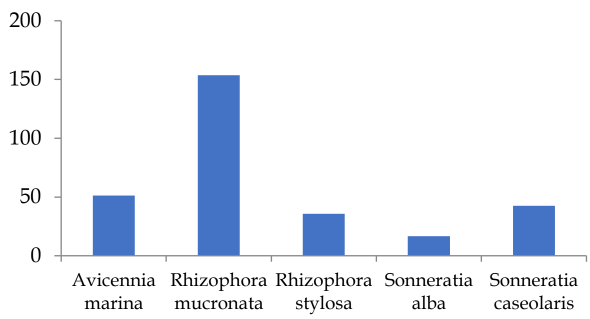

Figure 6. Mangrove Important Value Index on the coast of West Lombok Sheet

b. Sapling Mangrove

The highest relative density value of mangroves at the sapling level was *Rhizophora mucronata* 55.12% (Figure 7). Meanwhile, the lowest relative density of *Ceriops tagal* is 0.97%. The relatively high density of *Rhizophora mucronata* is due to its sandy and muddy soil substrate which allows mangrove species to grow well. In addition, the relative density of *Rhizophora mucronata* species can generally grow well if the soil conditions range from silt to sandy mud.

The relative frequency value of mangroves with a high sapling level observed was *Rhizophora mucronata,* which was 42%. Meanwhile, the lowest relative frequency of *Aegiceras corniculatum, Avicennia lanata, Ceriops tagal, Rhizophora apiculata,* and *Sonneratia alba* is 2%. The causative factor of the high relative frequency of *Rhizophora mucronata* mangrove species in this study other than the substrate is the pH of the waters. Thus, *Rhizophora mucronata* is a very good growth factor, most of the biota can live around this species because the pH is quite good, which is around 7-8.5.

The same study was conducted on mangrove vegetation at the sapling level in the Cempi Bay area of Sumbawa, and found the dominating family, *Rhizophoraceae* (Nasiti et al., 2015). This family has an evenly distributed distribution of *Rhizophora mucronata* and *Sonneratia alba* species. In particular, many species of *R. apiculata, R. mucronata, R. stylosa* were found because they were on muddy substrates.

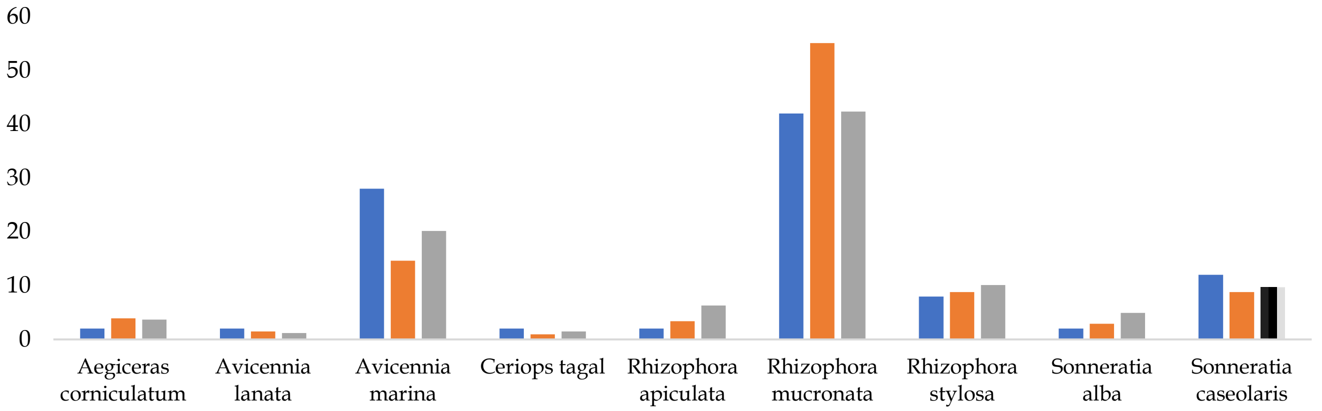

Figure 7. Frequency of Density and Dominance of Mangrove on the coast of West Lombok Sheet
Description: Blue beam (frequency (F)); red beam (Density (E)); green block (dominance (C))

Important value index analysis was calculated based on the dominance level of mangrove species in the study area (Figure 8). The significance value of the tree level of the species *Rhizophora mucronata* is 139.5%. Meanwhile, the lowest importance value index was owned by the Ceriops tagal mangrove species with 4.46%. The high importance value index is not far from the environmental resources around mangrove species, both from the soil substrate, namely mud and sand. Likewise, the substrate can be found at all research location stations.

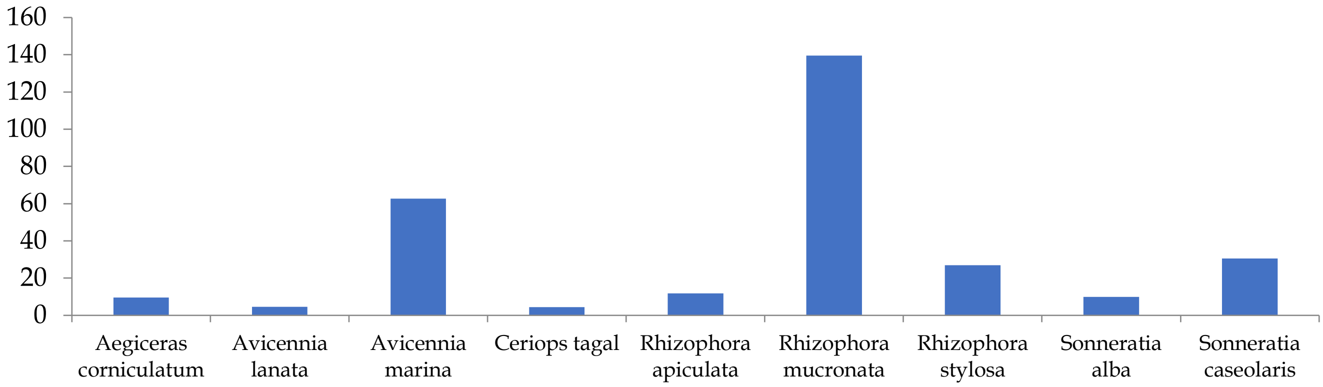

Figure 8. Mangrove Important Value Index on the coast of West Lombok Sheet

Mangrove Ecological Index

The ecological index value at station 1 shows the value of diversity (H') as much as (0.78%) is categorized as low, closeness (E) as much as (0.71%) is categorized as high, dominance (C) as much as (0.54%) is categorized as medium, and species richness (R) as much as (0.46%) is categorized as low. Furthermore, at station 2, the value of diversity (H') was (1.56%) in the moderate category, evenness (0.87%) was in the high category, dominance (C) was (0.44%) in the low category, and species richness (R) was (1.14%) in the low category. Whereas at station 3, the value of diversity (H') was (0.99%) categorized as low, evenness (E) was categorized as low (0.61%), dominance (C) was (0.50%) categorized as medium and species richness (R) was (0.89%) categorized as low (Figure 9).

The categories of high and low diversity are influenced by several factors, especially the level of uniformity and dominance values. This opinion is also the same as the statement by Agustini et al (2016) that if the dominance index is high, then only one species dominates. But if the dominance index value is low, then there are only a few species of dominance.

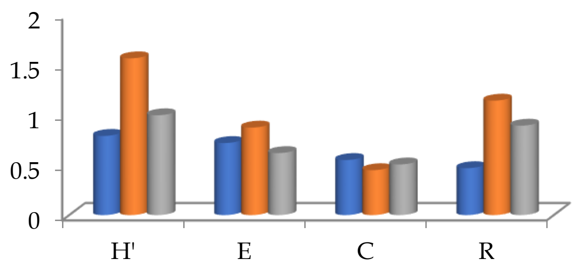

Figure 9. Mangrove Ecological Index on the Sheet coast of West Lombok

Description: Blue beam (station 1); red beam (station 2); green beam (station 3)

Composition of Mangrove Crab Species

The results of this study showed that there were 2 families of mud crabs namely *Portunidae* and *Ovalipidae.* Furthermore, 10 species of mud crabs found in mangroves were the species *Callinectes, Liocarcinus holsatus, Necora pubescent, Portunus tritubercalatus, Portunus sanguinolentus, Portunus pelagicus, Ovalipes australiensis, Ovalipes sp* and 2 of *them Scylla serrata* and *Scylla olivacea* were observed. Furthermore, the highest number of species was from the *Portunidae* family *namely Scylla serrata* as much as 46.2%. Meanwhile, the family of *Ovalipidae species Callinectes, Liocarcinus holsatus, (Ovalipes australiensis, and Ovalipes sp)* showed the lowest number of species at 2.98%. Furthermore, the highest number of individuals observed was from the family *Portunidae,* the species *Scylla serrate* had 31 individuals, followed by the species *Callinectes, Liocarcinus holsatus, Ovalipes australiensis, and Ovalipes sp* with the lowest number of individuals 2.

The results of the number of individual mud crab species is evidence of the benefits provided by mangroves and the surrounding environment for the sustainability of mud crabs. Meanwhile, the high number of individuals is also often associated with the amount of resources such as food and the environment provided by mangroves. Therefore, the existence of the family of *Portunidae* species of *Scylla serrata* is an indicator of the success of mangrove conservation in the study area.

Mud Crab Ecological Index

The mud crab ecological index value at station 1 shows a diversity value (H') of (1.21%) in the moderate category, closeness (E) of (0.87%) in the high category, dominance (C) of (0.33%) in the low category, and species richness (R) of (0.95%) in the low category. Furthermore, at station 2, the value of diversity (H') was (1.56%) categorized as medium, closeness (E) was categorized as high (0.96%), dominance (C) was categorized as (0.22%) low, and species richness (R) was categorized as low (1.60%). Whereas at station 3, the value of diversity (H') was (0.32%) categorized as low, evenness (E) was categorized as low (0.20%), dominance (C) was (0.36%) categorized as low and species richness (R) was (1.15%) categorized as low (Figure 10).

The categories of high and low diversity are influenced by several factors, especially the level of uniformity and dominance values. This opinion is also the same as the statement by Sirait et al (2018) that if the dominance index is high, it indicates the presence of one particular species. But if the dominance index value is low, then there are only a few species of dominance.

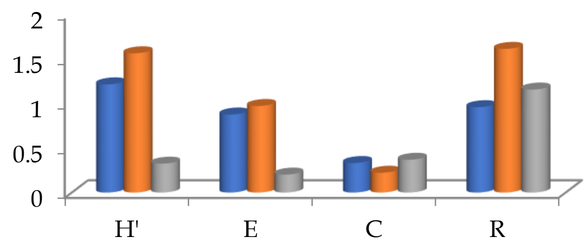

Figure 10. Ecological Index of Mangrove Crab on the Sheet coast of West Lombok

Description: Blue beam (station 1); red beam (station 2); green beam (station 3)

Relationship between Mangrove Density and Mangrove Crab

Pearson correlation measurement results are used to determine the relationship between variable x (mangrove density) and variable y (mangrove crab density) (Figure 11). The results of the regression analysis between mangrove density and mud crab density showed a positive characteristic with the equation y = 0.2482x + 0.0004. Positive regression means that each variable x increases (mangrove density) will cause (mangrove crab density) to also increase, while the value (r^2) indicates that 58% of mangrove density is a factor in the occurrence of mangrove crab density.

The existence of a relationship between mangrove density and mud crab density indicates that mangrove vegetation has an important role for mud crabs. The results of research by (Kusuma et al., 2021) that the high density of mangrove crabs in mangrove locations that have high density is because these locations have more litter productivity and contain organic matter. In line with the opinion (Pratiwi & Ernawati, 2016) that mangrove vegetation can provide a source of food, shelter, and tides in mangrove waters will associate well with mangrove crabs.

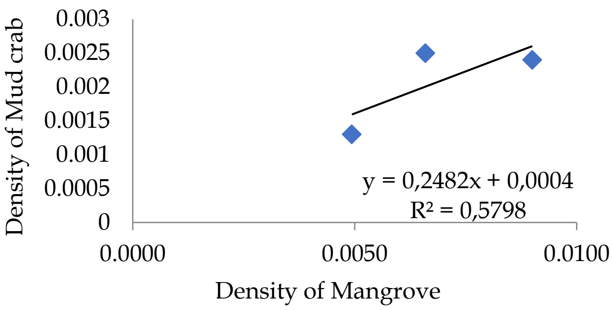

Figure 11. Relationship between Mangrove Density and Mud Crab abundance on the coast of West Lombok

Mangrove Association with Mud Crab

The results of the association analysis showed that there were 2 mangrove crab species associated with 2 mangrove species (Table 2). The species is *Scylla serrata* which is associated with the mangrove *Rhizophora mucronata*, while the mangrove crab species *Ovalipes australiensis* is associated with the mangrove species *Rhizophora stylosa*. The association of 2 mangrove species with 2 mangrove crab species is due to the very high frequency of both in the same habitat.

Mangrove species *Rhizophora mucronata* and *Rhizophora stylosa* each had a positive association with 2 mangrove crab species. This positive association explains that around the species *Rhizophora mucronata* and *Rhizophora stylosa*, mangrove crab species can be found at each study site. This is presumably because the mangrove ecology of the types *Rhizophora mucronata* and *Rhizophora stylosa* can support the life of the two mangrove crab species. Both mangrove species have taproots enabling both mangrove crab species to associate with mangroves. One of the characteristics of the root form is the riding so that the two species of mud crabs find it easier to find food and take shelter in the roots of the mangroves.

Table 2. Association of mud crabs with mangroves on the Sheet coast of West Lombok

Spesies Kepiting Bakau	Spesies Mangrove	
	Rm	Rs
Callinectes		
Liocarcinus holsatus		
Necora puber		
Portunus tritubercalatus		
Portunus sanguinolentus		
Portunus pelagicus		
Scylla olivacea		
Scylla serrata	+	
Ovalipes australiensis		+
Ovalipes sp		

Environmental Parameters

Measurements of environmental conditions were carried out at each research location at 3 stations (Table 3). The results of environmental parameter measurements at each station location are different. Based on the decision of the Minister of Environment No. 51 of 2004 in the attachment to marine biota quality standards where a good pH is in the range of 7-8.5. The measurement results show that the pH of the waters is categorized as very good for the growth of mangrove crabs, especially *Scylla serrata* species.

Table 3. Environmental parameters on the coast of West Lombok Sheet

Parameter			Stasiun
	1	2	3
Temperature	30	29.5	29
Salinity	30	31	30
DO	5.19	4.59	4.28
Nitrate	0.66	1.11	0.70
Phosphate	73.64	46.50	48.64
pH	7	7	7

Salinity is the concentration of mineral salts in the form of constituent substances in waters. Salinity at each station measurement ranges from 30-31 ppt. The same opinion was conveyed (Ardian et al., 2022) that crabs can adapt to an environment where salinity can change, so that mangrove crabs will also change the concentration of body fluids through the processes of diffusion and osmosis.

Temperature measurements at each station have different results. The highest water temperatures are at station 1 (30°C), station 2 (29.5°C), station 3 (29°C). Differences in temperature values in mangrove waters are included in the category according to the survival of mangrove crabs. The same opinion was conveyed by (Halipulfikri et al., 2020) that crabs can survive at temperatures of 12°C - 35°C and can grow under optimal conditions at temperatures ranging from 23°C-32°C.

According to the Decree of the Minister of Environment No. 51 of 2004, the optimal DO level according to the life of marine organisms is >5 mg/l. The results showed that DO values ranged from 4-5.19 mg/l, so they were still in accordance with applicable regulations. The low DO values at station 1 and station 2 are due to the research location being close to residential areas so that it is filled with quite a high amount of waste. High waste can cause a decrease in DO levels in the waters and reduce the number of species growth due to unfavorable environmental conditions. The type of substrate found in the study site is muddy and sandy mud. The same opinion was conveyed by (Ardian et al., 2022) that the sandy mud substrate is used as a habitat by mangrove crabs.

The measurement value of nitrate content at each location is different. The highest nitrate content was found at station 2 (1.11 mg/L). The lowest average density of mangroves is at station 2. This means that the high nitrate content will affect the growth of mangroves. Likewise, if the nitrate value at the station is low it can also cause mangrove vegetation to also have a low value. In addition to the low nitrate content, it is also thought to be due to the environmental conditions of the sandy substrate mangroves. The same opinion with (Yahra et al., 2020) sandy substrates more easily release the nutrient content inside compared to denser substrates. Meanwhile, the highest phosphate measurement was at station 1 (73.64 mg/L). The highest average density of mangroves is at station 1. This is the highest phosphate value presumably because the location of station 1 is very close to residential areas so that the waste originating from local residents' activities contains high phosphorus.

Conclusion

Based on the research conducted, it can be concluded that a total of 10 species of mangrove crabs were found in this study. Then the highest diversity value at station 2 (H'=1.56) is in the medium category. And there are 2 species of mangrove crabs associated with mangrove species. *Rhizophora mucronata* has a positive association with the species *Scylla serrata*, and *Rhizophora stylosa* has a positive association with the mangrove crab species *Ovalipes australiensis*.

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Author Contributions
Jurlia Apriliani Tonti Riska conceptualization, which includes research ideas, design with methodology, and data analysis. Abdul Syukur and Lalu Zulkifli conceptualization has been carried out by reviewing investigation research, literature review, and provided feedback on the manuscript.

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Conflicts of Interest
The author declares no conflict of interest.

References

Alwidakdo, A., Azham, Z., & Kamarubayana, L. (2014). Studi Pertumbuhan Mangrove pada Kegiatan Rehabilitasi Hutan Mangrove di Desa Tanjung Limau Kecamatan Muara Badak Kabupaten Kutai Kartanegara. Agrifor. *Jurnal Ilmu Pertanian dan Kehutanan, 13*(1), 11-18.

Adila, A., Septifitri., & Ali, M. (2020). Penggemukan Kepiting Bakau (Scylla Serrata) dengan Pakan yang Berbeda. *Jurnal Ilmu-Ilmu Perikanan dan Budidaya Perairan, 15*(2), 86–94.

Agustini, N., Z. Ta'alidin & Purnama, D. (2016). Struktur Komunitas Mangrove di Desa Kahyapu Pulau Enggano. *Jurnal Enggano. 1*(1): 19-31.

Aini, A., Budihastuti, R., & Hastuti, endah dwi. (2016). Pertumbuhan semai Rhizophora mucronata pada saluran tambak Wanamina dengan lebar yang berbeda. *Jurnal Biologi, 5*(1), 48–59.

Ardian, A., Kustiati, & Saputra, F. (2022). Kualitas Habitat Kepiting Bakau(Scylla serrata- Forsskål) di Perairan Pantai Desa Sengkubang Kecamatan Mempawah Hilir Kabupaten Mempawah. Jurnal Protobiont, 11(2), 44–50. https://jurnal.untan.ac.id/index.php/jprb/article/viewFile/60716/75676595679

Candri, D, A., Junaedah, B., Ahyadi, H., & Zamroni, Y. (2018). Keanekaragaman Moluska pada Ekosistem Mangrove di Pulau Lombok. BioWallace Jurnal Ilmiah Ilmu Biologi, 4(2), 88-93.

Dewi, S. K., & Herawatiningsih, R. (2017). Kondisi Tanah dalam Kawasan Mangrove di Desa Nusapati Kabupaten Mempawah Kalimantan Barat. *Jurnal Hutan Lestari, 5*(2), 177–182.

Dyani,N.R., & Citra, S.U,D., (2021). Kelimpahan Kepitimg Bakau (Scylla Sp) Di Kawasan Ekowisata Mangrove Bagek Kembar, Nusa Tenggara Barat. *Journal Of Empowerment Community And Education.1*(2), 54-59.

Eddy, S., Iskandar, I., Ridho, M. R., & Mulyana, A. (2019). Restorasi Hutan Mangrove Terdegradasi Berbasis Masyarakat Lokal. *Jurnal Indobiosains, 1*(1), 1–13. https://jurnal.univpgri-palembang.ac.id/index.php/biosains

English, S., Wilkinson, C. & Baker, V. (1994). Survey Manual for Tropical Marine Resource. *Australian Institute of Marine Science*, 390 hlm.

Halipatulfikri, Adi, W., & Utami, E. (2020). Kajian Parameter Lingkungan terhadap Kelimpahan Kepiting Bakau (Scylla sp) di Perairan Muara Semubur Desa Tuik Kabupaten Bangka Barat. *Journal Sumber Daya Perairan, 14*(2), 53–60. https://www.journal.ubb.ac.id/index.php/akuatik/article/view/2426

Hartoko, A., Hendrarto, I. B., Merici, A., Widiyanti, D., Perikanan, J., Perikanan, F., Kelautan, I., Diponegoro, U., & Soedarto, J. H. (2013). Perubahan Luas Vegetasi Mangrove di Pulau Parang, Kepulauan Karimunjawa Menggunakan Citra Satelit. *Journal of Management of Aquatic Resources, 2*(2), 19–27. http://ejournal-s1.undip.ac.id/index.php/maquares

Imamsyah, A., Bengen, D. G., & Ismet, M. S. (2020). Struktur Vegetasi Mangrove Berdasarkan Kualitas lingkungan biofisik di taman hutan raya ngurah rai bali. *Ecothropi, 14*(1), 88–99.

Ismail., Sulistiono., Hariyadi, S., & Madduppa, H. (2019). Hubungan Antara Degradasi Mangrove Segara Anakan dan Penurunan Hasil Tangkapan Kepiting Bakau (Scylla Sp) di Kabupaten Cilacap, Provinsi Jawa Tengah. *Jurnal Ilmu Pertanian Indonesia, 24*(3), 179–187. https://doi.org/10.18343/jipi.24.3.179

Karimah. (2017). Peran Ekosistem Hutan Mangrove Sebagai Habitat Untuk Organisme Laut. Jurnal Biologi Tropis, 17(2), 51–57. https://doi.org/10.29303/jbt.v17i2.497.

Krebs, C. J. (1994). Ecology, the Experimental Analysis of Distribution and Abundance. New York: Addison - Wesley Educational Publishers.

Kusuma, K. R., Safitri, I., & Warsidah, W. (2021). Keanekaragaman Jenis Kepiting Bakau (Scylla Sp.) Di Kuala Kota Singkawang Kalimantan Barat. *Jurnal Laut Khatulistiwa, 4*(1), 1. https://doi.org/10.26418/lkuntan.v4i1.44784

Ludwig, J. A., & Reynolds, J. F. (1988). Statistical Ecology A Primier On Methods and Computing. Canada: Wiley - Interscience Publications.

Nasiti, A, S., Ridwan, M., Utaminingrum, H, I, P, & Putri, M, R, A. (2015). Pemetaan Kawasan, Komposisi Dan Struktur Mangrove Sebagai Dasar Pengelolaan Sumberdaya Ikan Di Teluk Cempi, Sumbawa. *Jurnal Biologi Indonesia*, *1*(1), 141–154.

Odum, H. T. (1994). Ecological and general systems: *an introduction to systems ecology*. Univ. Press of Colorado.

Pratiwi, R. (2011). Biologi Kepiting Bakau (Scylla Spp.) Di Perairan Indonesia. *Oseana, 36*(1), 1–11.

Rahman, F. A., Rohyani, I. S., Suripto, Hadi, A. P., & Lestari, D. P. (2019). Komposisi Vegetasi Mangrove Berdasarkan Strata Pertumbuhan di Teluk Sereweh , Kabupaten Lombok Timur , Nusa Tenggara Barat. *Jurnal Pendidikan Biologi dan Sains, 4*(2), 53–61. Retrieved from http://ejournal.unwmataram.ac.id/bios/article/view/183

Ritohardoyo, S., & Ardi, G. B. (2014). Arahan Kebijakan Penegolahan Hutan Mangrove : Kasus Pesisir Kecamatan Teluk Pakedai, Kabupaten Kuburaya, Provinsi Kalimanta Barat. *Jurnal Geografi,11*(1), 43–57.

Ruru, R. A., Rumengan, A. P., Darus, P. S., Paruntu, C. P., Bara, R. A., & Rondonuwu, A. B. (2023). Estimasi Stok Karbon Pada Komunitas Mangrove Di Desa Budo Kecamatan Wori Kabupaten Minahasa Utara. *Jurnal Ilmiah Platax, 11*(1), 15–26.

Saputri, M., & Muammar, M. (2019). Karakteristik Habitat Kepiting Bakau (Scylla Sp.) Di Ekosistem Mangrove Silang Cadek Kecamatan Baitussalam Kabupaten Aceh Besar, Provinsi Aceh. BIOTIK: *Jurnal Ilmiah Biologi Teknologi dan Kependidikan, 6*(1), 75. https://doi.org/10.22373/biotik.v6i1.4436

Septiani, M., Sunarto, Mulyani, Y., Riyantini, I., & Prihadi, D, J. (2019). Pengaruh Kondisi Mangrove Terhadap Kelimpahan Kepiting Biola (Uca Sp.) Di Karangasong Kabupaten Indramayu. *Jurnal Perikanan dan Kelautan, 10*(1), 84–91.

Sipahelut, P., Wakano, D., & Sahertian, D. E. (2020). Keanekaragaman Jenis dan Dominansi Mangrove di Pesisir Pantai Desa Sehati Kecamatan Amahai, Kabupaten Maluku Tengah. Biosel. *Biology Science and Education, 8*(2), 160-170. https://doi.org/10.33477/bs.v8i2.1145

Sirait, M., Firsty, R., & Pattulloh. (2018). Komparasi Indeks Keanekaragaman Dan Indeks Dominansi Fitoplankton Di Sungai Ciliwung Jakarta. *Jurnal Kelautan, 11*(1), 75-79.

Subur, R., & Sarni, S. (2018). Kapasitas Adaptif Mangrove Pada Pulau Kecil Mikro Studi Di Pulau Maitara Kota Tidore Kepulauan Propinsi Maluku Utara. *Jurnal Biologi Tropis, 18*(2), 123–133. https://doi.org/10.29303/jbt.v18i2.801

Sulistiono, I. P., Sulistiono, S., Yonvitner, Y., Samosir, A. M., Wildan, D. M., & Ervina, A. (2021). Pendugaan Pertumbuhan Kepiting Bakau (Scylla Serrata Forskal) di Perairan Karangsong, Indramayu, Provinsi Jawa Barat. *Jurnal Teknologi Perikanan dan Kelautan, 12*(1), 27–38. https://doi.org/10.24319/jtpk.12.27-38

Sulistiono, S., Yahya, N. M., & Riani, E. (2021). Distribusi Scylla spp. di perairan estuari Sungai Donan Segara Anakan Bagian Timur, Cilacap. *Habitus Aquatica, 2*(1), 1–11. https://doi.org/10.29244/haj.2.1.1

Syahrera, B., Purnama, D., & Zamdial, Z. (2016). Asosiasi Kelimpahan Kepiting Bakau Dengan Keberadaan Jenis Vegetasi Mangrove Kelurahan Sumber Jaya Kecamatan Kampung Melayu Kota Bengkulu. *Jurnal Enggano, 1*(2), 47–55. https://doi.org/10.31186/jenggano.1.2.47-55

Tarumasely, T. F., Soselisa, F., & Tuhumury, A. (2022). Habitat Dan Populasi Kepiting Bakau (Scylla serrata) pada Hutan Mangrove di Kecamatan Teluk Ambon Baguala. *Jurnal Hutan Pulau-Pulau Kecil, 6*(2),177-162. doi: 30598,jhppk.2022.6.2.177

Utomo, B., Budiastuty, S., & Muryani, C. (2018). Strategi Pengelolaan Hutan Mangrove Di Desa Tanggul Tlare Kecamatan Kedung Kabupaten Jepara*. Jurnal Ilmu Lingkungan, 15*(2), 117. https://doi.org/10.14710/jil.15.2.117-123

Wintah, W. (2018). Analisis Zonasi Ekosistem Mangrove Pada Kawasan Mangrove Bekas Tsunami di Aceh Barat Selatan*. Jurnal Litbang Kota Pekalongan, 14*(1), 90–94. https://doi.org/10.54911/litbang.v14i0.69

Yahra, S., Harahap, Z. A., Yusni, E., & Leidonald, R. (2020). Analisis Kandungan Nitrat Dan Fosfat Sertaketerkaitannya Dengan Kerapatan Mangrove di Pantai Labu Kabupaten Deli Serdang. *Jurnal Enggano*, 5(3), 350–366.

Yonvitner, Wahyudin, Y., Mujio, & Trihandoyo, A. (2019). Biomasa Mangrove dan Biota Asosiasi di Kawasan Pesisir Kota Bontang. *Jurnal Biologi Indonesia, 15*(1), 123–130. https://doi.org/10.47349/jbi/15012019/123

Zamroni, Y., & Rohyani, I. S. (2008). Produksi Serasah Hutan Mangrove di Perairan Pantai Teluk Sepi, Lombok Barat. *Biodiversitas Journal of Biological Diversity, 9*(4), 284–287. https://doi.org/10.13057/biodiv/d090409

Zulkarnain, Wahju, R. I., Wahyudi, T., Purwangka, F., & Dwi, Y. P. (2019). Penggunaan bubu lipat modifikasi pada penangkapan rajungan. 3(2), 155–167. https://jurnal.ipb.ac.id/index.php/pspalbacore/article/view/2909.