JEK
Journal of Earth Kingdom
JEK 2(2): 79-95
ISSN 3024-9821

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Community structure of Crabs (*Crustacea: Decapoda*): Response to vegetation variation and environmental parameters in mangrove ecosystems

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Received Date: December 4, 2024 Revised Date: January 16, 2025 Accepted Date: January 31, 2025

ABSTRACT
Background: Mangrove ecosystems are crucial for maintaining biodiversity, including crab communities, which are vital to the stability of these ecosystems. Crabs contribute to nutrient cycling and the food web, reinforcing the overall ecological health of coastal habitats. This study focuses on the crab communities in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency, examining how environmental conditions affect their distribution and diversity. **Methods:** The research involved surveys at three stations representing different mangrove vegetation conditions. Crab species were identified and their diversity and abundance recorded. Environmental parameters, such as temperature, salinity, and pH, were measured, and the diversity index (H') was calculated to assess species diversity and the relationship between crab communities and environmental factors. **Findings:** A total of 11 crab species from 4 families were identified, including *Uca (Paraleptuca) annulipes* and *Ocypode ceratophthalmus*. The diversity index ranged from 1.3 to 1.6, indicating moderate diversity. Environmental conditions, with temperatures between 32–34 °C, salinity from 13–19 ppt, and pH from 6.5 to 7, were conducive to crab survival. Station III, with healthier mangrove vegetation, supported greater crab diversity and abundance compared to degraded stations. **Conclusion:** The study highlights the crucial role of healthy mangrove ecosystems in sustaining crab biodiversity and ecosystem stability. It underscores the importance of mangrove conservation for maintaining biodiversity and protecting coastal ecosystems from degradation. **Novelty/Originality of this article:** By linking the health of mangrove ecosystems to crab diversity and abundance, it emphasizes the direct impact of environmental factors on crab populations. The findings highlight the importance of mangrove conservation not only for species richness but also for maintaining the ecological balance in coastal ecosystems, offering valuable data for future biodiversity management and conservation efforts.

KEYWORDS: mangrove, diversity, crab community, environmental parameters, ecosystem

1. Introduction

Coastal and marine areas are integrated and interconnected ecosystems, where there is an exchange of materials and energy transformation between components within the ecosystem and with external components (Carlson et al., 2021). The sustainability of natural resources in this area is highly dependent on the continuity of the function of coastal and marine ecosystems. One of the main ecosystems in coastal areas is the mangrove ecosystem,

Cite This Article:
Aliwu, P. L., Baderan, D. W. K., Aydalina, R. V., Zakaria, Z., & Hamidun, M. Z. (2025). Community structure of crabs (Crustacea: Decapoda): Response to vegetation variation and environmental parameters in mangrove ecosystems. *Journal of Earth Kingdom*, *2*(2), 79-95. https://doi.org/10.61511/jek.v2i2.2025.1440

which plays an important role in maintaining ecological balance (Rahim & Baderan, 2019). Mangrove forests have a significant area in Indonesia, reaching around 24,000 km^2 or 1.3% of the total area of Indonesia (Tarumasely et al., 2022). Mangroves are an important habitat for various types of flora and fauna, both aquatic and terrestrial, such as crabs, fish, shrimp, birds, reptiles, and mammals (Nagelkerken et al., 2008).

Mangrove forests have important ecological functions, including as a habitat provider for various types of fauna and as a balancer of the biological cycle in aquatic ecosystems. The diversity of fauna in the mangrove ecosystem is very high, especially aquatic fauna such as crabs, fish, and shellfish (Tarumasely et al., 2022). Crabs, for one, play an important role in the dynamics of the mangrove ecosystem because they are involved in the bioturbation process, namely the excavation and stirring of sediment, which plays a role in increasing the productivity of aquatic ecosystems (Lapolo et al., 2018; Tongununui et al., 2021; Barua et al., 2021; Xie et al., 2022).

The types of mangrove crabs that live in mangrove forests are diverse. Mangrove crabs consist of several families, such as Ocypodidae, Portunidae, Eriphiidae, and Grapsidae, with four main genera, namely Uca, Scylla, Epixanthus, and Sarmatium (Crane, 1975). On the other hand, research by Jacobs et al. (2019) reported that the genus Scylla is one of the types found in mangrove forests.

In Gorontalo Province, one of the significant mangrove areas is located in Tabongo Village, Dulupi District, Boalemo Regency. According to data from the Bone Bolango River Basin Management Center, in 2023, the area of mangrove forest in Boalemo Regency reached 233.11 km^2, with 116.42 km^2 of which was in Tabongo Village. The mangrove forest in Tabongo Village is a habitat for various species, including six main mangrove species, namely Sonneratia alba, Rhizophora apiculata, Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, and Avicennia alba. However, this mangrove area has experienced significant degradation due to human activities, such as deforestation for construction materials and land conversion into ponds, which has caused a decrease in the diversity and abundance of aquatic fauna, including crabs (Djamadi et al., 2024). This habitat degradation has had a negative impact on the biotic environment, including disruption of the population of aquatic biota, namely crabs in the environment (Anggraeni, 2015).

A study was conducted in Tabongo Village, Dulupi District, Boalemo Regency, which focused on the distribution of crab species. This study found several crab species, namely Uca annulipes, Uca dussumieri, Uca triangularis, Uca vocans, and Scylla olivacea (Fazhan et al., 2020). These crabs were found spread across four different types of mangrove stands, namely Rhizophora mucronata, Ceriops tagal, Rhizophora stylosa, and Sonneratia alba (Katili et al., 2017). Although previous research conducted by Katili et al. (2017) has identified several crab species in the mangrove area of Tabongo Village, the study focused more on the distribution of species in certain mangrove stands. However, research on the overall structure of the crab community in this area has never been conducted. The study only covered some aspects of the crab community, such as the types of species found, without looking deeper into the relationship between population density, diversity, and environmental factors that affect the crab community as a whole.

Based on the Background, it is necessary to continue this research with a more comprehensive approach involving analysis of the structure of the crab community in order to provide more complete information about the condition of the mangrove ecosystem in Tabongo Village. This research is expected to provide deeper insight into the role of the mangrove ecosystem on crab diversity, as well as its impact on environmental sustainability and the sustainability of coastal biological resources.

2. Method

The research location was carried out in the mangrove area of Tabongo village, Dulupi sub-district, Boalemo Regenc, and sample identification was carried out at the Agricultural Laboratory of Gorontalo State University. The research was carried out from October to November 2024. This type of research is descriptive quantitative. This study was conducted to identify the types of crabs in the Tabongo mangrove area. The research method uses the Free Collection Sampling method, Referring to Research (Pratiwi & Astuti, 2012) and *purposive sampling techniques* by dividing three different observation stations based on the environmental tone at the research location—purposive sampling technique by dividing into three research stations, determining the station based on different environmental tones. The division of stations in this study is divided into 1) The first station is in the coastal area adjacent to residential areas; 2) The second station is placed in the middle of the mangrove, which has more mangrove cover; 3) The third station is placed in a more natural zone and is less frequently reached by human activities, making it ideal for research on mangrove biodiversity and conservation. This point can be considered to be in the area around the mangrove forest in the middle of it. The parameters measured in this study are the diversity index, evenness index, density index, abundance index, and dominance index.

2.1 Data collection techniques

2.1.1 Samples, research points, and specimen identification

Samples were collected using a free collection method by lifting rocks, dismantling rotten tree trunks, digging sand, and taking crabs around the roots and stems of mangroves. The samples obtained were put into sample bottles and labeled according to the collection station, following the procedures of the study (Pratiwi & Astuti, 2012). Crab samples were collected using the picking method, while crabs in the holes were taken using tongs. In addition, measurements of environmental physical parameters, such as temperature, pH, and salinity of the waters at each station, were carried out using tools such as thermometers, pH meters, and refractometers.

The determination of the research point was carried out using the purposive sampling method, which selected points that represent the diversity of characteristics of the research area. Sampling was divided into three observation stations, for station 1 (N: 00^{0}30'24.52'' E: 122^{0}27'55.68''), Located near the coast and community ponds. Station 2 (N: 00^{0}30'25.69'' E: 122^{0}27'58.14'') located that the second point is closer to a more natural area or mangrove conservation, with the possibility of slightly more open space and less disturbance from human activities compared to the first point which is closer to settlements and transportation routes. Station 3 (N: 00^{0}30'26.08'' E: 122^{0}28'04.21'') is in a more natural zone and less accessible to human activities, making it ideal for research on mangrove biodiversity and conservation. This point can be in the area around the mangrove forest in the middle of it.

Specimen identification was conducted at the agricultural laboratory of Gorontalo State University. Samples that had been collected from various points in the mangrove area were then grouped based on morphology and physical characteristics such as carapace shape, number of leg segments, and claw structure. The identification process was carried out using a microscope and relevant taxonomic identification guides to ensure that each specimen was identified to the genus or species level. The results of this identification are very important in determining the species composition of the crab community in the mangrove ecosystem, as well as in analyzing the relationship between the species found and environmental conditions at the research location.

2.2 Data analysis

Biodiversity can be assessed using indices that measure species diversity, richness, and evenness within an ecosystem. The Species Diversity Index (H') provides an overall measure of biodiversity by quantifying the variability in species composition. It is calculated using the Shannon-Wiener formula (Shannon & Wiener, 1963) (Equation 1), where *pi* is the proportion of individuals of species iii relative to the total number of individuals.

$$H' = -\sum_{i=1}^{s}(pi \ln pi) \quad \text{(Eq. 1)}$$
$$pi = n/N$$

The Richness Index (R) reflects the relative richness of species in relation to the total number of individuals. It is calculated using the Margalef formula (Magurran, 2004) in Eqaution 2. In this Equation, SSS is the total number of species, and NNN is the total number of individuals.

$$R = \frac{S-1}{\ln(N)} \quad \text{(Eq. 2)}$$

The Species Evenness Index (E) evaluates how evenly individuals are distributed among the species in a community. It is calculated using the formula (Equation 3). These indices collectively provide a detailed understanding of the biodiversity in an ecosystem, covering species diversity, richness, and distribution.

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

3. Results and Discussion

Tabongo Village is administratively located in Dulupi District, Boalemo Regency, Gorontalo Province. The total area of mangrove forest in Tabongo Village reaches around 116.42 hectares. This area functions as a habitat for various types of flora and fauna, including mangrove species such as Rhizophora mucronata and Sonneratia alba, as well as fauna such as mangrove crabs (Faqih & Juramang, 2023). This forest is also a major source of livelihood for local communities through community-based fisheries and ecotourism activities. In this study, sampling was divided into three research stations.

3.1Results

Based on the results of the research conducted at the research location, 11 species from 4 families were found, namely Ocypodidae, Oziidae, Sesarmidae, and Grapsidae. There are seven species from the Ocypodidae family, two species from the Sesarmidae family, one species from the Oziidae family, and one species from the Grapsidae family. The results of crab identification at the station are shown in Table 1.

Table 1. Classification and types of crabs in the mangrove area of Tabongo village

Kingdom/ Class/ Order	Family	Genus	Species	Number of Individuals/ Stations		
				I	II	III
Animals/ Crustaceans/ Decapods	Ocypodidae	Uca	*Uca (Paraleptuca) annulipes*	28	-	-
			Uca (Paraleptuca) perplexa	20	-	-
			Uca gelasimus vocans	18	-	-
			Uca Tubuca Demani	-	36	40
			Uca (Paraleptuca) crassipes	-	-	19
			Uca (Tubuca) coarctata	-	23	37
		Ocypode	*Ocypode ceratophthalmus*	35	-	-
	Sesarmidae	Perisarcoma	*Perisesarma guttatum*	15	-	18
			Perisesarma bidens	-	25	20
	Grapsidae	Metoporapsus	*Metopograpsus latifrons*	-	14	-
	Oziidae	Baptist	*Baptozius vinosus*	-	-	6
Total					354	

3.1.1 Classification of Uca (Paraleptuca) annulipes

Uca annulipes has a body size of 25–60 mm with a trapezoidal carapace, black with white spots on the anterior part (Fig. 1). The large claws are red on the cerpus, merus, and manus, while the dactylus and pollex are white. The carapace of adult males is up to ±40 mm wide, with a clear anterolateral edge and a smooth claw surface without large nodules. Its habitat is sandy substrate, and this species is found in the Indo-West Pacific region, such as India, South China, Indonesia, the Philippines, and Malaysia. According to Wilsey & Potvin (2000), several types of Uca can live in the same habitat but have different behaviors and microhabitats, so their ecological niches are separate.

Fig. 1. Paraleptuca annulipes

3.1.2 Classification of Uca (Paraleptuca) perplexed

The morphology of the carapace is trapezoidal in shape, black in color with white striped patterns. The width of the carapace is larger than the length, the face of the carapace is narrow, the orbit is wide, and both corners of the orbit are flat. The large claws in males are yellowish, from the merus to the manus, and have a smooth surface (Fig. 2).

Polex and dactylus are yellowish-white. Dactylus is wider than Rolex. There is one large tooth in the middle of the dactyls and poles, several fairly large teeth on the dactyls, and small serrations on the inside of the proponent. The outer end of the polex is keeled, and there is one tooth on the inner end of the polex; the tip of the dactylus is curved like a hook, and the dactylus is longer than the polex. The legs are light brownish-whitish.

Fig. 2. Paraleptuca perplexed

3.1.3 Classification of Ucaglasimus vocans

The front of the carapace is narrow, the orbit on the carapace of adult males is swooped, and there is no anterolateral edge. On the large claw, there is a triangular depression at the base of the polex whose tip reaches 2/3 of the length of the polex; on the surface of the manus, there are large bumps, especially near the depression triangular, no grooves on the outer surface of the poles and dactyls, the poles and dactyls are flat and wide, there are triangular teeth in the middle of the poles. The cutting edge on the small claw finger is longer than the manus (Fig. 3).

Fig. 3. Ucaglasimus vocans

The carapace and legs tend to be white with a hint of orange. The large claw polex is yellow, and the dactylus is white. The size of the adult male carapace is up to ± 50 mm. Mud substrate habitat. Distribution throughout the coast of Indonesia, China, Burma, Thailand, the Philippines, and Malaysia (Ummah, 2019).

3.1.4 Classification of Uca Tubuca Demani

It is a member of the genus Tubuca, with a narrow carapace face; the base area of the orbit is equipped with a row of bumps (Fig. 4). Short anterolateral edges, the outer corner of the orbit is swooped, the carapace width is 25–34 mm, the carapace length is 16–20 mm, and the carapace is purplish pink. It has a pair of claws; in males, there are large claws (major cheliped) and small claws (minor cheliped); the large claws in males have short and less clear grooves.

Fig. 4. Uca Tubuca Demani

The outer surface of the dactyls and the outer surface of the poles and manus are equipped with bumps of quite a large size. The dactylus is wider than the polex and is equipped with a row of teeth at the tip of the claw. The dactyls and poles of the large claw are white, while the manus is red to pink. It has four pairs of legs with a purplish-pink color.

3.1.5 Classification of Uca (Tubuca) coarctate

Uca coarctate measures ±30-75 mm (Fig. 5); the carapace is dark blue to black with light blue motifs; on the ventral part, there are two large white dots; the merus is yellowish orange, the carpus is white; the dorsal part of the manus is white, the ventral part is slightly rough red, and the dactyl and pollex are white. The front of the carapace is narrow, the orbit on the carapace of adult males does not dive, in the orbit area, there is a short row of bumps, and the anterolateral edge is short. It does not reach the posterior edge; the anterolateral angle is sharp. The outer surface of the manus on the large claw has large bumps, the largest near the base of the pole; the tip of the dactyls is hook-shaped, the tip of the pole is slender, and the middle part is without a triangular structure. The fingers of the small claw are equipped with teeth, and the dorsal edge of the poles and dactyls is covered with setae (Ummah, 2019).

Fig. 5. Uca (Tubuca) coarctate

3.1.6 Classification of Uca (Paraleptuca) crassipes

Uca crassipes measure ±20-30 mm with prominent bright red characteristics, a wide carapace face, red legs, reddish-white dactyl and pollex, and red manus. The front of the carapace is wide; the anterolateral edge is clearly visible; the base of the orbit is smooth; the ridge in the orbit area is absent; the angle of the orbit is not dipped, and the dorsal edge is straight (Fig. 6). The surface of the manus of the large claw is smooth, and the grooves on the outer surface of the poles and dactyls are absent.

The dactyls and poles are cylindrical; at the base of the poles, there is a triangular depression. The posterior merus of the small claw is equipped with a row of vertically arranged nodules. The color of the carapace and legs is bright red. The poles and dactyls of the large claw are white; the manus is red. The size of the carapace of the adult male carapace is up to ± 30 mm. Mud substrate habitat Distribution Bali, Maluku Islands, Papua, Philippines, China, Japan. and Thailand (Ummah, 2015).

Fig. 6. Uca (Paraleptuca) crassipes

3.1.7 Classification of Ocypode ceratophthalmus

Most members of the genus Ocypode have habitats in tropical coastal areas (Fig. 7). Ocypode ceratophthalmus is a marine crab that acts as a scavenger. Ocypode ceratophthalmus is a type of crab that can "run" very fast and also likes to hide in holes it makes in the sand, making it difficult to search and capture (Eprilurahman et al., 2015; Fazhan et al., 2024). Ocypode ceratophthalmus has a characteristic grayish-blue carapace in the shape of a box without anterolateral teeth.

Fig. 7. Ocypode ceratophthalmus

The most distinctive feature of Ocypode ceratophthalmus is its eyes, which protrude upward and are long above the cornea. There are blunt serrations on the chelae. On the mandibular palp, there are long setae (longer than Varuna litterata) that are quite dense. The shape of the abdomen and pleopod of the female cannot be used to differentiate characters. In females, the pleopod is modified into a comb-like structure that functions as a place to store eggs (Eprilurahman et al., 2015).

3.1.8 Classification of Perisesarma Bidens

The carapace is square, slightly wider than long, with a two-notched front and a concave center. The surface of the carapace has clear regional divisions and is smooth. There are short setae spread over the entire surface, the gastric region is clearly visible, and the branchial region has a very clear prominent line.

Fig. 8. Perisesarma Bidens

The anterolateral part has a sharp outer corner of the eye socket; there is one epibranchial tooth behind the outer orbit, and there are short setae along the edge of the carapace. The left and right chelipeds are equally large; there are two pectinated crests on the upper part of the palm with a transverse arrangement. The upper dactylus has a row of dactylar tubercles (Fig. 8).

3.1.9 Classification of Perisesarma guttatum

The morphology of this crab in the carapace section is square, 1.22 wider than long, and the front is not too prominent with two notches with a slightly concave middle (Fig. 9). The surface of the carapace has a clear area division that is smooth; there are short setae scattered, the gastric region is clearly visible, and the branchial region has a clear, prominent line. The anterolateral angle is sharp, and there are tapering epibranchial teeth pointing slightly to the side by forming a wide gap like the letter V; there are short setae along the edge of the carapace.

Fig. 9. Perisesarma guttatum

Cheliped is equally large between left and right. The first peak of the pectinated crest has 16-18 teeth, and the second peak has 12-15 longer teeth. Dactylus has 12-14 very prominent dactylar tubercles and is oval. The fourth leg is the longest, has a ratio of 1.77 length to carapace width, and the length of the rumen is 2.12 times its width. The abdomen of the male crab has a telson length of 0.91 times its width, has a tip that forms an obtuse triangle, and the sixth segment is 2 times wider than its length. G 1 is sturdy; the tip forms a protrusion, is chitinous, and has a long setae on the upper third. This crab species has a habitat in the mangrove ecosystem.

3.1.10 Classification of Metopograpsus latifrons

The characteristics are four pairs of dark brown walking legs and irregular white spots, as well as fine hairs on the dactylus, propodus, and carpus. The third pair of walking legs is the longest among the other pairs of walking legs and the widest merus. A pair of equally large claws are light brown with brownish-white claw tips.

Fig. 10. Metopograpsus latifrons

On the propodus and carpus, rough spots were found on the claws (Amin et al., 2021). Morphologically, Metopograpsus latifrons has sharp and pointed claws on its legs, making it easy for this species to climb mangrove roots and trees (fig. 10). Metopograpsus latifrons are mangrove tree-climbing crabs, but they are not always on tree trunks or roots (Sinamo et al., 2020).

3.1.11 Classification of Baptozius vinous

Carapace oval in cross-section; slightly convex dorsally. Large claws have prominent, molar-like to peg-like teeth; anterior thoracic sternum broad in cross section without longitudinal groove on sternite 4; male abdomen relatively narrow with lateral margins tapering toward telson. The surface of the carapace is generally smooth, with minimal sculpturing or ridges.

Fig. 11. Baptozius vinous

The eyes are well-developed and positioned laterally, providing a wide field of vision. The walking legs are relatively long and slender, adapted for efficient movement across various substrates. The exoskeleton is robust, offering protection against predators and environmental stressors. The chelipeds are asymmetrical in some individuals, with one claw often being slightly larger than the other. Additionally, the telson is relatively short and rounded, complementing the streamlined shape of the abdomen (Fig. 11).

3.1.12 Diversity index, iWealth index, evenness index

The average diversity index (H') of crabs in the mangrove forest area of Tabongo village, Boalemo district, for station I is 1.5, this value indicates a moderate diversity category, for station II is 1.3, this value indicates a moderate diversity category, and for station III is 1.6, this value indicates a moderate diversity category (Table 2). Furthermore, the results of the average diversity index are shown in Table 4.2. Then, the location, if based on the category of diversity index measurement values, shows that diversity is classified as moderate, and productivity is sufficient. Moreover, ecological pressure is moderate (1.0<H<3.322).

Table 2. Diversity Index, iWealth Index, Evenness Index ,

Diversity Index (H')			Species Richness Index	Equity Index		
I	II	III		I	II	III
1.5613	1.3345	1.6574	1.703782	0.9701	0.9627	0.9250

Furthermore, based on the research results obtained in the mangrove area of Tabongo village, the average crab species richness index for stations I, II, and III was 1.70. The species richness determination category for the Margalef Richness Index is low. Moreover, the average evenness index of crab species in the mangrove forest area of Tabongo village, Boalemo district, for stations I, II, and III is 0.92 (Table 3). Furthermore, the results of the average evenness index of species are shown in the table. Then, the location, if based on the category of evenness index measurement values, shows that High Evenness is a stable Community (0.6 <E ≤ 1.0).

Table 3. Measurement of environmental parameters

No	Parameters of the Aquatic Environment	Station		
		I	II	III
1.	Soil pH	6.5	6	7
2.	Salinity	19.2	13.2	0.32
3.	Temperature	34.3 ^{0}C	33.9 ^{0}C	32.7 ^{0}C
4.	Humidity	53%	53%	56%
5.	Light Intensity	2976	1469	1242
6.	Wind velocity	2	1.3	1.1

3.2 Discussion

Based on the results of the study in the mangrove forest area of Tabongo Village, Dulupi District, Boalemo Regency, which is divided into three observation stations, 11 species of crabs were found, namely: Uca (Paraleptuca) annulipes, Uca (Paraleptuca) perplexed Uca gelatinous vocals, Uca Tubuca Demani, Uca (Paraleptuca) crassipes, Uca (Tubuca) coarctate, Ocypode ceratophthalmus, Perisesarma guttatum, Perisesarma Bidens, Metopograpsus latifrons, Baptozius vinous. The results of the calculation of the diversity index show that Station I has a diversity index (H') of 1.5, station II has a diversity index (H') of 1.3, and Station III has a diversity index (H') of 1.6. Based on the benchmark value of the Shannon-Wiener diversity index, the diversity of crabs in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency is in the moderate criteria, sufficient productivity, moderate ecological pressure, and a fairly balanced ecosystem.

The diversity index at station III is higher compared to stations I and II. This is because the mangrove vegetation at station III is still in fairly good condition compared to the mangrove vegetation at stations I and II; the condition of the mangrove vegetation at stations I and II has experienced significant degradation due to human activities, such as deforestation for construction materials and conversion of land into ponds, which causes a decrease in the diversity and abundance of aquatic fauna, including crabs (Djamadi et al., 2024).

According to community ecology theory, each species has a distinct ecological niche, which affects its distribution and abundance in a habitat. Crabs of the genus Uca, such as Uca (Paraleptuca) annulipes and Uca (Paraleptuca) perplexa, are known for their burrowing activity in mud and sand substrates that help aerate the soil. These species are usually found in sheltered intertidal areas with wet substrates and are adapted to tidal changes (Kristensen, 2008; Banes, 2010; Nurrahman, 2023).

Species of the Sesarmidae family, such as Perisesarma guttatum and Perisesarma bidens, are more likely to live in areas with hard substrates and dense mangrove vegetation. They play an important role in the breakdown of organic matter in the mangrove environment by feeding on fallen leaves. Ocypode ceratophthalmus, which belongs to the Ocypodidae family, is a more nocturnal species often found on sandy beaches. Their activity in digging holes in the sand helps the process of sedimentation and beach stabilization. Based on ecological niche theory, each of these crab species has a crucial role in maintaining the balance and function of the mangrove ecosystem as a whole.

Crab species found in the Mangrove Forest area at the observation location are a group of aquatic Mangrove fauna that occupy both hard (roots and trunks of mangrove trees) and soft (mud) substrates; of course, they have special adaptation properties in maintaining their existence in their habitat. The habitat occupied by the species will provide the needs required for the growth of the species; these needs are in the form of food availability. For example, station III, which has a fairly dense Mangrove density and more Mangrove cover, of course, will provide sufficient food for crab species.

The structure of the crab community in the mangrove area of Tabongo Village includes three main indicators Species diversity (H'), species richness (R), and species evenness (E) are important parameters in ecological studies. The results showed that the study, station III had the highest H' value, indicating a more stable and diverse community than stations I and II, which were degraded due to human activities. The presence of mangrove vegetation will influence the high diversity of crab species. Mangrove forests have high productivity and support the surrounding environment because they are rich in nutrients with temperature, pH, oxygen, and salinity that are in optimum conditions. Species richness indicates the number of species in a community. The crab richness value at the research location has a total richness value of 1.70. Thus, the crab species richness value at the research location is categorized as low because the number of mangrove crab species found at the research location for each species is not too many. In addition, the high and low wealth values in the mangrove area of Tabongo Village are influenced by the expansion of an organism's ability to live and reproduce in the area. The high wealth value is also thought to be related to the type of substrate that is suitable as a crab habitat and the existence of adaptation strategies and biological interactions between populations in the aquatic community (Wally et al., 2020).

Mangrove crabs are fauna whose habitat and distribution are found in freshwater, brackish water, and seawater (Sharifian et al., 2020). The types are very diverse and can live in various columns in each water. Most of the crabs that we know live in brackish waters, especially in the mangrove ecosystem. Some types that live in this ecosystem are Hermit Crab, Uca sp, Mud Lobster, and mangrove crab (Sharifian et al., 2021). Most crabs are fauna that actively forage for food at night nocturnally. The value of the species evenness index ranges from 0.920 – 0.971. If compared to the existing criteria, the value of the species evenness index is close to 1. This shows that the number of individuals between each species is relatively the same, and although different, it is not too significant. The highest species evenness value is at Station 1, which is 0.9701; although only a few types of crabs were found, the abundance of individuals of each type represented was evenly distributed in the community, and no type dominated. This is in accordance with Odum's (1971) opinion, which stated that the value of the species evenness index will be high if there is no dominance or concentration of individuals on a particular species. Conversely, if there is species dominance, the species evenness value will be low. In a community containing many species, some of which are predominant groups, the number of species included in the predominant group decreases if an environment becomes extreme, namely experiencing environmental disturbances or pressures, either physical, biological, or chemical (Odum, 1971).

Some crab species were not found at other stations due to different habitat preferences influenced by specific environmental conditions. For example, species of the genus Uca, such as Uca (Paraleptuca) annulipes and Uca preflexa, were more abundant at Station I, which had a sandy substrate. This substrate supports burrowing behavior, which is an important characteristic for these species. On the other hand, species such as Perisesarma spp., which prefer hard substrates and areas with high mangrove vegetation density, dominated Station II. The absence of certain species at other stations could be attributed to substrate incompatibility or the lack of environmental elements that support their specific needs, such as shelter and food sources.

In addition, environmental stresses and anthropogenic disturbances also play a role in species distribution. Stations I and II may experience higher disturbance, such as human activities that alter habitat structure, thus affecting the presence of some species. In contrast, Station III, which has a more stable substrate and abundant food availability, supports higher species diversity. These conditions create an ideal environment for various crab species, allowing them to adapt and reproduce well. The interaction of biotic factors, such as competition and predation, as well as abiotic factors, such as temperature and salinity, also affect the distribution of species between different stations.

In a study by Leviton (1982), he explained that the distribution of organisms in an ecosystem is strongly influenced by habitat preferences, which include substrate suitability, food availability, and protection from predators. Habitats that provide optimal conditions will tend to be inhabited by certain species that have specific ecological needs. For example, Uca spp. are more commonly found on sandy substrates because they support burrowing activities as shelter.

This shows that, the high and low values of the diversity index, species richness and evenness index of crabs in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency, the presence of crabs is influenced by various biotic and abiotic factors around them. Conducive environments, such as temperature, salinity, and pH, play an important role in supporting crab life in this area to be in ideal conditions, thus creating a good habitat for crabs for their survival.

In addition to the factors of diversity, richness, and evenness, measurements of environmental parameters, parameters such as temperature, salinity, and pH show that the water conditions at the study site still support the presence of crab species. The measured water temperature at the three stations ranged from 32°C to 34°C, which is still in the range that supports the survival of crabs, that the ideal temperature for crab growth is between 23°C to 32°C. The salinity of the water ranges from 10 ppt to 19 ppt, which is still within the tolerance range of crabs. According to Kasry (1996), crabs can tolerate salinity in the range of 10% to 33%. However, some studies show that mangrove crabs are also able to survive in salinities lower than 10%.

The results of pH measurements at the three stations indicated pH values ranging from 6.5 to 7. In accordance with the Decree of the Minister of Environment No. 51 of 2004 concerning Seawater Quality Standards for Biota, this pH value is still within acceptable limits that support mangrove crab life should be between 7 to 8.5. Waters with a pH range of 6.5 to 7.5 are categorized as quite good for crabs, while waters with a pH between 7.5 to 9 are considered very good for crab growth. The environmental conditions of coastal mangrove forests support the survival of this crab species that can adapt to the environmental conditions in mangrove forests.

The relationship between crab communities and environmental parameters in the mangrove area of Tabongo Village shows that ideal habitat conditions, such as temperatures between 32°C to 34°C and salinities of 10-19 ppt, support the presence of various crab species. Species such as Uca spp. have the ability to adapt to muddy substrates with varying salinity levels, while Perisesarma spp. prefers habitats that have hard substrates and dense vegetation. Meanwhile, the decline in diversity at Stations I and II could be attributed to human disturbance causing habitat degradation, thus affecting environmental parameters such as temperature and vegetation density.

These favorable environmental factors, such as the availability of suitable substrates, mangrove vegetation density, and the condition of the physical parameters of the water, play an important role in maintaining the balance of the mangrove ecosystem. A good habitat will provide basic needs for crabs, such as food, shelter, and space to breed. Thus, the diversity of crab species in the mangrove area of Tabongo Village reflects the complex interaction between biotic and abiotic factors that support the life of aquatic fauna in the ecosystem.

4. Conclusion

Based on the results of the study and discussion, it can be concluded that the diversity of crabs in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency, is classified as moderate because the average value of the diversity index of the three stations is H'= 1.3-1.6 The richness of crab species in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency shows that the crab richness value at the research location has a total richness value of 1.70. The evenness of crabs in the mangrove area of Tabongo Village, Dulupi District, Boalemo Regency ranges from 0.920 – 0.971. When compared with the existing criteria, the evenness index value of the species is close to 1. This shows that the number of individuals between each type is relatively the same, and although different, it is not too significant. The highest evenness value of the species is at Station 1, which is 0.9701.

Acknowledgment
The authors express gratitude to the examiners for providing invaluable assistance, insightful feedback, and constructive suggestions. Gratitude is also extended to the Boalemo Regency government for granting the necessary permits to conduct this research. Support and cooperation from all parties were vital in ensuring the successful completion of this study.

Author Contribution
P.L.A was responsible for conceptualization, methodology, data collection, data analysis, and manuscript drafting. D.W.K.B., R.V.A., Z.Z., and M.S.H provided supervision, critical review, manuscript editing, and valuable insights throughout the research process.

Funding
This research received no external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The authors declare no conflict of interest.

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