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Crab diversity in tongke-tongke mangroves, east sinjai district, sinjai regency

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ABSTRACT

This study used a qualitative, exploratory approach to explore the diversity and distribution of crabs in the Mangrove Forest Area of Tongke-Tongke. This study aims to identify the crab species present in the area. Conducted in January 2023, the research focused on four stations representing two distinct zones within the mangrove ecosystem. Stations 1, 3, and 4 were situated in the rehabilitation zone, characterised by varying levels of vegetation density and substrate conditions, while Station 2 represented an ecotourism area with higher human activity. Observations identified 11 crab species across six families, each exhibiting distinct morphometric and ecological adaptations to their respective microhabitats. Environmental parameters, including substrate type, salinity, temperature, and dissolved oxygen, were found to significantly influence species distribution and diversity. The findings emphasize the ecological importance of mangroves as biodiverse habitats supporting specialized niches for various crab species. This study contributes valuable insights into the conservation and sustainable management of mangrove ecosystems, particularly in balancing ecological preservation and human utilization.

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INTRODUCTION

Indonesia is a tropical archipelago with high biodiversity (Arifanti et al., 2022), features mangrove areas characteristic of its coastal regions (Aminuddin & Burhanuddin, 2023). Mangrove forests are vital resources for coastal communities (Ashton et al., 2024), providing both food and non-food resources (Stiepani et al., 2021). Food resources from mangroves include fauna and flora, with commonly harvested fauna being shellfish, shrimp, and crabs (P. Li et al., 2025).

Among the diverse fauna inhabiting mangrove ecosystems (Chukwuka et al., 2018; Yeo et al., 2021), Certain keystone species play crucial roles. Crabs are one such species, their activities significantly impact various ecosystem processes. Crabs contribute to nutrient conversion, enhance mineralization (McLaughlin et al., 2018), improve oxygen distribution in the soil (Chen et al., 2021), aid in the carbon cycle (Tongununui et al., 2021), and serve as a food source for various aquatic biota (X. Li et al., 2021). Furthermore, within the food web, crabs function as detritivores, consuming organic matter such as dead mangrove leaves and branches.

Mangrove loss, regardless of the cause, inevitably leads to a decline in crab species found in the affected area. This decline can serve as an indicator of environmental degradation. Therefore, studies on community structure, particularly focusing on crab species, are necessary.

Community structure is a concept that examines the composition and species diversity within a community. Assessing crab community structure is often used to indicate environmental stability due to crabs' relatively sedentary nature, relatively long lifespans, adaptability to various environmental pressures, and significant role in nutrient cycling. Analysing crab community structure can provide insights into whether an aquatic ecosystem is disturbed or not.

Identifying crab species is a prerequisite for determining their diversity. One method for crab species identification involves observing morphometric characteristics. Morphometric characteristics involve measuring morphological features to compare the sizes of organisms, such as standard length, width, height, and others.

The Tongke-Tongke mangrove area, located in Sinjai Regency, specifically in Tongke-Tongke Village, East Sinjai District, is a combination of natural and rehabilitated mangroves, covering approximately 132.5 hectares. This area is designated for tourism development as outlined in Sinjai Regency Regulation Number 28 of 2012 concerning the spatial plan of Sinjai Regency 2012-2023. The Tongke-tongue mangrove ecosystem offers various advantages, including ecological, economic, socio-cultural, and environmental services, necessitating conservation efforts to preserve the coastal organism life chain and provide various life necessities for humans and other living beings (Suzana et al., 2011). The crab species inhabiting the Tongke-Tongke mangrove area are poorly documented. Limited research and publications exist regarding crab presence in this location, making the study of crab species' presence crucial.

RESEARCH METHODS

Research Design

This research is a qualitative study with an exploratory approach that describes the presence of crabs in the Mangrove Forest Area of Tongke-Tongke. This study was conducted in January 2023 at 4 stations representing two types of zones in the Tongke-Tongke mangrove forest area. Stations 1, 3, and 4 are areas included in the rehabilitation zone, while Station 2 is an ecotourism area (Figure 1).

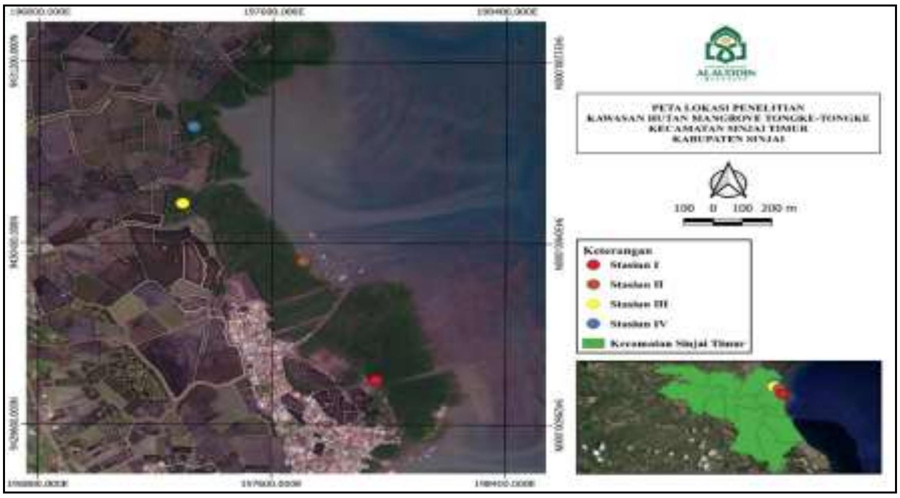

Figure 1. Research Site

Population and Samples

The diversity of crab species is an observation of all crab species found in the Tongke-Tongke mangrove forest area obtained using a purposive random sampling technique. The samples are then determined for their morphometric characteristics and ecological indices.

Instruments

The tools and materials used in conducting this research are camera, datasheet, stationery, GPS, callipers, sample box, Environment Meter, pH meter, DO Meter, forceps, scales, alcohol 70%, and identification book.

Procedures

This research was conducted through several stages. The first stage was preparation, which included initial observations to determine four research stations. These four stations represented two types of zones within the mangrove area: a rehabilitation zone and an ecotourism zone, considering the mangrove forest conditions and the level of human activity in each zone. The second stage was crab sampling. At the four designated stations, sampling was carried out using an exploratory or roving method. Crab samples were collected directly (hand sorting) based on the mangrove forest conditions, substrate type, and observed activities at the sampling location. The next stage was measuring the morphometric characteristics of the crabs. The characteristics measured included carapace length (CL), which is the distance from the midpoint of the frontal margin to the dorsal abdominal border; carapace width (CW), which is the distance from the tip of the last anterolateral spine on the right side to the tip of the last anterolateral spine on the left side; swimming leg length (SLL), which is the distance from the boundary between the propodus and dactylus of the swimming leg to the distal tip of the dactylus; swimming leg width (SLW), which is the distance from the upper edge of the midpoint of the dactylus of the swimming leg to the lower edge of the swimming leg; carapace spines (CS), by observing the shape of the spines found on the carapace circumference; and carpus spines (CaS), by observing the presence or absence of spines on the *carpus*. These morphometric measurements were performed using callipers (Saputra et al., 2020). The final stage was observing habitat characteristics. Habitat characteristic measurements were conducted directly at each station using appropriate measuring instruments. The characteristics measured included temperature (air and water), light intensity, pH, salinity, and dissolved oxygen content. These measurements were taken in the morning between 05:00 and 07:00 WITA (Central Indonesian Time) and in the afternoon between 12:00 and 14:00 WITA.

Data Analysis

Data analysis techniques in this study involved calculating several ecological indices to analyse the crab community. First, crab diversity was calculated using the Shannon-Wiener diversity index. The value of this diversity index was then categorized into three criteria: low ($H' < 2.0$), medium ($2.0 \leq H' \leq 3.0$), and high ($H' \geq 3.0$). Second, crab dominance was calculated using the Index of Dominance formula. The value of the dominance index was categorised into two criteria: not dominant ($0 < D \leq 0.5$) and dominant ($0.50 < D \leq 0.75$). Third, evenness was calculated using the Evenness from Shannon Index of Diversity. The value of the evenness index was categorized into three criteria: stressed ($0.0 < E \leq 0.50$), unstable ($0.50 < E \leq 0.75$), and stable ($0.75 < E \geq 1.00$).

RESULTS

The types of crabs found in the Tongke-Tongke Mangrove Forest area, Sinjai Timur District, Sinjai Regency, have different morphometric characteristics. The results of the measurement of morphometric characteristics of crabs found in the Tongke-Tongke Mangrove Forest area, Sinjai Timur District, Sinjai Regency, can be seen in Table 1.

Table 1. Morphometric Characteristics of Crabs Found in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency

Crab Species	CS	RS	CW (cm)	RCL (cm)	LCL (cm)	LL (cm)	Weight (gr)
Clibanarius longitarsus	Present	Blunt	2.37	-	-	1.37	4.53
Coenobita cavipes	Present	Blunt	2.49	-	-	1.17	5.84
Coenobita rugosus	Present	Blunt	3.7	-	-	1.39	20.69
Episesarma chengtongense	Present	Blunt	3.87	-	-	4.04	46.71
Episesarma versicolor	Present	Pointed	3.32	-	-	3.56	39.87
Epixanthus dentatus	Present	Pointed	3.56	-	-	5.24	64.86
Metopograpsus frontalis	Present	Pointed	2.15	-	-	2.43	7.79
Scylla serrata	Present	Pointed	3.85	0.61	1.14	5.43	29.23
Uca dussumieri	Present	Pointed	1.09	-	-	1.69	1.36
Uca inversa	Present	Pointed	0.95	-	-	1.41	1.18
Uca perplexa	Present	Pointed	0.7	-	-	1.31	1.14

Notes:
CS (Carapace Shape), RS (Rostrum Shape), CW (Carapace Width), RCL (Right Chela Length), LCL (Left Chela Length), and LL (Leg Length

Based on the research conducted in the Tongke-Tongke Mangrove Forest area, Sinjai Timur District, Sinjai Regency, 11 species from 5 families were obtained. The number of species obtained at each station is shown in Table 2.

Table 2. Crab Species Diversity Across Stations in the Tongke-Tongke Mangrove

Family	Species	Total Individu				Total
		Station I	Station II	Station III	Station IV	
Coenobitidae	*Coenobita cavipes*	6	7	16	13	42
	Coenobita Rugosus	11	8	21	7	47
Diogenidae	*Clibanarius longitarsus*	2	-	19	8	29
Eriophyidae	*Epixanthus dentatus*	8	2	23	12	45
Grapsidae	*Episesarma chengtongense*	22	14	31	9	76
	Episesarma versicolor	15	13	8	6	42
	Metopograpsus frontalis	17	33	24	16	90
Ocypodidae	*Uca dussumieri*	46	28	-	-	74
	Uca perplexa	31	12	-	-	43
	Uca inversa	56	-	-	-	56
Portunidae	*Scylla serrata*	25	16	31	14	86

The number of species varied across the four stations. A comparison of species richness at each station, based on our observations, is presented in Figure 2.

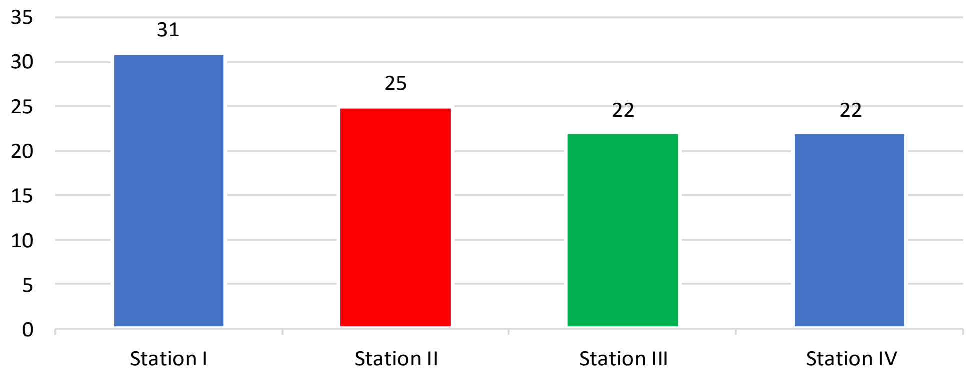

Figure 2. Crab Species Diversity Across Stations in the Tongke-Tongke Mangrove

Data collection results have found 6 different families at each station. The percentage of Families obtained can be seen in Figure 3 percentage of families at each Station in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency.

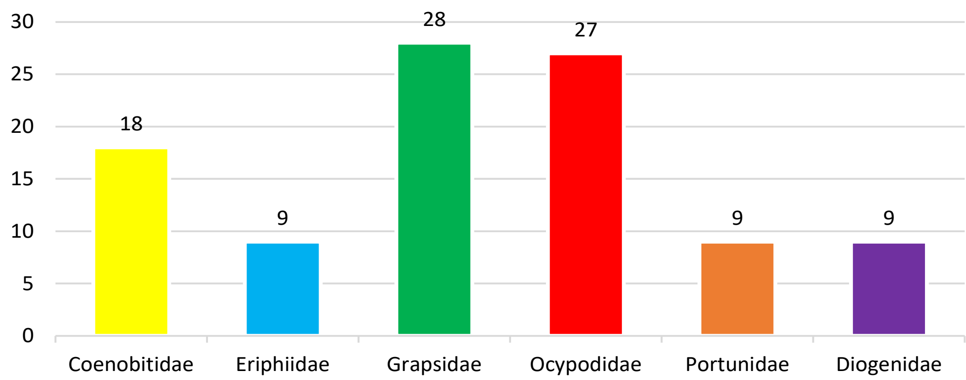

Figure 3. Percentage of species by Crab Family found in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency

Ecological indices are measures used to assess crab diversity at each station, including diversity (H'), evenness (E), and dominance (D). The ecological indices of crabs found in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency, can be seen in Figure 4.

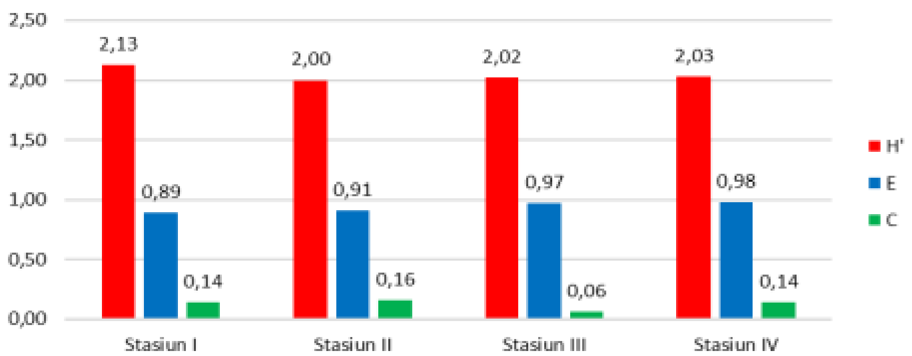

Figure 4. Crab Ecological Indices at Each Station in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency. H' means Diversity Index, E means Evenness Index, and C means Dominance Index.

The characteristics of the crab habitat observed at each station included temperature (air and water), light intensity, pH, salinity, and dissolved oxygen content. The results of the observations on crab habitat characteristics in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency, can be seen in Table 3.

Table 3. Characteristics of crab habitats found in the Tongke-Tongke Mangrove Forest Area, Sinjai Timur District, Sinjai Regency

Station	Air Temp (°C)	Water Temp (°C)	Salin (⁰/₀₀)	Light Inten (lux)	pH	DO (ppm)
I	23.2-30.2	29.1-30.19	26.5-26.7	261.7-361.0	7.1-7.4	5.12-5.29
2	24.9-30.4	28.76-29.96	27.4-27.6	275.6-375.0	7-7.4	5.24-5.83
3	30.4-31.6	29.75-30.31	26.4-26.5	312.7-367.8	7.2-7.5	5.84-6
3	30-30.2	29.54-30.94	26.7-26.9	341.0-365.0	7.1-7.4	5.51-5.72

The relationship between habitat characteristics and the diversity of crab species in the Tongke-Tongke Mangrove Forest Area, East Sinjai District, Sinjai Regency, was analyzed using Canonical Correspondence Analysis (CCA). The results obtained are presented in Figure 5.

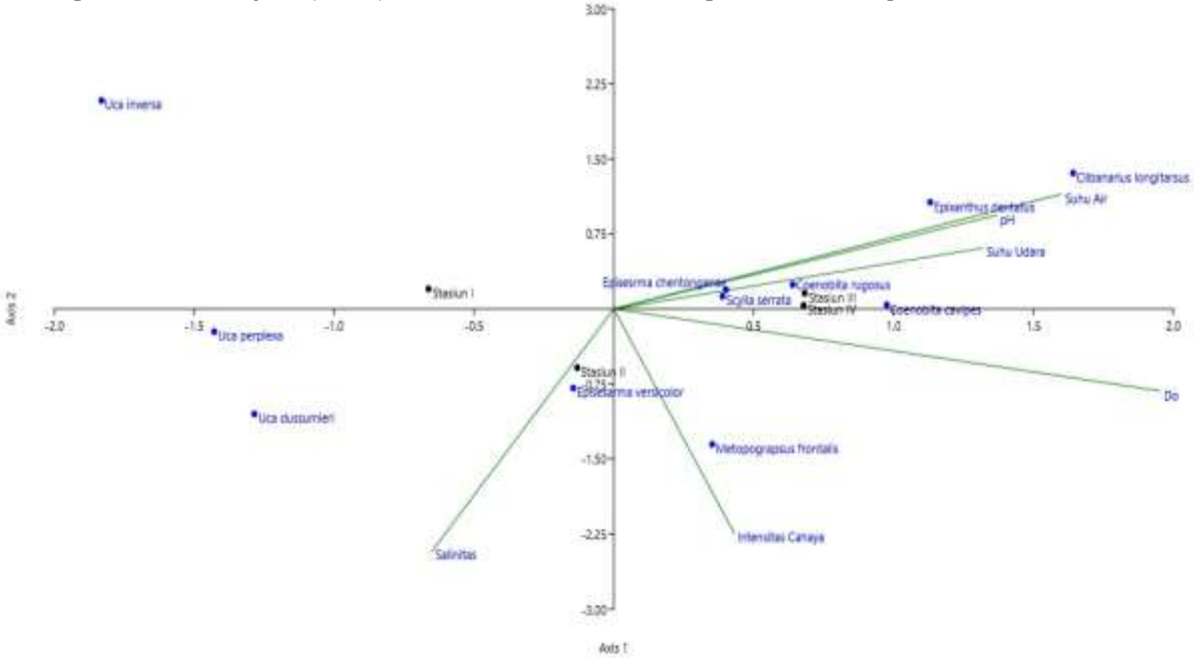

Figure 5. The Canonical Correspondence Analysis (CCA) of the relationship between habitat characteristics and the diversity of crab species in the Tongke-Tongke Mangrove Forest Area.

DISCUSSION

Observations conducted in the study area led to the identification of 11 crab species, such as *Clibanarius longitarsus, Coenobita cavipes, Coenobita rugosus, Episesarma chengtongense, Episesarma versicolor, Epixanthus dentatus, Metopograpsus frontalis, Scylla serrata, Uca dussumieri, Uca inversa*, and *Uca perplexa*. Morphometric distinctions between these species were notable, particularly in the dimensions of their carapaces, which served as critical identification markers (Sampedro et al., 1999). Differences in coloration, claw size, and body adaptations further emphasized the unique ecological roles and evolutionary adaptations of each species (Davie, 2021). Table 1 summarizes these characteristics, underscoring the morphological diversity within the community. This diversity reflects the ecological complexity of the mangrove ecosystems these crabs inhabit (Doherty & Laidre, 2023; Laidre, 2021a; Steele & Laidre, 2023), were varying substrates and environmental gradients shape species distribution and interactions (Al Jufaili, Echreshavi, & Esmaeili, 2023; Doherty & Laidre, 2022).

The species *C. longitarsus* exhibited a carapace length of 2.37 cm and width of 1.37 cm, with blunt spines and a greenish-brown body. Its slightly larger right claw and overall morphology align with findings by Al Jufaili, Echreshavi, Esmaeili, et al. (2023); García Amabile et al. (2022); Laidre (2021b); and Miri et al. (2021). *C. cavipes* displayed a bluish-grey carapace measuring 2.49 cm in length and 1.17 cm in width, accompanied by orange antennae and a noticeably larger left claw (Preston et al., 2015; Schuster, 2024). *C. rugosus*, with its brown carapace of 3.7 cm by 1.39 cm, exhibited blunt spines and distinctive hair-covered claws (Couzin & Laidre, 2009; Handschuh & Aspöck, 2020; Honryo et al., 2022). These differences illustrate the subtle morphological variations that aid in niche specialization and resource utilization (Bates & Laidre, 2018; Grosberg et al., 2012; Laidre, 2012).

Square-shaped carapaces were prominent in *E. chengtongense* and *E. versicolor*, with the former measuring 3.87 cm in length and 4.04 cm in width (Laidre, 2011; Vermeij, 2020). The reddish-black body and red claws of *E. chengtongense* contrast with the grayish-brown body and purple claws of *E. versicolor*. (Krieger et al., 2021) highlighted the flat, setae-covered carapace of *E. chengtongense*, distinguishing it from other species. The hexagonal carapace of *E. dentatus*, measuring 3.56 cm in length and 5.24 cm in width, is sharp-edged, with a blackish-brown body covered in white spots (Krieger et al., 2021; Wang et al., 2022). Its robust right claw enhances predatory efficiency (Chrastina et al., 2015; Hernáez et al., 2024; Huang et al., 2025; McGhee, 2019).

Unique morphologies were observed in *M. frontalis*, characterized by a slightly broader square carapace and a blackish-purple body (Iguchi et al., 2018; Wang et al., 2023; Yamamoto et al., 2019). Its sharp dactylus enables navigation through narrow crevices, a trait well-suited for the mangrove environment (Aguirre-Reyes et al., 2015; Córdova-Murueta et al., 2003; Perez & Backwell, 2017; Yamamoto et al., 2019). The paddle-shaped swimming legs of *S. serrata*, paired with its hexagonal carapace measuring 3.85 cm in length and 5.43 cm in width, highlight its adaptation to aquatic mangrove habitats. Smaller crabs like *U. dussumieri*, *U. inversa*, and *U. perplexa* featured square carapaces ranging from 0.7 cm to 1.69 cm in width. Distinct coloration patterns, such as orange and white claws in *U. dussumieri* or entirely white claws in *U. perplexa*, further illustrated their niche differentiation (Frasnelli et al., 2012; Kurvers et al., 2017; Palmer, 2009).

Adaptations to specific microhabitats were evident among the crab species studied. Hermit crabs like *C. longitarsus*, *C. cavipes*, and *C. rugosus* preferred sandy tidal zones, often utilizing gastropod shells for protection (Liu et al., 2020; Sabzi et al., 2017). Climbing crabs such as *E. chengtongense*, *E. versicolor*, and *M. frontalis* relied on spiny legs to ascend mangrove roots and trunks. The ability to climb provided these species access to food resources unavailable to others (Letzkus et al., 2006; Teles et al., 2023; Tomassetti et al., 2019; Zucca et al., 2011). Swimming crabs, including *S. serrata*, exhibited paddle-shaped legs ideal for submerged habitats, while the dark coloration of *E. dentatus* facilitated camouflage for predation in muddy substrates (Ackerly, 2003; Adhikari & Hartemink, 2016; Airoldi et al., 2008). Intertidal zones were dominated by fiddler crabs, such as *U. dussumieri*, *U. inversa*, and *U. perplexa*, whose specialized claws aided in burrowing and feeding (Alongi, 2002, 2021; Arakaki et al., 2020).

The taxonomic classification of the identified species grouped them into six families: *Coenobitidae*, *Diogenidae*, *Eriophyidae*, *Grapsidae*, *Ocypodidae*, and *Portunidae* (Table 2). The most frequently encountered species, *M. frontalis* (*Grapsidae*), demonstrated remarkable adaptability, thriving across various mangrove environments. Araújo Júnior et al. (2016) attributed the success of *Grapsidae* crabs to their high tolerance for temperature and salinity fluctuations. Other families, such as *Ocypodidae* and *Coenobitidae*, exhibited habitat preferences tied to substrate composition and vegetation density (Clark & Backwell, 2017; Colpo & Negreiros-Fransozo, 2004). This taxonomic diversity reflects the ecological complexity and functional specialization within mangrove ecosystems (Brustolin et al., 2022; Pan & Pratolongo, 2022a).

Differences in species dominance were observed across the four study stations. Sandy substrates at Station I supported populations of *U. inversa*, which thrived in sparsely vegetated intertidal zones. In contrast, *C. longitarsus* was less common, reflecting its preference for muddy substrates (Júnior et al., 2022; Pan & Pratolongo, 2022b; Pratolongo, 2022). Stations II and IV, characterized by dense mangrove vegetation, provided an optimal environment for *M. frontalis*, which relies on organic matter for foraging (Ballesteros, 2006; K. C. Li et al., 2021; Pan & Pratolongo, 2022c). Nutrient-rich detritus from river flows made Station III a favorable habitat for *S. serrata* (Boudreau & Worm, 2012; Freiwald & Henrich, 1994). The absence of Ocypodidae crabs in Stations III and IV was likely due to limited sandy areas and dense root systems that hinder burrowing.

Patterns of species diversity varied among the stations. Station I recorded the highest diversity, with 11 species accounting for 31% of the total. The sandy substrate likely facilitated oxygenation, supporting a wider array of species (Bedini et al., 2014; El-Hacen et al., 2019). Nine species (25%) were recorded at Station II, with the absence of *C. longitarsus* attributed to elevated salinity levels. Stations III and IV each supported eight species (22%), reflecting reduced diversity in muddy substrates with lower oxygen availability. These variations underline the role of habitat characteristics in shaping community structure.

Families Grapsidae and Ocypodidae exhibited the highest species diversity, contributing 28% and 27% of the total, respectively. (Heard et al., 2021) emphasized the adaptability of these families to the fluctuating environmental conditions typical of mangrove ecosystems. Transitional zones between terrestrial and marine environments create complex environmental gradients, necessitating specialized adaptations for survival (Hereward et al., 2017). This adaptability underscores the ecological significance of these families within mangrove habitats. Other families, such as *Coenobitidae* and *Portunidae*, demonstrated narrower ecological niches but critical functional roles in their respective habitats (Ginantra et al., 2021).

Ecological indices provided insights into the stability of the studied ecosystem. Moderate diversity indices (H') ranging from 2.00 to 2.13 indicated a stable community structure with balanced species representation (P. Li et al., 2025). Evenness indices (E) further supported this balance, showing equitable distribution among species without significant dominance (Collyer et al., 2022; de Bello et al., 2021; Kosman et al., 2021a; Ricotta et al., 2022). Low dominance indices (C) of 0.06 to 0.16 highlighted the absence of monopolization by any single species. These findings reflect a well-functioning ecosystem capable of sustaining biodiversity under current environmental conditions (Gregorius & Gillet, 2022; Kosman et al., 2021b; Safitri et al., 2025).

Environmental parameters strongly influenced crab survival and distribution. Temperature readings across the stations ranged between 18–35°C, aligning with the ideal range of 25–30°C for crab activity (Ajijah et al., 2022; De Zoysa, 2022; Raunsay et al., 2024). Salinity levels, varying between 10–35‰, were suitable for most species, reflecting the dynamic interplay between tidal influx and freshwater input (Correia & Lopes, 2023; Farriols et al., 2021; Hartop et al., 2024). Light intensity ranged from 144 to 1852 lux, creating favorable conditions for activity and shelterseeking behaviors (Jesse et al., 2020). Dissolved oxygen (DO) levels, measured at 4–6 ppm, supported metabolic functions critical for survival (He et al., 2024; Ruff et al., 2024; Sharma et al., 2024). The pH levels remained within the optimal range of 5–9, ensuring chemical stability for aquatic life.

Canonical Correspondence Analysis (CCA) highlighted species-specific dependencies on environmental factors. Temperature and pH were primary influences on species such as *C. cavipes*, *C. rugosus*, and *S. serrata*. Dissolved oxygen and light intensity strongly correlated with *M. frontalis*, while salinity shaped the distribution of *E. versicolor*, *U. dussumieri*, and *U. perplexa*. Station-specific gradients revealed distinct patterns, with Stations III and IV showing strong influences from temperature and pH, and Station II shaped by salinity levels. Minimal environmental influence was observed at Station I, reflecting its relatively uniform sandy substrate (Reidy et al., 2025; Speir et al., 2025).

These findings underscore the complex interactions between environmental factors and species distribution within mangrove ecosystems. The intricate balance of habitat characteristics supports a diverse community of crabs, each occupying a specialized niche (Vincent et al., 2025). These relationships highlight the ecological importance of mangroves as transitional zones that foster biodiversity while maintaining ecosystem stability (Dewey et al., 2025). Continued monitoring of these factors will be essential in understanding the resilience of mangrove communities to environmental change and human impact.

CONCLUSION

The study revealed a diverse assemblage of crabs within mangrove ecosystems, comprising 11 species from six families, each exhibiting unique morphometric and ecological adaptations. Species distribution was strongly influenced by environmental parameters, including substrate type, vegetation density, temperature, salinity, dissolved oxygen, and pH. Variations in habitat characteristics across stations determined species dominance and diversity, with sandy substrates and nutrient-rich detritus supporting higher diversity. Morphological and behavioural specializations, such as climbing abilities, camouflage, and substrate preferences, underscored the evolutionary adaptations of these crabs to their niches. Ecological indices confirmed a stable and balanced community structure, reflecting the health of the mangrove ecosystem. These findings emphasize the critical role of mangroves as biodiverse habitats that support species resilience and ecological balance. Continued conservation and monitoring efforts are essential to protect these habitats from environmental changes and anthropogenic pressures.

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