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The correlation between environmental parameters and the abundance of crabs in the mangrove ecosystem of Gemuruh River, Koto XI Tarusan District, West Sumatera

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ABSTRACT

Crabs are a member of the mangrove ecosystem fauna and get their food source from litter. They turn the litter into detritus and maintain ecological balance. In addition, environmental conditions in the mangrove ecosystem also play an essential role in the abundance of brachyuran crabs. Influential environmental factors include temperature, salinity, water pH, and substrate type. This study aims to determine the effect of environment types on the presence of brachyuran crabs from families Ocypodidae and Sesarmidae in the mangrove ecosystem in Gemuruh River, Koto XI Tarusan District. The method used is a descriptive method, which is a direct observation approach to crabs and environmental conditions in the mangrove ecosystem area. Collection of crab samples and environmental condition data used a purposive sampling technique. The result shows six species distributed in the area, namely *Uca bellator, U. rosea, Perisesarma eumolpe, Sarmatium germaini*, *P. plicatum,* and *Sesarma curoense.* The distribution of species crabs in vegetation mangroves is *Rhizophora stylosa, R. apiculata, R. mucronata, Sonneratia alba,* and *Nypa fruticans.* The environmental parameters (temperature, salinity, water pH) at each station were within the relatively good category for the growth of the Ocypodidae and Sesarmidae crab families. Based on the analysis results of the relationship between the abundance of brachyuran crabs and environmental parameters (temperature, salinity, water pH), it can be seen that there is no significant correlation between temperature, salinity, and water pH with the abundance of Ocypodidae and Sesarmidae brachyuran crabs families in the mangrove ecosystem of Gemuruh River. The factor with a dominant influence on the abundance of these crabs is the substrate type.

Introduction

The mangrove ecosystem is an area with high biodiversity and is a type of forest ecosystem able to grow and develop in tidal areas, especially in the flooded part of the river. The mangrove vegetation in the mangrove ecosystem is very dense and abundant. Mangrove has a key role in the life of organisms living in the ecosystem, especially brachyuran crabs. In addition, the mangrove ecosystem is used as a feeding ground, nursery ground, and spawning ground for these organisms (Freitas *et al.*, 2021; Maharajan *et al.*, 2015).

Crabs in the mangrove vegetation often look for food sources that come from mangrove litter that falls into the substrate which provides organic matter, supporting the large number of crabs in the mangrove vegetation (Freitas *et al.,* 2021). Water conditions in the mangrove ecosystem are very vulnerable to environmental disturbances that may damage and affect the life of biota and other organisms. One of these organisms is the crab which survives and lives in the mangrove ecosystem. These crustaceans (*Brachyuran* crabs) also participate in the cycling of nutrients, controlling the remineralization of detritus in the mangrove ecosystem (Bandekar, 2021; Chakravarty *et al.,* 2016).

Brachyuran crabs are inhabitants of mangrove

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ecosystems and associated mudflat habitats, as well as the intertidal and subtidal habitats (Ng, 2021). Brachyuran crabs are comprised of many families including the Ocypodidae, Sesarmidae, Portunidae, Macrophthalmidae, and Dotilidae (Cannicci and Ng, 2017; Costello and Chaudhary, 2017; Stiepani *et al.,* 2021). In Indonesian waters, the types of small crabs found in this ecosystem are members of the Ocypodidae and Sesarmidae families. These crabs are considered a major element of the mangrove ecosystem that can live in unique environmental conditions (Wang *et al.,* 2022).

Ecosystem imbalance caused by environmental conditions will affect this type of crab and may result in a reduced presence of these crabs. Environmental parameters are a limiting factor for the existence of crabs of the Ocypodidae and Sesarmidae families. Stable environmental conditions in a mangrove ecosystem may allow an abundant growth and development of crab species from the Ocypodidae and Sesarmidae families (Leoville *et al.,* 2021; Tiralongo *et al.,* 2020). In the mangrove ecosystem, the key to environmental parameter that affects the species richness of Ocypodidae and Sesarmidae crabs families is temperature. A good temperature for the growth and development of these crabs is around 28^{0}C-32^{0}C (Chaudhary *et al.,* 2016; Sharifian *et al.,* 2020).

The mangrove ecosystem at Gemuruh River is often used as a source of livelihood for fishers. In addition, many development activities take place around the mangrove ecosystem area. In this case, many activities can disturb environment conditions and affect the abundance of brachyuran crabs, especially if there is no information about environmental parameters and about how the environment affects the abundance of crabs.

This study aims to determine the relationship between environmental parameters and the abundance of Ocypodidae and Sesarmidae crabs in the Gemuruh River mangrove ecosystem and to determine the abundance of Ocypodidae and Sesarmidae crabs in the Gemuruh River mangrove ecosystem, Koto XI Tarusan District.

Materials and Methods

Location and time of research

This research was conducted in the mangrove ecosystem area in Sungai Gemuruh, Koto XI Tarusan District, West Sumatera Province (Figure 1). The study was conducted in May 2022. For one month, sampling was conducted three times every week. Based on previous research, the types of mangroves identified in this area include *Acrostichum aureum, Bruguiera cylindrica, Rhizophora apiculata, Rhizophora stylosa, and Nypa fruticans* (Dafikri and Kamal, 2021). This research was conducted using a descriptive method. This method is used because it allows researchers to describe the conditions observed in the field in a manner that is more specific, transparent, and deep. The descriptive method is commonly used to conduct research on status, groups of people, conditions, objects, or events in the present time, with the aim to obtain a systematic picture of the phenomenon investigated (Krisnawati *et al.,* 2018).

Determination of the research location used the purposive method. This method was done deliberately based on certain considerations. The descriptive method is a method used to conduct research on the status, groups of people, conditions, objects, or events in the present time, with the aim to obtain a systematic picture of the phenomenon investigated.

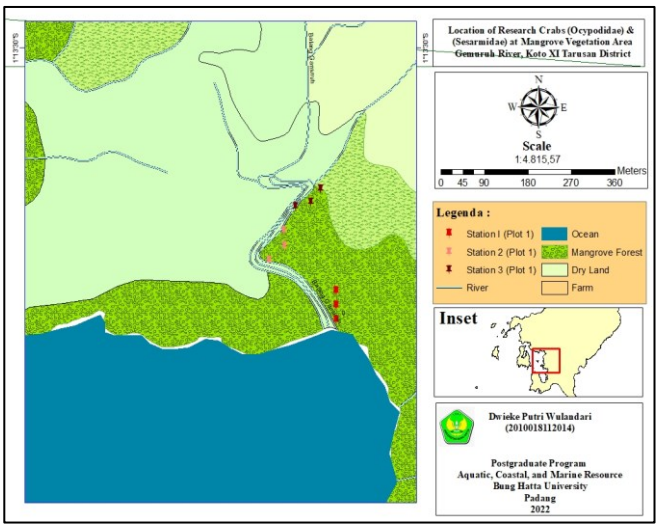

Figure 1. Research location in the mangrove ecosystem of Gemuruh River, Koto XI Tarusan District.

Sample collection

This study was conducted in the mangrove ecosystem area at Sungai Gemuruh. Meanwhile, data collection for Ocypodidae and Sesarmidae crabs and environmental parameters were conducted using *purposive sampling,* assisted by paths and plots as observations in the study. Sampling used a *purposive sampling* technique aimed to obtain samples that match the criteria specified in the study and becomes a reference for explaining the problems found in collecting research samples.

A total of three stations were sampled: Station 1 is located in a mangrove area with a sparse density of mangrove vegetation; Station 2 is located in a

mangrove area with a medium density of mangrove vegetation; and Station 3 is located in a mangrove area with a high density of mangrove vegetation. At each station, a transect line of 80 meters was stretched, and each of the transect lines was assisted by three plots measuring 5x5 meters. Crab sampling was conducted at the lowest tide starting from 05.00 to 09.00 a.m. and then continued again in the afternoon from 15.00 to 16.30 p.m.

The sampling of crabs was conducted based on the transects that had been installed and marked. Crab samples were taken from the surface of the substrate using hands that had been fitted with gloves, while crab samples in holes were taken using the digging technique, namely by digging a hole as deep as 15 cm using a small shovel. The collected samples were then cleaned with running water to remove traces of sediment attached to the crabs. After that, the collected crabs were soaked in 70% alcohol for 5 minutes, then they are removed using tweezers and stored in a clean collection bottle. Mangrove ecosystem water quality parameter measurements were also collected, including temperature, salinity, and pH using the tools provided. The obtained environmental parameter data were then analyzed descriptively.

Data Analysis

Environmental parameters research data were analyzed to see the relationship between environmental parameters and the abundance of Ocypodidae and Sesarmidae crabs. It was analyzed using a multiple linear regression model by drawing conclusions from the results of the T-test compared to the results obtained. The abundance of crab families Ocypodidae and Sesarmidae is calculated using the number of individuals per unit area or per unit volume, abundance can be calculated using the formula below (Indraswari *et al.,* 2017; Krisnawati *et al.,* 2018).

$$Di = \frac{ni}{A}$$

where,
Di = Abundance of Brachyuran Crabs (ind/m2)
ni = Number of individuals of the first type (ind)
A = Sampling box area

Results

This study analyzed if environmental factors (temperature, salinity, pH, and substrate) are determining factors for the number of crabs from the Ocypodidae and Sesarmidae families. The results, show that there is not much difference in environmental parameter values at each research observation station around the mangrove ecosystem area in Gemuruh River as presented in Table 1.

Species abundance varies between each station. In this research, two species were recorded from the family Ocypodidae, and four species were recorded from the family Sesarmidae. Observed Brachyuran crabs from family Ocypodidae were *Uca bellator*, and *U. rosea.*, while from family Sesarmidae were *Perisersama eumolpe*, *Sarmatium germaini*, *P. plicatum, Sesarma curoense* (Table 2).

Table 1. Environmental parameters and ocypodidae and sesarmidae crab families.

No.	Station	Mangrove Species	Environmental Parameters			
			pH	Salinity (PPT °/₀₀)	Temperature (⁰C)	Substrate
1.	Station I	- *Rhizophora stylosa* - *Rhizophora apiculata*	8.0-8.1	17-20	30.2-31	Muddy
2.	Station II	- *Rhizophora stylosa* - *Rhizophora apiculata* - *Rhizophora mucronata* - *Sonneratia alba* - *Nypa fruticans*	7.6-7.8	15-18	28.5-30	Muddy
3.	Station III	- *Rhizophora apiculata* - *Sonneratia alba* - *Nypa fruticans*	7.9-8.4	16.6-18	28.1-28.2	Muddy-sand
Total			**7.9**	**18.0**	**29.3**	**-**

Table 2. Species abundance of Ocypodidae and Sesarmidae crab families.

No.	Family	Species	Mangrove Species	Abundance of Crabs (ind/m²)		
				ST. I	ST. II	ST.III
1.	Ocypodidae	*Uca bellator*	- *Rhizophora apiculata* - *Rhizophora mucronata*	2.76	6.20	1.04
2.		*Uca rosea*	- *Rhizophora mucronata* - *Rhizophora apiculata*	4.04	1.88	4.08
3.	Sesarmidae	*Perisesarma eumolpe*	- *Rhizophora apiculata* - *Rhizopora mucronata* -*Sonneratia alba*	4.88	6.40	7.36
4.		*Sarmatium germani*	-*Sonneratia alba*	4.36	5.56	3.92
5.		*Perisesarma plicatum*	- *Rhizophora apiculata* - *Sonneratia alba* - *Rhizophora mucronata*	6.56	7.24	6.56
6.		*Sesarma curoense*	- *Sonneratia alba*	2.48	2.68	1.56
Total				**25.08**	**29.96**	**24.52**

Table 3. Correlation analysis of environmental parameters with the abundance of crab families (Ocypodidae and Sesarmidae).

Coefficients[a)]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance level (α)
	B	Std. Error	Beta		
Constant	29.746	20.882		1.424	0.18
Temperature (X1)	-0.547	0.593	-0.272	-0.922	0.375
Salinity (X2)	0,11	0.465	0.081	0.236	0.818
pH (X3)	-1.412	2.284	-0.202	-0.618	0.548

[a)]Dependent variable: abundance of crabs (Ocypodidae and Sesarmidae)

Discussion

Analysis of the abundance of crabs (Ocypodidae and Sesarmidae)

Based on the results presented in Table 2 on the abundance of crab species from families Ocypodidae and Sesarmidae, the crab species with the highest abundance at station 1 was *Perisesarma plicatum* from the Sesarmidae family with a value of 6.56 ind/m^2**.** Meanwhile, at station 2, the highest abundance among all the species observed in all observation lines was from the Sesarmidae family, namely *P. plicatum* with a value of 7.24 ind/m^2**.** For station 3 the highest abundance of crab was recorded for *Sesarma curoense* with a value of 7.36 ind/m^2). In contrast to the results of research conducted by Le *et al.* (2018) in Duyen Hai City, Vietnam, which found that in the mangrove area in their study location, the highest abundance and dominant distribution of crab species were found to be Ocypodidae crabs with 45.5% of overall abundance, while Sesarmidae crabs were non-dominant, only accounting for 13.6% of overall abundance. This happens because Ocypodidae crabs in this area can survive extreme conditions in the mangrove environment (Le *et al.,* 2018). According to the result of research conducted by Katili and Utina (2019), the high abundance of Sesarmidae crabs, and the difference in the abundance index values of 0.0189 Ind/m^2 at station I, and 0.0188 Ind/m^2 at station II are due to the selection of habitats favored by each species.

However, a high abundance of the Sesarmidae family crab species was found among those that are associated with the mangrove species *Rhizophora apiculata, Rhizophora mucronata,* and *Sonneratia alba.* The abundance of species found at each station in the mangrove forest in the Gemuruh River, was due to the fact that at stations 2 and 3 the mangrove vegetation around the observation plot were dense and the vegetation was relatively more mature, making it possible for crabs to grow and develop in an optimal manner. This is also in line with several past studies which stated that mature mangrove vegetation can provide litter (nutrients) that act as a food source for crabs in the mangrove ecosystem (Zolkhiflee *et al.*, 2021).

The abundance of crabs of the Sesarmidae family that are found in many species of mangrove

vegetation is caused by several environmental factors and the density of mangrove vegetation. At each station, six species of crabs were observed and found among different mangrove vegetation scattered in each station. The mangrove species were *Rhizophora stylosa, R. apiculata, R. mucronata, Sonneratia alba,* and *Nypa fruticans*. The species of crabs from the families Ocypodidae and Sesarmidae were distributed in the *Rhizophora* zone. As found in the mangrove ecosystem in Nori, North Sulawesi, where 14 species of crabs from six families were found, and some of which came from the Ocypodidae and Sesarmidae families, namely *Parasesarma semperi*, *Parasesarma* sp., *Uca annulipes*, and *U. triangularis*. These crabs were commonly found around mangrove species and were scattered in various vegetation zones. The crabs were widely distributed among the Rhizophora mangrove species. *Parasarma* and *Uca* were found shelter in the middle of Rhizophora. This vegetation presents rich nutrients for the Ocypodidae and Sesarmidae crabs (Pratiwi and Widyastuti, 2018).

The environmental condition of crabs (Ocypodidae and Sesarmide) habitats in the Gemuruh River mangrove ecosystem

The varying differences in temperature are influenced by the amount of sunlight intensity or it can be said that it depends on the weather conditions in the area. The temperature in the mangrove ecosystem area is still classified as a good temperature category for the development and growth of the four species of crabs observed in the mangrove ecosystem area in Gemuruh River. As seen in Table 1 the temperature at station I based on the measurement results ranged from 30,2^{0}C-31^{0}C, the salinity values of the research ranged from 17-20 $^o/_{oo}$, and pH values at station I were 8.0-8.1. Mangrove vegetation species observed in Station I was *Rhizophora apiculate* and *R. stylosa*. The substrate in the station I were muddy. At station II based on the measurement results, the temperature ranged from 28.5-30^{0}C, the salinity values of the research ranged from 15-18 $^o/_{oo}$, and pH values at station II were 7.6-7.8. Mangrove vegetation species observed in Station II were *Rhizophora apiculata, R. stylosa, Sonneratia alba, R. muronata, and Nypa fruticans*. Substrates in station II were muddy. Based on the measurement results at station III, the temperature ranged from 28.1-28.2^{0}C, the salinity values of the research ranged from 16,6-18 $^o/_{oo}$, and pH values at station III were 7.9-8.4. Mangrove vegetation species observed in Station III were *Rhizophora apiculata, Sonneratia alba,* and *Nypa fruticans*. Substrate in station III were muddy-sand.

Generally, for other types of aquatic organisms, the optimum temperature is between 20-30^{0}C, but for the development and growth of breeding crabs, the optimum temperature is between 26-30^{0}C (Paulo *et al.,* 2020; Wulandari and Kamal, 2021). The salinity values obtained on each transect of the research station ranged from 18-18.7$^o/_{oo}$. Meanwhile, the pH at each station ranged from 8.1-9.9. A pH value <5 or >9 creates unfavorable conditions for crabs, but if the environmental pH is good it will affect the mangrove ecosystem so that the resulting litter can be sufficient for the life of these small crabs (Baksir *et al.,* 2022; Natania *et al.,* 2017).

Analysis effect of environmental factors on the abundance of crabs families (Ocypodidae and Sesarmidae)

Environmental parameters are key factors for the survival of these small crabs from the Ocypodidae and Sesarmidae families. The relationship or correlation between environmental parameters and the abundance of crab species in the mangrove vegetation area of the Gemuruh River is presented in Table 3, and the previously provided equation shows the influence of environmental conditions in the mangrove vegetation area of the Gemuruh River, with Temperature, Salinity, and pH as independent variables, and the abundance of crab species observed as the dependent variable. Partially, it can be said that the correlation of the temperature variable (X1) has a t-value of -0.922 < 2.0201, with the significance level, is obtained by the equation 0.375 > 0.05.

The salinity variable (X2) has a t-count value with the equation of 0.236 < 2.0201 and a sig value of 0.110 > 0.05. For the pH variable, the equation for the t value is -0.618 < 2.0201 and the sig value for the equation is -1.412 > 0.05.

For all the independent variables (Temperature, Salinity, and pH), based on both the t-value and the sig value obtained on all station lines in the Gemuruh River mangrove vegetation area, the hypothesis is rejected which means that the environmental parameters (temperature, salinity, and pH) had no significant effect on the abundance of collected crabs of the Ocypodidae and Sesarmide families in the mangrove vegetation of the Gemuruh River. This insignificant result is also caused by the small number of samples obtained.

In addition, the environmental factor with the dominant influence is the content of organic matter present in the substrate. Brachyuran crabs prefer to live in a mangrove ecosystem with a muddy substrate because there are many sources of organic

food that are abundant in muddy substrates (Karniati *et al.,* 2021; Stumpp *et al.,* 2021). The substrate is also a very influential factor in the abundance of crab species because the substrate in the mangrove vegetation type contains organic material that comes from the litter that falls into the substrate and decomposes into nutrients for crabs (Mohanty *et al.,* 2019). For each type of crab found in mangrove vegetation with different substrates, the highest abundance of species was found on mud substrates associated with *Rhizophora apiculata* and *Rhizophora mucronata*. However, if the mangrove vegetation is too dense, it will affect the environment and the substrate so that the abundance of species will be affected, as happened at station I in the area Mangrove Ecosystem Gemuruh River, Koto XI Tarusan, District. If we look at the relationship between environmental parameters and the abundance of species that have been analyzed, it can be concluded that all environmental parameters have no influence, but this does not indicate that the surrounding environment is not suitable for the life of Ocypodidae and Sesarmidae crabs, because if we look at the parameter results, all environmental parameters are within relatively stable limits.

Conclusion

Although environmental factors do not have a strong influence on the abundance of crab species, the environmental conditions at each station are relatively good for the life of crabs from the Ocypodidae and Sesarmidae families, with a substrate of mud & sandy mud, a temperature range of 28-31^{0}C, salinity range of 17-20‰, and pH range of 7.6-8.4. Analysis of environmental parameters using multiple linear methods concluded that temperature, salinity, and pH had no correlation with the abundance of brachyuran crabs in the Gemuruh River mangrove ecosystem. The crab species found around the mangrove vegetation were *U. bellator, U. rosea, P. eumolpe, S. germaini*, *P. plicatum, and Sesarma curoense.*

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