

# Association of Crab Species (Brachyura) Based on Mangrove Density Levels along the Coast of Tugurejo, Semarang, Indonesia

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**Abstract-** Mangrove ecosystem have ecological functions as a spawning ground, nursery ground, and feeding ground. The purpose of this study was to determine the correlation of an abundance of crabs with the density of mangroves in the mangrove ecosystems of Tugurejo Village, Semarang. This research was hand picking of sampling methods and determining sampling locations using a purposive sampling method. The research location is divided into three stations, namely Station 1 (Non estuary), Station 2 (Transition area), Station 3 (Estuary). Samples were taken from a sampling plot of 10 m x 10 m. The results of this study identified two types of mangroves: *Rhizophora mucronata* and *Avicennia marina*. The results of this study found 4 types of crabs including *Metaplex elegans*, *Parasesarma charis*, *Metopograpsus latifrons*, *Uca coarctata*. The ecological function of crabs in the mangrove ecosystem is as indicator species. The dominant crab species found was *Uca coarctata*, with a percentage value of 36.25%. The correlation of the abundance of crabs with mangrove density shows that higher the value of mangrove density, make the abundance of crabs increases. The crab abundance value on the coast of Tugurejo Village the lowest was 700 ind/ha, and the highest was 2000 ind/ha.

**Keywords:** Density of Mangrove, Abundance of Crab, Morisita Index

## I. INTRODUCTION

Tugurejo Village is a coastal area situated in Tugu Sub-district, Semarang City, covering an area of 855.838 hectares, with the largest land use being dry land (744.007 hectares) and fish ponds (508 hectares). The fishpond area is managed within a mangrove forest zone, home to associated species such as crabs, fish, prawns, and several terrestrial species such as birds. The current condition of the mangroves along the coast of Tugurejo Village is relatively good compared to neighbouring areas. The

Tugurejo sub-district has seen numerous mangrove planting initiatives undertaken by local communities as well as government agencies, private sector organisations, NGOs, school pupils and university students. However, this does not automatically ensure the safety of the mangroves in the sub-district from various pressures causing damage due to human activities, particularly those of communities living near the mangroves to meet their livelihood needs. According to Kariada and Irsadi (2014), the degradation of the coastline and mangrove areas in the coastal zone of Semarang City has led to a decline in the environmental quality of the coastal region. This decline in environmental quality will also affect the aquaculture environments situated within that coastal area. Numerous efforts have been undertaken by both the government and the community in several coastal locations in Semarang. Nevertheless, significant damage continues to occur, making the conservation of mangroves essential.

High-density mangroves provide a more complex habitat structure, including branching roots and dense vegetation. This structure offers a variety of different microhabitats and shelters, which can support a wide range of species. This diversity of habitat structures allows various organisms to find suitable habitats and food sources that meet the needs of the species within them. High mangrove density can also provide additional protection from predators for many species. Dense mangrove roots can serve as safe shelters for fish, crustaceans and small invertebrates, enhancing survival and breeding opportunities. Conversely, low density can reduce habitat quality and affect the species that depend on it. According to Razali et al. (2020), mangrove density can also be used as an indicator of mangrove health status, as

mangroves with low density are always found near at-risk areas.

Crabs are indicator species in mangrove forests that serve to convert nutrients and enhance mineralisation, improve oxygen distribution in the soil, aid the carbon cycle, and provide a natural food source for various types of aquatic biota. These interactions can influence the balance of species communities and contribute to overall species diversity. The relationship between crabs and the mangrove ecosystem is a mutualistic symbiosis as it is mutually beneficial. The mangrove ecosystem provides an ideal habitat for crabs to take shelter. Mangroves also serve as a spawning ground for crabs. The complex root structure of mangroves creates numerous crevices and hiding places, thereby protecting crab eggs and larvae from predators. The tranquil environment within mangrove areas also provides stable, ideal conditions for spawning. Furthermore, mangroves are rich in food sources, such as algae, detritus, and other small organisms, which support the growth of crab larvae and juveniles. Therefore, research into mangrove density is crucial for understanding the dynamics of this ecosystem, planning conservation efforts, and assessing the impacts of human activities and climate change.

The mangrove forest along the coast of Tugurejo Village plays a vital role as a spawning ground, shelter and food source for aquatic life, as well as providing a setting for various activities such as aquaculture and ecotourism. Mangroves play a highly significant role in the ecology of the area. The degradation of mangrove land at research site 4 has led to a decline in the environmental quality of the coastal area. This decline in environmental quality will also affect the pond environment in the coastal area. Consequently, it will also affect the quality of the biota within it. The presence of crabs in the mangrove ecosystem can serve as an indicator of whether the mangrove forest is still functioning properly or not, as crabs are an important part of the mangrove food chain, acting as both predators and prey.

## II. MATERIALS AND METHODS

The materials used in this study comprised mangrove data, crab data and water quality data collected directly from the Tugurejo coastal area at three stations, each comprising two plots. The crabs collected were identified to determine their abundance, and the water quality parameters measured included temperature, pH, salinity and dissolved oxygen (DO).

The mangrove area on the coast of Tugurejo Village covers approximately 3.00 hectares and is geographically located at the coordinates 110°35'00.2" E and 6°96'83.6" S (Figure 1). The study site was divided into three stations, each comprising two plots. The selection of stations was based on considerations of environmental conditions, resulting in the choice of three research stations. Station 1 is based on the mangrove belt situated at the coordinates 110°20'55.3"E and 6°57'42.5"S; Station 2 is based on the mangrove belt near the fish ponds situated at the coordinates 110°20'58.6"E and 6°57'36"S; Station 3 is based on the mangrove along the estuary located at coordinates 110°21'18.3"E and 6°57'14.8"S. Sampling points were determined using purposive sampling. According to Santri et al. (2020), purposive sampling is a method of sampling that is not random but is based on specific, deliberate considerations.

The identification of mangrove species and mangrove density was carried out directly at the study site. The coastal area of Tugurejo Village that contains mangroves is the Tapak area. The sampling technique used during the study involved purposive, rather than random, sampling, based on specific considerations believed to provide the most relevant and useful information for the study. Samples were taken from several different points in accordance with predetermined locations. According to Maharani and Bernard (2018), this technique was employed with specific considerations in line with the research requirements. Samples were taken from 10 m x 10 m sampling plots spaced 5 metres apart. Crab sampling was carried out using the hand-picking method. According to Putra et al. (2023), this method involves collecting crabs directly by hand during low tide to facilitate sampling. This is because crabs are active

during low tide. Crabs on the surface of the substrate were collected by hand (hand-picking). Crabs found inside burrows were collected by digging them out with a spade. This sampling method was adapted from the approach used by Rozanda et al. (2020). Crab samples were collected from three 1 m × 1 m sampling points within a 10 m × 10 m plot. This sampling method was adapted from the method used in the journal by Siahaan et al. (2018). The crabs obtained were then preserved using 70% alcohol.

The crab samples collected were then placed in containers and stored in a coolbox. Morphological observations were carried out in the laboratory. The crab species identified were examined using a crab identification guide, and the results were documented using a camera.

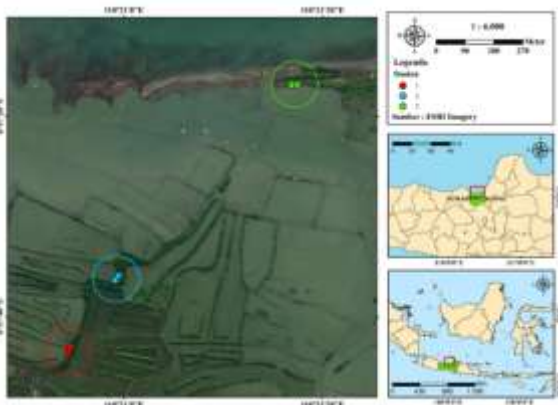


Figure 1. Map of the Research Location

Species density (K) is the number of individuals of species *i* within a unit area. Mangrove density data in the field can be calculated using the formula (Sofian et al., 2012):

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

Notes: K = Density of species *i* (ind./m<sup>2</sup>); *n* = Number of individuals of species *i*; A = Area (m<sup>2</sup>)

The analysis of the observed data concerns crab abundance by species. Crab abundance in the field can be calculated using the following formula (Bengen et al., 1992):

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

Notes: N = Abundance of species *i* (ind./m<sup>2</sup>); *n* = Number of individuals of species *i*; A = Area (m<sup>2</sup>)

The Morisita index is a calculation used to measure the distribution pattern of a species and is not influenced by the size of the sampling unit. The criteria for the Morisita index, according to Syahrial and Sastriawan (2018), are  $I\delta = 1$  (random distribution pattern),  $I\delta < 1$  (uniform distribution pattern) and  $I\delta > 1$  (clumped distribution pattern). The distribution pattern of crabs in the field can be calculated using the formula (Fadilah et al. 2023):

$$Id = \frac{\Sigma X^2 - \Sigma X}{n(\Sigma X)^2 - \Sigma X}$$

Notes: Id = Morisita index; *n* = Total number of plots;  $\Sigma X$  = Total number of individuals per plot;  $\Sigma X^2$  = Sum of squares of the number of individuals per plot

Simple linear regression analysis is a statistical technique that can be used to explain the effect of one independent variable on one dependent variable. The independent variable (X) in this study is mangrove density, whilst the dependent variable (Y) is crab abundance, calculated using SPSS (Statistical Package for the Social Sciences).

Principal Component Analysis (PCA), is a technique for reducing multivariate data that seeks to transform an initial data matrix into a smaller set of linear combinations that capture a significant portion of the variance in the original data; the original independent variables are reduced to new independent variables. The analysis was conducted using data on temperature, DO, pH, and salinity. According to Fahrezi et al. (2023), the PCA analysis was performed using STATISTIC 10.0 software. PCA is a statistical method that aims to present the maximum information contained within a data matrix in graphical form.

### III. RESULTS AND DISCUSSION

#### A. Mangrove Species and Density

The mangrove species found along the coast of Tugurejo Village include *Rhizophora mucronata* and *Avicennia marina*. The identification of mangrove species was carried out by examining differences in the leaves, roots, stems and flowers, using the mangrove identification guide shown in Figure 2 below.



(a) Rhizophora mucronata, (b) Avicennia marina

Mangrove species density is classified into three categories in accordance with Ministerial Decree No. 201 of 2004. Based on the results of research conducted on the coast of Tugurejo Village, the calculations for mangrove species density are shown in Table 1.

Table 1. Density of Mangrove

Stasiun	Plot	Species	Density (ind/ha)	Criteria
1	1	<i>Rhizophora mucronata</i>	2500	Very Dense
	2	<i>Rhizophora mucronata</i>	1800	Very Dense
2	1	<i>Avicennia marina</i>	200	Low Density
		<i>Rhizophora mucronata</i>	900	Low Density
	2	<i>Avicennia marina</i>	300	Low Density
		<i>Rhizophora mucronata</i>	1000	Moderate Density
3	1	<i>Avicennia marina</i>	300	Low Density
	2	<i>Avicennia marina</i>	800	Low Density
Average			975	Moderate Density

Observations along the coast of Tugurejo Village show that mangrove density at Station 1 was 2,500 plants/ha and 1,800 plants/ha, Station 2 at 1,000 plants/ha, 3,100 plants/ha, 1,100 plants/ha, and 2,000 plants/ha, and Station 3 at 300 plants/ha and 800

plants/ha. Based on the Density Criteria according to Minister of Environment Decree No. 201 of 2004, these conditions are classified as sparse, moderate, and dense. This is supported by the water quality in the Tugurejo Village coastal area, which is suitable for mangrove ecosystem life. The average density of mangroves being dense is influenced by environmental conditions such as the substrate. Suitable substrate influences mangrove density (Abubakar et al., 2022). The study site in the coastal area of Tugurejo Village is close to the sea and is dominated by muddy substrate. Overall, the condition of the mangrove ecosystem along the coast of Tugurejo Village remains quite good at Station 1 and Station 2. The density of *Rhizophora mucronata* at Station 1 falls into the dense category, at 2,500 individuals per hectare and 1,800 individuals per hectare. The *Rhizophora* sp. mangrove species possesses a higher adaptive capacity compared to other species. *Rhizophora* sp. can grow at salinities of 32–34 ppt. One genus of *Rhizophora* sp. that exhibits tolerance to harder substrates or sand is *Rhizophora mucronata* (Nedhisa and Tjahjaningrum, 2019). Station 2 hosts a fairly diverse range of mangrove species, namely *Rhizophora mucronata* and *Avicennia marina*. Mangrove species diversity is influenced by environmental conditions. According to Tefarani et al. (2019), environmental factors can influence mangrove diversity.

#### B. Crab Species and Abundance

An identification of crabs associated with mangroves on the coast of Tugurejo Village revealed four species belonging to three different families: Varunidae, Sesarnidae and Ocypodidae. The identification of associated crab species was carried out by examining differences in the shell, carapace and colouration, using the crab identification guide presented in Figure 3





Figure 3. Types of Crabs

- (a) *Metaplex elegans* (b) *Parasesarma charis*  
 (c) *Parametopograpsus latifrons* (d) *Uca coarctata*

The results of the study show that the abundance of crab species collected along the coast of Tugurejo Village can be seen in Figure 4 below:

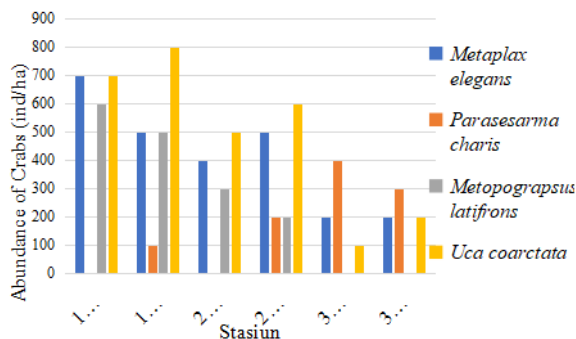


Figure 4. Abundance of Crab Species

Figure 4 shows the distribution of four crab species across several stations, with variations in population abundance. The species *Metaplex elegans* showed a decline in abundance, with the highest value at Station 1, Plot 1, at 700 ind/ha, decreasing to 200 ind/ha at Station 3. The highest abundance of *Parasesarma charis* was found at Station 3, at 400 ind/ha. The species *Parametopograpsus latifrons* showed a decline in abundance from Station 1 to Station 2, from 600 ind/ha to 300 ind/ha. The species *Parametopograpsus latifrons* was not found at Station 3. The species *Uca coarctata* was found at every station, with the highest abundance recorded at Station 1, namely 800 ind/ha. Overall, most species showed a decline in abundance as the stations progressed, with variations in the data.

Based on the results obtained from the identification carried out in the mangrove ecosystem of the Tugurejo coastal area, the crab species found belong to the family Varunidae, namely the species

*Metaplex elegans*; the family Sesarmidae, comprising the species *Parasesarma charis* and *Parametopograpsus latifrons*; and the family Ocypodidae, namely the species *Uca coarctata*. The abundance of crabs at Station 1 was found to be an average of 1,950 ind/ha, at Station 2 an average of 1,350 ind/ha, and at Station 3 an average of 700 ind/ha. The highest species abundance was recorded at Station 1. This figure is lower compared to a previous study by Hartati (2016), which reported crab abundances of 9,200 ind/ha at Station A, 8,000 ind/ha at Station B, and 7,200 ind/ha at Station C. Crabs thrive in areas with high mangrove density, as mangroves provide a habitat for them to breed and seek shelter from predators. Low mangrove density makes it difficult for associated crabs to find suitable habitat. This density ensures that the mangrove canopy cover is sufficiently dense, making it an ideal habitat for crabs (Ristiyanto et al. 2019).

#### C. The Relationship between Mangrove Density and Crab Abundance

Linear regression test was conducted to examine the relationship between the independent variable and the dependent variable. The independent variable in this test was mangrove density (X) and the dependent variable was crab abundance (Y). Based on the results of the linear regression, the coefficient of determination ( $R^2$ ) was 0.883, meaning that 88.3% of crab abundance (the dependent variable) based on the independent variable—namely mangrove type—shows a very good and strong predictive level. However, 11.7% is still attributed to other factors outside the independent variable. This linear regression equation can be expressed as  $Y = 0.435 + 0.001X$ .

Based on the results of the relationship between mangrove density and crab abundance on the coast of Tugurejo Village, a regression analysis was conducted to determine this relationship. The significance value obtained for the relationship between mangrove density and crab abundance was 0.005, and the R value was 0.940. The interpretation of the correlation is that the closer the R value is to 1, the stronger the correlation; this is consistent with the statement by Oktamalia et al. (2018). Based on the regression results, a correlation coefficient (r) of 0.89 was obtained, indicating that the correlation between

mangrove density and the presence of mangrove crabs is very strong. The  $R^2$  value obtained was 0.883, meaning that the presence of crabs on the coast of Tugurejo Village is still influenced by mangrove density by 88%, whilst 12% is influenced by other factors.

Another factor affecting crab abundance is the degradation of mangroves, such as the conversion of land into fish ponds and residential areas. In line with the findings of Siringoringo et al. (2017), the mangrove forests in the Belawan Sicanang sub-district have already undergone significant land conversion into fish ponds and settlements. This situation has led to a decline in habitat quality and a reduction in the mangrove crab population due to the destruction of the areas where these organisms are reared and forage. Furthermore, environmental conditions such as substrate quality can also influence crab abundance. According to Siahaan et al. (2018), crab populations are also influenced by substrate type and water depth. Mangrove forest environments provide excellent habitats for various fauna, featuring a substrate base shaded by trees where organisms can attach themselves, and, most importantly, an abundance of organic detritus as a food source.

The correlation between crab abundance and mangrove density on the coast of Tugurejo Village was higher than that found in the study by Unthari et al. (2018) in the Bungin River area of Banyuasin Regency, South Sumatra Province, which yielded an  $R^2$  value of 0.125, indicating a very weak correlation. This indicates that density influences mangrove crab abundance because the study site had sparse mangrove density, resulting in a lack of natural food sources for mangrove crabs derived from mangrove litter. Furthermore, the low mud content in the substrate meant that mangrove roots produced insufficient substrate favoured by mangrove crabs.

Crab abundance can increase or decrease depending on the availability of food sources. According to Fahzeri et al. (2023), high mangrove density can provide sufficient food. The leaves, stems, and roots of mangrove trees provide organic matter consumed by crabs. Furthermore, leaf litter that has degraded into humus supports a microbial ecosystem that

provides nutrients for the crabs. The abundance of mangrove crabs in coastal areas is influenced by the density of the mangrove ecosystem as their habitat; high density allows for an increase in the amount of nutrients available to mangrove crabs (Gita et al., 2015). The relationship between mangrove density and crab abundance, analysed using a regression test, yielded a calculated F-value of 30.089 and a table F-value of 1.71; thus, the calculated F-value is greater than the table F-value. Based on a significance level of 0.05, a p-value of 0.005 was obtained, leading to the acceptance of H1 and the rejection of H0, meaning there is a relationship between mangrove density and crab abundance in the coastal area of Tugurejo Village.

#### *D. The Relationship Between Environmental Parameters and Crab Abundance*

Principal Component Analysis (PCA) was performed using the variables temperature, dissolved oxygen (DO), pH, salinity, and crab abundance data. The data obtained from the PCA analysis revealed correlations between each of the influencing variables. The relationship between environmental parameters and crab abundance is shown in Figure 5 below:

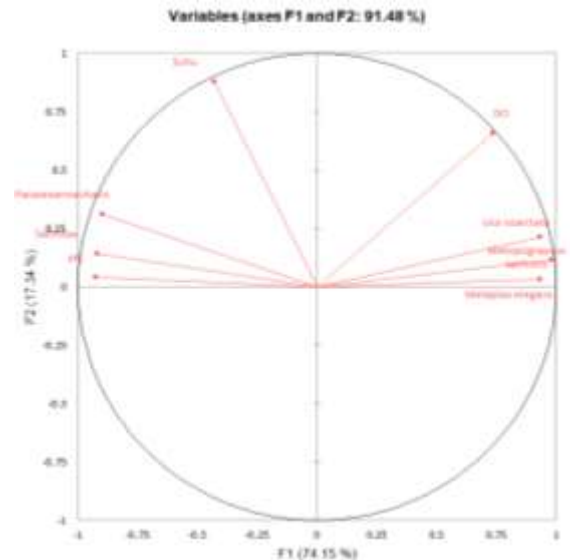


Figure 5. Correlation Matrix Plot

Based on the results of environmental parameter measurements and crab abundance calculations along the coast of Tugurejo Village, Principal Component

Analysis (PCA) was conducted to determine the relationship between them. The results of the correlation graph indicate a relationship between dissolved oxygen (DO) levels and the crab species *Uca coarctata*, *Metopograpsus latifrons*, and *Metaplax elegans*. Dissolved oxygen content influences the number and species of crabs in the water. This range of DO values falls within the 'good' category for crab growth and development. This is consistent with the view of Katiandagho (2014), who states that mangrove crabs can survive in aquatic environments with oxygen levels of 2.65–4.000 mg/l.

*Parasesarma charis* follows a similar trend or is relatively close to salinity on this graph, compared with other variables. This indicates that there is a stronger relationship between the presence of *Parasesarma charis* and salinity. *Parasesarma charis* tends to be found under specific salinity conditions that support its habitat. According to Ristiyanto et al. (2019), crabs of the family Sesamididae can live on the sediment surface and have a wide tolerance to water salinity.

## VI. CONCLUSION

Based on the results of the research conducted, several conclusions can be drawn. The mangrove species found on the coast of Tugurejo Village include *Rhizophora mucronata* and *Avicennia marina*. Mangrove density varies, with results at Station 1 at 2,150 ind/ha, Station 2 at 1,200 ind/ha, and Station 3 at 600 ind/ha. The crab species found in the mangrove ecosystem along the coast of Tugurejo Village include *Metaplax elegans*, *Parasesarma charis*, *Parametopograpsus latifrons*, and *Uca coarctata*. The most abundant crab species was *Uca coarctata*, with an abundance of 750 ind/ha at Station 1. Crab abundance in the mangrove ecosystem was influenced by mangrove species density with an  $R^2$  of 88.3%, indicating a very high level of predictive power, whilst 11.7% was influenced by other factors.

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