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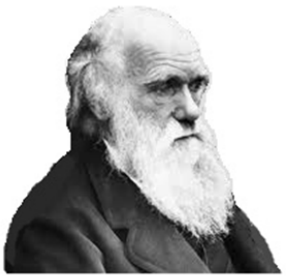

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# The Relationship between Benthic Macrofauna Community Structure and Density of Mangrove Vegetation in Mempawah Mangrove Park, West Kalimantan, Indonesia

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**ABSTRACT**

This research was conducted in Mempawah Mangrove Park, West Kalimantan on July – August 2018. The research aims to map the benthic macrofauna community structure and its relationship with the structure of mangrove vegetation. The research method was a survey and use purposive sampling data method in observation stations based on different stages of mangrove vegetation. The observation stations consists of *Avicennia marina* and *Rhizophora stylosa* as the species of mangroves. Station 1 consists of mangroves in seedling size, station 2 consists of mangroves in pole size, and station 3 consists of mangrove trees. The benthic macrofauna consist of 8 species from 3 different classes, merostomata, malacostraca, and gastropods. The highest abundance value (155 ind/$m^2$), diversity index (1,875) and similarity index (0,668) is in station 2. The relationship between benthic macrofauna abundance and mangrove density has -0,356 as the correlation coefficient which indicates that an increase of benthic macrofauna abundance is in line with the decrease of mangrove density. High density value in research shows that the mangrove is in seedling size, and vice versa a low density value indicates the mangrove trees. The coefficient of determination (0,1272) indicating that the abundance of benthic macrofauna is affected by the mangrove density as 12,72% and 87,28% affected by other factors.

***Keywords*:** Community Structure, Density, Macro-faunal benthic, Mangrove, Mempawah Mangrove Park

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## 1. INTRODUCTION

Indonesia has the largest mangrove forest area in the world (estimated at 7,8 million hectares) and reaches 23% of the world's total mangrove forest area. West Kalimantan is one of the locations for the mangrove ecosystem distribution in Indonesia. (Kusmana 2014)[1]. Mangrove is an ecosystem that has an important role as a link to balance the biological cycles in coastal areas. In recent times, public awareness of the benefits of mangrove both economically and ecologically continues to increase. This is evidenced by the increasing of vigorously mangrove conservation activities, including the development of Mempawah Mangrove Park in Mempawah Regency, West Kalimantan which was inaugurated on 2016.

Mempawah Regency has the potential of mangrove ecosystem as the second largest regency in West Kalimantan. Administratively, Mempawah Regency is bordered by Bengkayang Regency on the north side, Kubu Raya Regency and Pontianak City on the south side, Landak Regency on the east side and the Natuna Sea on the west side (Khairuddin *et al*. 2016)[2]. One of the locations of mangrove ecosystem in West Kalimantan is the mangrove forest in Dusun Pasir Laut, Desa Pasir, Mempawah Regency with the type of vegetation that dominates the area consists of *Avicennia* sp., *Rhizophora* sp., *Sonneratia* sp., and *Nypa* sp. (Nutriawani *et al.* 2017)[3].

The role of mangrove ecosystem for life can be seen from the abundance of fauna that depend on the mangrove ecosystem. The fall-mangrove leaves will be decomposed by microorganism into a simple component of organic matter, then made a source of food for fauna that live at the surrounding location (Suwondo *et al.* 2006)[4]. The biological function of mangrove is specifically felt directly by the benthic macro-faunas living settled at the base of the mangrove area. Benthic macro-faunas use the mangrove ecosystem as the main habitat and they can reflect the changes of environmental factors, so they can be used as an indicator of aquatic environmental quality (Iswanti *et al.* 2012)[5].

The community structure of benthic macro-fauna that living sedentary in mangrove ecosystem and its relationship with the mangrove vegetation structure in Mempawah Mangrove Park should be known and researched to observe the success of mangrove conservation. This research aims to map the community structure of benthic macro-fauna and its relation to the mangrove vegetation structure in Mempawah Mangrove Park, West Kalimantan. The results of this research are expected to be used as information that can be input for mangrove conservation management in Mempawah Mangrove Park, Mempawah Regency, West Kalimantan.

## 2. MATERIALS AND METHODS

The data sample collected in July – August 2018, located in Mempawah Mangrove Park as an ecotourism area in Dusun Pasir Laut, Mempawah Regency, West Kalimantan (Figure 1). Research was done by survey method, which is obtaining data and information factually based on direct observation in Mempawah Mangrove Park. The selection of observation station was done by a purposive sampling method with consideration of difference mangrove vegetation size. Data analysis methods were done by comparative descriptive and associative.

The selection of observation station based on the representation of location related to different mangrove vegetation size, covering 3 stations, i.e. station 1 (00°23,828' LU 108°56,743' BT) represents mangrove vegetation with seedling size and borders with sea,

station 2 (00°23,824' LU 108°56,753' BT) represents mangrove vegetation with pole size, and station 3 (00°23,825' LU 108°56,756' BT) represents mangrove trees and close to the mainland. At each station, there was a plot quadrant transect with 10 m × 10 m size, and on each plot quadrant transect there were 5 sub-plots of 1 m x 1 m at the corners and central part of quadrant transect. The collection of mangrove data was done by identifying the type and calculating the number of mangrove stands in each plot quadrant transect and measure the circumference of the trunk of mangrove trees. Data retrieval of benthic macro-fauna carried out using Ekman Grab in 5 sub-plots 1 m × 1 m size in mangrove vegetation observation transect 10 m × 10 m size.

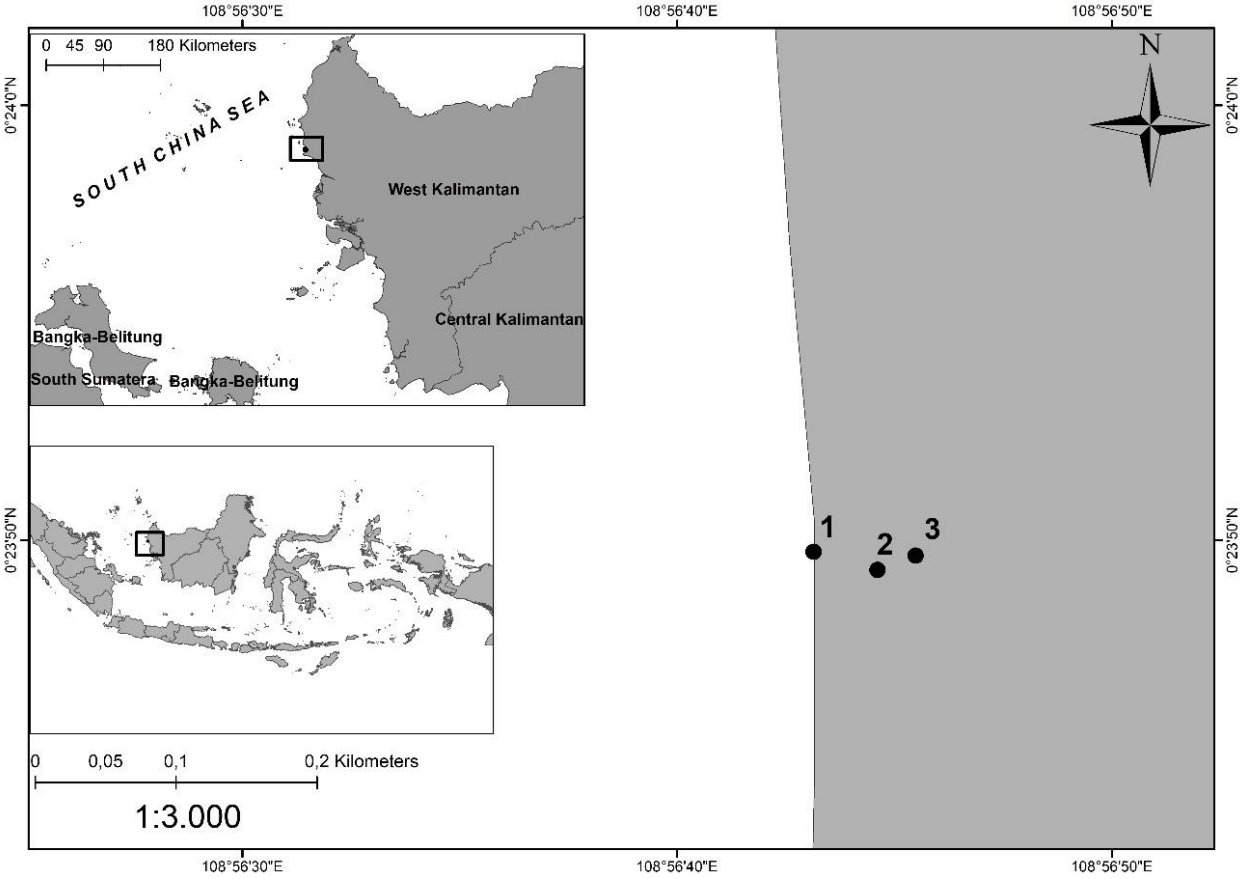


**Figure 1.** Sampling Site

The observed parameters include the abundance of benthic macro-fauna and the density of mangrove vegetation. The abundance of organisms expressed as an individual number per unit area. The relative abundance represents the percentage of individuals of a species against the total number of individuals in a particular region (Suryani 2006)[6]. These are the calculation formula of abundance and relative abundance of benthic macro-fauna.

$$K = \frac{Ni}{A} \qquad R = \frac{Ni}{N} \times 100\%$$

Description:

K : Abundance index (individual number) (ind/$m^2$)
R : Relative abundance index
Ni : Individual number a type of benthic macro-fauna found
N : Total number of individuals benthic macro-fauna found
A : Unit area where benthic macro-faunas were found ($m^2$)

Density is one of the quantitative parameters that can be used to describe a community of plants, including mangroves (Alfaro 2006)[7]. Density is an individual number of organisms per unit of space (both area and volume). This is the formula to calculate species density of mangroves.

$$K = \frac{\text{Individual number (stands)}}{\text{Observed unit area } (m^2)}$$

The research data are analysed by comparative descriptive, comparing the community structure (abundance index) of benthic macro-fauna to the vegetation structure (density) of mangrove in different sizes. Meanwhile, to get an overview of the relation between mangrove density and abundance of benthic macro-fauna using Pearson Correlation Test. This analysis was done to prove the estimation that mangrove vegetation structure as the free variable would have a noticeable effect on the benthic macro-fauna community structure as bound variables.

## 3. RESULTS AND DISCUSSION

### 3. 1. Research Sites

Mempawah Mangrove Park is a mangrove ecotourism in West Kalimantan with an area of ± 4 hectares. As a rehabilitated nature park, the mangrove vegetation structure at this location is divided by stadia, which is mangrove trees closest to the mainland, and the smaller size head towards the sea (Mayangsari *et al.* 2017)[8]. Associated with the base of conservation and preservation of mangrove ecosystem in Mempawah Mangrove Park carried out routine activities in replanting mangrove saplings to prevent abrasion on the coast. Station 1 is the closest area to the sea with *Rhizophora stylosa* in seedling size as the result of conservation activities conducted by Mempawah Mangrove Park. Station 2 is on the east side of station 1, consist of *Rhizophora stylosa,* and *Avicennia marina* in pole size. Station 3 represents the mangrove trees, consist of *Rhizophora stylosa,* and *Avicennia marina* that grows naturally.

### 3. 2. Abundance of Benthic Macro-faunas

Based on the collection of research data, benthic macro-fauna obtained as many as 8 types, with details *Carcinoscoprious rotundicauda* from merostomata (Anggraini *et al.* 2017)[9], arthropod; *Uca tetragonon, Uca forcipata* and *Scylla serrata* from malacostracans (Gita *et al.* 2015)[10], arthropod; *Pythia plicata, Cerithidea quoyii, Littoraria albicans* and *Onchidium damelii* from gastropod, mollusca (Kenny and Smith 1987)[11]. The following (Table 1) is the total abundance data by identifying benthic macro-fauna at each observation station at Mempawah Mangrove Park.

**Table 1.** Total Abundance of Benthic Macro-fauna

| Station | Species | Abundance Index (ind/m$^2$) | Relative Abundance Index (%) |
|---|---|---|---|
| **Station 1** | *Scylla serrata* | 18 | 16,40 |
| | *Uca forcipata* | 32 | 28,34 |
| | *Uca tetragonon* | 62 | 55,26 |
| | **Total** | **112** | **100** |
| **Station 2** | *Cerithidea quoyii* | 31 | 19,82 |
| | *Littoraria albicans* | 17 | 10,68 |
| | *Onchidium damelii* | 37 | 23,94 |
| | *Pythia plicata* | 15 | 9,91 |
| | *Scylla serrata* | 25 | 16,34 |
| | *Uca forcipata* | 18 | 11,33 |
| | *Uca tetragonon* | 12 | 7,98 |
| | **Total** | **155** | **100** |
| **Station 3** | *Carcinoscorpius rotundicauda* | 1 | 0,43 |
| | *Cerithidea quoyii* | 30 | 21,55 |
| | *Littoraria albicans* | 28 | 19,83 |
| | *Onchidium damelii* | 26 | 18,82 |
| | *Pythia plicata* | 32 | 23,13 |
| | *Scylla serrata* | 19 | 13,51 |
| | *Uca forcipata* | 4 | 2,73 |
| | **Total** | **140** | **100** |

Overall, the highest abundance of benthic macro-fauna was founded at station 2, 155 ind/m$^2$, station 3 with 140 ind/m$^2$ and at least at station 1 with 112 ind/m$^2$. The difference in abundance values due to differences in mangrove size, because it would affect the difference in production of litter as a food source for benthic macro-fauna (Muhammad *et al*. 2017)[12]. The abundance of benthic macro-fauna in station 3 with mangrove trees was not the highest, because

there were rocks blocking the tide to directly enter the location. In addition, the location that is close to the mainland also makes station 3 receive more influence of anthropogenic activity, prone to the tourist activity who come to the ecotourism area of Mempawah Mangrove Park, such as throwing garbage or trampled the mangrove roots that further would affect the quality of mangrove vegetation and impact on the survival of benthic macro-fauna.

Benthic macro-faunas and their habitat in mangrove ecosystem are bordered horizontally (land to sea) and vertically (vegetation falls to the substrate). The high number of identified benthic macro-fauna at station 2 because it horizontally still has a direct influence on tide of sea water and fresh water in sufficient quantities. Supporting to this, mangrove vegetation that composes station 2 was in pole size, with a sufficiently vertical height supporting the life of arboreal fauna found on the surface of the substrate due to falling from mangrove roots, stems or leaves.

At station 1 there are 3 species identified from the malacostracans that live by making holes in the substrate, supported by the mangrove composition of *Rhizophora* sp. mangroves in seedling size that does not have a complicated rooting system that can interfere the activity of *Scylla* sp. and *Uca* sp. on searching for food or shelter from predators (Tahmid *et al.* 2015)[13]. The benthic macrofauna from merostomate (*Carcinoscorpius rotundicauda*) are only found on station 3 because it is located close to the mainland, so has a lower salinity that is the most suitable habitat for the species (Chen *et al.* 2015)[14]. The composition of benthic macrofauna in station 3 is still similar to station 2, there is only difference in the abundance of each type. This corresponds to the preference of each species, for example, *Littoraria albicans* prefer to live in the mangrove vegetation *Avicennia* sp. so the number of abundance will adjust the number of vegetation's existing at each station (Reid 1985)[15].

Gastropoda is the most discovered class of benthic macrofauna species at the time of research (*Onchidium damelii, Cerithidea quoyii*, *Littoraria albicans*, and *Pythia plicata*) (Raven and Vermeulen 2007)[16]. Gastropods are identified benthic macrofauna that directly act as detritivores in the drainage of mangrove foliage (Masni *et al.* 2016)[17] or feeding organisms such as algae attached to the mangrove roots (Mujiono 2012)[18]. Not only in terms of food availability, but gastropods found to be a type that is in need of mangrove vegetation ranging from the pole size and the trees (Silaen *et al.* 2013)[19], either by the presence of a canopy (Yolanda *et al.* 2016)[20], or buttress roots as the physical structures (Chapman *et al.* 2005)[21].

### 3. 3. Density of Mangroves

Based on data observation and calculation of mangrove vegetation in Mempawah Mangrove Park, West Kalimantan showed in Figure 2. At station 1 there was only *Rhizophora stylosa* in seedling size, as a result from conservation activity in Mempawah Mangrove Park. At station 2 there were 2 types of mangroves, *Rhizophora stylosa*, and *Avicennia marina* in pole size. Meanwhile, station 3 consists of mangrove trees that have grown naturally with the type *Rhizophora stylosa* and *Avicennia marina*. Different size of mangroves at each station will affect the following mangrove density value.

*Avicennia marina* is a type of original mangrove that grows naturally in Mempawah Mangrove Park, West Area. Thus, the *Avicennia* found in mangrove trees and pole size zone. According to Noor *et al*. (2002) this species is a pioneer plant on the coast with the ecological ability to live and grow in various tidal habitats, having a high salinity tolerance[22]. The form of conservation activities conducted by Mempawah Mangrove Park is a *Rhizophora stylosa* planting with a distance of 1 meter in at an area near the sea (station 1). *Rhizophora stylosa* is

mangrove vegetation with one or many stems, can reach the height of 10 meters and high dominancy level, which can also be classified as pioneer plant[22].

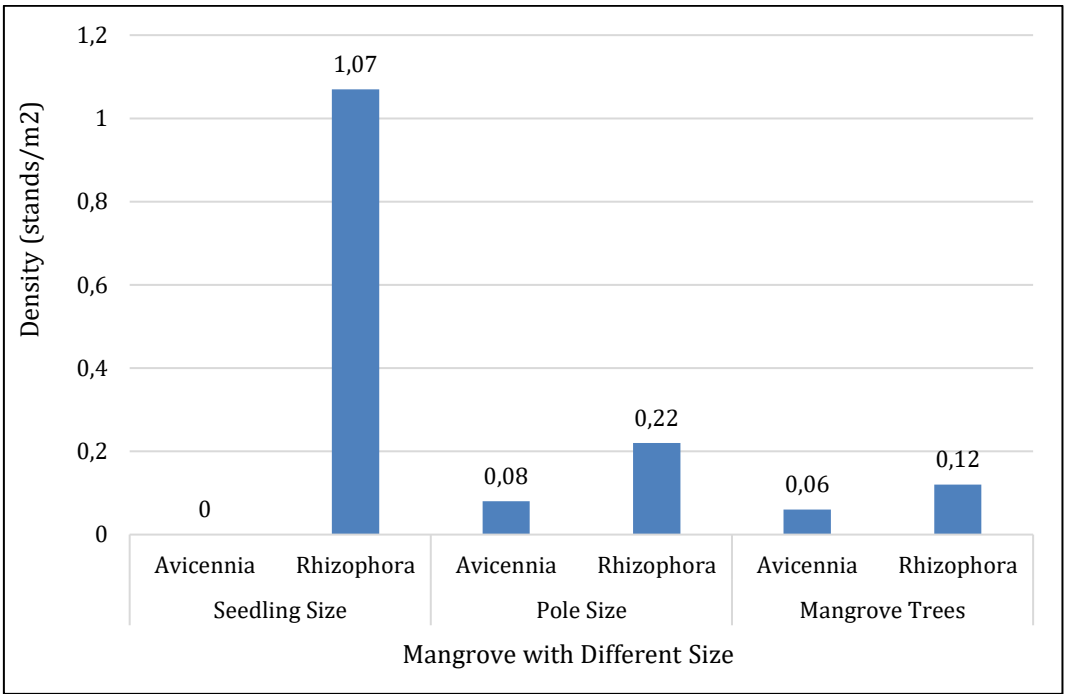


**Figure 2.** Density of Mangrove with Different Size

### 3. 4. Relationship between Abundance of Benthic Macro-fauna and Mangrove Density

Correlation is used to declare the relationship degree between two variables, if there is a relationship between variables, then the changes occurring on a single variable will be followed by other variable changes. Calculation of correlation between benthic macro-fauna with mangrove density in different size, using X as the total density of mangroves (stand/$m^2$) and Y as the total abundance of benthic macro-fauna (individual/$m^2$) on each plot of each observation station. The value of the correlation coefficient (rxy) obtained is the amount of -0,3566 (negative). The negative linear relationship of X and Y variables indicates that when the X variable (mangrove density) tends to increase, the Y variable (the abundance of benthic macro-fauna) tends to decrease. This statement in accordance with the results of the processing research data that showed when the mangrove density in different size value is high (station 1) then the abundance of benthic macro-fauna value at that station will be low (112 individual/$m^2$) and instead.

The correlation coefficient value is negative because the observation station is distinguished on the basis of differences in mangrove size, high density value in the result is a group of mangrove vegetation in seedling size, so the number of individuals stand more than the pole size or the mangrove trees in the same area. The value of the benthic macro-fauna abundance would be higher in low density mangroves (because that were in bigger size), in this research consist of mangrove trees. According to [12] stating that the tree-level mangrove ecosystem has a lot of leaf carriages so that used as a habitat for biota, including benthic macro-

fauna. The value of correlation coefficient of 0,25 < x < 0,5 is a moderate relationship indicating the relationship between benthic macro-fauna abundance with mangrove density is still influenced by other factors such as environmental factors.

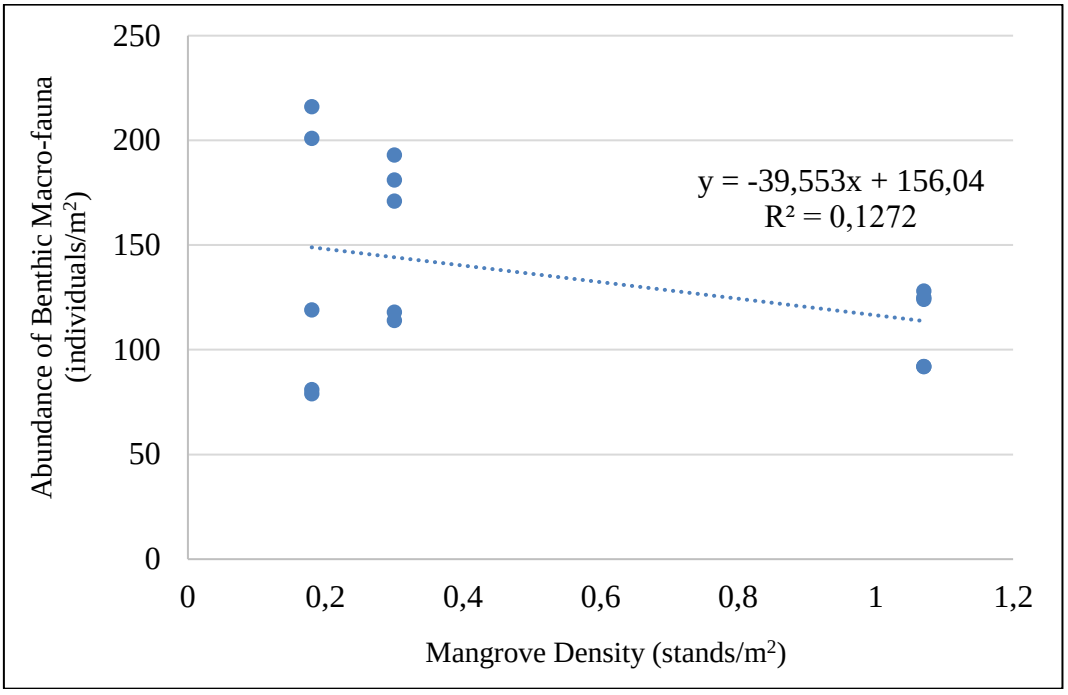


**Figure 3.** Linear Regression

Linear regression analysis results in regression equation y = -39.553*x* + 156.04 with $R^2$ = 0.1272 (Figure 3). Regression is negative in value, which means the relation between mangrove density and abundance of benthic macro-fauna is contradicting, associated with the difference of mangrove vegetation size affecting the density. This illustrates every increase on mangrove density 1 stands/$m^2$ will be followed by 39 individuals/$m^2$ of benthic macro-fauna abundance. The value of a small coefficient of determination (near zero) indicates the ability of a free variable (mangrove density) in explaining the bound variable (abundance of benthic macro-fauna are very limited. The abundance of benthic macro-fauna is only 12.72% influenced by mangrove density, and the 87.28% are influenced by other factors.

## 4. CONCLUSIONS

The results of the study showed that the abundance of benthic macro-fauna most found at station 2 (155 ind/$m^2$) which is mangrove in pole size. The correlation coefficient between the density of mangrove vegetation and the abundance of benthic macro-fauna have a value -0,3566 which means negative correlation with moderate (enough) relationship. The coefficient of determination value is 0.1272 indicates the abundance of benthic macro-fauna (ind/$m^2$) influenced by total mangrove density data in different size (stand/$m^2$) as 12.72%.

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