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Density, morphometric characteristics and distribution pattern of Asiatic hard clam (*Meretrix meretrix*) in Karang Gading estuary, Deli Serdang District, Indonesia

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Abstract. *Rimelahas WL, Mulya MB, Barus TA. 2022. Density, morphometric characteristics and distribution pattern of Asiatic hard clam (*Meretrix meretrix*) in Karang Gading estuary, Deli Serdang District, Indonesia. Biodiversitas 23: 5210-5216.* Asiatic hard clam (*Meretrix meretrix*) has a wide distribution, ranging from mangrove forest areas in the Indo-Pacific to mangrove swamp areas in South America. In Indonesia, clam is found on the island of Sumatra, one of which is in the estuary waters of the Karang Gading Wildlife Sanctuary, Deli Serdang District, North Sumatra, Indonesia. In this area, fishermen are often found catching clams. The catch of clams in addition to its own consumption is also widely sold in traditional markets. The existence of clam capture activities carried out continuously can threaten the sustainability of this commodity in nature. This study aims to find out the density, morphometric characteristics, distribution patterns and the relationship of clam density with aquatic physicochemical. Sampling was carried out in July-August 2021 in the estuary waters of Karang Gading Wildlife Sanctuary Deli Serdang District using a purposive sampling method. Sampling was done by using a clam rake with a radius length of 35 cm. At each station, 5 sampling points were determined and 3 dredgings were carried out at each point which is done 2 times with 30-day intervals at 07.00-11.00 WIB. The results concluded that the highest density of clam is found in station I with a value of 3896 ind/m^2, the pattern of growth of the clam at each station is negative allometric, the pattern of the group and uniform clam distribution, and the correlation of physical and chemical factors of the waters with the density of the clam shows that phosphate has a very strong correlation to the density of the clam, while the temperature correlates moderately with the density of the clam.

Keywords: Correlation, mangrove, *Meretrix meretrix*, sanctuary, Sumatra

INTRODUCTION

Asiatic hard clam (*Meretrix meretrix*) is a member of the phylum Mollusca who belongs to the bivalve class and belongs to the group of invertebrate animals (Metillo et al. 2018). Clam usually lives in marine and coastal waters. In coastal areas, clam lives between mangrove roots on mud substrates, sandy mud and mangrove litter that is decomposed into the mud. Clams generally live sedentary lives and some types of live clams immerse themselves or hide in the substrate. Clam is usually found in mangrove and estuary ecosystems (Ambarwati et al. 2021). Clam has an important role in the environment and contributes to the community's economy (Malana 2021).

Clam has a wide distribution, spread from mangrove forest areas in the Indo-Pacific to mangrove swamp areas in South America (Jabarsyah and Arizono 2016). In Indonesia, clams are found in various regions ranging from Sumatra (Ginting et al. 2017) to Papua (Waromi et al. 2017). One of the Sumatran waters that clam finds a lot is the estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, North Sumatra, Indonesia.

The estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, are located on the east coast of North Sumatra. The Karang Gading Wildlife Reserve area has undergone a conversion of mangrove land into residential land and economic activities such as encroachment and oil palm plantations owned by communities and entrepreneurs (Simanullang and Susetya 2018). In this area, fishermen are also often found catching clams. The capture of clam is generally carried out using fishing gear in the form of claws with a radius length of 35 cm. Their catch is usually consumed because this commodity has a high content of proteins (Admodisastro et al. 2021), lipids, especially omega-3 fatty acids, essential amino acids, vitamin B13 (Tran et al. 2019) and important minerals such as Na and Fe which are stored in their tissues (Hamli and Al-asif 2021).

Clam is widely sold in traditional markets in the area and outside the area, such as Stabat and the city of Medan. However, the use of clam as a managed resource must be considered (Azmia et al. 2014). The existence of clam capture activities carried out directly from nature and the absence of potential in the cultivation of this commodity by the community can also threaten its sustainability in nature. The continuous capture and utilization of clams by fishermen in the estuary waters of the Karang Gading Wildlife Sanctuary, Deli Serdang District, is feared to reduce the number (stock) of the population of this commodity in nature. With the tendency of fishermen to catch clams, it is feared that it will have a negative impact on the population in the estuary waters of the Karang

Gading Wildlife Sanctuary, Deli Serdang District, in the future and may even result in the biological resources of the clam type gradually running out without any efforts to conserve the clam in the area. Based on this, it is necessary to conduct research on density, morphometric studies and distribution patterns of clams in the estuary waters of the Karang Gading Wildlife Sanctuary, Deli Serdang District, North Sumatra so that it can be used as preliminary data in maintaining its sustainability in the future.

MATERIALS AND METHODS

Study area

This research was conducted in July-August 2021 in the estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, North Sumatra, Indonesia. The sampling point of this study was determined in 3 stations using the purposive sampling method. The station was Paluh Lima, Paluh Rangsang, and Paluh Simpang Canggang. The station I (Paluh Lima) is located at coordinate points 3°52'06.6" N and 98°36'31.77" E. Station II (Paluh Rangsang) is located at coordinate points 3°52'13.0" N and 98°36'49.8" E. Station III (Paluh Simpang Canggang) is located at coordinate points 3°52'58.5" N and 98°37'19.7" E (Figures 1 and 2).

The three stations are fishermen's catchment areas and chosen by its different characteristics, where station I is a mangrove area that is visually dominated by the *Rhizophora mucronata* with a depth of 3 meters, station II is a mangrove area too but dominated by *Avicennia alba* with a depth of 4.3 meters, and station III is the meeting area between two rivers, Secanggang and Kuala Besar rivers with a depth of 5.5 meters.

Procedure

Clam sampling

Sampling of clams is carried out using the clam rake with a radius length of 35 cm. At each station, 5 different sampling points were determined with a distance between points of about 20 meters which was carried out 3 times the pulling of claws at each point. Sampling was carried out at the lowest low tide in the morning at 07.00-11.00 WIB. The clam obtained were observed for morphometric characteristics by measuring the length of the shell from the anterior end to the posterior end, measuring the width of the shell from the dorsal side to the ventral side, and the thickness of the shell starting from the outermost side of the left shell to the outermost side of the right shell using a caliper.

Measurement of aquatic physical and chemical factors

Measurements of physical and chemical factors of water were carried out at the same point as clam collection and were carried out as many as 3 repetitions before clam sampling.

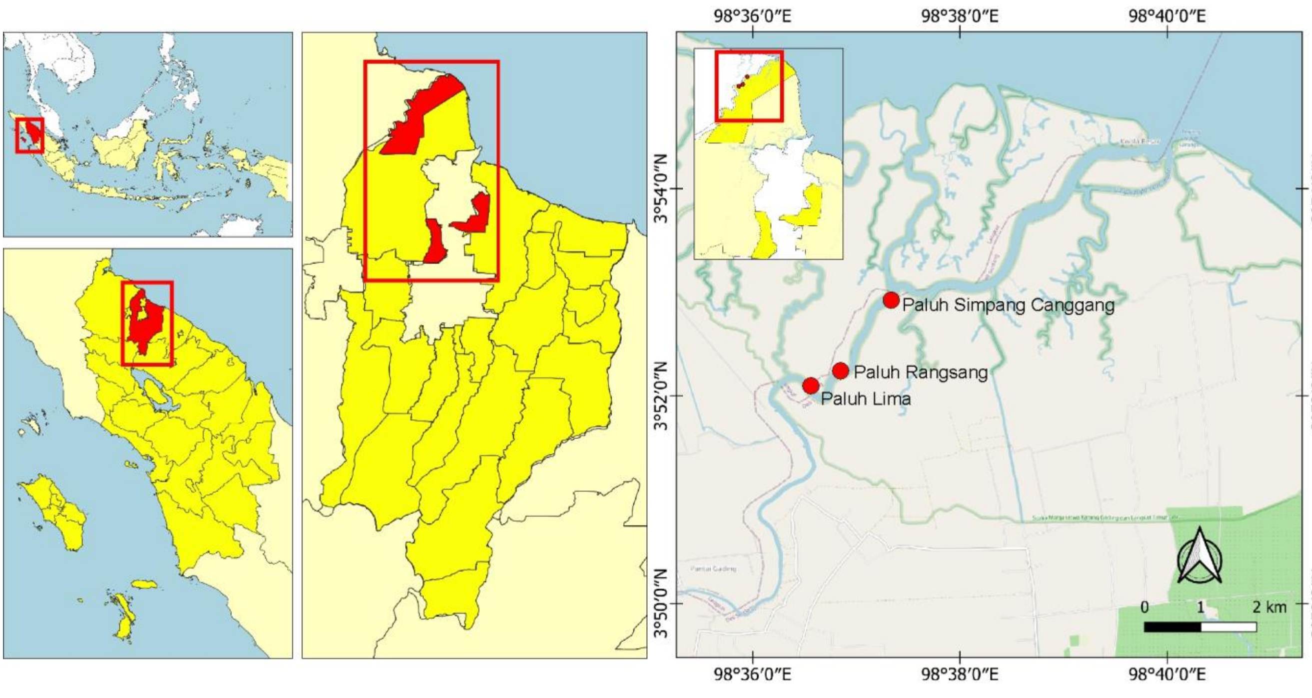

Figure 1. Map of research locations in 3 stations, i.e., Station I (Paluh Lima), Station II (Paluh Rangsang) and Station III (Paluh Simpang Canggang) of Deli Serdang District, North Sumatra, Indonesia

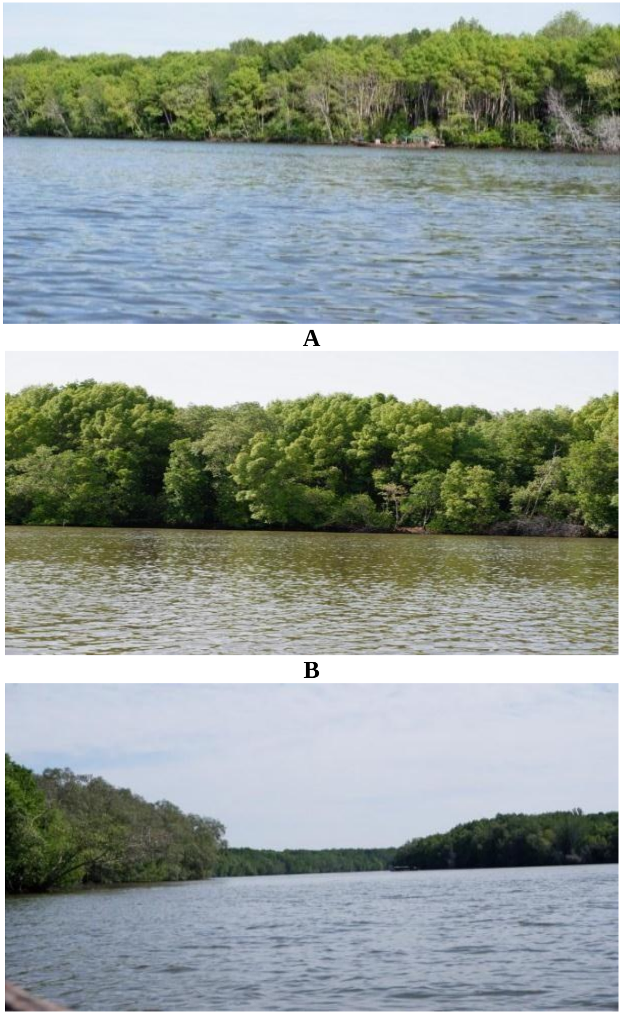

Figure 2. Research locations in 3 stations, i.e., A. Station I (Paluh Lima), B. Station II (Paluh Rangsang), and C. Station III (Paluh Simpang Canggang) of Deli Serdang District, North Sumatra, Indonesia

Data analysis

Density of clam (K). The density of a clam is calculated from the number of pupates obtained per claw area using the formula:

$$K\ (ind/m^2) = \frac{n}{A}$$

Where:
K : Density index of acquired species (ind/m)
n : The number of individuals obtained (ind)
A : Plot area (m^2)

Morphometric analysis. Morphometric analysis related to the nature of growth is calculated using the following formula:

$$W = aLb$$

Where:
L : Shell length
W : Wet weights
b : Constant

Clam distribution pattern. The pattern of clam spread can be calculated using the Morisita distribution index with the following formula (Krebs 1989):

$$Id = n\left[\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}\right]$$

Where:
Id : Distribution index Morisita
n : Number of plots
$\sum x$: Total number of individuals in squares (x1+ x2+….)
$\sum x^2$: Total number of individual squares (x2+x2+)

To meet the statistical properties of the sampling distribution, a null hypothesis test regarding randomness with the chi- square test was proposed, namely:

$$X^2 = Id\ (\sum x-1) + n - \sum x\ (db= n-1)$$

If the x^2 count is smaller than the x^2 table, it indicates that the population spread is random.

Correlation analysis. The correlation analysis was calculated using Pearson correlation analysis with the SPSS Version 25.00 application. Before analyzing this data, Kolmogorov Smirnov's normality was tested and the p value > 0.05, then the data was normally distributed.

Canonical correspondence analysis. Canonical correlation analysis is calculated using Past Statistical Software.

RESULTS AND DISCUSSION

Physical and chemical factors of waters

Based on the research that has been carried out, the results of measuring the physical and chemical factors of water in Table 1 are obtained**.**

Density clam

The results of the analysis can be seen in Figure 3, which shows that station I has the highest density of clams compared to stations II and III. The density obtained at station I has a value of 3896 ind/m^2, while the density at station II has a value of 2597 ind/m^2 and at station III it is 2771 ind/m^2.

Morphometric analysis

The results of morphometric measurements of clam obtained results as in Table 2.

At station I the length of the shell ranges from 2.00-4.70 cm, the width of the shell ranges from 2.00-4.30 cm, as well as the thickness of the shell, ranges from 1.00-3.40 cm and the wet weight ranges from 3.78-16.18 g. At station II the length of the shell ranges from 2.10-4.70 cm, the width of the shell ranges from 2.00-4.00 cm, as well as the thickness of the shell, ranges from 0.80-2.90 cm and the wet weight ranges from 4.83-17.29 g. At station III the length of the shell ranges from 2.60-4.90 cm, the width of the shell ranges from 2.10-4.20 cm, as well as the thickness of the shell, ranges from 1.10-3.00 cm and the wet weight ranges from 5.80-18.86 g.

Table 1. The results of measurements of chemical physical factors of waters in clam habitats in the estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, North Sumatra, Indonesia

Parameter	Unit	Station			Quality standards
		I	II	III	
Physical					
Temperature	°C	28.5	30	28.5	28-32
Brightness	cm	54	66.5	145	-
Chemistry					
DO	mg/L	2.9	2.7	2.35	>5
BOD_5	mg/L	0.8	1.5	0.8	20
Salinity	$^0/_{00}$	20.5	17.5	25	s/d 34
pH	-	5.53	5.57	5.38	7-8.5
Nitrate	mg/L	0.09	0.07	0.1	0.008
Phosphate	ppm	8.16	10.2	9.5	0.015

Table 2. The size of the figures the length of the shell, the width of the shell, the thickness of the shell and the wet weight

Station	PC (cm)	LC (cm)	TC (cm)	BB (g)
I	2.00-4.70	2.00-4.30	1.00-3.40	3.78-16.18
II	2.10-4.70	2.00-4.00	0.80-2.90	4.83-17.29
III	2.60-4.90	2.10-4.20	1.10-3.00	5.80-18.86

Where: PC: Shell length; LC: Shell width; TC: Shell thickness; TC: Wet weights

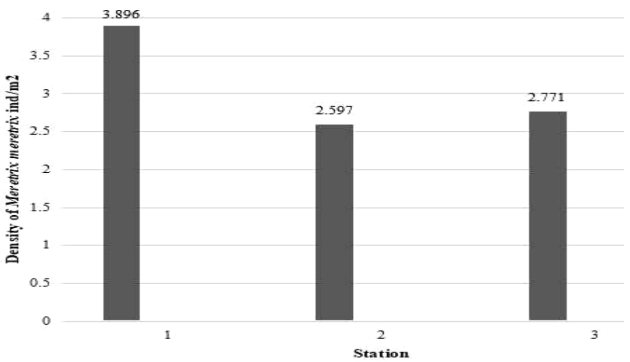

Figure 3. Density of clam (ind/m^2) in the estuary waters of the Karang Gading Wildlife Sanctuary, Deli Serdang District, North Sumatra, Indonesia

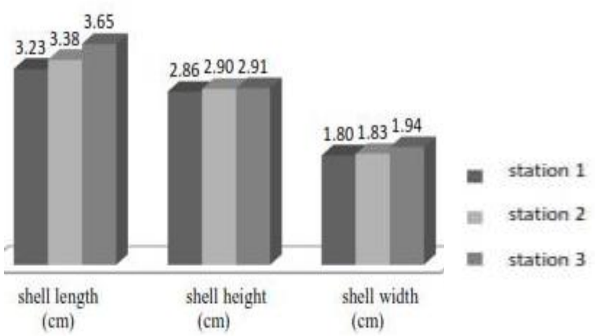

Figure 4. Morphometric comparison (shell length, shell height, shell width) at each station

The results of morphometric measurements of the clam showed that the parameters of shell length, shell height and shell width at station III were always higher than the values from the station I and station II. The shell length, shell height, and shell width of station III were 3.65 cm, 2.91 cm and 1.94 cm, respectively, while at station I the values were 3.23 cm, 2.86 cm and 1.80 cm, and at station II the values were 3.38 cm, 2.90 cm and 1.83 cm (Figure 4).

Based on the observations, the distribution of clam frequencies showed different results at each station. The minimum and maximum total length of clam in the Karang Gading Wildlife Reserve ecosystem, Deli Serdang District as a whole, is 2-13 cm. The combined frequency of clams with a total number of 107 individu is the most at a class interval size of 3.17-3.74 cm with a total of 34 individu. The distribution of the frequency of the combined clam length can be seen in Figure 5.

The relationship of the value of the wet weight to the length of the shell at each station can be seen in Figure 6.

Clam distribution pattern

The results of the calculation of the Morisita distribution index at each clam observation station get various values. At station I and station II, the Morisita distribution index is categorized in groups, and at station III, the Morisita distribution index is categorized uniformly. The results of the analysis are seen in Table 3.

Correlation of clam density with physical and chemical factors of waters

Pearson's correlation analysis value was obtained by analyzing the relationship of clam population density with physical and chemical factors in waters using the SPSS version 25 application. The value of the correlation index (R) can be seen in Table 4.

Station distribution based on environmental physicochemical factors and *Meretrix meretrix* size

The station distribution diagram based on the parameters of environmental chemical and physics factors and the size of the *M. meretrix* on the 1st and 2nd axes (Figure 7) forms several individual groups, each group has different physicochemical characteristics.

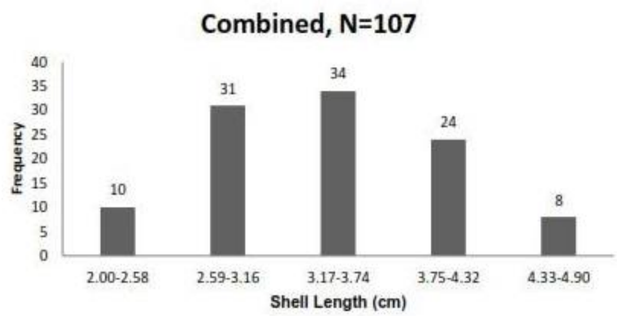

Figure 5. Spread of combined length size

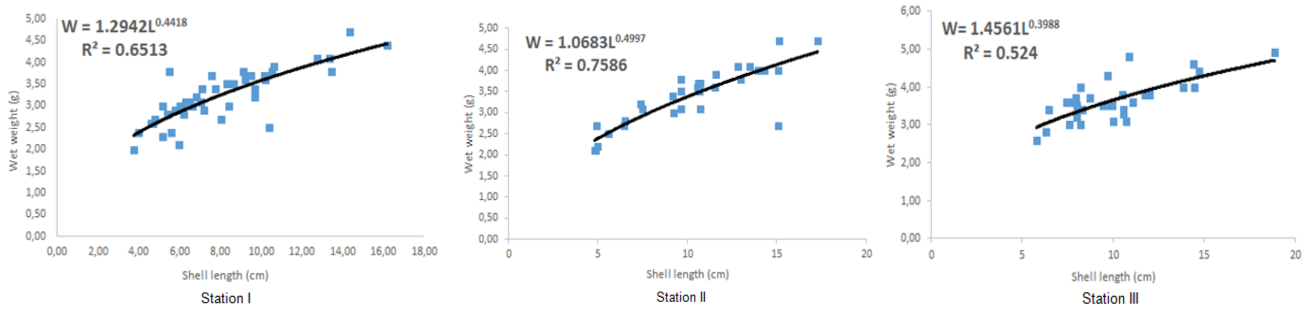

Figure 6. Morphometric relationship of wet weights to shell length

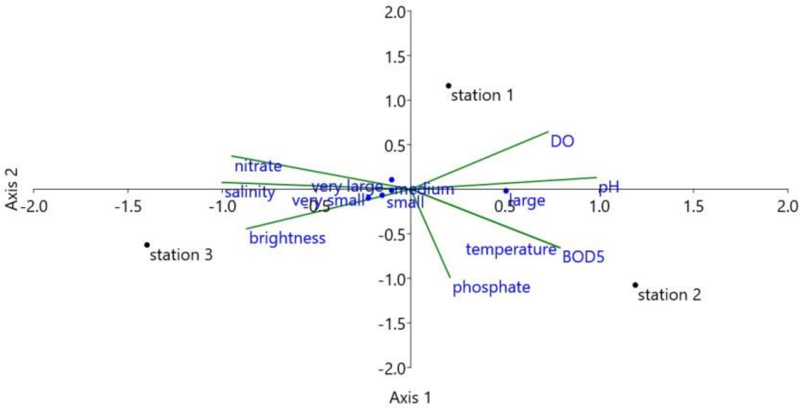

Figure 7. Distribution of stations based on environmental physico-chemical factors and the size of the *Meretrix meretrix*

Table 3. Morisita distribution pattern at each observation station

Station	Morisita distribution index	Category
I	1.596	Group
II	1.011	Group
III	0.907	Uniform

Table 4. Correlation of clam density with physical and chemical factors in the estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, North Sumatra, Indonesia

Parameter	Correlation value	Information
Temperature	-0.426	Moderate and negative-valued correlation
DO	0.164	Very low correlation and positive value
BOD_5	-0.24	Low and negative value correlation
Brightness	-0.426	Moderate and negative-valued correlation
Salinity	0.005	Very low correlation and positive value
PH	0.012	Very low correlation and positive value
Nitrat	-0.15	Very low correlation and negative value
Fosfat	0.976	Correlation is very strong and positive value

Discussion

Measurements of physical and chemical factors of water include temperature, brightness, DO, BOD5, salinity, pH, and nitrate and phosphate content. Temperature measurements at the three stations ranged from 28.5-30ºC. Indraswari (2014) stated that a clam is an aquatic animal that can live in intertidal to subtidal areas with a temperature of 26-31ºC in the good category as a place for clam growth. The brightness of the water at all three stations ranges from 54-145 cm. Nurhatika et al. (2018) stated that the magnitude of the brightness value at each station indicates the ability of sunlight to penetrate the water column. This is because the mouth of the river is an area of clam retrieval, so the turbidity level increases and the brightness is reduced. The value of dissolved oxygen content (DO) ranges from an average of 2.35-2.9 mg/L. The DO values at all three stations are classified as low. In line with Nurhatika et al. (2018) DO is a factor that regulates the composition and abundance of aquatic species. The highest dissolved oxygen for aquatic species is 10 mg/L. The amount of dissolved oxygen in the waters is influenced by several factors such as turbidity, temperature, salinity and movement of water masses such as currents, waves and tides (Rizal et al. 2022).

The BOD5 value of each station ranges from 0.8-1.5 mg/L. The high value of BOD5 at station II is caused by community activities that cause organic waste, which affects the decrease in dissolved oxygen around the waters. According to Silaen and Mulya (2018) the high value of BOD5 indicates the number of organic matter compounds that enter the water. The BOD5 parameter is one of the parameters to determine the level of water pollution, if the BOD5 value is higher than the quality standard, then the water is said to be polluted, and vice versa if the BOD5 value is lower, then the water pollution level is low (Sari et al. 2020). Salinity values at each station range from 17.5-250/00. Indraswari (2014) states that clams can live in intertidal to subtidal areas with salinity ranging from 10-300/00. The pH value with an average of 5.38-5.57 is still relatively low. Solanki et al. (2012) state that low pH values can be caused by the accumulation of organic matter and the decomposition of biological oxidation vegetation, releasing CO_2, ultimately lowering the pH. In line with the research of Iyama et al. (2019) stated that the decrease or acid of water is caused by several factors, such as community activity (fishermen) and acid rain. Nitrates at each station ranged from 0.07-0.1 mg/L and the lowest phosphate value at the station I was 8.16 ppm. The varying value of nitrates and phosphates at each station is caused by the presence of mangroves, waste from agriculture, domestic, and others. Nitrates and phosphates are most likely to be deficient in contaminated environments (Alprol et al. 2021). Nitrogen can enter into lakes and rivers as inorganic nitrogen and ammonia, since nitrogen can enter aquatic systems in various forms, there is a large supply of nitrogen available in this system (Gorde and Jadhav 2013).

The highest density of clams at station I. High density of clams is due to environmental conditions that support the presence of clams, factors that affect the density of clams include dissolved oxygen (DO). At station I, it has a DO value of 2.9 mg/L. Dissolved oxygen levels in water are usually less than 10 mg/L so, so values can still be tolerated by aquatic biota. The lowest density value is found at station II. The low-density value at station II is due to the low nitrate content. Nitrate content has an important role in the process of photosynthesis and the process of growth of organisms. According to Simanullang and Susetya (2018), nitrate and phosphate content are substances needed to support the process of growth and development of clams. The population density of clams includes a low population density of 3896 ind/m^2.

The results of the analysis above show that the growth pattern of clams living in the estuary waters of the Karang Gading Wildlife Reserve, Deli Serdang District, is a negative allometric, namely, length gain is more dominant than weight gain. This is in line with the research of Silaen and Mulya (2018) which states that negative allometric growth patterns ($b < 3$) show that length gain is more dominant or faster than weight.

Differences in the relationship pattern of shell length, shell width, shell thickness, and wet weight of clam at each station are thought to be the result of genetic factors, physical and chemical factors of water, and nutrients such as food availability, causing space competition. Silaen and Mulya (2018) stated that growth is influenced by two factors, namely intrinsic factors (inside) and extrinsic factors (outside). The relationship of length with weights indicates relative growth, meaning that it can change with time if changes occur in the environment, such as physicochemical factors and food availability which are estimated to cause the value of b will also change.

The measurements that have been made show that the value of the clam distribution index belongs to the pattern of group distribution and regular genus. The distribution index at stations I and II is grouped because the aquatic biota chooses to live in a habitat that suits their needs to support their existence which indirectly affects their distribution patterns. The distribution index at station III is categorized as a uniform distribution pattern caused by direct interaction between individuals in the population, causing competition between one individual and another for equal life opportunities.

The correlation of clam density with physical and chemical factors of water shows that temperature has a negative relationship to clams density with a value of -0.426, which has a moderate degree of relationship. Temperature is correlated opposite to the density of the clam, meaning that the higher the temperature, the lower the density level of the clam. In line with Li et al. (2018), which stated that temperature has a negative relationship with the density of aquatic biota, it shows that low temperatures can affect the population of aquatic biota.

Correlation analysis showed that the phosphate content had a positive relationship to clams density, with a value of 0.976 belonging to a very strong category. The phosphate content naturally comes from a body of water itself through the process of decomposition or decomposing of the rest of the organisms that have died. If the phosphate level is low, the growth of the clam will be blocked. Conversely, if the phosphate level is high, the growth of clam will increase. The phosphate content in water is very important because it is often a limiting nutrient for the growth of clam (Khatri and Tyagi 2015).

The results of the canonical analysis carried out divided the individuals into 3 groups, of which in the group of individuals I (first) consisting of station I is characterized by high dissolved oxygen and pH. The high pH at station I is due to the concentration of dissolved oxygen. The pH value of water is inseparable from various activities in the water, such as the occurrence of the process of photosynthesis by phytoplankton. Such photosynthetic activity can increase the level of dissolved oxygen in the waters. Individual group II (second) consists of station II characterized by high temperature, BOD5 and phosphate with a large size of hard clam. The high level of phosphate at station II with large size of *M. meretrix* is caused by the decomposition or decomposer of the remaining organisms that have died to form organic compounds into inorganic that can be used as food for the hard calm. The presence of phosphates greatly affects the growth of *M. meretrix*. If the phosphate level is high, the growth of *M. meretrix* will increase (Handoko et al. 2013). The III (third) group of individuals consisting of station III is characterized by brightness with a very large, small and very small size of the *M. meretrix*. At station III, it is located in the paluh Simpang canggang area, which is the confluence of the Secanggang river with Kuala Besar, which is an open area, so that the incoming sunlight is higher and causes the brightness of the waters to increase. With increasing brightness of the waters can cause varying sizes.

The results showed that the highest population density of clam (*M. meretrix*) was found at station I, which was 3896 ind/m^2, and the lowest was found at station II, which was 2597 ind/m^2. The growth pattern of clam at all stations is allometric negative ($b<3$), where the highest b value is found at station II which is 0.4418 and the lowest is found at station III, which is 0.3988 ind/m^2. The highest Morisita clam distribution index is found at station I, which is 1.59 with a group category, and the lowest is found at station III, which is 0.9 with a uniform category. The correlation of physical and chemical factors of water with the density of the clam population shows that phosphates have a very strong correlation to the density of clam, while temperature is moderately correlated with the density of clam.

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REFERENCE

Admodisastro VA, Doinsing JW, Duisan L, Al-Azad S, Madin J, Ransangan J. 2021. Population dynamics of Asiatic Hard Clam, *Meretrix Meretrix* (Linnaeus, 1758) in Marudu Bay, Malaysia: Implication for fishery resource management. J Fish Environ 45 (2): 92-105.

Alprol AE, Heneash AMM, Soliman AM, Ashour M, Alsanie WF, Gaber A, Mansour AT. 2021. Assessment of water quality, eutrophication, and zooplankton community in Lake Burullus, Egypt. Diversity 13: 268. DOI: 10.3390/d13060268.

Ambarwati R, Purnomo T, Fitrihidajati H, Rachmadiarti F, Rahayu DA, Faizah U. 2021. Morphological variations of *Meretrix* sp. from Bancaran, Madura, Indonesia. Intl Jt Conf Sci Eng 209: 214-217. DOI: 10.2991/aer.k.211215.040.

Azmi NF, Ghaffar MA, Cob ZC. 2014. Parasites of the hard clam *Meretrix meretrix* Linnaeus from Western Johor Straits, Malaysian. AIP Conf Proc 1614: 777. DOI: 10.1063/1.5027962.

Ginting EDD, Susetya IE, Patana P, Desrita. 2017. Identification of type of bivalves in the Waters of Tanjung Balai, North Sumatra Province. Acta Aquat 4 (1): 13-20.

Gorde SP, Jadhav MV. 2013. Assessment of water quality parameters: A review. J Eng Res Appl 3 (6): 2029-2035.

Hamli H, Al-Asif A. 2021. Trends of bivalve (bivalvia) research in East Malaysia: A systematic review. Asian-Australas J Biosci Biotechnol 6 (2): 50-59. DOI: 10.3329/aajbb.v6i2.56140.

Handoko H, Yusuf M, Wulandari SY. 2013. Sebaran nitrat dan fosfat dalam kaitannya dengan kelimpahan fitoplankton di Kepulauan Karimunjawa. Mar Oceanogr Bull 2 (1): 48-53. DOI: 10.14710/buloma.v2i2.6939. [Indoenesia]

Indraswari. 2013. Morphometry of Tofu Shell *Meretrix Meretrix* Linnaeus, 1758 at the Makassar People's Market. Berita Biologi 13 (2): 137-142. [Indonesian]

Iyama WA, Edora OS, Ade P. 2019. Physicochemical assesment of surface water quality and the sagbama creek water body, Bayelsa State, Nigeria. Glob J Sci Front Res: Chem 19 (1): 1-11.

Jabarsyah A, Arizono T. 2016. Clam identification at east coast of Tarakan Island. Omni-Akuatika 12 (2): 92-98. DOI: 10.20884/1.oa.2016.12.2.104.

Khatri N, Tyagi S. 2015. Influences of natural and anthropogenic factors on surface and groundwater quality in rural and urban areas. Front Life Sci 8 (1): 23-39. DOI: 10.1080/21553769.2014.933716.

Krebs CJ. 1989. Ecological Methodology. Harper Collins Publishers Inc, New York (US).

Li B, Cao J, Guan L, Mazur M, Chen Y, Wahle RA. 2018. Estimating spatial non-stationary environmental effects on the distribution of species: A case study from American lobster in the Gulf of Marine. ICES J Mar Sci 75 (4): 1473-1482. DOI: 10.1093/icesjms/fsy024.

Malana ML. 2021. DNA Barcoding of marine bivalve *Meretrix* (Karibuyo) in Northern Philippines. Intl J Mod Agric 10 (1): 1087-1091.

Metillo E, Sienes RK, Juranus RJr. 2018. Lunar periodicity in reproduction of two venerid clams *Meretrix Meretrix* and Katelysia *hiantini* in Panguil Bay Northen Mindanao, Filipina. J Biosci 13 (6): 70-80. DOI: 10.12692/ijb/13.6.70-81.

Nurhatika S, Ermavitalini D, Saputro TB, Apriyatmoko Y. 2018. Biodiversity and characterization of high lipid content microalgae in Porong River Estuary East Java, Indonesia. Biodiversitas 19 (2): 627-632. DOI: 10.13057/biodiv/d190234.

Rizal A, Apriliani I, Dewanti LP. 2022. Water quality index based on interrelation between plankton and benthos in Cimanuk River, Majalengka District, West Java, Indonesia. World Sci News 168: 81-98.

Sari A, Tuwo A, Rani C, Saru A. 2020. Water quality study and pollution index based on physicschemical parameters in the Youtefa Bay Tourism Area, Jayapura. IOP Conf Ser: Earth Environ Sci 564: 012030. DOI: 10.1088/1755-1315/564/1/012030.

Silaen SN, Mulya MB. 2018. Density and white shrimp growth pattern (*Penaeus merguiensis*) in Kampung Nipah Waters of Perbaungan North Sumatera. IOP Conf Ser: Earth Environ Sci 130: 012044. DOI: 10.1088/1755-1315/130/1/012044.

Simanullang YA, Susetya IE. 2018. Abundance and growth clam (*Meretrix meretrix*) in the Estuarine Waters of the Karang Gading Wildlife Sanctuary. Jurnal Aquacoastmarine 6 (4): 1-11.

Solanki HA, Gupta U, Verma P. 2012. Water quality analysis of an organically polluted lake by investigating different physical and chemical parameters. Intl J Res Chem Environ 2 (1): 105-111.

Tran QT, Tra LTT, Pham MQ, Do TL, Vu MH, Nguyen DC, Bach LG, Bui LM, Pham QL. 2019. Fatty acid, lipid classes and phospholipid molecular species composition of the marine clam *Meretrix lyrata* (Sowerby 1851) from Cua Lo Beach, Nghe An Province, Vietnam. Molecules 24 (5): 895. DOI: 10.3390/molecules24050895.

Waromi OF, Wasaraka ZA, Lantang D. 2017. Analysis of shell pelecypoda (bivalvia) type at Ambai Village Ambai Island, Yapen Island District. Novae Guinea Jurnal Biologi 8 (2): 180-192. [Indonesia]