Morphological characteristics and other features of mangrove clams (*Geloina expansa*) at Kerteh River, Terengganu, Malaysia

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Abstract. *Geloina expansa* or "lokan" is one of the clams that can be found in mangrove ecosystems and has a high economic value. The objectives of this study were to access morphological characteristics and to determine the relation between abundance and sediment grain size of *G. expansa* in Kerteh River, Terengganu, Malaysia. The clams were collected from four plots (100 m²), each plot having nine subplots. Sediment samples were sieved through a stack of 7 different mesh size sieves for grain of the following categories: very coarse, 1000 µm (VC1000); coarse, 500 µm (C500); medium coarse, 355 µm (MC355); medium, 250 µm (M250); medium fine, 125 µm (MF125); fine, 63 µm (F63); and ultra-fine, <63 µm (UF). In this study, 164 individuals were collected from Kerteh. The length of *G. expansa* ranged from 1.5 to 8.9 cm. The height ranged from 1.7 to 8.5 cm. The relationship between abundance and sediment grain size was evaluated using the Spearman correlation. The abundance and sediment grain size of *G. expansa* at Kerteh River showed no significant correlation, but plot 1d with the presence of medium fine (MF125) grains had the highest abundance of *G. expansa*. The findings provide a new viewpoint for practical management tools to maintain Kerteh River natural resources and safeguarding local communities' source of livelihood.

Key Words: abundance, bivalve, conservation, habitat preference, sediment.

Introduction. *Geloina expansa* is a clam species from the phylum Mollusca, family Cyrenidae. It is commonly called the mangrove clam. The color of the outer shell is light green anteriorly to dark green posteriorly. Inside the shell it is pearly white, but the outer shell can be black, depending on environmental factors. *G. expansa* is a filter feeder, filtering phytoplankton, particles of organic matter and inorganic particles (Eyre & Ferguson 2006). Hence, they are biological indicators of changes in the mangrove ecosystem (Macintosh et al 2002). The mangroves of Kerteh river are located in Kemaman District of Terengganu, peninsular Malaysia. Kerteh river is surrounded by mangrove forests and located nearby a coastal hill, which support vast biological resources (Nor et al 2022). Kerteh is known as an industrial complex operating oil and gas landing activities (Sukri et al 2017). The mangroves at Kerteh river are riverine mangrove present along the riverbank. The mangrove ecosystem is the main habitat for *G. expansa*. It is suspected that the abundance is influenced by environmental factors (Kassim et al 2018). Ingole et al (2002) reported that *G. expansa* can usually be found in Indo-Pacific mangrove areas, including Cambodia, Malaysia, Philippines, Thailand and Vietnam. The clams prefer to bury in the mud around the mangrove trees (Ingole et al 2002; Bayen et al 2005). The clams play an important role in the food web of mangrove ecosystems.

High organic carbon content in mangrove sediment may influence the availability of bivalves (Kabir et al 2014). Sediment grain size refers to the range of particle sizes in a sediment. From a previous study, it was determined that *G. expansa* can found at sites with fine silt and absent at sites with a high sand particle size (Elvira & Jumawan 2017). There are contradictory results regarding the correlation of grain size with clam abundance. For example, Jayawickrema & Wijeyaratne (2009) determined that sediment grain size has a high correlation with the density of *G. expansa*. However, according to Yahya et al (2016), the sediment grain size has a low correlation with the density of *G. expansa* in Setiu wetlands. The abundance of *G. expansa* has decreased over the years because of poor environmental factors such as low water quality, sediment grain size and others. According to de la Huz et al (2002), sediment grain size is very important and can influence metabolic activity, abundance and growth rate of bivalves. Sediment grain size is significantly correlated with the density of bivalve at Tok Bali mangrove ecosystem (Kassim et al 2018). Most bivalves, including this species, need a particular substrate to survive. They prefer a substrate near *Avicennia* sp. (Clemente & Ingole 2011). There is a lack of information regarding the morphology, abundance and preference for sediment grain size of *G. expansa* at Kerteh river. Thus, the objectives of this study were to characterize the morphology of *G. expansa* and to determine the relation between abundance and sediment grain size for *G. expansa* at Kerteh river, Malaysia.

Material and Method

Description of study site. The study was carried out in June 2020 at Kerteh river, Terengganu (5°41'18.6"N; 102°42'27.4"E), Northern Terengganu, peninsular Malaysia (Figure 1).

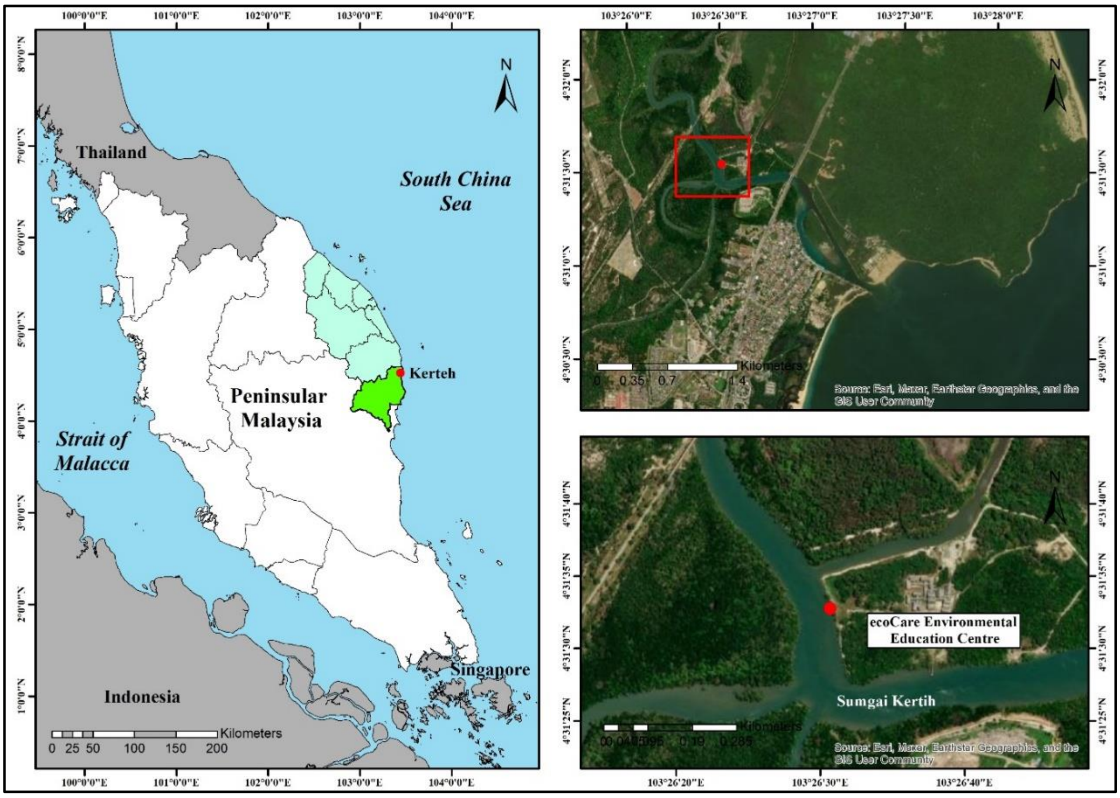

Figure 1. Location of sampling site at Kerteh, Terengganu.

Sampling method. *G. expansa* was collected near the mangroves at Kerteh river. Four plots at the mangrove area of Kerteh river were randomly prepared during the low tide. The plots had an area of 10x10 m each. *G. expansa* was sampled from nine 1x1 m subplots (nine replicates). The sampling areas were scraped using a hand shovel at a 30 cm depth to collect the species. The clams were collected and placed in a tray. Sediment samples were collected in plastic bags. The plastic bags were labelled, including the date and plot numbers. The samples of *G. expansa* were preserved in 75% ethanol.

Morphological measurements. The shell length and shell height were determined for all samples using a caliper (0.1 mm accuracy) (Figure 2) (Yahya et al 2018).

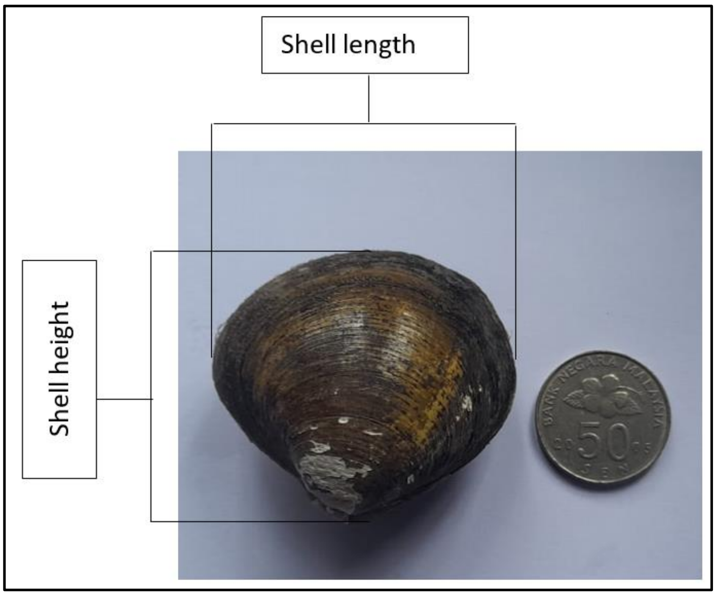

Figure 2. The morphological measurement of *Geloina expansa*.

Sediment analysis. The methods used for the sediment grain size and total carbon determination followed Jaafar et al (2018). 500 g were air dried at 55ºC for a week prior to analysis. Then, sediments were crushed and dried again. 400 g were sieved for sediment grain size through a stack of 7 different mesh size sieves on an automated sieve shaker for grain of the following categories: very coarse, 1000 μm (VC1000); coarse, 500 μm (C500); medium coarse, 355 μm (MC355); medium, 250 μm (M250); medium fine, 125 μm (MF125); fine, 63 μm (F63); and ultra-fine, <63 μm (UF). Sediment grain sizes for each layer were represented in percentage. The lost on ignition method was used to determine total carbon in sediment samples. 10 g of sample were ignited in a furnace at a temperature of 700ºC for approximately 5 h before the final sample was weighted again after cooling, to obtain the amount of carbon that has been lost. Before ignition in a furnace, the crucibles were dried in an oven at a temperature of 100ºC for 1 h. After that, the amount of carbon was calculated and represented in percentage.

Data analysis. Spearman's Rank Correlation was applied to determine the relation between abundance of *G. expansa* and sediment grain size. The statistical analysis was applied for the 95% confidence level. Statistical analyses were conducted with the help of SPSS® version 25.

Results and Discussion

Morphological measurement. The highest length value of *G. expansa* at Kerteh river was 8.9 cm and the lowest was 1.5 cm. The highest value for height of *G. expansa* at Kerteh river was 8.5 cm and the lowest was 1.7 cm.

According to Ransangan & Soon (2018), *G. expansa* at Marudu Bay have a length from 2.1 cm to 8.9 cm, similar to that of *G. expansa* at Kerteh river. Meanwhile, in peninsular Malaysia, the length of *G. expansa* ranged from 1.1 cm to 7.25 cm in Setiu wetlands (Yahya et al 2018). Clams usually compete with each other for nutrients and space (Connell 1961).

Abundance of G. expansa at Kerteh river. 164 individuals of *G. expansa* were collected at Kerteh river. Table 1 shows that *G. expansa* at plot 4 had the largest abundance, with 137 individuals and *G. expansa* at plot 1 had the lowest abundance, with only 8 individuals.

According to Beasley et al (2005), strong water waves will change the sediment structures and affect the abundance of clams. Sediments in mangroves are very important, because they have high organic carbon levels, with smaller grain sizes (Demopoulos 2004). Sediments in mangroves are usually not suitable to many organisms, but are preferred by bivalves. At Kerteh river, *G. expansa* has been regularly harvested by the local population. According to Soon et al (2016), harvesting clams can affect the sustainability of natural stocks of the species. In this study, *G. expansa* was mostly found in the *Avicennia* sp. zone of the mangroves, similar to the observations of Meehan (1982).

Total carbon. Table 1 shows the total carbon Kerteh river. Total carbon was observed at a high percentage in plots 1 and 3, with averages of 8.2 and 7.5%, respectively. Plots 2 and 4 had a lower total carbon, with averages of 3.8 and 4.3% respectively. However, total carbon with the average of 4.3% was preferred by *G. expansa* at Kerteh river.

Table 1

The *Geloina expansa* abundance and total carbon in Kerteh river

Plot	*1*	*2*	*3*	*4*
Number of individuals	8	9	10	137
Total carbon (%)	8. 2	3.8	7.5	4.3

Composition of grain size. Figure 3 showed the composition for different grain size at each plot Kerteh river.

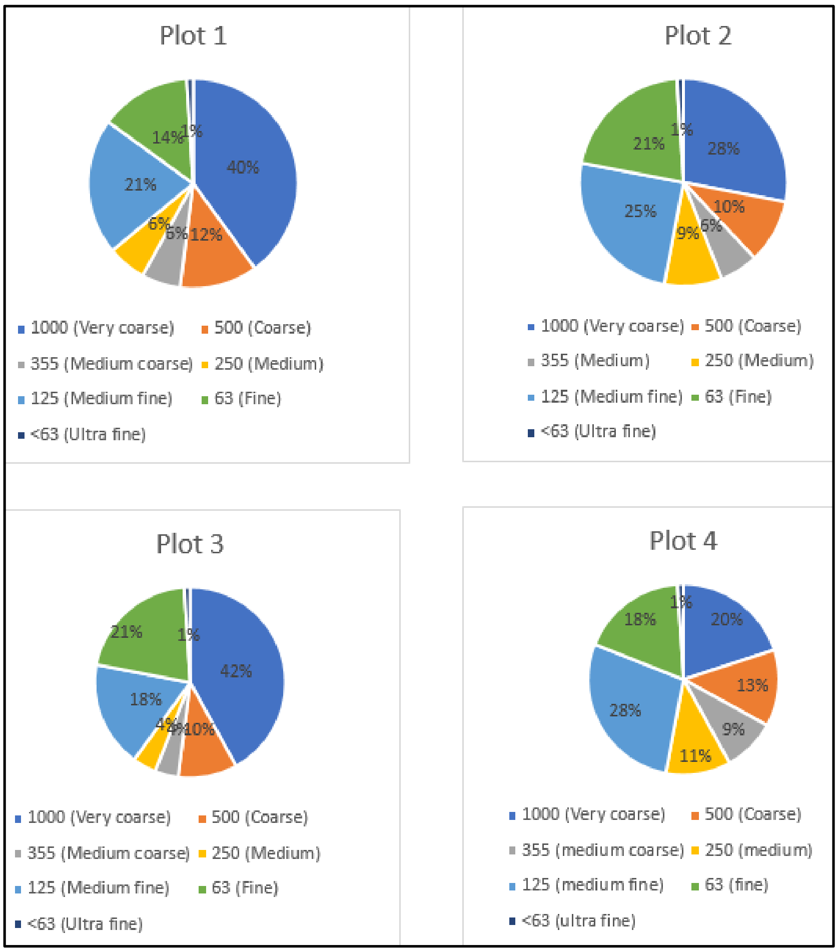

Figure 3. Composition of grain size (%) in Kerteh river.

Plots 1, 2 and 3 were dominated by very coarse 1000 μm (VC1000) grain and plot 4 was dominated by medium fine 125 μm (MF125) grain. Plot 1 had 58% very coarse 1000 μm to medium coarse 355 μm (MC355) grain and 42% medium 250 μm (M250) to ultrafine <63 μm (UF) grain. Plot 4 had a higher percentage of grain size from medium to ultra fine than plot 3, 58% for plot 1d and 44% for plot 3, respectively.

The relation between the abundance of G. expansa and sediment grain size. Table 2 shows the correlation coefficient between sediment grain size and the abundance of *G. expansa*. The relation was not significant. However, the abundance of *G. expansa* still showed a strong positive correlation with certain grain sizes. Plots 1 and 3 had a strong positive correlation coefficient with medium 250 μm grain (M250) (r=0.894 for plot 1; r=1 for plot 3). Plot 2 showed a strong positive correlation with medium fine 125 μm (MF125) grain (r=0.632), while plot 4 had a strong positive correlation with very coarse 1000 μm (VC1000) grain (r=0.949). Thus, the range of sediment grain sizes that were preferred by *G. expansa* was from VC1000 to MF125.

Table 2

Spearman correlation coefficient (r) between sediment grain size and abundance of *Geloina expansa* at Sunagi Kerteh according to sampling plots

Grain size / *Plot*	*VC1000*	*C500*	*MC355*	*M250*	*MF125*	*F63*	*UF*
Plot 1	-0.447	-0.447	0.000	0.894	0.000	-0.447	-0.894
Plot 2	0.316	-0.105	-0.632	-0.632	0.632	-0.105	-0.632
Plot 3	-0.400	-0.400	0.200	1.000	-0.200	-0.400	-1.000
Plot 4	0.949	0.316	0.632	0.632	-0.632	0.316	-0.632

Three plots (1, 2 and 3) were dominated by very coarse 1000 μm (VC1000) grain because they were near the river. Plot 4 was dominated by medium fine 125 μm (MF125) grain. According to Bahari et al (2021), the highest density of *G. expansa* found at Setiu wetlands (peninsular Malaysia) was in medium fine (MF125) grain. The structure of the sediments can change because of water movement from the river during the wet season (Ong et al 2012). Usually, sediment near the river has more coarse grain size compared to area afar from the river. This is expected due to the influence of strong water movement and tide, especially during the wet season.

Medium fine 125 μm (MF125) grain plays an important role in settling the drifting *G. expansa* larvae. Environmental factors such as the type of sediment affect the population density and morphology of bivalves, including *G. expansa* (Claxton et al 1998). Although the present study did not find significantly strong correlations between abundance of *G. expansa* and sediment grain size, there were still strong relations between abundance of this species and sediment grain size.

According to Spooner & Vaughn (2006), the total carbon influences the abundance of bivalves. Total carbon is the main food of bivalve (Ligon et al 1995) and could affect the abundance of *G. expansa* in this study. The total carbon level preferred by *G. expansa* was not too high or too low. De Falco et al (2004) reported that the smaller the sediment grain size contains higher levels of total carbon in soil.

Conclusions. At Kerteh river, the length of *G. expansa* ranged from 1.5 to 8.9 cm. The height of *G. expansa* ranged from 1.7 to 8.5 cm. 164 individulas of *G. expansa* were sampled at Kerteh river. The range of sediment grain size preferred by *G. expansa* was from very coarse 1000 μm (VC1000) to median fine 125 μm (MF125). Total carbon with an average of 4.3% was preferred by *G. expansa*. Future studies are needed and have to consider several different time scales, ranges of habitats and other environmental conditions.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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