Habitat preferences of mangrove clam (*Geloina expansa*) in East coast of Peninsular Malaysia

[1]Nur A. Bahari, [2]Nik S. Nik Jaafar, [1]Siti M. Muhammad Nor, [1]Wan B. Wan Omar

[1] Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia; [2] Malaysia Nature Society, JKR 641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur, Malaysia. Corresponding author: W. O. Wan Bayani, bayani@umt.edu.my

Abstract. Mangrove clam (*Geloina expansa*) or '*Lokan*' is one of the clams that is consumed and extensively collected by the local communities throughout the year. The objective of this study was to identify the habitat preferences for the mangrove clam, and use them as indicators for its sustainable management. The relation between clam abundance and sediment grain size of *G. expansa* in Setiu Wetlands was evaluated by using Spearman's Rank Correlation. At the study sites, clams were collected from four plots (100 m^2) and each plot had nine subplots. Sediment samples were sieved through a stack of seven different mesh sizes. Results showed that very course grain size (VC1000), medium grain size (M250) and ultra-fine grain size (UF) were significantly correlated with the clam population (VC1000: $r = 0.949$; M250: $r = 0.949$; UF: $r = 0.949$; $p < 0.05$). This research provided some insights into how sediment composition can be an effective tool to indicate changes that had happened in the mangrove forests and how the clam growth and distribution could affect its sustainable management. This knowledge can benefit the conservation of clams and help to maintain their populations for long term survival.

Key Words: abundance, *Geloina expansa*, conservation, habitat preference indicators, sediment, Setiu Wetlands

Introduction. Mangrove forests can be found along tropical and subtropical regions along the coastlines (Tomlinson 2016). These forests provide numerous benefits ecologically and economically (Lokman & Sulong 2001). In terms of ecology, mangrove provide various ecosystem services for instance protecting the coastline from erosion and the storm, nursery habitat for fish and crustacean juveniles and as boundary to filter the pollutants. Economically, coastal communities benefits from the mangrove resources such as mangrove woods, fisheries products and mangrove fruits and juice (i.e *Nypa* juice). In terms of floristic component, main genera of mangrove in the world are *Avicennia*, *Bruguiera*, *Rhizophora*, *Sonneratia*, *Ceriops* and *Lumnitzera* and these genera are easily identified based on their root morphological characters. The mangrove ecosystem also contains macrobenthic organisms such as molluscs (snails, mangrove clams and oysters), phytoplankton and arthropods (crabs and shrimps).

Setiu Wetlands is a unique ecosystem that is located in Setiu District, Terengganu. The wetlands consist of nine interconnected ecosystems, which act as an important ecological protection and home to the diverse species of flora and fauna. However, the wetlands have been threatened by infrastructural development (Salam et al 2017). Clam is one example of bivalve and it is a famous seafood in Malaysia because it is rich in nutrients and can increase the amount of red blood cells. The mangrove clam, *Geloina expansa* (Mousson, 1849) is a bivalve species that can be found in Setiu Wetlands. *G. expansa* is a large and heavy bivalve (Ng & Sivasothi 2001). According to De la Huz et al (2002), sediment grain size is very important as it can affect the metabolic activity, abundance and growth rate of bivalve. Furthermore, high organic carbon content in mangrove sediment also may influence the availability of bivalve (Kabir et al 2014). Sediment grain size is significantly correlated with the density of bivalve at Tok Bali mangrove ecosystem (Kassim et al 2018). In Malaysian mangrove, *G. expansa* has been extensively collected by the local communities throughout the year (Yahya et al 2018). However, study on abundance of *G. expansa* and sediment grain size in Setiu Wetlands is limited. Therefore, this study aims to investigate suitable habitat preference indicators by using the relation between abundance of *G. expansa* and sediment grain size in Setiu Wetlands and to use these indicators for the sustainable management of the species.

Material and Method

Description of study site. This study was carried out on July, 2020 at Setiu Wetlands, Terengganu (5°41'19"N, 102°42'4"E) (Figure 1). Setiu Wetlands is located about 62.9 km from Universiti Malaysia Terengganu. The mangrove species that can be found in this area belong to genera *Avicennia*, *Sonneratia*, *Nypa*, *Rhizophora* and *Bruguiera*. Plot 1a and plot 1b are near the river (5 meter), while plot 1c and plot 1d are located far from the river (10 meter). The morphological of *G. expansa* is in Figure 2.

Figure 1. Location of sampling site at Setiu Wetland Terengganu, Malaysia.

Figure 2. The morphology of *G.expansa.*

Sampling method. *G. expansa* was collected at Setiu Wetlands. At the mangrove area in Setiu Wetlands four plots were randomly prepared during the low tide. Each plot had an area of 10 m x 10 m. The clams were sampled by using nine subplots of size 1 m x 1 m (nine replicates). To collect the species, the sampling areas were scraped by using a hand shovel until the depth reaching 30 cm. The clams were collected and placed in a tray. Meanwhile, the sediment was placed in plastic bags. The plastic bags were labelled with date and station numbers included. Then, the *G. expansa* samples were preserved in 75% of ethanol.

Sediment analysis. The methods for sediment analysis were followed Jaafar et al (2018) with modifications. Prior to analysis, 500 grams of sediment were air dried at

55°C for one week. Then, the sediments were crushed with mortar and pastle and dried again to ensure that the samples were really dry. For sediment grain size analysis, 400 grams were sieved through a stack of 7 different mesh sizes on an automated sieve shaker, which started with 1000 µm for very coarse grain (VC1000), followed by 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 size for each layer was represented in percentage. Loss on ignition method was used to determine total carbon in sediment samples (Jaafar et al 2018). Ten (10) grams of samples were burnt in a furnace at temperature of 700°C for approximately 5 hours. The final samples were weighed again after cooling to obtain the amount of carbon that has been lost. After that, the amount of carbon was calculated and represented in percentage.

Statistical analysis. Spearman's Rank Correlation was applied to determine the relation between abundance and sediment grain size of the species. The statistical analysis was deemed for the 95% confidence level. Statistical analyses were conducted by SPSS® Version 25.

Results

Composition of grain size. In Setiu Wetlands, Plot 1a and Plot 1b were dominated by coarse 500µm (C500). Meanwhile, Plot 1c and Plot 1d were dominated by medium fine 125 (MF125), based on Figure 3.

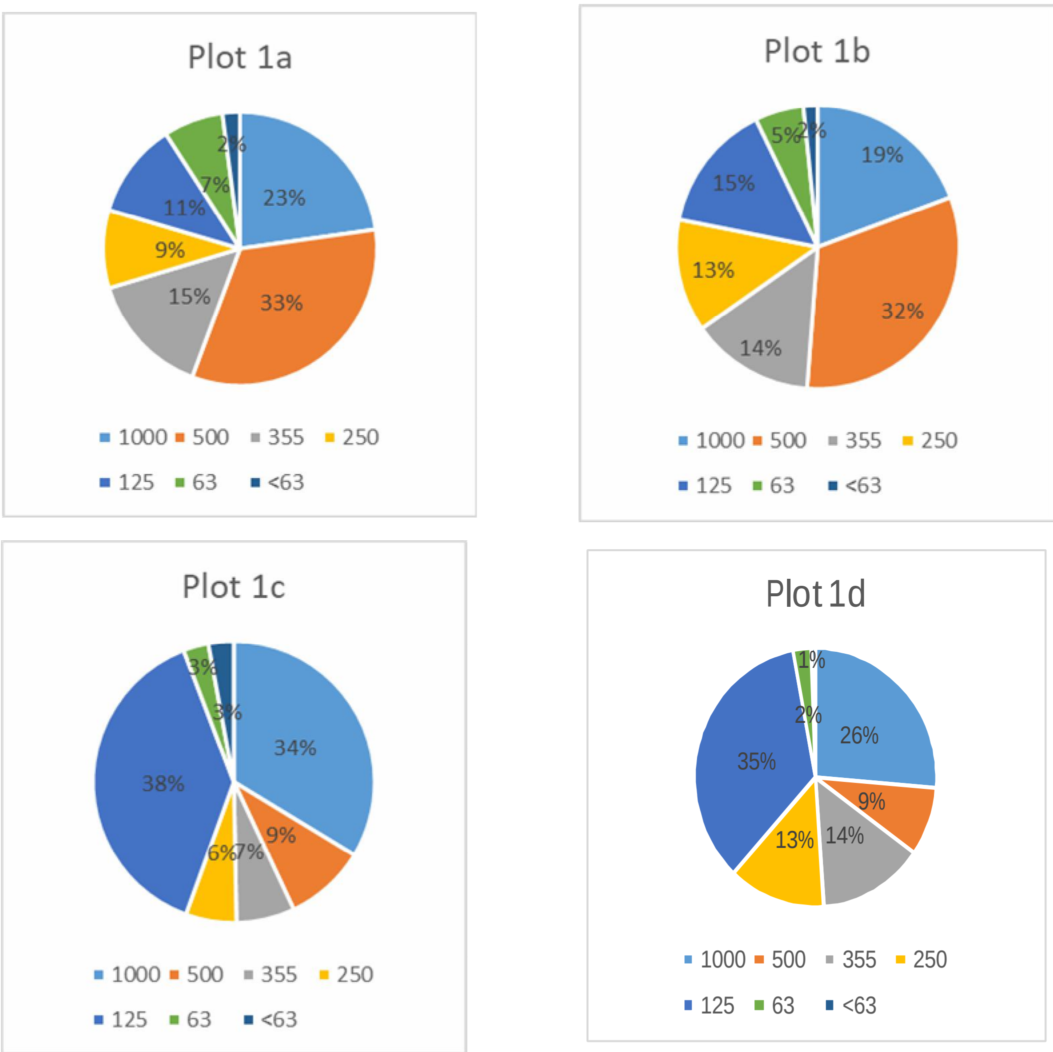

Figure 3. Composition of grain size (%) in Setiu Wetlands.

In Setiu Wetlands, Plot 1a had the highest percentage of grain size from very coarse 1000 µm (VC1000) to medium coarse 355 µm (MC355), which was 71.0%. But, the rest was medium 250 µm to ultra-fine < 63 µm (UF) grain size (29.0%). Plot 1b had a higher percentage of grain size from very coarse 1000 µm (VC1000) to medium coarse 355 µm (MC355) as compared to Plot 1c, which was 65.0% for Plot 1b and 50.0% for Plot 1c. However, Plot 1b had lower percentage of grain size from medium 250 µm (M250) to ultra-fine < 63 µm (UF) as compared to Plot 1c, which was 35.0 % for Plot 1b and 50.0% for Plot 1c. The result showed that Plot 1d had the lowest percentage of grain size from very coarse 1000 µm (VC1000) to medium coarse 355 µm (MC355), which was 49.0%. The balance was medium 250 µm (M250) to ultra-fine < 63 µm (UF) grain size (51.0%).

Total carbon. Table 1 shows that plot 1d had the largest number of *G. expansa* collected (47 individuals), followed by plot 1c (32 individuals), plot 1a (27 individuals) and plot 1b (21 individuals). Total carbon was observed at high percentage in plot 1a and plot 1b with an average of 7.4% and 6.5%, respectively. Plot 1c and plot 1d had a slightly lower total carbon with an average of 4.7% and 4.1%, respectively. However, total carbon with an average 4.1% was more preferred by the *G. expansa* in Setiu Wetlands. Therefore, the range of total carbon that most *G. expansa* preferred was 4.1-4.7%.

Table 1

The number of individuals and total carbon measured in Setiu Wetlands

Measuring factor	*Station*			
	1a	*1b*	*1c*	*1d*
Number of individuals (per m^2)	27	21	32	47
Total carbon (%)	7.4	6.5	4.7	4.1

The relation between abundance of G. expansa and sediment grain size. The correlation coefficient between sediment grain size and the abundance of *G. expansa* is given in Table 2. According to Spearman's Rank Correlation analysis, the relation between abundance of *G. expansa* and sediment grain size in Setiu Wetlands showed a strong positive correlation and significant differences with the presence of very coarse 1000 µm (VC1000) at plot 1a, medium 250 µm (M250) and ultra-fine <63 µm (UF) at plot 1c. Although plot 1a and plot 1b had the highest coarse 500 µm sediment (C500) while plot 1c and plot 1d had highest median fine 125 µm sediment (MF125), positive correlation was not shown with the *G. expansa*. Therefore, the range of sediment grain size that was preferred by *G. expansa* was from VC1000 to UF.

Table 2

Spearman's Rank Correlation coefficient (r) between sediment grain size and *G. expansa* abundance in Setiu Wetlands according to plot

Plot	*Grain size*						
	VC1000	*C500*	*MC355*	*M250*	*MF125*	*F63*	*UF*
1a	0.949*	-0.316	-0.632	-0.632	0.632	-0.316	0.632
1b	-0.316	0.105	-0.211	-0.211	0.211	0.105	0.211
1c	0.632	0.211	-0.316	0.949*	0.316	0.211	0.949*
1d	0.200	0.200	0.400	0.000	-0.400	0.200	0.000

*Correlation was significant at the 0.05 level.

Discussion

Abundance of G. expansa in Setiu Wetlands. In Setiu Wetlands, *G. expansa* at plot 1d had the largest abundance of 47 individuals. *G. expansa* at plot 1b had the lowest abundance of 21 individuals. This was because the surrounding at plot 1d had good substrate such as soil with *Avicennia* sp. According to Meehan (1982), *G. expansa* was mostly found in the *Avicennia* zone of mangroves, which was the same with this study.

Substrate may also play a major role in *G. expansa* distribution. Substrates that facilitate aerial respiration will favour a larger abundance of bivalve than those that hinder such activity. Lyimo et al (2002) reported that the rhizospehere of *Avicennia* sp. was highly oxidised with almost complete absence of sulphide. In Setiu Wetlands, villagers usually collect clams to increase their monthly household income. Harvesting of clams by humans also affects the species sustainability of natural stock (Tan et al 2016). According to Beasley et al (2005), strong water wave would change the sediment structures and finally affect the abundance of clams.

The relation between abundance of G. expansa and sediment grain size. From this study, plot 1a and plot 1b in Setiu Wetlands were dominated by coarse 500 µm (C500) because they were near the river. Usually sediment near a river has more coarse grain size as compared to a place away from the river. This result was expected due to influence by the strong water movement and combination of tides, especially during the wet season. According to Ong et al (2012), the coarse sediments occurred at higher water movement from the river during the wet season, whereby the finer sediments were transported out into the sea. So, it could change the structure of sediment grain size.

Plot 1c and plot 1d were dominated by medium fine 125 µm (MF125). According to Clemente & Ingole (2011), the highest density of *G. expansa* was found at Chorao Island (India), with medium fine, and thus was the same with this study. The findings suggested that medium fine 125 µm (MF125) played an important role for the drifting *G. expansa* larvae to settle down. This was because medium fine 125 (MF125) had the largest abundance of *G. expansa* in Setiu Wetlands. Environmental factor such as the type of the sediment affects the population density and morphology of bivalve, including *G. expansa* (Claxton et al 1998).

Total carbon refers to carbon that is contained in soil organic matter. From this result, the highest abundance of *G. expansa* with presence of 4.1% of total carbon was found at plot 1d. Organic matter is the main food of bivalve (Frissell et al 1986; Ligon et al 1995) and in this study organic matter had affected the abundance of *G. expansa*. According to Spooner & Vaughn (2006), the total carbon had relation with life of bivalve. The sediment grain size influences the amount of total carbon in soil. De Falco et al (2004) reported that the smaller the sediment grain size, the larger total carbon in soil. However, this study showed that the larger the sediment grain size, the larger the total carbon.

Conclusions. The range of sediment grain size that were preferred by *G. expansa* in Setiu Wetlands was from very coarse 1000 (VC1000) to ultra-fine < 63 (UF). Total carbon with average 4.1% was more preferred by the *G. expansa* in Setiu Wetlands. Preparing a management and conservation plan for the sustainable development of Setiu Wetlands is a challenging task. Future studies are needed and the species ecology and biology perspective have to be considered to get good and accurate results.

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

References

Beasley C. R., Fernandes C. M., Gomes C. P., Brito B. A., dos Santos S. M. L., Tagliaro C. H., 2005 Molluscan diversity and abundance among coastal habitats of northern Brazil. Ecotropica 11:9-20.

Claxton W. T., Wilson A. B., Mackie G. L., Boulding E. G., 1998 A genetic and morphological comparison of shallow- and deep-water populations of the introduced dressenid bivalve *Dresseina bugensis*. Canadian Journal Zoology 76(7):1269-1276.

Clemente S., Ingole B., 2011 Recruitment of mud clam *Polymesoda erosa* (Solander, 1876) in a mangrove habitat of Chorao Island, Goa. Brazilian Journal of Oceanography 59(2):153-162.
De Falco G., Magni P., Teräsvuori L. M. H., Matteucci G., 2004 Sediment grain size and organic carbon distribution in the Cabras lagoon (Sardinia, Western Mediterranean). Chemistry and Ecology 20(1):367-377.
De la Huz R., Lastra M., Lopez J., 2002 The influence of sediment grain size on burrowing, growth and metabolism of *Donax trunculus* L. (Bivalvia: Donacidae). Journal of Sea Research 47(2):85-95.
Frissell C. A., Liss W. J., Warren C. E., Hurley M. D., 1986 A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10(2):199-214.
Jaafar N. M. S. N., Yunus Y. N. D., Ismail M., 2018 The relationship of sediment grain size and Asian hard clam distribution as sustainable management indicator. International Journal of Civil Engineering and Technology 9(9):1824-1830.
Kabir M., Abolfathi M., Hajimoradloo A., Zahedi S., Kathiresan K., Goli S., 2014 Effect of mangroves on distribution, diversity and abundance of molluscs in mangrove ecosystem: a review. AACL Bioflux 7(4):286-300.
Kassim Z., Ahmad Z., Ismail N., 2018 Diversity of bivalves in mangrove forest, Tok Bali Kelantan, Malaysia. Science Heritage Journal 2(2):4-9.
Ligon F. K., Dietrich W. E., Trash W. J., 1995 Downstream ecological effects of dams. BioScience 45(3):183-192.
Lokman M. H., Sulong I., 2001 Mangroves of Terengganu. Mangrove Research Unit (MARU) and Forestry Department Peninsular Malaysia, 135 pp.
Lyimo T. J., Pol A., Op den Camp H. J. M., 2002 Methane emission, sulphide concentration and redox potential profiles in Mtoni mangrove sediment, Tanzania. Western Indian Ocean Journal of Marine Science 1(1):71-80.
Meehan B., 1982 Shell bed to shell midden. Australian Institute of Aboriginal Studies, Aboriginal Studies Press, Canberra, 189 pp.
Ng P. K. L., Sivasothi N., 2001 A guide to mangroves of Singapore. Available at: http://mangrove.nus.edu.sg/guidebooks/text/2098.htm. Accessed: August, 2020.
Ong M. C., Kamaruzzaman B. Y., Azhar M. S. N., 2012 Sediment characteristic studies in the surface sediment from Kemaman Mangrove Forest, Terengganu, Malaysia. Oriental Journal of Chemistry 28(4):1639-1644.
Salam M. R., Zulkifli M. K. F., Ahmad W. J. W., 2017 Distribution and rarity of mangrove and coastal plants in developing indicators of hotspots in Setiu Wetland. Proceeding of Setiu Wetland 2017 Scientific Expedition Seminar. WWF Malaysia, pp. 14-23.
Spooner D. E., Vaughn C. C., 2006 Context-dependent effects of freshwater mussels on the benthic communities. Freshwater Biology 51:1016-1024.
Tan K. S., Denil D. J., Ransangan J., 2016 High mortality and poor growth of green mussels, *Perna viridis*, in high chlorophyll-*a* environment. Ocean Science Journal 51(1):43-57.
Tomlinson P. B., 2016 The botany of mangroves. 2nd edition. Cambridge University Press, Cambridge, 418 pp.
Yahya N., Idris I., Rosli N. S., Bachok Z., 2018 Population dynamics of mangrove clam, *Geloina expansa* (Mousson, 1849) (Mollusca, Bivalvia) in a Malaysian mangrove system of South China Sea. Journal of Sustainability Science and Management 13(5):203-216.

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Authors:
Nor Ain Bahari, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia, e-mail: ainbahari96@gmail.com
Nik Shibli Nik Jaafar, Malaysia Nature Society, JKR 641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur, Malaysia, e-mail: nmshibli75@gmail.com
Siti Mariam Muhammad Nor, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia, e-mail: sitimariam@umt.edu.my
Wan Bayani Wan Omar, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia, e-mail: bayani@umt.edu.my

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