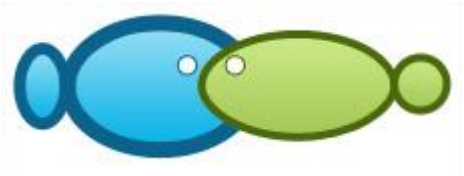

The abundance of blood cockle (*Anadara cornea*) and its sediment grain size preferences at Setiu Wetlands lagoon, east coast of Peninsular Malaysia

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Abstract. The blood cockle, *Anadara cornea*, is one of the clam species that generates income and provides food for the local communities at Setiu wetlands in the state of Terengganu. However, this species is reportedly declining at an alarming rate, especially on the east coast of Peninsular Malaysia. This study aimed to assess the relationship between the abundance of *A. cornea* and sediment grain size. The clams were collected from five plots (100 m^2 $plot^{-1}$), each further divided into three subplots. The clams were collected by hand from the top of a 10-cm of surface sediment. Sediment samples were collected using a scoop and brought back to the laboratory, where the sediment was sieved through 7 layers of different mesh sizes. A total of 580 *A. cornea* individuals were collected at the Setiu lagoon. The relation between sediment grain size and abundance of *A. cornea* was evaluated using Spearman correlation. It was found that its abundance is negatively correlated with sediment size of 1.0 and 2.0 mm and positively correlated with 0.0032, 0.125, 0.25, 0.50, and 0.71 mm. A weak negative correlation of r = -0.308 and r = -0.319 was detected for sizes of 2.0 and 1.0 mm respectively, which shows that the abundance of *A. cornea* decreases with larger sediment grain size. The smallest sediment grain size of 0.0032 mm shows a strong relationship with the abundance of *A. cornea*, r = 0.821, suggesting its abundance increases in small sediment grain size. The other sediment grain sizes (0.71 mm (r = 0.410), 0.50 mm (r = 0.205), 0.25 mm (r = 0.306), and 0.125 mm (r = 0.306)) have a positive weak correlation with the abundance of *A. cornea*. This research provided an insight into how sediment composition can effectively indicate the type of conducive habitat for this clam and how distribution could affect its sustainable management. This finding helps with conserving and maintaining its populations and safeguarding local communities' source of livelihood.

Key Words: blood cockle, density, habitat, mangrove, morphology.

Introduction. Setiu Wetlands is a unique ecosystem located northeast of Peninsular Malaysia in the 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 (Salam et al 2017). There are 11 families of bivalves found in the lagoon of Setiu wetlands (Yahya et al 2017) including family Arcidae. The blood cockle *Anadara cornea* belongs to this family. Recently, this species has been traded and eaten by the local community in Setiu wetlands. The population density and size of *A. cornea* have decreased over time, suggesting that it has been exploited without control (Ibrahim et al 2018).

According to Mirzaei et al (2014), *Anadara* spp. (clams) growth rate has a year-round continuous reproduction and high population abundance, making them ideal for fisheries. However, the clams found mostly in the estuarine environment are subject to fluctuating environmental conditions, which significantly influence their growth and reproduction (Meshram & Mohite 2016). *Anadara* spp. is an infaunal bivalve that lives in

aquatic sediment. *Anadara* spp. are mainly distributed in mangroves, muddy vegetation, and mixed areas (Khalil et al 2017). The growth of *Anadara* spp. is influenced by biological and environmental factors (life stage, food availability, stocking density) and physical factors (temperature, salinity and currents) which vary in each region (Riniatsih & Wibowo 2010). *A. cornea* has a growth pattern similar to that of other *Anadara* species (Meshram & Mohite 2016).

Sediment grain size is very important because it affects bivalves' metabolic activity, abundance, and growth rate (De la Huz et al 2002). According to Nel et al (2001), grain size influences the burrowing performance of the species. The fastest burrowing time is in fine and medium sediments but increases in very fine and coarse extremes. The burial time is associated with shell width, with large individuals taking longer to bury themselves. Bergen et al (2001) reported that the taxa numbers and total organism abundance were lowest in the deep sediment habitat and highest in the middle habitat. This finding suggests that the energy profile of the water flowing immediately above the sediment-water interface determines the particle size in surface sediments, which affects properties such as the ease of burrowing that limits the surviving organisms. Hunt (2004) stated that juvenile bivalve often live near the sediment surface where the current and waves erode them.

Hence, sediment grain size can be used as a reference habitat (Bergen et al 2001), which can be applied to determine the abundance of *A. cornea*. Therefore, this study on abundance and sediment grain size may serve as a guideline for local communities and researchers to sustainably manage this species. Overall, the sediment grain size is important because it determines the abundance, distribution, and life habits. Therefore, it is the primary environmental factor.

Material and Method

Description of study site. The study was conducted in August 2020 at Setiu Wetlands Terengganu (5°41'19"N, 102°42'4"E) Terengganu, Peninsular Malaysia (Figure 1). Figure 2 shows the morphology of *A. cornea*.

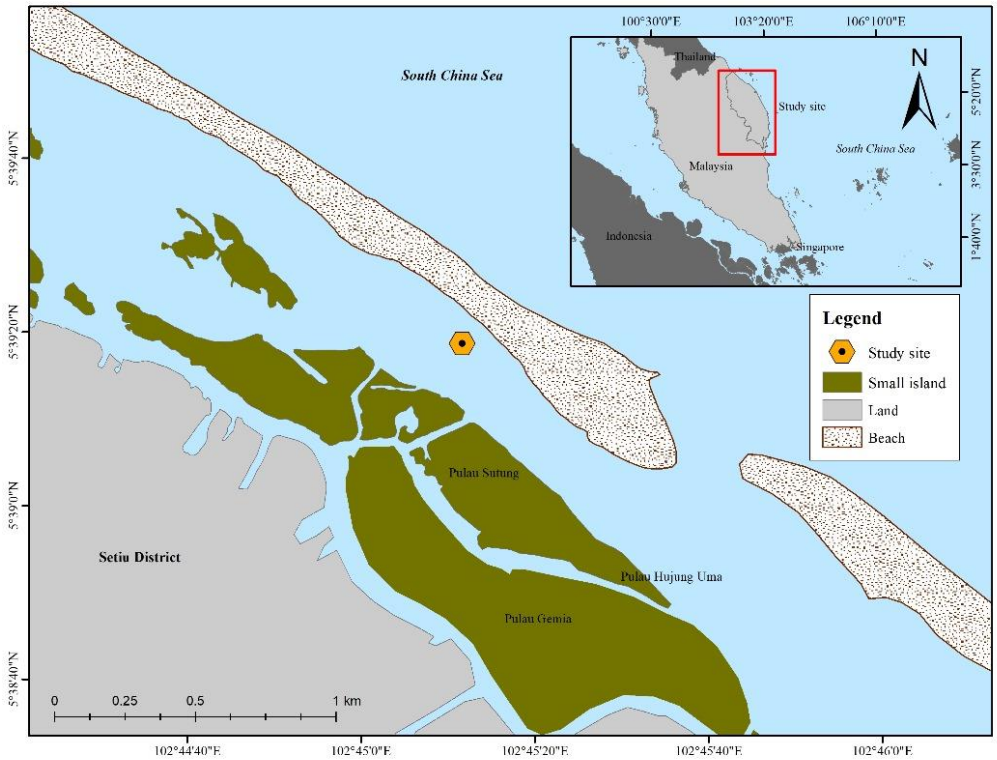


Figure 1. Location of sampling site at a lagoon in Setiu Wetlands, Terengganu, Malaysia.

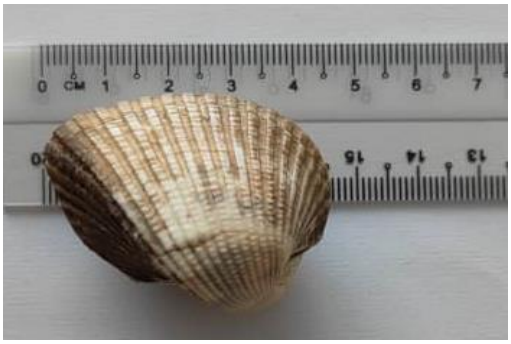


Figure 2. The morphology of *A. cornea* in Setiu Wetlands.

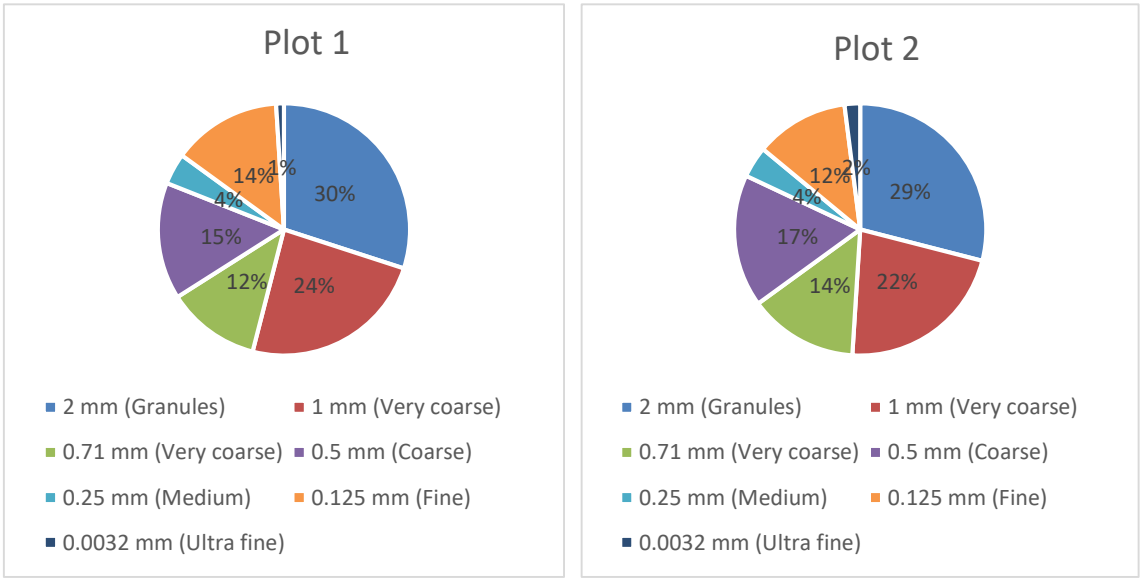
Sampling method. At the Setiu lagoon area, five plots were randomly prepared during the low tide. Each plot had an area of 10 m x 10 m. *A. cornea* was sampled using three subplots of size 1 m x 1 m (three replicates). The species were collected using a hand shovel at a 10 cm to 15 cm depth. Sediment samples also were collected using a scoop for grain size analysis. The samples and sediments were transferred in different plastic bags and labelled with the date and plot numbers. Then, the cockles were preserved in 75% ethanol.

Sediment analysis. The sediment analysis was conducted according to Jaafar et al (2018) with modifications. Before analysis, 500 grams of sediment were air-dried at 55ºC for a week. Then, the sediments were crushed and dried again. For sediment grain size analysis, 400 grams were sieved through a stack of 7 mesh size sieves for sediment grain of the following categories: granules (2 mm), very coarse (1 and 0.71 mm), coarse (0.5 mm), medium (0.25 mm), medium fine (0.125 mm), and ultra-fine (0.0032 mm). The sediment grain size for each layer was represented in percentage.

Statistical analysis. Spearman's rank correlation was applied to determine the relationship between the abundance of *A. cornea* and sediment grain size. The statistical analysis was conducted using SPSS version 25 and applied the 95% confidence level.

Results

Composition of grain size. Figure 3 shows the composition for different grain sizes at Setiu Wetlands. In Plot 1 to 5 were dominated with 2.0 mm granules. Plot 1 had 81% granules (2 mm) to coarse (0.5 mm) and 19% medium (0.25 mm to ultra-fine, 0.0032 mm) grain. Plot 2 had a higher percentage (82%) of granules to coarse than plots 3, 4, and 5: 80% for plot 3, 74% for plot 4, and 79% for plot 5.



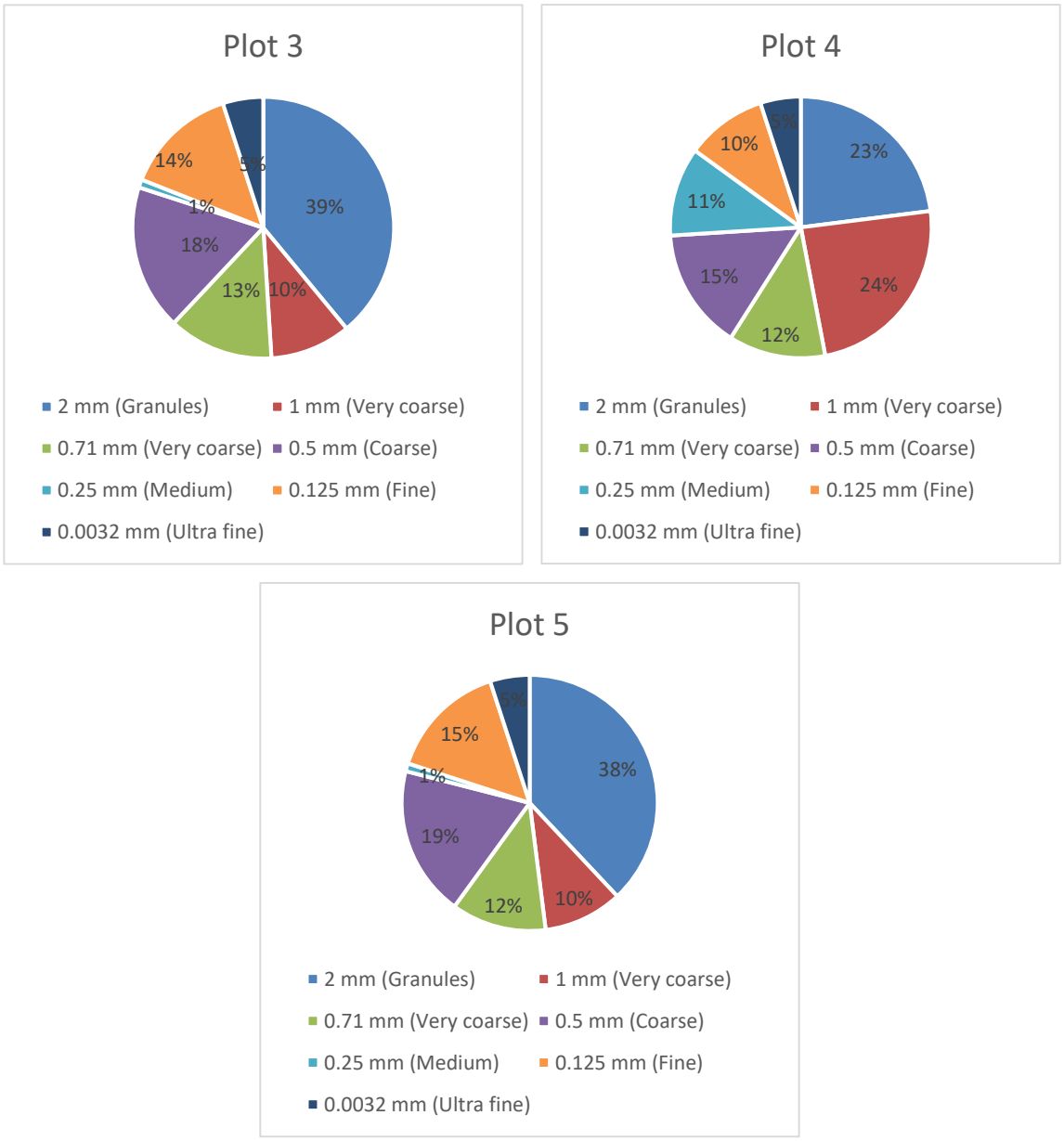


Figure 3. Composition of grain size (in %) at Setiu Wetlands.

The abundance of A. cornea at Setiu Wetlands lagoon. Table 1 shows that plot 3 had the largest number of *A. cornea* (a total of 208 individuals were collected), followed by plot 4 (197 individuals), plot 5 (98 individuals), plot 1 (53 individuals), and plot 2 (24 individuals).

The relation between the abundance of A. cornea and sediment grain size. Table 1 shows the correlation coefficient between the abundance of *A. cornea* and sediment grain size. The abundance of *A. cornea* was variably distributed along different sediment grain sizes. Its abundance is negatively correlated with the size of 1.0 mm (very coarse) and 2.0 mm (granule) but positively correlated with 0.0032 mm (ultra-fine), 0.125 mm (medium fine), 0.25 mm (medium), 0.50 mm (coarse), and 0.71 mm (coarse). A weak negative correlation of r = -0.308 and r = -0.319 was detected for sizes of 2.0 and 1.0 mm respectively, indicating that the abundance of *A. cornea* reduces in larger sediment grain size. The smallest sediment grain size of 0.0032 mm shows a strong relationship with the abundance of *A. cornea*, revealing r = 0.821. It shows that its abundance increases in small sediment grain size. Other sediment grain sizes (0.71 mm (r = 0.410), 0.50 mm (r = 0.205), 0.25 mm (r = 0.306), and 0.125 mm (r = 0.306)) have a positive weak correlation.

Table 1

Spearman correlation coefficient (r) between sediment grain size and *A. cornea* abundance in Setiu Wetlands lagoon

	2.0 mm	*1.0 mm*	*0.71 mm*	*0.50 mm*	*0.25 mm*	*0.125 mm*	*0.0032 mm*	*A. cornea*
2.0 mm	1	-0.611	-0.684	-0.896	-1	-1	0.063	-0.308
1.0 mm		1	-0.973	-0.973	-0.811	-0.811	0.000	-0.319
0.71 mm			1	0.895	0.684	0.684	0.158	0.410
0.5 mm				1	0.895	0.895	-0.158	0.205
0.25 mm					1	0.895	-0.053	0.306
0.125 mm						1	-0.053	0.306
0.0032 mm							1	0.821
A. cornea								1

Discussion

The abundance of A. cornea in the Setiu Wetlands. In this study, 580 individuals of *A. cornea* were collected at Setiu Wetlands lagoon. Table 1 shows that plot 3 had the highest *A. cornea* abundance (208 individuals), and plot 2 had the lowest (24 individuals). Ibrahim et al (2018) reported that the lowest *A. cornea* abundance at the Setiu Wetlands lagoon was in December 2015 (249 individuals). The highest abundance was in March 2016 (391 individuals). They were retrieved from the wild to be traded by the coastal communities for more than 20 years. The population density and size of *A. cornea* have been decreased over time (personal communications with the locals), suggesting that these species are exploited from the lagoon without control (Ibrahim et al 2018). Clam harvesting by humans can affect the sustainability of the natural stock of the species (Tan et al 2016).

The relation between abundance of A. cornea and sediment grain size. There was a lack of information on the relation between abundance and sediment grain size in Malaysia. Table 2 shows that the abundance of *A. cornea* has a strong positive correlation with the smallest sediment grain size of 0.0032 mm (ultra-fine). Plots 3, 4, and 5 had a higher percentage of ultra-fine sediment than plots 1 and 2. Although plot 2 had the highest sandstone, the species did not prefer it. The results in this study show same result in the previous study but from different species which is positive correlation between abundance and sediment grain such as very coarse (1 mm), medium (0.25 mm), and ultra-fine of *Geloina expansa* in the Setiu Wetlands (Bahari et al 2021) and in the Kerteh River (Bahari et al 2023). Jaafar et al (2018) reported that medium coarse and coarse grain were significantly related to the clam *Meretrix meretrix* abundance in the Setiu Wetlands. Jaowatana et al (2024) found that blood cockle (*Anadara granosa*) on Bandon Bay, Thailand's eastern and western coast preferred crumble clay as their habitat. In Indonesia, Prasetiyono et al (2022) reported that blood cockles preferred soft mud. Srisunont & Srisunont (2022) found this cockle in clay.

The abundance of *A. cornea* also shows a positively weak correlation with medium fine, medium, and coarse sediment. Medium fine grain plays an important role in settling the drifting clam larvae. A positive correlation between sediment structure and bivalve distribution is important to long-term restoration of coastal ecosystems (Donadi et al 2014). According to Jayawickrema & Wijeyaratne (2009), the sediment grain size is highly correlated to clam density, such as *Meretrix casta*, in the Dutch canal in Sri Lanka. Kassim et al (2018) found that the sediment grain size is significantly correlated with the density of bivalves in the Tok Bali mangrove ecosystem, where the sediment was fine sand.

According to Yaacob & Mustapa (2010), sediment grain-size distribution near the Setiu lagoon-estuary system consists mostly of coarse to very fine particles. Fine sediment particles are often deposited and accumulated because of a lack of wave or current action that forms a 'muddy' sediment (Winterwerp & Van Kesteren 2004). Strong water waves change the sediment structures and affect the abundance of bivalves (Beasley et al 2005).

Syahira et al (2021) stated that the substrate is critical in cultivating blood cockle because it is a food source, habitat, shelter, and reproduction place.

Conclusions. A total of 580 individuals of *A. cornea* were sampled at the Setiu Wetlands lagoon. The abundance of *A. cornea* is positively correlated with 0.0032, 0.125, 0.25, 0.50, and 0.71 mm grain size. The smallest sediment grain size of 0.0032 mm strongly correlates with the abundance of *A. cornea*. Its abundance increases in small sediment grain size. Future studies are needed and should consider several time scales, species ecology, ranges of habitat, and other environmental conditions.

Acknowledgements. We thank the Faculty of Science and Marine Environment, University Malaysia Terengganu, for providing the equipment and facilities to complete this project.

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

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Received: 20 December 2024. Accepted: 27 March 2025. Published online: 03 July 2025.
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How to cite this article:
Su'ib A. F. A., Sahari M. S. I., Razali N. A. M., Nor S. M. M., Abdullah S., Jaafar N. S. N., Wan Omar W. B., 2025 The abundance of blood cockle (*Anadara cornea*) and its sediment grain size preferences at Setiu Wetlands lagoon, east coast of Peninsular Malaysia. AACL Bioflux 18(4):1643-1649.