Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(4): 1469 – 1478 (2024)
www.ejabf.journals.ekb.eg

Filtration Rates and Pseudofaeces Production of the Mud Clam, *Geloina expansa* (Mousson 1849) (Bivalvia: Cyrenoididae) at Increasing Salinity Concentrations

Francis Albert T. Argente[1, 2*], Paul John L. Geraldino[1], Julie B. Otadoy[1]
[1]Biology Department, University of San Carlos – Talamban Campus, Cebu City, Philippines
[2]Fisheries Science Department, Pangasinan State University – Binmaley Campus, Binmaley, Pangasinan, Philippines

[*]**Corresponding Author:** francisargente@psu.edu.ph

ARTICLE INFO
Article History:
Received: April 9th, 2024
Accepted: July 23rd, 2024
Online: Aug. 16, 2024

Keywords:
Ecophysiology,
Mollusks,
Filter-feeders,
Silt particles,
Bohol

ABSTRACT

Knowledge on the optimum environmental conditions for a potential aquaculture species is necessary to simulate such situation in an artificial setting. *Geloina expansa* is an economically- and ecologically-important bivalve which thrives in brackishwater mangroves or *Nypa* zones. Fluctuating salinity conditions may possibly affect the filtering capacity of *G. expansa*. Laboratory experiment was conducted to determine the effect of salinity concentrations and body size on the filtration rate and pseudofaeces production of *G. expansa*. The results indicated that filtration rates of the clams significantly increased ($P < 0.05$) at low salinities (7-15ppt). Moreover, salinity levels did not affect pseudofaeces production. Additionally, filtration and pseudofaeces production were not affected by body size. These findings are vital for the development of aquaculture techniques for *G. expansa* in the Philippines.

INTRODUCTION

Promoting development is accompanied by a rising demand for food that could be obtained from aquatic ecosystems. Bivalves, amidst a variety of aquatic species, are presently subject to an extensive aquaculture in order to satisfy the prevailing demand. However, certain fisheries continue to heavily depend on natural stock despite the considerable potential for mariculture **(Beukema & Dekker, 2018; del Norte-Campos *et al.*, 2023)**. It is imperative to understand the physiological and ecological characteristics of a species in order to assess the viability of its mariculture.

The aquaculture industry is a significant sector of the Philippines' fisheries, supplying many Filipinos with inexpensive yet nutritious food. The industry generated a cumulative output of 2,349.25 thousand metric tons of diverse commodities in 2022 **(PSA, 2023)**. Nevertheless, climate change may have placed the Philippine aquaculture industry in an unstable state **(Santos *et al.*, 2011; Macusi *et al.*, 2015)**. A number of highly valued cultivable species that are native to Southeast Asia have exhibited indications of susceptibility to the changes in environmental conditions **(Piamsomboon *et al.*, 2016; Guerrero, 2019)**. Exploration for novel and more adaptable species is one of the suggested strategies to alleviate the adverse consequences of climate change within the aquaculture sector **(D'Abramo & Slater, 2019)**. In order to prelude the development of aquaculture techniques, it is necessary to compile biological information on a potential aquaculture species. Biological information that determines the ideal environmental conditions for optimal physiological responses is crucial for the development of a sound cultivation technology. In order to simulate the optimal environmental conditions for a potential aquaculture species in an artificial setting, it is necessary to have knowledge of those conditions.

The mud clam species *Geloina expansa* (Fig. 1), which is synonymous to *Polymesoda erosa* and *P. expansa* **(WoRMS Editorial Board, 2022)**, is commonly found in the *Nypa* zones of the Loay-Loboc River in Bohol, central Philippines. It is a suspension filter-feeder that thrives in shallow estuarine waters with muddy substrates. From an economic standpoint, *G. expansa* provides support for an artisanal fishery in various regions of the Philippines including the Loay-Loboc River **(Argente, 2013; Argente & Ilano, 2021)**. Furthermore, it is noteworthy that, this bivalve serves as a bioremediation agent in its natural habitat, collecting a wide range of persistent organic pollutants and heavy metals **(Dsikowitzky *et al.*, 2011; Elvira *et al.*, 2016; Ali & Yep, 2016)**. It has also been documented to possess resilience to adverse environmental conditions **(Morton, 1976; Argente *et al.*, 2014)**. Due to these characteristics, this species of bivalve is a viable candidate for aquaculture. Hence, knowledge gaps regarding the biology of this bivalve must be addressed.

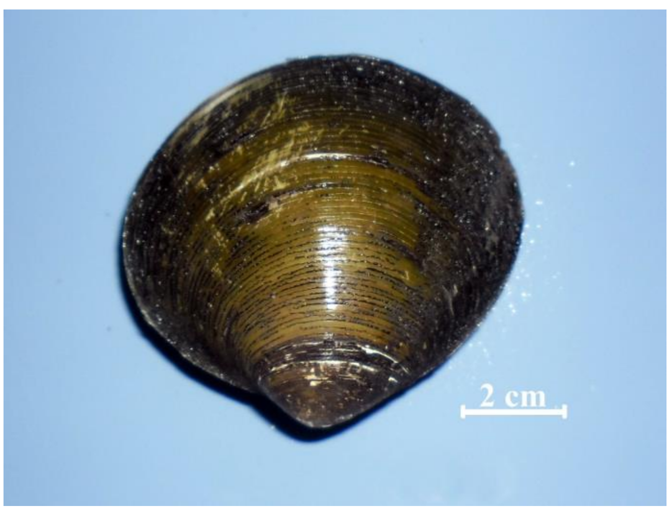

Fig. 1. *Geloina expansa*

G. expansa is classified as a suspensivore, a type of filter-feeder described as such by **Argente *et al.* (2014)**. Its gills utilize a bio-filter mechanism to extract particulates from a moving water current **(Mardones *et al.*, 2024)**. This mode of obtaining nutrients makes a substantial contribution to the process of bentho-pelagic coupling **(Jones *et al.*, 2011; Argente *et al.*, 2014)**. Filter-feeding facilitates the elimination of suspended particles from the water column, leading to the formation of biodeposits **(Clavier & Chauvaud, 2010)**. These biodeposits consist of mucus-coated particles that undergo processing within the mantle cavity before being expelled via the inhalant siphon or along the ventral mantle margin **(Broekhoven *et al.*, 2015)**.

G. expansa natural populations may be subject to fluctuating salinity conditions in their habitats as a result of erratic weather disturbances. The extent to which *G. expansa* can tolerate the salinity concentrations typically found in natural mangrove/*Nypa* environments is currently unknown. Biological parameters, including filtration rates and pseudofeces production, were employed in this laboratory investigation to characterize the feeding physiology under different salinity conditions. The information provided by these ecophysiological parameters can be of significant aid in the development of aquaculture techniques for *G. expansa* in the Philippines.

MATERIALS AND METHODS

Clam collection and collection site

The clams were collected from a *Nypa* zone of a disturbed estuarine river in Loay, Bohol, Philippines (9.61235°N, 124.02235°E). At the collection site, water samples were collected in order to measure the prevailing salinity (7ppt) and total suspended particulates level (40mg L^{-1}). In addition, samples of substrate (30% total organic matter) were gathered to separate the silt which served as particles suspended in the experiments.

The clams were transported to the laboratory within twenty-four hours upon their collection and acclimated for twelve hours prior to the experiment in containers filled with varying salinity of filtered water used in this study. During the period of acclimation, the clams were not fed to guarantee filtration activity. The experiment utilized clams of two sizes: smaller-sized (47.4± 4.3mm; mean ± SD shell length) and larger-sized (58.0± 2.4mm) individuals of *G. expansa*.

Experimental procedure

Water media were prepared by mixing filtered fresh and seawater. Four increasing salinity concentrations (7, 15, 25 and 35 pt) were used as treatments. The prevailing salinity condition in the collection site was 7ppt, hence served as the control treatment. The turbidity concentration used was 350mg L^{-1}, which was less than half of the threshold for *G. expansa* **(Argente *et al.*, 2014)**.

Randomized complete block design (RCBD) was utilized in the experiment, and the experimental replicates served as the blocking variable. An experimental unit was comprised of a solitary clam affixed to a bamboo stick using aquatic epoxy and positioned in a plastic container containing 1L of filtered water of the desired salinity concentration as well as silt particles. Throughout the investigation, the container was aerated from the bottom in order to maintain the suspension of silt particles. Placing a plastic portion above the air source prevented clam distress, which could have an adverse effect on filtration activity. For each size class, six replicates were performed for each experimental salinity concentration.

Every clam was assigned at random to an experimental set, and a waiting interval of around five minutes was observed before the start of the incubation period, which lasted for 120 minutes (2 hours). Following the completion of the experiment, the clams were taken out from the experimental units. Pseudofaeces attached to the bamboo sticks, clam shells, and container walls were gathered and placed in pre-labeled petri dishes. They were then dried in an oven at a constant temperature of 75°C until they reached a consistent dry weight. The water in the experimental units was filtered using pre-weighed (with a constant dry weight) Whatmann™ GFC 47mm filters. The filters containing residues were allowed to dry in the air for 24 hours, and then dried in an oven at a temperature of 75°C until they reached a constant dry weight.

The filtration rate (FR; mg min^{-1} $ind.^{-1}$) and pseudofaeces production (PP; mg min^{-1} $ind.^{-1}$) of the *G. expansa* were determined based on the following equations **(Argente *et al.*, 2018)**:

$$FR = [TSS_i - (Filter_r – Filter_i)] / \text{Time elapsed}$$

$$PP = \text{Wt of Pseudofaeces} / \text{Time elapsed}$$

Where, TSS_i is the initial quantity (mg) of total silt in the experimental unit; $Filter_i$ is the initial weight (mg) of the filter; $Filter_r$ is the weight (mg) of filter with residue, and Time elapse is 120 minutes.

Statistical treatment

Results of the experiment were statistically treated using the 2-way ANOVA to determine the effect of salinity concentrations and body size on the filtration rate and pseudofaeces production of *G. expansa*. Tukey HSD test was used as post hoc test. The significance level was set at $P \leq 0.05$.

RESULTS

The results of the laboratory experiment showed that salinity concentration (SC) influenced the filtering activity of *G. expansa*. It appeared that FR (Fig. 2) significantly increased (*P*< 0.05) at lower salinities (7- 15ppt). However, results also revealed that shell size was not a factor that affects the FR (*P*> 0.05). On the other hand, SC and body size showed no significant influence to PP (Fig. 3).

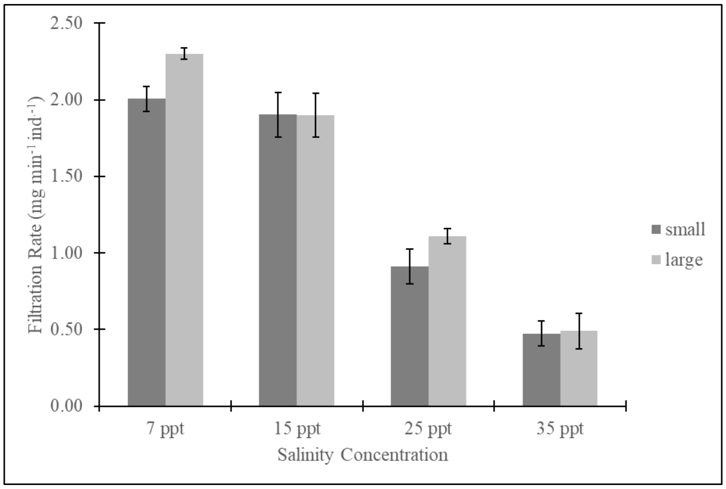

Fig. 2. Filtration rate of small- and large-sized *G. expansa* at increasing salinity concentrations. Bars indicate SD of the mean

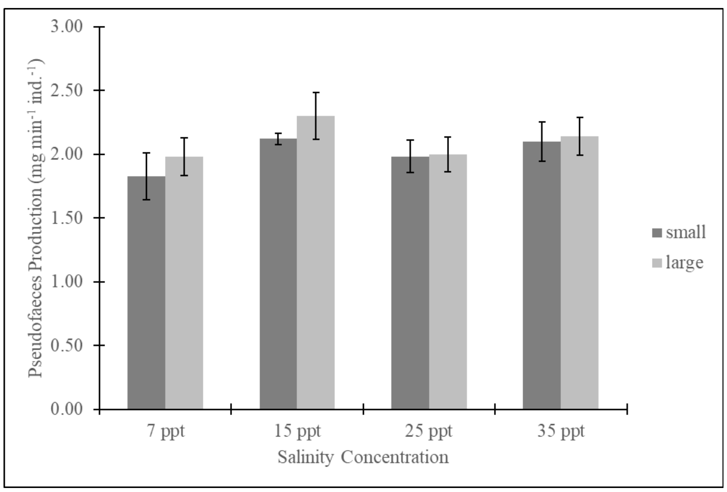

Fig. 3. Pseudofaeces production of small- and large-sized *G. expansa* at increasing salinity concentrations. Bars indicate SD of the mean

DISCUSSION

Salinity is a major environmental factor that may influence the physiology of bivalves **(Pourmozaffar *et al.*, 2019)**. Changes in salinity have altered filtration rates which impacted growth, reproduction and mortality of several bivalve species **(Lavaud *et al.*, 2017; Peteiro *et al.*, 2018)**. Moreover, salinity fluctuations negatively affect the abundance of phytoplankton in aquatic environment **(Yuan *et al.*, 2020)**. This is proven catastrophic particularly to filter-feeding organisms such as clam species **(Norkko *et al.*,**

2005; Yurimoto *et al*., 2014). It is also noteworthy to mention that salinity thresholds of bivalves are associated with their filtration activity **(McFarland *et al.*, 2013; Argente *et al*., 2018)**. A balance between food supply and habitat alterations will lead to increased growth and survivability of bivalves **(Carmichael *et al*., 2012)**.

Result of the current study showed maximized FR at lower salinities. This indicates that the feeding of *G. expansa* was optimum at these salinity levels and may result to faster weight gain. With the right quantity and quality of food, bivalves maximized growth at their ideal environmental conditions **(Marsden, 2004; Jimenez *et al.*, 2009; Li *et al*., 2022)**. Similar results were reported in other estuarine bivalves such as *Crassostrea madrasensis* and *C. virginica* **(Rajesh *et al.*, 2001; McFarland *et al.*, 2013)**.

Bivalves produced pseudofaeces to maximize energy gain rather than utilizing more for metabolic processes **(Kooijman, 2006; Argente *et al*., 2018)**. In this experiment, salinity did not influence the PP of *G. expansa*. This result lends credence to the notion that clams perform optimal filtration, particularly at reduced salinities, enhancing their efficiency in maintaining water quality under these conditions. Despite variations in filtration rates at differing salinity levels, the production of pseudofaeces, which could potentially indicate stress, remained unaffected. A correlation has been observed between the rate of filtration and the production of pseudofaeces in bivalves **(Morillo-Manalo & del Norte-Campos, 2010; Argente *et al.*, 2018)**. An excess of pseudofaeces production may indicate stressful environment in bivalves **(Woodin *et al.*, 2020)**.

BS of *G. expansa* did not influence FR and PP at any salinity level. The clams were actively filtering throughout the experiment, regardless of its size. This outcome implies the resilience of this bivalve, which can endure changes in salinity, regardless of its level of age. Similar observations were reported on the effect of BS in the feeding responses of *Gafrarium pectinatum* and *Mytilus edulis* **(Riisgard *et al*., 2013; Argente *et al*., 2018)**. BS of *G. pectinatum* has no effect on FR and PP, however a strong linear relationship was observed between FR and PP **(Argente *et al*., 2018)**. Comparable FR were claimed for the regular- and dwarfed-sized individuals of the temperate bivalve, *M. edulis* **(Riisgard *et al*., 2013)**.

CONCLUSION

G. expansa is a resilient species with the ability to respond to salinity fluctuating waters. Filtration activity is maximized at lower salinity, hence will lead to faster weight gain. Moreover, size is a non-factor in its physiological responses suggesting high survivability. As a result of its resiliency to fluctuating salinity conditions, *G. expansa* is a potential candidate species for aquaculture.

REFERENCES

Ali, S.A.M. and Yep, Y.M. (2016). Petroleum hydrocarbon in mud clam (*Polymesoda erosa*) and its ambient medium in the coastal area of Putatan and Tuaran, Sabah. Trans. Sci. Technol., 3(1-2): 218-226.

Argente, F.A.T. (2013). Commercially important mangrove bivalves of Visayas, Philippines. Dayew, 1(1): 36-40.

Argente, F.A.T.; Cesar, S.A. and Dy, D.T. (2014). High turbidity affects filtration rate and pseudofaeces production of the mud clam *Polymesoda erosa* (Solander 1786) (Bivalvia: Corbiculidae). Biotropia, 21(2): 71-81.

Argente, F.A.T.; Fontanilla, S.M.R.; Corbillon, M.C.; Malanum M.A.S. and Fillone F.A. (2018). Physiological responses of the pectinate Venus clam, *Gafrarium pectinatum* (Bivalvia: Veneridae) to increasing turbidity concentrations. Int. J. Fish. Aquat. Stud., 6(1): 83-86.

Argente, F.A.T. and Ilano, A. (2021). Population dynamics and aquaculture potential of the mud clam, *Geloina expansa* (Mousson, 1849) (Bivalvia: Cyrenidae) in Loay-Loboc River, Bohol, central Philippines. J. Sustain. Sci. Manag., 16(4): 43-55.

Beukema, J.J. and Dekker, R. (2018). Effects of cockle abundance and cockle fishery on bivalve recruitment. J. Sea Res., 140: 81-86.

Broekhoven, W.V.; Jansen, H.; Verdegem, M.; Struyf, E.; Troost, K.; Lindeboom, H. and Smaal, A. (2015). Nutrient regeneration from feces and pseudofeces of mussel *Mytilus edulis* spat. Mar. Ecol. Prog. Ser., 534: 107-120.

Carmichael, R.H.; Shriver, A.C. and Valiela I. (2012). Bivalve response to estuarine eutrophication: the balance between enhanced food supply and habitat alterations. J. Shellfish Res., 31(1): 1-11.

Clavier, J. and Chauvaud, L. (2010). Biodeposit production by *Bractechlamys vexillum* (Bivalve: Pectinidae) in a tropical lagoon. J. Sea Res., 64: 231-240.

D'Abramo, L.R. and Slater, M.J. (2019). Climate change: response and role of global aquaculture. J. World Aquac. Soc., 50(4): 710-714.

del Norte-Campos, A.G.C.; Burgos-Nuñeza, L. and Lapara, S. (2023). Bivalve gleaning fishery in Batan Estuary, Aklan, Western Visayas, Philippines. Philipp J. Sci., 152(1): 219-229.

Dsikowitzky, L.; Nordhaus, I.; Jennerjahn T.C.; Khrycheva, P.; Sivatharshan, Y.; Yuwono, E. and Schwarzbauer, J. (2011). Anthropogenic organic contaminants in water, sediments and benthic organisms of the mangrove-fringed Segara Anakan Lagoon, Java, Indonesia. Mar. Pollut. Bull., 62: 851-862.

Elvira, M.V.; Garcia, C.M.; Calomot, N.H.; Seronay, R.A. and Jumawan, J.C. (2016). Heavy metal concentration in sediments and muscles of mud clam *Polymesoda erosa* in Butuan Bay, Philippines. J. Biodivers. Environ. Sci., 9(3): 47-56.

Guerrero, R.D. (2019). Farmed Tilapia production in the Philippines is declining: what has happened and what can be done. Philipp J. Sci., 148(2): xi-xv.

Jimenez, C.R.; Jimenez, J.U. and Tumanda, M.I. (2009). Growth and survival of the surf clam, *Katylesia hiantina*, spats as function of density, substrate and salinity. J. Environ. Aquat. Resour., 1(1): 62-71.

Jones, H.F.E.; Pilditch, C.A.; Bryan, K.R. and Hamilton, D.P. (2011). Effects of infaunal bivalve density and flow speed on clearance rates and near-bed hydrodynamics. J. Exp. Mar. Bio. Ecol., 401: 20–28.

Kooijman, S.A.L.M. (2006). Pseudo-faeces production in bivalves. J. Sea Res., 56: 103-106.

Li, Z.; Kim, Y.H.; Aldridge, D.C. and Kim, B.H. (2022). Physiological response of the freshwater mussel *Unio douglasiae* in *Microcystis aeruginosa* bloom waters. Biomed Res. Int. https://doi.org/10.1155/2022/2928235.

Lavaud, R.; La Peyre, M.K.; Casas, S.M.; Bacher, C. and La Peyre, J.F. (2017). Integrating the effects of salinity on the physiology of the eastern oyster, *Crassostrea virginica*, in the northern Gulf of Mexico through a dynamic energy budget model. Ecol. Modell., 363: 221-233.

Macusi, E.D.; Abreo, N.A.S.; Cuenca, G.C.; Ranara, C.T.B.; Cardona, L.T.; Andam, M.B.; Guanzon, G.C.; Katikiro, R.E. and Deepananda K.H.M.A. (2015). The potential impacts of climate change on freshwater fish, fish culture and fishing communities. J. Nat. Stud., 14(2): 14-31.

Mardones, M.L.; Mardones-Toledo, D.A.; Büchner-Miranda, J.A.; Salas-Yanquin, L.P.; Gray, M.W.; Cubillos, V.M.; Montory, J.A. and Chaparro, O.R. (2024). Food acquisition by the intertidal filter feeder bivalve *Perumytilus purpuratus*: Can the gill explain a differential performance between smaller individuals and the larger ones? J. Exp. Mar. Bio. Ecol., 571: 151982. https://doi.org/10.1016/j.jembe.2023.151982

Marsden, I.D. (2004). Effects of reduced salinity and seston availability on the growth of the New Zealand little-neck clam *Austrovenus stutchburyi*. Mar. Ecol. Prog. Ser., 266:-157-171.

McFarland, K.; Donaghy, L. and Volety, A.K. (2013). Effect of acute salinity changes on hemolymph osmolality and clearance rate of non-native mussel, *Perna viridis*, and the native oyster, *Crassostrea virginica*, in southwest Florida. Aquat. Invasions, 8(3): 299-310.

Morillo-Manalo, L. and del Norte-Campos, A. (2010). Filtration and respiration rates of the short-necked clam *Paphia undulata* (Born, 1778) (Mollusca, Pelecypoda: Veneridae) under laboratory conditions. Sci. Diliman, 22(2): 21-29.

Morton, B. (1976). The biology and functional morphology of the Southeast Asian mangrove bivalve, *Polymesoda* (*Geloina*) *erosa* (Solander, 1786) (Bivalvia: Corbiculidae). Can. J. Zool., 54: 482-500.

Norkko, J.; Pilditch, C.A.; Thrush, S.F. and Wells R.M.G. (2005). Effect of food availability and hypoxia on bivalves: the value of using multiple parameters to measure bivalve condition in environmental studies. Mar. Ecol. Prog. Ser., 298: 205-218.

Peteiro, L.G.; Woodin, S.A.; Wethey, D.S.; Costas-Costas, D.; Martinez-Casal, A.; Olabarria, C. and Vazquez, E. (2018). Responses to salinity stress in bivalves: evidence of ontogenetic changes in energetic physiology on *Cerastoderma edule*. Sci. Rep., 8(8329). https://doi.org/10.1038/s41598-018-26706-9

Philippine Statistic Authority (PSA). (2023). Fisheries situation report, January to December 2022. Reference No. 2023-SSO-006.

Piamsomboon, P.; Inchaisri, C. and Wongtavatchai, J. (2016). Climate factors influence the occurrence of white spot disease in cultured penaeid shrimp in Chanthaburi province, Thailand. Aquac. Environ. Interact., 8: 331-337.

Pourmozaffar, S.; Jahromi, S.T.; Rameshi, H.; Sadeghi, A.; Bagheri, T.; Behzadi, S.; Gozari, M.; Zahedi, M.R. and Lazarjani, S.A. (2019). The role of salinity in physiological responses of bivalves. Rev. Aquacult. https://doi.org/10.1111/raq.12397

Rajesh, K.V.; Mohamed, K.S. and Kripa, V. (2001). Influence of algal cell concentration, salinity and body size on the filtration and ingestion rates of cultivable Indian bivalves. Indian J. Mar. Sci., 30: 87-92.

Riisgard, H.U.; Luskow, F.; Pleissner, D.; Lundgreen, K. and Lopez, M.A.P. (2013). Effect of salinity on filtration rates of mussels *Mytilus edulis* with special emphasis on dwarfed mussels from the low-saline central Baltic Sea. Helgol. Mar. Res., 67: 591-598.

Santos, M.D.; Dickson, J.O. and Velasco, P.E.L. (2011). Mitigating the impacts of climate change: Philippine fisheries in focus. Fish People, 9(2): 101-110.

Woodin S.A.; Wethey, D.S.; Olabarria, C.; Vázquez, E.; Dominguez, R.; Macho, G. and Peteiro, L. (2020). Behavioral responses of three venerid bivalves to fluctuating salinity stress. J. Exp. Mar. Bio. Ecol., 522: 151256. https://doi.org/10.1016/j.jembe.2019.151256

WoRMS Editorial Board. (2022). World Register of Marine Species. Checklist dataset https://doi.org/10.14284/170.

Yuan, M.; Jiang, C.; Weng, X. and Zhang M. (2020). Influence of salinity gradient changes on phytoplankton growth caused by sluice construction in Yongjiang River Estuary area. Water, 12(2490). https://doi.org/10.3390/w12092492

Yurimoto, T.; Kassim, F.M.; Fuseya, R. and Man, A. (2014). Mass mortality event of the blood cockle, *Anadara granosa*, in aquaculture ground along Selangor coast, Peninsular Malaysia. Int. Aquat. Res., 6: 177-186.