Tropical Life Sciences Research 27(Supp. 1), 45–51, 2016

The Effects of Salinity on the Filtration Rates of Juvenile Tropical Oyster *Crassostrea iredalei*

Geraldine Olive Ju Lien Chang*, Lai Ven Inn, Aileen Tan Shau Hwai and Zulfigar Yasin

Marine Science Lab, School of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia

Published date: 1 November 2016
To cite this article: Geraldine Olive Ju Lien Chang, Lai Ven Inn, Aileen Tan Shau Hwai and Zulfigar Yasin. (2016). The effects of salinity on the filtration rates of juvenile tropical oyster *Crassostrea iredalei*. *Tropical Life Sciences Research* 27(Supp. 1): 45–51. doi: 10.21315/tlsr2016.27.3.7
To link to this article: http://dx.doi.org/10.21315/tlsr2016.27.3.7

Abstract: A small scale laboratory study was conducted to determine the effects of salinity ranging from 15, 20, 25, 30, 35, 40, and 45 ppt on the filtration rates of juvenile oyster *Crassostrea iredalei* with 25 ppt as the control. Three juvenile oysters (shell weight: 1.04 ± 0.12 g; shell length: 1.9 ± 0.2 cm; shell height: 1.9 ± 0.1 cm) were used to test the filtration rates in each salinity over the course of 8 hours. The hourly filtration rates were determined from the exponential decrease in algal (*Chaetoceros calcitrans)* concentration as a function of time. The oyster in 35 ppt salinity produced the highest overall filtration rate (FR_2) with 134.06 ± 15.66 mL^{-1} hr^{-1} $oyster^{-1}$ and the lowest overall filtration rate (FR_2) occurred in oyster exposed to 15 ppt and 45 ppt with 31.30 ± 6.90 mL^{-1} hr^{-1} $oyster^{-1}$ and 32.11 ± 7.68 mL^{-1} hr^{-1} $oyster^{-1}$ respectively throughout the 8 hours. The result from this study can be useful for optimum oyster culturing and the oysters can be employed as a natural biofilter in marine polyculture farming.

Keywords: Oyster Filtration Rate, *Crassostrea iredalei*, Salinity

INTRODUCTION

Oysters belong to Class Bivalvia under Phylum Mollusca. The commercial oyster species which are normally found in Malaysian waters are *Crassostrea iredalei* and *Crassostrea belcheri* (Nawawi 1993). *Crassostrea* spp. oysters are known to thrive in estuarine conditions and usually produce abundant spatfall (Angell 1986).

In Wilson and Seed's (1974) laboratory experiments, it was found that particulate matter present in water stimulates and maintains the pumping rate in mussels. In the same experiment, it was shown that mussel pumping rate stopped at 15 and 50 ppt. In terms of food selection, Shumway *et al*. (1985) found that bivalves have preferences of algae cell selection. Food rejection also

*Corresponding email: goppietu@gmail.com

exists once the animals' digestive capacity reaches a certain threshold concentration whereby the surplus filtered particulate is rejected as pseudofeces (Bayne & Newell 1983).

This study focuses on determining salinity ranges affecting oyster filtration rates for culturing *C. iredalei* in Malaysian estuaries which are subjected to mixed and semi-diurnal tides and monsoons with variable precipitation rate. This study is of importance to produce higher quality oysters to market in the multimillion Ringgit export industry and also its possible application as a biofilter in polyculture farming with animals who thrive in similar salinities to minimise the need of constructing new culture pens and possibly doubling the income of culturists.

MATERIALS AND METHODS

Acclimatisation of Sample

Single celled diatom, *C. calcitrans* with an average cell size of 5 µm were cultured in 1000 L tank and were used for this experiment. Juvenile oysters of species *C. iredalei* with the shell weight of 1.04 ± 0.12 g, shell length of 1.9 ± 0.2 cm and shell height of 1.9 ± 0.1 cm were acclimatised in 20 L plastic aquariums containing filtered seawater of salinity between 25 and 26 ppt for 4 days. Aeration was provided throughout the acclimatisation period and the oysters were fed twice daily with cultured algae.

Experiment Preparation

Filtered seawater with salinity between 30 to 32 ppt were either diluted with distilled water to achieve lower salinity (15, 20, 25 ppt) or added with sodium chloride (NaCl) to achieve higher salinity (35, 40, 45 ppt) and measured with a refractometer (Vee Gee STX-3) The temperature was monitored to be in the range of 26°C–28°C. The pH level was monitored to be at a range of pH 7.8 to pH 8.3 throughout the experiment with a portable pH meter (Hanna HI 8424).

Twenty one aquaria measuring 10 × 20 × 15 cm each were set up with aeration for the experiment with each aquarium containing 2 L seawater of a different salinity (15, 20, 25, 30, 35, 40, 45 ppt with 25 ppt being the control) added with an average of 58.57 ± 2.96 × 10^4 cells mL^{-1} of *C. calcitrans*. There were three replicates for each salinity. A total of 63 juvenile oysters were picked from the acclimatisation aquarium and introduced into each aquarium containing three oysters. Seawater sample from each aquarium was sampled hourly over the period of 8 hours and the algal concentration was counted with a haemocytometer under a light microscope with ×100 magnification.

Determination of Filtration Rate

The filtration rate (FR) was obtained via the indirect method of measuring the decrease in algae concentrations in the oyster aquarium using the formula (Coughlan 1969) below:

$$FR = (V/nt) \ln (C_0/C_t)$$

where,

V = volume of water per aquarium (mL)
n = number of animals per aquarium
t = time (hour)
ln = log base *e*
C_0 and C_t = algal concentrations (cells) at time 0 and at time t (hour), respectively.

This formula was used to calculate the hourly filtration rates (FR_1) and overall filtration rate (FR_2) in each salinity.

Statistical Analysis

The filtration rates by different salinities were analysed with SPSS version 22. Independent sample analysis consisting of the Kruskal-Wallis test and the Dunn-Bonferroni post hoc test was applied to the data as it was found not to be normally distributed in nature.

RESULTS AND DISCUSSION

Throughout the experiment, no mortality was reported on the experimented individuals of *C. iredalei*. This could be contributed by the fact that *Crassostrea* oyster were able to tolerate in a salinity range of 0–42 ppt (Shumway 1996). Current study only reported survival of oyster juvenile after 8 hours and the effects of prolonged high and low salinity exposure could not be concluded.

Figure 1 shows the hourly filtration rates trend of the *C. iredalei* juvenile at different salinity. Dips and peaks in different hours were observed, suggesting that at the dips, juvenile oyster slowed down its filtration and increased its filtration during the peaks.

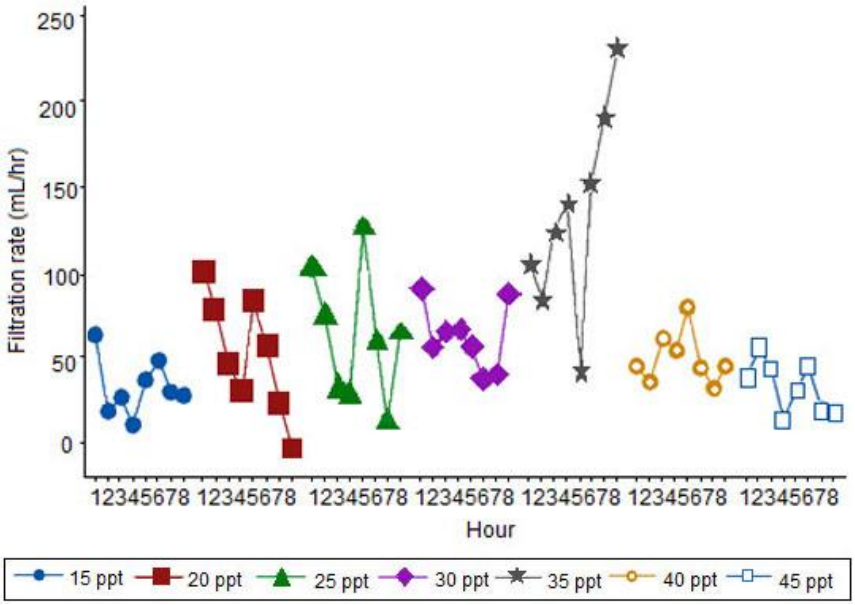

Figure 1: The hourly filtration rate (FR_1) of *C. iredalei* juvenile cultured in different salinities.

The lowest filtration rates were reported in 15 and 45 ppt (Fig. 1) as these were extreme salinity values. This could be contributed by a mechanism to tolerate salinity where bivalves close their valves to isolate themselves from the external environment and osmolarity differences, lessening filtration. As a result, normal physiological processes are inhibited (McFarland *et al.* 2013). Being able to withstand the large salinity difference, Carregosa *et al*. (2014) inferred that there is an osmoregulation correlation with the increased *Venerupis philippinarum* clam's inner sodium availability with external salinity of 7, 14, and 42 ppt. Coughlan *et al*. (2009) suggests that survival of marine organisms at low salinities could be contributed by higher energy consumption of the organism to regulate and maintain intracellular osmolarity.

The highest average filtration rate in this study was reported in 35 ppt water whereby the *C. iredalei* juveniles cleared the most algae from the water column (Fig. 2). In a related study, Enríquez-Ocaña *et al.* (2012) reported the highest filtration rate in mangrove oyster, *Crassostrea corteziensis*, to be under the conditions of 35 ppt and 32°C. O' Connor *et al*. (2008) concluded in his study on the survival and growth of *Saccostrea glomerata*, that the optimal growth salinity for juveniles was found to be at 35 ppt in 30°C, which could also be said about the juveniles in this study that in the short exposure to 35 ppt. *C. iredalei* juvenile could optimally grow until a certain period of time where survivability becomes more important than growth, where the same study by O' Connor *et al*. (2008) reported the optimal survival salinity was found to be at 30 ppt in 23°C.

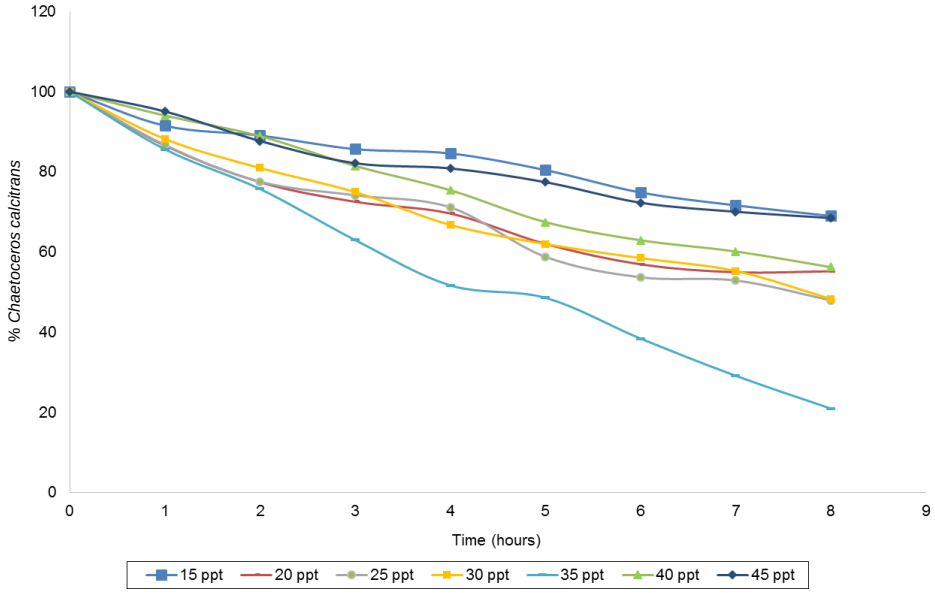

Figure 2: *C. calcitrans* hourly clearance trend.

The Kruskal-Wallis test showed that the filtration rates in control salinity 25 ppt and 30 ppt were statistically similar, suggesting that juvenile oyster culture within the range of 25 to 30 ppt would yield almost similar results.

If short periods of low salinity exposure during rainfall happens, the oysters could still survive, as it would continue to feed but at a slower rate (Sutton *et al*. 2012). However if rainfall persists for a longer period of time, death of oyster due to starvation or hypoxia from prolonged valve closure could happen. Besides that, glycogen storage in the oyster would be depleted during times of low salinity exposure, suggesting that the oyster would be less firm, less springy, less creamy, and less appealing to consumers (Tan *et al*. 2016).

With its ability to filter in a wide range of salinity, oyster could be deployed into aquaculture farms such as fish or shrimp farms to maximise the space usage of the culture infrastructure. Its filtration mechanism could naturally lessen luminous bacteria linked with shrimp culture (Tendencia 2007) and lessen pollution index in shrimp ponds (Su *et al*. 2011) reducing the need of manual human filtration, added chemicals, and ultimately lowering production costs. However, constant aeration is still needed to circulate the water body so as to avoid oxygen deficient layers which might affect both the main culture organism and the oysters. Also, the stocking density should be taken note of so as to not subject both the main culture organism and oyster for space competition.

CONCLUSION

C. iredalei juvenile are able to continue filtering in at least 8 hours of exposure in the salinity range of 15–45 ppt where the highest filtration rate occurred in 35 ppt. This study has shown that the juveniles did not stop filtering even in lower or higher than normal salinity, but the filtration rate just slowed down. Further studies on the tipping point of growth versus survivability could be called upon to understand the life priority of different stages of oyster.

ACKNOWLEDGEMENT

This research was funded by Sciencefund, Ministry of Science, Technology and Innovation, Malaysia, grant number 04-01-05-SF0532.

REFERENCES

Angell C L. (1986). *The biology and culture of tropical oysters.* Manila: International Center for Living Aquatic Resources Management.

Bayne B L and Newell R C. (1983). Physiological energetics of marine molluscs. In A S M Saleuddin and K W Wilbur (eds.). *The mollusca*, vol. 4, *Physiology*, part 1. New York: Academic Press. http://dx.doi.org/10.1016/b978-0-12-751404-8.50017-7

Carregosa V, Figueira E, Gil A M, Pereira S, Pinto J, Soares A M V M and Freitas R. (2014). Tolerance of *Venerupis philippinarum* to salinity: Osmotic and metabolic aspects. *Comparative Biochemistry and Physiology Part A* 171: 36–43. http://dx.doi.org/10.1016/j.cbpa.2014.02.009

Coughlan J. (1969). The estimation of filtering rate from the clearance of suspensions. *Marine Biology* 2(4): 356–358. http://dx.doi.org/10.1007/BF00355716

Coughlan B M, Moroney G M, van Pelt F N A M, O'Brien N M, Davenport J and O'Halloran J. (2009). The effects of salinity on the Manila clam (*Ruditapes philippinarum*) using the neutral red retention assay with adapted physiological saline solutions. *Marine Pollution Bulletin* 58(11): 1680–1684. http://dx.doi.org/10.1016/j.marpolbul.2009.06.020

Enríquez-Ocaña L F, Nieves-Soto M, Piña-Valdez P, Martinez-Cordova L R and Medina-Jasso M A. (2012). Evaluation of the combined effect of temperature and salinity on the filtration, clearance rate and assimilation efficiency of the mangrove oyster *Crassostrea corteziensis* (Hertlein 1951). *Archive of Biological Science Belgrade* 64(2): 479–488. http://dx.doi.org/10.2298/ABS1202479O

McFarland K, Donaghy L and Volety A K. (2013). Effect of acute salinity changes on hemolymph osmolality and clearance rate of the non-native mussel, *Perna viridis*, and the native oyster, *Crassostrea virginica*, in Southwest Florida. *Aquatic Invasions* 8(3): 299–310. http://dx.doi.org/10.3391/ai.2013.8.3.06

Nawawi M Y B H. (1993). *A guide to oyster culture in Malaysia*. Pulau Pinang, Malaysia: Fisheries Research Institute.

O'Connor W A, Dove M and Finn B. (2008). Sydney rock oysters: Overcoming constraints to commercial scale hatchery and nursery production. *Fisheries Final Report Series*, 104. New South Wales: NSW Department of Primary Industries.

Shumway S E. (1996). Natural environmental factors. In V S Kennedy, R I E Newell and A F Eble (eds.) *The Eastern Oyster* Crassostrea virginica. Maryland: Maryland Sea Grant College, University of Maryland, 467–513. http://dx.doi.org/10.1016/0022-0981(85)90222-9

Shumway S E, Cucci T L, Newell R C and Yentsch C M. (1985). Particle selection, ingestion, and absorption in filter-feeding bivalves. *Journal of Experimental Marine Biology and Ecology* 91: 77–92.

Su Y, Ma S and Lei J. (2011). Assessment of pollutant reducing effect by poly-culture and bioremediation in sediment of marine shrimp ponds. *Procedia Environmental Sciences* 10(part B): 1559–1567.

Sutton A E, Yankson K and Wubah D A. (2012). The effect of salinity on particle filtration rates of the West African Mangrove oyster. *Journal of Young Investigators* 24(4): 55–59.

Tan S H A, Teh C P, Chang G O and Zulfigar Y. (2016). Tetraploid induction in tropical oysters, *Crassostrea belcheri* (Sowerby) and *Crassostrea iredalei* (Faustino). *Aquaculture Research* 1–7.

Tendencia E A. (2007). Polyculture of green mussels, brown mussels and oysters with shrimp control luminous bacterial disease in a simulated culture system. *Aquaculture* 272 (1–4): 188–191. http://dx.doi.org/10.1016/j.aquaculture.2007.07.212

Wilson J H and Seed R. (1974). *Laboratory experiments in pumping and filtration in Mytilus edulis L. using suspension of colloidal graphite. Irish Fisheries Investigation Series B*. Dublin: The Stationery Office.