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Assessment of Temperature Effects on Early Larval Development Survival of Hatchery-reared Tropical Oyster, *Crassostrea iredalei*

[1]Teh Chiew Peng[*], [2,3]Thiyagarajan Vengatesen and [1]Aileen Tan Shau Hwai

[1]Marine Science Lab, School of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia
[2]School of Biological Sciences, Kadoorie Biological Sciences Building, The University of Hong Kong, Pokfulam Road, Hong Kong SAR
[3]Swire Institute of Marine Science, The University of Hong Kong, Cape d'Aguilar Road, Shek O, Hong Kong SAR

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Abstract: The influence of the cool and warm temperatures on early life development and survival of tropical oyster, *Crassostrea iredalei* was studied. D-hinged larvae (day 1 larvae) were reared to three different temperatures (20°C, 27°C, and 34°C) for nine days. Oyster larvae reared in temperature 27°C, acted as control (ambient temperature). The highest survival rate occurred when the larvae were reared in 20°C and 27°C. Larvae reared at 34°C exhibited reduced survival but increase in the growth rate. The growth rate in larvae reared in high temperature (34°C) was significantly higher compared to larvae reared in 20°C and 27°C ($p<0.05$). The results from the present study indicated that tropical oyster larvae, *C. iredalei* had faster growth rate at the high temperature (34°C). However, the larval survival was decreasing according to days. There is no significant difference in the larval growth and survival in lower temperature (20°C) and control condition (27°C).

Keywords: Tropical Oyster, Global Warming, Larvae, Early Development

INTRODUCTION

Tropical oyster, *Crassostrea iredalei* has been commercially culture in most of the oyster farms in Southeast Asia countries such as Malaysia, Thailand, Philippines, and Vietnam. As an intertidal and tropical species, the tropical oyster, *C. iredalei* is able to tolerate to varying abiotic conditions. However, the temperature range for survival and growth of this tropical oysters has not been evaluated. There is an increase in demand for hatchery produced oyster spat lately. However, the global warming and increase of seawater temperature rise

[*]Corresponding author: cherrie_tcp@yahoo.com

had increased the energy demand of the bivalves and reduced the production (Petton *et al.* 2013). According to Scavia *et al.* (2002), the continuous increases in ocean temperatures projected to occur this century will impact marine life. Primary productivity, stratification and organism physiology will be affected by the increase of temperature in seawater. Temperature is a vital factor that influences the larval development, survival, and spawning of most of the marine invertebrate (Eversole 2001; Barber & Blake 2006). Higher temperature in the ocean can triggered bivalve larvae to be exposed to other environmental factors such as ocean acidification (Cherkasov *et al.* 2010). Small fluctuation of the seawater temperature will depress the rate of the survival and development of bivalve larvae (Loosanoff 1965; Fritz 2001; Cragg 2006). This study aims to investigate the tolerance level and the effects of lower and higher seawater temperatures on the growth and survival rate of the tropical oyster, *C. iredalei* larvae.

MATERIALS AND METHODS

Experiments were conducted at Swire Institute of Marine Science (SWIMS) located in Hong Kong on the southern part of Cape D' Aguilar. Healthy ripe tropical oyster, *C. iredalei* were used for this experiment. The gametes of the oysters were obtained by "strip spawning". Eggs were washed through a 80 µm nitex mesh to separate the debris, collected on a 30 µm nitex mesh and subsequently pooled. The sperm was washed through 20 µm to remove the debris and was pooled. Sperm was mixed with the mature eggs. The density of the embryos were calculated using a Sedgewick rafter. Feeding was started when the embryos reached the D-hinged stage in Day 1. The larvae were fed with monoculture of microalgae *Isochrysis galbana*.

The effects of temperature on the tropical oyster larval rearing was studied by growing the larvae in different temperatures. i.e. 20°C (maintained by using water cooler), 27°C (control, ambient water temperature), and 34°C (kept constant using immersion water heater system). These temperatures were maintained constant throughout the rearing duration. Each of the experimental unit for temperature consisted of four replicates using 5.5 L bottles with 5 L of 0.22 µm filtered seawater. Day one D-hinged larvae were stocked at an initial density of 20 larvae mL^{-1}. Seawater in each of the bottle was changed every 48 h. From the four replicates for each treatment, 1 mL subsample were collected to estimate the larval survival every water change. Furthermore, shell area of 30 larvae were measured from the subsample by using Image J. The same procedure was conducted out for each treatment. The experiment was terminated when the larval survival was less than 10%. The growth and survival of the larvae were recorded.

Larval performances were analysed by one-way analysis of variance followed by Least Significant Difference test (LSD); where necessary data were arcsine transformed to achieve homogeneity of variance using Statistix 9.0.

RESULTS

Larval Growth and Morphology

Increased in temperature had affected the morphology and growth of the larvae. There was a significant difference between the larval size reared in higher temperature (34°C) and the control (27°C) and lower temperature (20°C). The fitted regression lines and scatter plots between the shell growth (µm) and days. The corresponding fitted equation and the r^2 values for each temperature treatment was shown in Figure 1. The overall larval growth increased with the increase in water temperature. Shell growth were 191.27 ± 53.07, 260.04 ± 70.21, and 404.43 ± 54.52 µm day^{-1} for 20°C, 27°C, and 34°C, respectively. The overall growth rate at 34°C was significantly higher compared to other temperatures, including control (p<0.05).

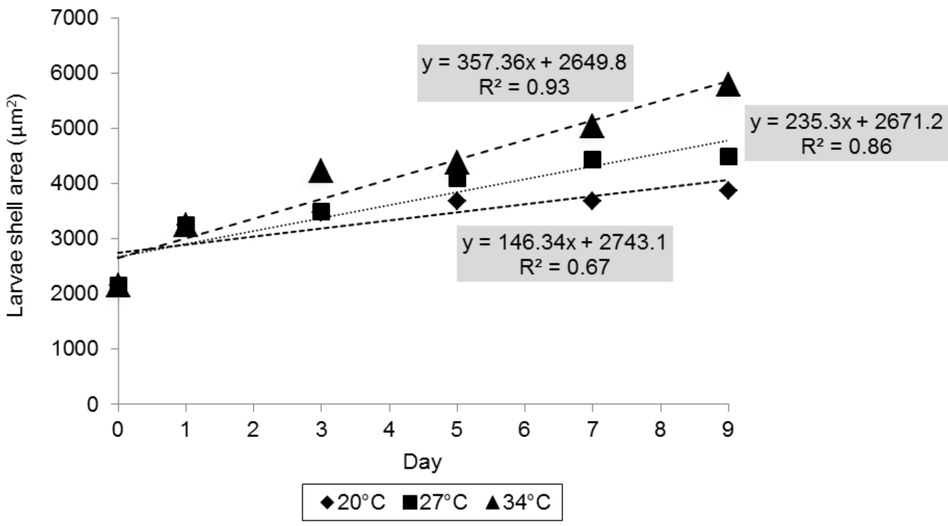

Figure 1: Regression lines of shell area for the effect of temperature on *C. iredalei* larval growth.

Larval Survival

Survival percentage was estimated at Day 1, 3, 5, 7, and 9. The experiment was terminated when the percentage of the larval survival was less than 10% (temperature 34°C: Day 7, <10%; temperature 20°C and 27°C: Day 11, <5%). Survival of tropical oyster larvae, *C. iredalei* cultured in the lower temperature (20°C) and ambient temperature (27°C) was higher than the survival of larval cultured in higher temperature (34°C) (Fig. 2). The survival of oyster larvae cultured in higher temperature decreased significantly from Day 1 to Day 3. The tropical oyster larvae showed no significant difference when cultured in lower temperature (20°C) with ambient seawater temperature (p<0.05).

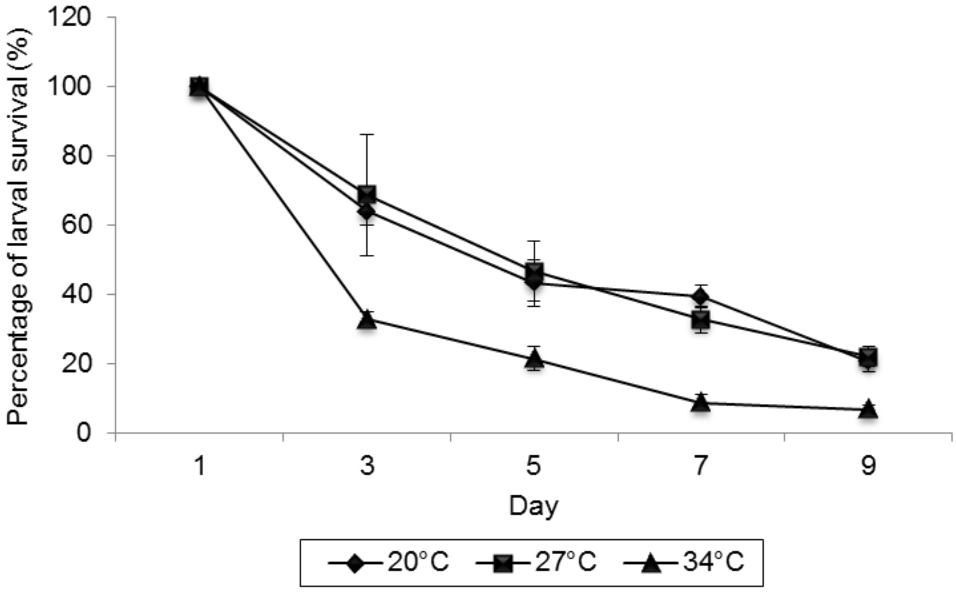

Figure 2: Effect of different temperatures on the percentage of larval survival in *C. iredalei* (mean ± SD; n=4).

DISCUSSION

The outcomes of the experimental larval rearing at three different temperatures demonstrated an immediate relationship between temperature and larval growth. In this study, larval growth rate increased and survival rate decreased when the larvae were cultured in high temperature (34°C). According to Widdows (1973), growth rate of bivalve larvae increases with an increase in temperature. However, Nair and Appukuttan (2003) studied on the effects of temperature on green mussel survival showed that green mussel larval cannot survived under temperature higher than 32°C. According to Nair and Appukuttan (2003), there are no study reported bivalve larvae surviving at the temperature more than 32°C. However, based on the study of Kheder *et al.* (2010), there are no effect of temperature was found on larval survival in oyster, *Crassostrea gigas*. This is different from the results of this study. Based on the study of Loosanoff and Davis (1963), the higher growth rate observed in bivalve larvae cultured in higher temperature mainly reflected on feeding, larvae have better assimilation of enzyme for feed digestion. Tropical oyster larvae are more tolerance in higher temperature compared to other bivalve larvae. According to Petton *et al.* (2013), the low temperature (approximately 13°C) reduced the mortality of the *Crassostrea gigas* larvae. There was no extensive research been conducted on the temperature impact of larval rearing of *C. iredalei*. No work has been carried out specifically on the temperature requirements of *C. iredalei* larvae for growth and survival.

CONCLUSION

The results from the present study indicated that tropical oyster larvae, *C. iredalei* had faster growth rate and higher tolerance level toward high temperature (34°C). However, the larval survival was decreasing according to the exposure time. There is no significant difference in the larval growth and survival in lower temperature (20°C) and control condition (27°C).

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