GROWTH PERFORMANCE OF THE MANGROVE OYSTER (*Crassostrea gasar*) UNDER CONTINUOUS AND PERIODIC SUBMERGENCE IN TIDAL PONDS

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ABSTRACT

Growth of the mangrove oyster (Crassostrea gasar) under continuous and periodic submergence in tidal ponds was investigated using rack and cage method. Two ponds, A and B were used for the study. Oysters in pond A were always submerged; while those in Pond B were submerged during flooding at high tides only (oysters in Pond B were exposed to air at ebb of tides). Five Netlon© cages were stocked with oyster spats and placed on rack stands in ponds A and B respectively. The initial stocking density in each pond was 375 spats, distributed equally among the cages at 75 spats each. Initial mean length and weight at stocking was 19.3 ± 4.38 mm and 1.0 ± 0.51 g, and 20.4 ±5.92 mm and 1.1 ± 0.75 g in Ponds A and B, respectively. No significant differences (P > 0.05) were recorded between the final mean length and weight of oysters of 50.3 ± 6.68 mm and 20.8 ± 6.53 g in pond A and, 52.3 ±7.14 mm and 18.8 ±5.73 g in pond B. The implication of these results is that both continuously submerged and periodically submerged culture systems for oyster production are favourable for good growth of oysters.

Keywords: filter feeders, phytoplankton, condition index, polymer nets

INTRODUCTION

Oysters occur in the tropics and subtropics where they are commonly harvested from the wild (Angell, 1986). In the tropics, oysters are widely distributed as in the temperate zones but have not been accorded the same regard and have remained merely as one of a number of naturally occurring foods (Kamara *et al.*, 1974). The challenges of environmentally-induced stress and overcrowding on mangrove roots result in stunted growth of mangrove oysters in the wild. Nevertheless, oysters grow well in captivity in a relatively short time and exploitation of wild oyster populations contribute little to worldwide oyster production when compared to cultured oysters (FAO, 2002).

Crassostrea gasar is a natural asset found along the West African coast (Nickles, 1955) and grows abundantly on mangrove roots in the Niger Delta (Afinowi, 1983). Mangrove oysters grow and survive in man-made structures in areas where the salinity is high enough (10-15 ‰) to permit oyster growth (Kamara *et al.*, 1974). Growth is so rapid at the prevailing high temperatures in mangrove areas, that oysters of a size which may be marketed after one season (i.e. eight months) are obtained (Kamara *et al.*, 1974).

Aquaculture production of oysters is a way of farming suitable waters and estuaries where hydrographical conditions are favourable to oyster growth. Bivalve aquaculture differs importantly from the culture of most finfish and crustaceans (Pohle *et al*., 2001; Crawford *et al*., 2003), exploiting naturally occurring phytoplankton, thereby making external feed inputs not necessary. Although bivalve molluscs are known to feed primarily on phytoplankton, studies have reported their ability to also exploit a range of nutrient sources which include inorganic substances, floating minute organic detritus, bacteria, fungi, and flagellates (Bricelj and Shumway, 1991; Gosling, 2003). The native mangrove oyster has two important attributes that provide it with an extraordinary potential, fecundity and an environment that permits a rapid growth rate (Kamara *et al.*, 1974). This study sought to investigate the growth performance of the mangrove oysters under continuous and periodic submergence during culture in tidal ponds.

MATERIALS AND METHODS

This study was carried out at the Brackishwater Experimental Fish Farm of the Nigerian Institute for Oceanography and Marine Research (NIOMR), Buguma, located in a fairly extensive swamp of the Buguma Creek, southeast of the Niger Delta, longitude 6° 47′E and 6° 59′E, and latitude 4° 31′N and 4° 59′N in Asari-Toru Local Government Area of Rivers State (Oribhabor and Ogbeibu, 2009).

Two earthen nursery ponds D and E were used for this study, which was carried out for seven months, from February to August 2010. The ponds were designated for the purpose of study, as experimental *pond A* and *pond B*, respectively. The ponds received water from Buguma Creek by tidal influence. The volume of tidal water entering or leaving Pond A was regulated at the sluice gate using four pairs of boards mud-packed to a depth of 1.2 m during the diurnal high and low tides, respectively. Pond B sluice gate was not mud-packed and so tidal water flooded and ebbed freely during the diurnal tidal cycles.

Netlon mesh cages of size: 39 x 24 x 15cm were constructed for the culture of the oysters to offer protection against predators. Rack stands were constructed in ponds *A and B*, using the mangrove sticks. The experimental cages: *A1, A2, A3, A4* and *A5* in Pond A were continuously submerged in tidal water; and the cages *B1, B2, B3, B4* and *B5* in Pond B were periodically submerged at high tide and exposed to air at low tide, throughout the period of study.

The seeds of oysters (spats) were collected from the wild (natural habitat) along Buguma Creek. The aerial roots of mangrove trees with attached oyster spats were cut at low tides. The mangrove roots were soaked in the pond water (protected from predator in a sack) over night to soften the roots and make the spats easy to dislodge. The spats were detached singly with hands and transferred into a recruitment netlon mesh cage placed in the pond. Oyster spats were stocked in ten netlon mesh cages of size 39 x 24 x15 cm, at an initial stocking density of 375 spats, distributed at 75 spats per cage for each group of five cages A1 – A5 and B1 – B5, to be stocked in ponds A and B, respectively, using off-bottom culture method by placing the netlon mesh cages on rack stands at 60cm above pond bottom. The mangrove oysters are filter feeders that utilised phytoplankton materials in the water and so were not given any form of feeds during the period of study.

The length (mm) and weight (g) of the three hundred and seventy-five (375) oyster spats stocked in each group of five cages A1 – A5 and B1 – B5, were taken and recorded prior to the arrangement of the cages in the ponds. Subsequently, data were taken and recorded at intervals of four weeks from the month of March to August, by random sampling of fifty (50) specimens of live oysters from each of the five cages in pond A (*A1, A2, A3, A4, A5*) and pond B (*B1, B2, B3, B4, B5*), after thorough cleaning with pond water to remove any debris from the shells. The shell length and weight were determined with a Manostat Vernier caliper calibrated in millimetre and OHAUS Scout Pro SPU401 balance, respectively. For length, readings were taken and recorded to the nearest 0.1 mm. For weight, readings were taken and recorded to the nearest 0.1 g. The condition factor of oysters cultured was determined at the end of the experiment, according to Quayle (1980), using the formula:

$$\text{Condition factor} = \frac{\text{Weight of dry meat}}{\text{Volume of shell cavity}} \text{ x } 1000$$

(Quayle, 1980).

Predators were frequently checked and removed from the culture systems where found once a month, according to Velasco1and Barros (2010). The physico-chemical parameters of the culture medium, salinity, temperature, pH, dissolved oxygen (DO) and biological oxygen demand (BOD), were determined and recorded monthly. Salinity (parts per thousand, $^{o}/_{oo}$) was determined using a hand-held refractometer. Water temperature (°C) was determined with mercury-in-glass thermometer. The pH was determined with a digital Pen Type pH-009(1) Meter. The dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined by Winkler's titrimetric method according to American Public Health Association (APHA, 1985).

The statistical analysis of the shell length and weight data were analyzed with the SPSS 15.0 statistical package. And the Two-sample t-test (Unpaired t-test) was performed to test for significant difference in the growth rates of the cultured oysters, under continuous and periodic submergence in tidal ponds.

RESULTS

The growth pattern in length of the cultured oysters fluctuated throughout the study period. Growth was rapid in the young spats within the first few months of stocking in both continuous and periodically submerged oysters. From the initial mean lengths (mean ± SD) of 19.3 ± 4.38 mm and 20.4 ± 5.92 mm of the oyster spats, mean lengths of 45.9 ± 7.95 mm and 40.8 ± 9.05 mm of growth of the oyster were obtained in ponds A (continuous submergence) and B (periodic submergence) after one month of culture, indicating a mean increase in length of 26.6 mm and 20.4 mm among the oysters for ponds A and B (Tables 1 and 2). Final mean shell length (mean ± SD) of 50.3 ± 6.68 mm was recorded in pond A and 52.3 ±7.14 mm recorded in pond B, in the last month of study. Paired t-test showed that there was no significant difference ($P > 0.05$) between the growth rates of the oysters cultured under continuous and periodic submerging in the tidal ponds.

Increase in oyster weight was also used to assess the growth of the mangrove oysters in this study. For oysters cultured in pond A, the mean

weight (mean ± SD) after one month of culture was 10.8 ± 3.90 g with a mean increase in weight of 9.8 g over the initial mean weight of 1.0 ± 0.51 g, Table 3. For oysters cultured in pond B, the mean weight (mean ± SD) after one month of culture was 8.1 ± 4.02 g with a mean increase in weight of 7.0 g over the initial mean weight of 1.1 ± 0.75 g, Table 4. Oysters cultured in ponds A and B recorded initial weight gains of 9.8 g and 7.0 g, respectively, indicating faster growth rate in the first month. Final mean weight (mean ± SD) gains of 20.8 ± 6.53 g and 18.8 ± 5.73 g were recorded for oysters in ponds A and B, respectively; corresponding to final weight gains of 19.8 g for pond A and 17.7g for pond B over the seven months culture period. This indicated that the conditions in both ponds were favourable for the growth of mangrove oysters under tidal pond culture system. Although, oysters from pond A recorded higher increase in weight over those in pond B in terms of food utilisation, Paired t-test showed that there was no significant difference ($P > 0.05$) among the oysters under continuous and periodic submergence in tidal ponds.

The values of the condition factor determined according to Quayle (1980) for oysters cultured in Pond A was 16.49 and for oysters cultured in Pond B 14.94. Water quality parameters of the culture medium are as shown in Table 5. Temperature ranged from 26 °C – 35.7 °C with a mean of 30 °C. The salinity ranged from 10 – 18‰, with a mean of 16‰. The pH ranged from 7.3 – 7.7, dissolved oxygen ranged from 1.5 – 4.6 mg/l and BOD ranged from 0.7 – 2.6 mg/l. The water quality parameters recorded during the period of study were considered desirable for the culture of mangrove oysters.

Table 1: Growth in oyster length for Pond A

Month	Total number of oysters	Number of oysters sampled	Mean length (mm)	Increase in mean Length (mm)	Standard deviation	Variance	Range
February	375	375	19.3	-	4.38	19.15	20.00
March	344	250	45.9	26.6	7.95	63.23	58.00
April	340	250	48.5	2.6	7.29	53.21	40.00
May	321	250	49.8	1.3	6.57	43.16	30.00
June	296	250	49.1	0.7	6.90	47.63	43.00
July	276	250	49.0	0.1	6.74	45.38	42.00
August	267	250	50.3	0.3	6.68	44.67	49.00

Table 2: Growth in oyster length for Pond B

Month	Total number of oysters	Number of oysters sampled	Mean length (mm)	Increase in mean length (mm)	Standard deviation	Variance	Range
February	375	375	20.4	-	5.92	35.00	23.00
March	361	250	40.8	20.4	9.05	81.91	44.00
April	356	250	44.4	3.6	7.36	54.14	36.00
May	348	250	48.2	3.8	7.75	60.04	50.00
June	343	250	51.4	3.2	7.12	50.72	49.00
July	339	250	51.9	0.5	7.14	50.94	40.00
August	339	250	52.3	0.4	7.14	50.97	46.00

Table 3: Growth in oyster weight for Pond A

Month	Total number of oysters	Number of oysters sampled	Mean weight (g)	Increase in mean weight (g)	Standard deviation	Variance	Range
February	375	375	1.0	-	0.51	0.3	1.80
March	344	250	10.8	9.8	3.90	15.21	18.70
April	340	250	13.8	3.0	4.55	20.73	27.10
May	321	250	17.4	3.6	5.93	35.16	28.90
June	296	250	19.4	2.0	6.45	41.60	35.40
July	276	250	19.8	0.4	6.33	40.03	35.90
August	267	250	20.8	1.0	6.53	42.63	40.80

Table 4: Growth in oyster weight for Pond B

Month	Total number of oysters	Number of oysters sampled	Mean weight (g)	Increase in mean weight (g)	Standard Deviation	Variance	Range
February	375	375	1.1	-	0.75	0.60	2.20
March	361	250	8.1	7.0	4.02	16.19	21.50
April	356	250	10.8	2.7	3.97	15.77	22.60
May	348	250	14. 3	3.5	4.64	21.54	23.00
June	343	250	17.0	2.7	4.97	24.72	24.40
July	339	250	18.0	1.0	5.13	26.31	29.40
August	339	250	18.8	0.8	5.73	32.86	38.00

Table 5: Water quality parameters of the culture medium over time (months)

Month	Salinity ‰	Temperature °C	pH	DO mg/l	BOD mg/l
February	18	35.7	7.6	4.6	2.6
March	18	30	7.7	2.7	1.8
April	18	31	7.4	1.8	1.2
May	15	29	7.5	1.7	0.9
June	15	29	7.4	1.6	0.7
July	15	26	7.3	1.5	1.0
August	10	27	7.3	1.5	1.0
Mean values	**16**	**30**	**7.5**	**2.2**	**1.3**

DO = Dissolved oxygen BOD = Biochemical Oxygen Demand

DISCUSSION

The rapid growth in length of the oysters cultured in ponds A and B, from February to March, give credence to the adaptability of mangrove oysters to growth in captivity. Also, the oysters under culture, demonstrated a steady monthly gain in weight, an indication that the conditions of the ponds were favourable for mangrove oyster culture. Mangrove oysters grow and survive in man-made structures in areas where the salinity is high enough (10-15‰) to permit oyster growth (Kamara *et al.*, 1974). The salinity range (10 – 18‰) recorded in this study was normal for the favourable growth of oysters. The condition factor obtained for the oysters cultured under the two conditions were high at 16.49 and 14.94 respectively, according to Sakuda (1966). According to Rheault and Rice (1996), condition index is commonly used to evaluate the effects of the surrounding environment on oyster species as indicated in O*strea edulis, Crassostrea gigas,* and

Crassostrea virginica ; and has been indicated to be an adequate parameter in describing the marketable quality and functional state or health condition of bivalves (Dridi *et al.*, 2007).

The growth in the oyster length of 50.3 mm and 52.3 mm, recorded during the study showed that market-size mangrove oysters are obtainable in seven months, under the two culture conditions. Afinowi (1983) reported a growth length of 36 mm within seven months of mangrove oyster culture in the Niger Delta area of Nigeria. Young and Serna (1982) reported growth in shell length of 90 mm within six months in the mariculture of the windowpane oyster. The observations made during this study under the two culture conditions of continuous and periodic submergence in tidal ponds were indication of the potential of the two systems to produce market-size oysters within same period, but with no significant difference in system performance. However, Jeff (2001) reported that continuous exposure to food (in subtidal region) does not necessarily translate into better growth rates as compared to oysters intermittently exposed to food (in intertidal region).

In this study, however, mangrove oysters cultured under continuous submergence were observed to gain more weight. This was attributed to their constantly filtering and utilizing phytoplankton from water, as upheld by some studies; such as reported in Mercado-Silva (2005) where the amount of time an oyster remains above water during tidal lows was shown to be related to the period of food intake available to the individual. The growth rate of *Crassostrea virginica* was reported to vary with the duration of tidal emersion, with oysters in the mid intertidal exposure treatment showing significantly slower growth than those continually submerged (Roegner and Mann, 1995). Bishop and Peterson (2006) also reported in their investigation on the relationship between duration of aerial exposure and growth rates for triploid *Crassostrea ariakensis* that immersion time, which relates to the available feeding time, provided a good predictor of growth rate during early-to-mid winter.

CONCLUSION

The two culture conditions as observed from the growth performance of the oysters showed potential to produce market-size oysters within the same period of seven months, though oysters under continuous submergence had the advantage of constantly filtering and utilizing phytoplankton from water but suffered more fouling on the shell. While oysters cultured under continuous submergence will be of advantage where oyster meat is shucked before sales, oysters under periodic submergence will have the advantage of consumer preference where oysters are sold shell-on.

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