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Growth and Survival of Ornate Spiny Lobster (*Panulirus ornatus*) in Nursery under Laboratory Condition

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ABSTRACT

Nursery of juvenile lobsters in the coastal area was attempted but survival was very low with unknown causes of mortality. The study determined whether communal or individualized houses affect the growth and survival of small and big juvenile lobsters after 60 days nursery culture in the laboratory. Four (4) treatments with four (4) replicates were identified in Completely Randomized Design (CRD) and these were small juvenile lobsters in communal tank (T1), small juvenile lobsters in individualized tank (T2), big juvenile lobsters in communal tank (T3) and big juvenile lobsters in individualized tank (T4). Results showed that communal tank for big juveniles attained significantly ($P<0.05$) highest weight increment of 5.31±1.66 g compared to individualized house for both sizes of lobsters (2.15±1.45 g and 0.68±0.49 g) and communal tank for small lobsters of 1.26±0.97 g. However, survival rate was very low in all treatments with communal tank obtained the highest survival of 45.75±8.50% with no significant difference among individualized tanks for both sizes of lobsters (29.00±20.93% and 20.75±15.76%) and communal tank for small lobsters (20.92±15.93%). Thus, communal tank is better than individualized tank in the nursery, particularly, for big juvenile lobsters but some aspects of the nursery may be improved to increase higher survival rate.

Keywords **—** Aquaculture, growth and survival, communal and individualized tanks in the nursery, Surigao del Norte, Philippines

INTRODUCTION

Farming of Spiny ornate lobsters becomes an important aquaculture industry in the Asia-Pacific region. Strong international market demand of lobsters and suitability of natural resources within the boundaries have led the industry to expand (Pahlevi, 2009). Vietnam, Indonesia and the Philippines are countries producing marketable sized lobsters from aquaculture utilizing their own local wild source of lobster seeds. However, the largest lobster farming in the world is found in Vietnam with an average annual production of 2,000 t (Ngoc, Thuy, & Ha, 2009; Pahlevi, 2009; Hall, Kenway, Salmon & Smith, 2009). Australia assessed the potential of lobster farming in its coastal areas and focused on *Panulirus ornatus* which they believed to be the fastest-growing tropical species of lobster (Hall, Kenway, Salmon & Smith, 2009).

In the Philippines, lobster culture is developed in Caraga Region. Juveniles are collected from Hinatuan, Surigao del Sur and grown in the coastal areas of Surigao del Norte, Dinagat Islands and Siargao Island for a period of 8 – 12 months. Wild juvenile lobsters occur all year round from Surigao del Sur with peak catch within March to June. Other sources of juvenile lobsters are also coming from Zamboanga and Leyte transported by air due to its long distance from the farming sites. Accordingly, lobsters weighing 500 g each and above are classified marketable sized stock and sold at P 2,800.00 per kilogram and those below 500 g each are utilized by growers at 250.00 to 450.00 per piece.

However, the industry is expanding and the farmers are now facing the shortage of wild juvenile lobsters which causes delay in the production cycle. The preferred size of each lobster seed acceptable by farmers for grow-out is 30g and above, but the most abundant size during peak season is 1g each and below which is vulnerable for high mortality. There were attempts on nursery of lobster using small juveniles in floating net cages suspended in the open water, but this method was not technically feasible due to high mortality.

In Vietnam, collection and transport of wild juvenile lobsters were very risky because of long transport from the collection site to nursery station and this resulted to 50% mortality (FAO, 2011-2017). Nursery was a submerged net cage consisting of mesh surrounding a steel frame and each cage was placed on the sea floor at 2-5 m depth. The cage was stocked at 50-100 pueruli/m^2, fed finely chopped trash fish, crustaceans and mollusks and lobsters were harvested 3-6 months during which the lobsters grew to 10-30g.

In Indonesia, collection of wild juvenile lobsters is different. Nursery has lower mortality because wild source of juvenile lobsters are collected within the farming site. Habitat traps are attached in the cages and used to capture the pueruli (FAO, 2016). Captured pueruli are immediately moved from the trap to the cage. Floating nursery cage was 3 m x 3 m x 3 m consisting fine mesh suspended from a floating bamboo frame and provided with seaweeds (*Gracillaria* sp.) as shelter for small lobster. Lobsters are fed with chopped fish flesh and grown for 1-3 months reaching 5-10 g. each (FAO, 2016). Stress was avoided because on land handling and transport in this case are not needed and high survival rate during nursery is likely to exist.

Nursery of juvenile lobsters was also investigated under laboratory conditions. Considering cannibalism in the nursery, growth and survival of juvenile lobster were determined using different shelter types and different housing conditions. Four shelter types such as wood with drilled holes, coral with drilled holes, net shelter and no shelter were introduced by Ngoc, Thuy and Ha(2009) in the nursery and it showed that growth of juvenile lobster was not affected among shelters, but survival was affected significantly among shelters which suggested that net shelter (80.6 ± 5.6%) may reduce cannibalism in the nursery. Irvin and Williams (2009) examined the effect of solitary and communal tanks to the growth and survival of juvenile lobster and showed that growth was significant between lobsters housed communally with daily growth coefficient of 1.02%/day and individually with daily growth coefficient of 0.71%/day. Survival rates of 89% and 72% of individual and communal tanks were not significantly different between each other.

The study of Sumbing, Al-Azad, Estim and Mustafa (2016) who investigated the growth and survival of spiny ornate lobster (*Panulirus ornatus*) in Land-based Integrated Multi-Trophic Aquaculture (MTA) system showed that there was no significant difference between recirculating system and flow-through system of lobster culture in terms of Specific Growth Rates (SGR) of 0.096 % day-1 and 0.125 % day-1 and survival rates of 80.0 % and 93.3 %, respectively.

Study on lobster aquaculture is very limited under Philippine setting despite its rapid development. Utilization of small juvenile lobsters from the wild stock for nursery must be investigated to increase seedstock for grow-out since demand is very high in the international market. The quality of wild lobster in terms of its robustness is influenced by the quality of water environment and is believed to be different among lobster-producing countries. To know the performance of locally available wild lobster, nursery of lobster under laboratory condition must be investigated. Intervention might consider the viability of the small juveniles and cannibalism that was commonly observed in the nursery for high mortality. The study identifies two factors (two sizes of juvenile lobster and two housing conditions) allowing to interact within the factor and between the factors and this makes different from previous studies using only a single factor.

OBJECTIVES OF THE STUDY

The study aimed to: 1) describe the pattern of growth of ornate spiny lobster(*Panulirus ornatus*) in 60-day nursery culture; 2) compare the growth and survival of two different sizes of ornate spiny lobster (*Panulirus ornatus*) housed communally and individually in 60-day nursery culture; and 3) determine some physico-chemical parameters of the rearing water such as temperature, salinity and dissolved oxygen relating growth and survival of ornate spiny lobster(*Panulirus ornatus*) within the 60-day nursery.

MATERIALS AND METHODS

Research Design

A 2 x 2 factorial in Completely Randomized Design (CRD) was followed as experimental design of the study. Factors were: A) Two different sizes of lobster (small and big sizes) and B) Two different housing conditions (communal and individualized tanks). Four (4) treatments were made in the experiment and each was replicated four (4) times. Treatments were small juvenile lobsters in communal tank (T1), small juvenile lobsters in individualized tank (T2), big juvenile lobsters in communal tank (T3) and big juvenile lobsters in individualized tank (T4). A total of sixteen (16) tanks were used in the study and each was assigned randomly within the study area.

Research Site

The study was conducted at Wet Laboratory of Institute of Fisheries Research and Development (IFRD) in Mindanao State University at Naawan, Poblacion Naawan, Misamis Oriental. The institution is equipped with complete aquaculture facilities and equipment where hatchery and nursery of some important and high-value species of fish are held for research and commercial production.

Test Organism

The spiny ornate juvenile lobster (*Panulirus ornatus*) with an average body weight and total length of 0.36±0.03g and 21.15±0.48cm for small sizes and 1.42±0.28g and 32.39±2.17cm for big sizes upon the stocking date in the nursery was used in the study as the test organism and its distinguishing characteristic is identified through its bond of yellow and black color around the body, walking legs and tail except for the pair of antennae that makes this organism ornate or painted.

Figure 1. Spiny ornate juvenile lobster (*Panulirus ornatus*) reared in communal and individualized tank for 60-day experiment in the nursery

Experimental Management

Wild juvenile lobsters were collected from Hinatuan, Surigao del Sur and transported by land to Naawan, Misamis Oriental. All juvenile lobsters after transport were held in wooden canvass tank for 1 week and were weaned to fresh diets such as fish, squid, shrimp and mussel. Each tank (65-L capacity) was provided with six (6) net shelters for communal tank (Figure 2: A) and six (6) circular sub-cages for individualized tank (Figure 2: B). Strong aeration and black plastic cellophane as tank cover were used. Upon the start of the experiment, small juvenile lobsters with average body weight and total length of 0.36±0.03g and 21.15±0.48cm and big juvenile lobsters with 1.42±0.28g and 32.39±2.17cm were distributed in 16 tanks both in communal and individualized tanks at stocking density of six (6) lobster per tank.

Figure 2. Two different tanks used in the nursery: A) communal tank and B) individualized tank

Live sandworms and frozen diets such as squid, shrimp, brown mussel and fish were fed daily throughout the study duration. Feed rate was 12% with two feeding frequencies at 7:00 AM and 4:00PM. Water management was also done daily in each tank by draining 20% of the total water volume and replenishing with new fresh seawater. All lobsters in each tank were taken as sample in every 15-day sampling interval within the study period for body weight, carapace length and total length using digital weighing scale (500g/0.01g) and plastic vernier caliper (6 in/150mm). Carapace length was measured from the base and in between of the eyes of the lobster to the edge of the head while total length was from the base and in between of the eyes of the lobster to the tip of the telson. Some physico-chemical parameters were monitored weekly such as water temperature and salinity using water thermometer and refractometer (ATAGO-TANAKA S-100) and bi-weekly for dissolved oxygen using titration method. The study was terminated after 60 days of culture.

Data on growth and survival were calculated using Panase and Mengumphan (2015) and Chand *et al.* (2015):

Weight Increment (WI) = Final Weight–Initial Weight

Carapace Length Increment (CLI) = Final Carapace Length–Initial Carapace Length

Total Length Increment (TLI) = Final Total Length-Initial Total Length

$$\text{Survival rate (\%)} = \frac{\text{Number of species survived at the end of experiment}}{\text{Number of species stocked}} \times 100$$

Statistical Analysis

Data on growth and survival rate were analyzed through Analysis of Variance (ANOVA) to test for significant differences among treatments and Tukey HSD was also used to identify which treatments showed significant differences.

RESULTS AND DISCUSSION

Growth trends among treatments were expressed through body weight and total length of lobster. Big juvenile lobster in communal tank houses (T3) showed superior growth both in body weight and total length among treatments with abrupt increase in growth between 30th to 60th days. The rest of the treatments such as small juvenile lobster in communal tank houses (T1), small juvenile lobster with individualized tank houses (T2) and big juvenile lobster in individualized tank houses (T4) had similar trend of growth both in body weight and total length with slight increase in growth between 45th day to 60th day (Figure 3and 4).

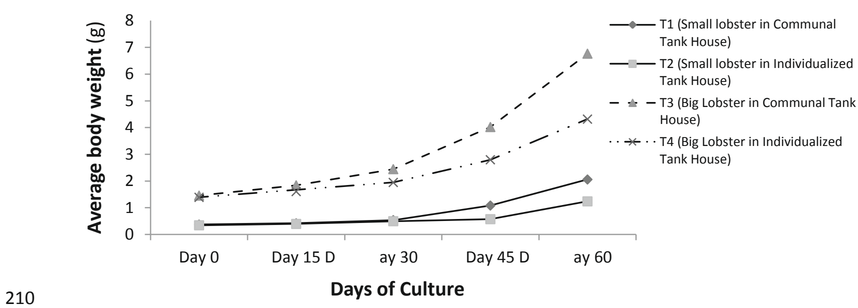

Figure 3. Growth trend of juvenile ornate spiny lobster (Panulirus ornatus) in terms of average body weight (g) within 60 days of culture.

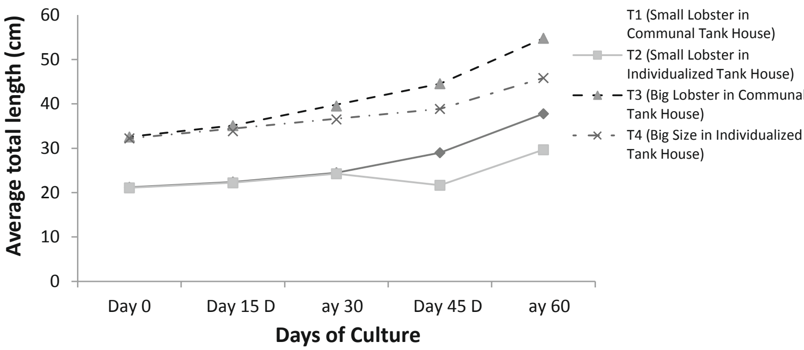

Figure 4. Growth trend of juvenile ornate spiny lobster (Panulirus ornatus) in terms of average total length (cm) within 60 days of culture.

Growth performance was evaluated through increment in body weight, carapace length and total length of lobster. Weight increment of big lobsters in communal tank (T3) was 5.31±.66g which was significantly (*P*<0.05) higher in all treatments. This is followed by big lobsters of individualized tank (T4), small lobsters in communal tank (T1) and big lobsters in individualized tank (T2) with weight increments of 2.15±1.45g, 1.26±0.97g, and 0.68±0.49 g., respectively with no significant difference among each other (Table 1). Since two (2) sizes (small and big) of lobster and two (2) tanks (communal and individualized) were two variables interacting in the study, relationships were also established between sizes and tank houses as well as between size and tank house with regards to weight increment. A significant difference of weight increment was found within two sizes of lobster and lobsters in two tank conditions. Big lobsters obtained weight increment of 3.73±2.23g which was significantly higher than small lobsters with 0.97±0.78g (Figure 5:A) while lobsters housed communally was 3.29±2.50g which was also significantly higher than lobsters housed individually with 1.41±1.27g (Figure 5:B). However, weight increments of lobster between size and housing condition were not significantly different.

Among the growth parameters, carapace length increment and total length increment did not differ statistically in this study (Table 1). Big lobster in communal tank (T3) obtained the highest carapace length of 0.78±0.12cm and it followed by small lobster in communal tank (T1) with 0.47±0.40cm, big lobster in individualized tank (T4) with 0.45±0.30cm and small lobster in individualized tank with 0.38±0.26cm which was the lowest carapace length increment among the treatments. Big lobster in communal tank (T3) still obtained the highest total length increment of 2.22±0.48cm, but it was followed by big lobster in individualized tank (T4) with 1.35±1.08cm, small lobster in communal tank (T1) with 1.23±0.93cm and small lobster in individualized tank (T2) with 0.65±0.50cm.

Table 1. Weight increment, carapace length increment and total length increment of Spiny Ornate Lobsters (*Panulirus ornatus*) among treatments after 60-day nursery culture. Values of the different superscripts within the column are significantly different at $P<0.05$ level of significance.

Treatment	Weight increment (g)	Carapace length increment (cm)	Total length increment (cm)
T1(small lobster in communal tank)	1.26 ± 0.97^{b}	0.47±0.40	1.23±0.93
T2(small lobster in individualized tank)	0.68 ± 0.49^{b}	0.38±0.26	0.65±0.50
T3(big lobster in communal tank)	5.31 ± 1.66^{a}	0.78±0.12	2.22±0.48
T4(big lobster in individualized tank)	2.15 ± 1.45^{b}	0.45±0.30	1.35±1.08

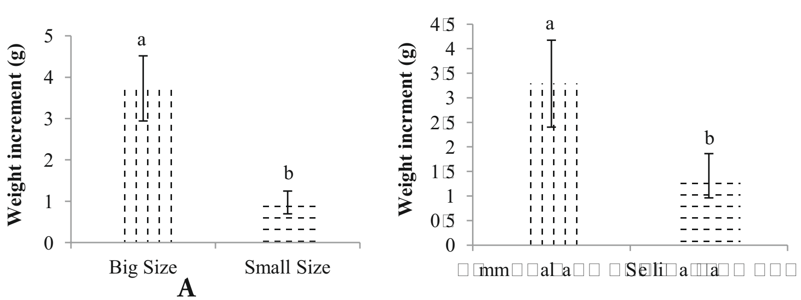

Figure 5. Average weight gain of Ornate spiny lobster(Panulirus ornatus) between sizes of lobster (A) and tank houses (B) after 60 days of nursery culture. Bar graphs with different superscript in A and B are significantly different (P<0.05)

The result of the study was supported by Irvin and Williams (2009) that there was a marked effect of communal and individualized tanks on the growth of lobsters stating a faster growth of lobster in communal tank than in individualized tank. They further emphasized that communal tank enhanced feeding behavior of lobster to be active during feeding time where feeding competition existed and provided additional food from dead lobsters which were also source of fresh protein for the surviving lobsters. Final body weight and weight increment of lobsters were 6.4g and 4.4g in communal tank by Irvin and Williams (2009) which were higher than final body weight and weight increment of lobster in communal tank by this study of 4.75g and 3.29g (Table 2). The increase in final body weight and weight increment in both studies seemed to have similar result since the study utilized smaller size of juvenile lobster than the study of Irvin and Williams (2009) upon the start of the experiment.

Some aspects were also considered with regard to significant growth between small and big juvenile lobsters. Based on the result, weight increment of lobsters corresponds to lobster's body weight upon the start of the study which means that bigger juveniles gain more weight than small juveniles. Important observation during the study period was also taken into consideration that most small lobsters were less active feeder than big lobsters. The presence of unconsumed food was noticed daily before water management. However, feeding response became more active as the small and big lobsters grew in the middle and up to the end of the study.

Survival rates of all treatments dropped drastically between 3rd to 4th week of the culture (Figure 6). Big lobsters in communal tank (T3) obtained the highest survival among the treatments with 45.75±8.50% while the rest of the treatments were 29±20.93% in big lobster in individualized tank (T4), 20.92±15.93% in small lobsters in communal tank (T1) and 20.75±15.76% in small lobsters in individualized tank (T2) after 60 days of culture (Figure 9). However, survival rates among treatments were not significantly different. Survival rates were also not significant within sizes of lobster and within tank conditions. The survival rate of lobsters housed communally was 33.33±17.8% which was higher than lobster housed individually with 24.88±17.7% while big was 37.38±17.3% which was also higher than small lobsters with 20.83±14.7% (Table 3).

In the study of Irvin and Williams (2009), survival rates of lobsters were 72% and 89% in communal and individualized tanks which were very high compared to survival rates of lobsters in this study. Irvin and Williams (2009) further explained about the survival rates of lobster using unpublished data on different initial sizes of lobster from 0.5g to 3.4g. Survival rates significantly improved as the initial size increased upon the start of the culture. This statement supports that the cause of very low survival was mainly due to small size of lobsters ranging from 0.87 g to 0.91 g (Table 2) upon the start of the study. Other factors causing mortality were also identified. The incidence of mass mortality occurred during the 4th to 5th week in which during that time water temperature (Figure 6) and salinity (Figure 7) dropped drastically. Incomplete molt was observed and prevalent of all dead lobsters. Dead lobsters with incomplete molt were manifested with incomplete separation of abdomen started from first abdominal segment from the head portion to the tip of the telson (Figure 7:A). This incomplete molt manifestation was opposite to the report of Irvin and Williams (2009) where incomplete separation was held at the head region of the organism (Figure 7:B). Cannibalism was also observed during the study but such activity was a secondary event that happened when incomplete occurred among lobsters (Irvin & Williams, 2009).

Irvin and Williams (2009) stated that mortality of ornate spiny lobster occurred during early nursery stage or first 30 days of culture (Ngoc *et al.* (2009) and its high survival depends on the quality of the seed at capture and on how the seed is subsequently handled during the nursery phase. Irvin and Williams (2009) also confirmed that incomplete molt was most likely due to a nutrient deficiency or insufficient nutrient reserves.

Table 2. Weight increment of ornate spiny lobster (*Panulirus ornatus*) by Irvin and Williams (2009) and this study

Factor	Irvin and Williams (2009)	This study	Irvin and Williams (2009)	This study
	Communal house (g)	Communal house (g)	Solitary Tank (g)	Solitary Tank (g)
Initial body weight (g)	2	0.91	2	0.87
Final body weight (g)	6.4	4.75	4.7	2.78
Weight increment (g)	4.4	3.29	2.7	1.41

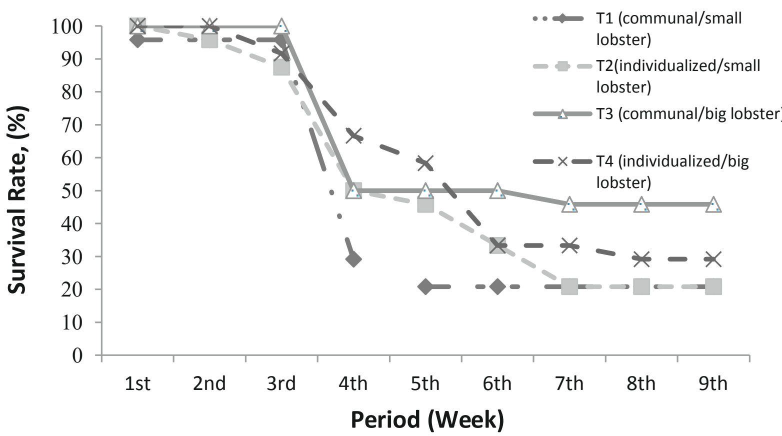

Figure 6. Weekly Survival Rates of Ornate spiny lobster (Panulirus ornatus) with no significant difference among treatments after the 60 days of culture.

Table 3. Survival Rate (%) between Small and Big Juvenile Lobsters and Lobsters in Communal and Individualized Tanks with no significant difference.

Parameter	**Tank Condition**		**Size**	
	Communal Tank	Individualized Tank	Big	Small
Survival Rate (%)	33.33±17.8	24.88±17.7	37.38±17.3	20.83±14.7

Figure 7. (A) Incomplete molt of lobster during occurrence of mass mortality (left) in this study and (B) incomplete molt (right) presented by Irvin and Williams (2009).

Water quality parameters were also monitored during the study in which salinity and temperature were taken weekly while dissolved was bi-weekly. Temperature readings ranged from 26.30^{0}C – 28.83^{0}C and fluctuated every 15 days for all treatments with a noticeable decrease on the 4^{th} week of the culture (Figure 8). Salinity reading ranged from 29.50 ppt – 31.50 ppt with also abrupt decrease on the 4^{th} week of culture was observed (Figure 9). Dissolved oxygen reading ranged from 4.97 ppm – 7.24 ppm and a slight increase and decrease were also observed during the culture period (Figure 10). Spiny ornate lobsters (*Panulirus ornatus*) were subjected for different temperatures and salinities by Jones (2009) and result showed that growth of lobster was significantly ($P < 0.01$) affected by temperature and salinity. Temperature affects growth and apparent feed intake of lobster with maximal growth within 25^{0}C - 31^{0}C and 27^{0}C was found to be optimal temperature at which molt increment was greatest and intermolt period the least. Lowest survival occurred at 35ppt due to higher cannibalism, but growth was highest and progressively less in lower salinities. McVey (1993) clearly stated the optimal temperature, salinity and dissolved oxygen which is 20^{0}C - 22^{0}C, 30 ppt and 6.4ppm, respectively which are ideal for lobster culture. Most of the temperature, salinity and dissolved oxygen readings during the study period were within the tolerable limit for lobster to grow well in the nursery based on the results of the previous studies.

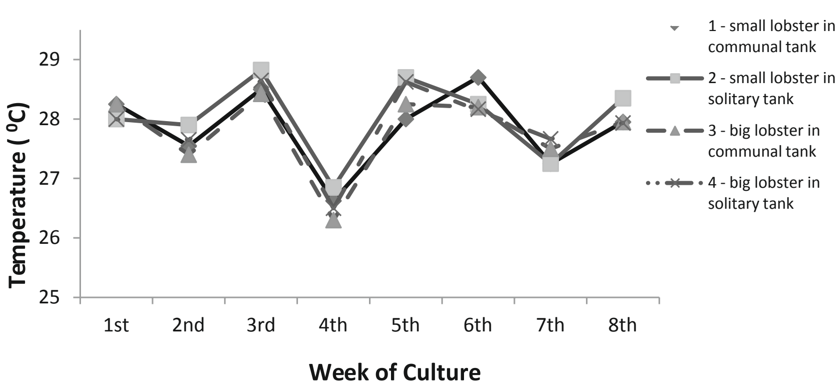

Figure 8. Variation in water temperature (0C) recorded during the 60-day nursery culture of spiny ornate lobster.

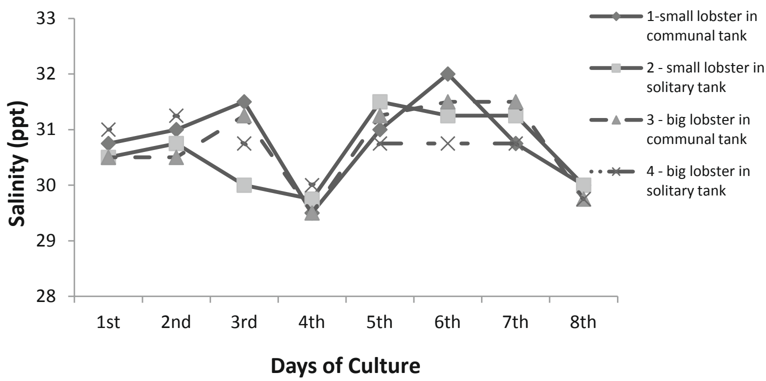

Figure 9. Variation in salinity (psu) recorded during the 60-day nursery culture of spiny ornate lobster.

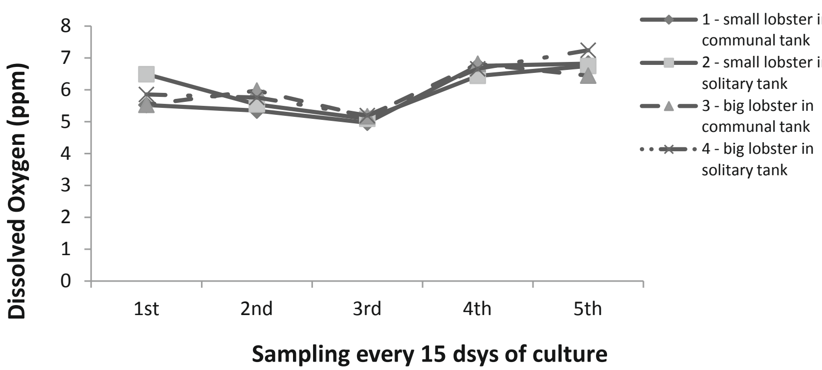

Figure 10. Variation in dissolved oxygen (ppm) recorded during the 60-day nursery culture of spiny ornate lobster

CONCLUSION

Big and small lobsters in communal tank can give better growth for ornate spiny lobster (*Panulirus ornatus*) in 60 days of culture in the nursery under laboratory condition. Two or more trial runs on lobster nursery maybe further conducted to determine consistency of results with regard to growth and survival and the result will help nursery growers engage commercial production of juvenile lobsters for grow-out. However, survival rate must be taken into consideration for improvement with some interventions of water quality control within the 60-day nursery and identification of some nutritive feedstuff especially for small lobsters. The survival rate is very low in this study, but this might be high compared to survival of lobster reared by local growers using their traditional nursery practice in the natural environment.

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