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Growth, survival, and physical qualities of Mangrove Crab (Scylla *olivacea*) in a net cage with different size and embedding depth

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ABSTRACT

This experiment was done to see the results of rearing Scylla olivacea crabs in cages of different size and embedding depth. The variables under considerations in the assessment were growth and survival rates and physical qualities of the experimental crabs. Additionally, this research aims to find out if the tested methods of confinement could produce better than the conventional culture practices. Three sizes of experimental cages such (45cm-l X45cm-w X60cm-h), (61.0cm-l X61.0 cm-w X75cm-h), and (76cm-l X76cm-w X90cm-h) and three embedding depths such as (30 cm), (45 cm), and (60 cm) labelled as treatment 1, treatment 2 and treatment 3 were tested. On the basis of cage size, highest mean on growth and survival rates of 279 grams and 88.90 % were obtained in treatment 3 followed by treatment 2 with 274.20 grams and 86.40 % and lowest mean of 269.31 grams and 82.25% was obtained from treatment 1. When assessed based on embedding depth highest growth and survival rates of 276.31 and 88.99% were obtained from treatment 3 followed by treatment 2 with 273.81 grams and 87.40% and treatment 1 with 272.71 grams and 81.25% being the lowest. Findings revealed that growth and survival rates obtained from three different cage sizes and three different embedding depths tested were relatively higher than that of what had been recorded and published. It was further noted that survival rates obtained were within the range (80-100%) considered as ideal. Growth and survival rates attained by different treatments were not significantly different. There were also no interaction effects attributed by size and embedding depth of experimental cages. Physical attributes of harvested mangrove crabs that were assessed based on the completeness of appendages, meat content, meat color, odor and taste were all at the mean value described as excellent. It is concluded that the methods of rearing tested improves growth, survival rates and mud crab physical qualities.

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INTRODUCTION

Scylla olivacea also known as mangrove Crabs or mud crabs are among of the highly esteemed fisheries commodity in Southeast Asian countries such as Taiwan, Malaysia, Singapore, Thailand, Indonesia and Philippines (Sayeed Z. et. al. 2021). The high consumptive growth rates on mud crab in many countries in Asia, America and Europe requires a significant increase of supply. The biggest consumers of mangrove crabs were China, USA, Japan, Korea, and Thailand. Countries with highly increasing consumption growth rates were Germany (24%), Malaysia (21%), Australia (15%), Hongkong (13%), and Spain (12%) (Aldon E.T. & Dagon N.J. 2022). Recently, only 5 % of mud crab available in markets comes from aquaculture while 95% were caught from natural sources (Bhuiyan, M.S., 2021). Thus to increase the production of this fishery commodity, technology on aquaculture should be boosted. In mud crab rearing, a problem on survivability of stocks due to cannibalism is one of the major deterrents on the attainment of maximum productivity (Mwaluma J.M. et. al. 2021; Bambang Y. et. al. 2019). Cannibalism usually occurred when rearing mud crab together in a culture pond (Genodepa, J.G. et. al 2017; Quinitio, E.T. 2015). Poor recovery rate of 47-50 % lower than the desired of 80-100% were also experienced in mangrove pen culture (National Institute of Ocean Technology-Entrepreneurs' Guide to Mud crab Fattening, 2015). Based on studies escape from enclosures also attributed 25% of stock losses in mangrove pen (Mirera and Mtile, 2009).

Mud crabs can be grown in highly intensive systems without loss of stocks due to cannibalism when they are held separately. However, problems on slow growth and mud crab quality such as inferior meat content, claw and limb losses due to entangling were noticed when they were held in cell-type bamboo cages (David M.O. 2009; Jitheran K.P. et. al. 2009; Shelley C. 2008). Mortality caused by fouling of water inside cell was also experienced when they are held in plastic containers (Lopulalan, Y. & Pattikawa J.A., et. al. 2021). The above-cited situations moved the researcher to work on this project. In this research, all causal factors that deter the attainment of optimal productivity of mud crabs in confine conditions were considered on the design and development of the experimental cages to be tested. The cages were only made up of polyethylene materials framed with bamboo pegs. The cages were made to be varied in size and embedded in the pond soil at varying depth to observe variability on its effects on growth, survival rates and physical qualities of mud crabs. Unlike cages made up of bamboo and plastic containers which were currently used, net enclosure allows free water movement that prevents fouling of water brought by uneaten feeds and crab wastes. It was also observed that mangrove crab use their pincers to destroy hard enclosing materials in their attempt to escape from cages. Soft and flexible enclosing materials such as net avoid body and claw injuries. Entanglement that causes claw and limb losses were also common incidence in bamboo cages. This could also be prevented by using nets with favorable meshed shape and size. Additionally, embedding the part of net cage in the pond soil will cater mangrove crab burrowing characteristics. Burrow provides a refuge and shelter from predation during molting and extreme water temperature (Fatihah S. N. et al., 2017).

OBJECTIVES OF THE STUDY

The following were the objectives of this research: (1) to measure and compare the growth and survivability rates of Scylla olivacea crabs in cages with different sizes; (2) to measure and compare the growth and survivability rates of Scylla olivacea crabs in cages with different embedding depths; (3) to test if cage size and embedding depth produce an interaction effects on growth and survivability of Scylla olivacea crabs; (4) to evaluate the effects of cage size and embedding depth on mud crab physical qualities; and (5) to find out if the experimental cages could produce better than the previous methods of confinement.

MATERIALS AND METHODS

Net Cages and Research Facility

Materials that were used in this experiment were forty-eight (48) net cages. The cages were made up of polyethylene net with 6cm missed size, framed with bamboo pegs with three varying length, width and height such as 45cm. X45cm. X60cm; 61.0 cm. X61.0cm. X75cm; and 76.0 cm. X76.0 cm. X90 cm. The net cages were embedded in the pond soil at three varying depths such as 30cm, 45cm and 60 cm. These were assembled with the used of polyethylene twine and provided with bottom and top cover to avoid escape of experimental crabs. The net cages were installed in brackish water pond with 1 hectare in area and which was regularly replenish with fresh brackish water of coastal source. The experimental cages differ with plastic container and bamboo cages on its enclosing materials used where it uses polyethylene net while the other two were made up of plastic and bamboo slats. The experimental cages were partially varied in pond soil while plastic containers and bamboo cages were allowed to float in the water thus having no soil substrates.

Experimental Crabs

Forty-eight (48) pieces Scylla olivacea species with proportional sexes and with varying weights ranging 130-140 grams and overall mean weight of 137 grams were proportionally distributed in each treatment and blocks on the basis weight and sexes and stocked at one crab per cage. Mud Crabs used in this experiment were collected at nearby mangrove swamps using traps thus stresses due to long transport period and method of catching were avoided assuring that all crabs used in the experiment were in good conditions.

Other Materials

Other materials utilized during the conduct of research were water monitoring kit for water quality, and instruments for stock sampling such as a gram calibrated weighing scale for weighing of feeds and body weight and a piece of measuring tool for length of crab samples.

Design of Experiment

The design use was 2X3 factorial in randomized complete block design (RCBD) experiment. The two factors involved, were cage size and embedding depth. Three treatments in both factors were created and every treatment was replicated sixteen times. The experimental units were randomly assigned in four blocks. Treatments in size of cages were: treatment 1- 45cm. X45cm. X60cm.; treatment 2- 61.0 cm. X61.0cm. X75cm.; and treatment 3- 76.0 cm. X76.0 cm. X90 cm. length, width and height respectively. Treatments in embedding depth were: treatment 1 (30cm.), treatment 2 (45cm.), and treatment 3 (60cm.) depths. The duration of experiment was three months.

Figure 1. The Experimental Set up (S- Size of Cage; D-Depth of Embedding)

Feeding of Mangrove Crabs

A combination of newly collected and newly catch fresh water mussel and trash fish were given directly to the stocks at 10% percent of their body weight (Entrepreneurs' Guide to Mud Crab Fattening p.3; Trino, A.T., Rodriguez E.M. 2000). The ratio of giving is 50/50 %. The increase of daily feed ration was estimated based on the forecasted increase of body weight, determined at the first sampling which was done after one month of rearing. This is visualize and plotted with the aid of scatter plot chart added with trend line available in Microsoft excel.

Monitoring of Water Physicochemical Parameters of Pond

Parameters were monitored daily and ranges observed within three months experimental period were within the ideal range for the culture of mangrove crabs. The water qualities observed were summarized as follows: dissolved oxygen is >4 ppm, pH is within 7.0-8.5, salinity within 15-30 ppt, temperature is within 26-32 ^{0}C, unionized ammonia is <0.1 ppm, nitrite is <.5 ppm, and sulfide within <0.1 (FAO Fisheries and Aquaculture Technical Paper 567 p.55 2011; Christensen 2004; Pedalpoli and Ramudu 2014). Dissolved oxygen, pH, ammonia, nitrite and hydrogen sulfide were monitored using digital D.O. meter, pH tester and water quality test kits. Monitoring was done. early morning hours before sunrise. Temperature and salinity were monitored at noon time using a thermometer and refractometer respectively.

Sampling Procedures u

Assessments of experimental crabs were done after 90 days of rearing. All recovered crabs from cages were counted and weighed to obtain the individual and total gain in weight, and survival rates attained by every treatment. Product quality assessment was also done in every treatment. Physical assessment was conducted to determine the quality of harvested crabs. Physical attributes such as completeness of appendages and claws, color, and meat content were assessed. The evaluators of examining the physical qualities were composed of mud crab fishers and local buyers. The evaluation of meat content of live crab is done manually. It is done by pressing the left and upper part of carapace. Hard crabs carapace or the one that does not move inward when press is an indicator of full meat content. While soft carapace or carapace that moves inward and when audible sound is produced when press is an indicator of inferior meat content. The female crabs on the other hand, were assessed by pressing the lower abdomen and the same case with that of the male, when it does not move inward it is full but when move inward is an indicator of inferior meat content (FAO Fisheries and Aquaculture Technical Paper 567 p.60, 2011).. Randomly chosen samples were cooked and subjected to internal quality assessment. A panel of evaluators were organized and scaled score sheet was used in scoring. The assessment includes examination of meat color, odor and taste.

Data Analysis

Statistical test used in data analysis was factorial analysis of variance (ANOVA) in a randomized complete block design (RCBD). Level of significance used was .05. In the data analysis mean of the body weight and survival rates were determined. Total gain in weight and growth per day of experimental crabs were computed in every treatment. Statistical significance of difference among treatments and interaction effects of cage size and imbedding depth on the growth and survival rates of crabs were assessed. Descriptive statistics and Likert's scale were used in the assessment of product quality.

RESULTS AND DISCUSSION

The following are the results of experiment based on the factors such as size of cages and imbedding depth.

Cage Size (Factor-A)

Below is the tabular presentation and discussions of the results obtained from different treatments on the dependent variables under considerations.

Table 1. Growth, Survival Rates, and Physical Qualities Of Mangrove Crabs Based on Cage Size

Treatments (Cage Size)	Gain in Body Weight (g)	Growth Per Day (g)	Survival Rate (%)	Physical Qualities (Mean&Description)
t1 - (45cm-l X45cm-w X60cm-h)	269.31±4.70[a]	2.99	82.25±8.49[a]	4.80 - Excellent
t2- (61.0cm-l X61.0 cm-w X75cm-h)	274.20±4.36[a]	3.05	86.40±6.78[a]	4.81 - Excellent
t3-(76cm-l X76cm-w X90cm-h)	279.11±3.05[a]	3.10	88.90±6.78[a]	4.88 - Excellent

Treatment' means of the same superscript were not significantly different (p>.05)

Effects on Growth Rate

Highest mean gain of 279.11 g indicating 3.10 g growth per day was observed in treatment 3. Mean gained of 274.20 g indicating growth rate of 3.05 g growth per day was observed in treatment 2. The lowest mean gain was obtained in treatment 1 of 269.31 g indicating growth rate of 2.99 g per day. The increase of mean body weight in every treatment resulted in growth rate per day relatively higher than the reported growth rates of 1.55 g/day, 1.29 g/day, and 1.9 g/day (Muhammad K. Y. et.al. 2017). It was also higher than the obtained results of .69 g/day when reared at floating cages and .92 g/day when reared at bottom cages (Mwaluma J.M.& Arara B.K. 2021). There was no significant difference on gain of mean body weight observed in different treatments ($f=.172$, $p>0.05$). There were also no observed interaction effects on mean gain attributed by cage size and imbedding depth ($f= 1.592$, $p>0.05$). The coefficient of variation (CV) of 8.76% denotes high degree index of reliability (Gomez and Gomez 1984, Gregorio 2016).

Effects on Survival Rate

Highest survival rate was observed in treatment 3 of 88.90% followed by treatment 2 of 86.40 % and lowest was obtained from treatment 1 of 82.25%. The survival rates obtained in every treatment are relatively higher than the recorded survival rates of mangrove crabs of 60-83% obtained from trials (SEAFDEC 2013). It was also higher than survival rates of 63.8% when reared in floating cages and 44.9% in bottom cages (Mwaluma J.M. & Arara B.K. 2021). Furthermore, survival rates taken from all treatments were within the range of 80-100% which was considered ideal survivability (Miya M. Y. and Alam M. J. 2006; Kuntiyo, 1992). There were no significant difference survival rates of all treatments ($f=1.800$, $p>0.05$). There were also no interaction effects attributed by size and imbedding depth combine effects ($f=1.263$, $p>0.05$). The obtained CV of 10.91 % implies very high index of reliability (Gomez and Gomez 1984, Gregorio 2016).

Effects on Physical Qualities

The following are the results of physical evaluation of harvested crabs. As to completeness of appendages, all treatments obtained a mean value of 5.0. In meat content, treatment 1 got mean value of 4.6, treatment 2- 4.7 and treatment 3- 4.9. In meat color, treatment 1 obtained mean value of 4.7, 4.8 in treatment 2 and 4.9 in treatment 3. In meat taste, treatment 1 has mean value of 5, treatment got 4.8 and 4.7 in treatment 3. As to meat odor, treatment 1 obtained a mean of 4.7, mean of 4.71 in treatment 2 and 4.9 in treatment 3. The obtained ratings from different

variables collectively generated a grand mean of 4.80 for treatment 1, 4.81 for treatment 2 and 4.88 for t3 which were all verbally described as excellent.

Imbedding Depth (Factor-B)

Below are the tabular presentation and discussions of the results obtained from different treatments on the dependent variables under considerations.

Table 2. Growth, Survival Rates, and Physical Qualities of Mangrove Crabs Based on Cage Size

Treatments (Cage Size)	Gain in Body Weight (g)	Growth Per Day (g)	Survival Rate (%)	Physical Qualities (Mean&Description)
T1- 30cm	272.71±3.73[a]	3.03	81.25±8.34 [a]	4.82 - Excellent
T2-45cm	273.81±4.70[a]	3.04	87.40±7.22 [a]	4.80 - Excellent
T3-60cm	276.31+4.97[a]	3.07	88.99±5.10 [a]	4.90- Excellent

Treatment' means of the same superscript were not significantly different (p>.05)

Effects on Growth Rate

Highest mean gain of 276.31 g indicating 3.07 g growth per day was observed in treatment 3. Mean gained of 273.81 g indicating growth rate of 3.04 g growth per day was observed in treatment 2. The lowest mean gain was obtained in treatment 1 of 272.71 g indicating growth rate of 3.03 g per day. The increase of mean body weight in every treatment resulted in growth rate per day relatively higher than the reported growth rates of 1.55 g/day, 1.29 g/day, and 1.9 g/day (Muhammad K. Y. et.al. 2017). It was also higher than the obtained results of .69 g/day when reared at floating cages and .92 g/day when reared at bottom cages (Mwaluma J.M.& Arara B.K. 2021). There was no significant difference on gain of mean body weight observed in different treatments (f=.469, p>0.05). There were also no observed interaction effects on mean gain attributed by cage size and imbedding depth (f=1.592, p>0.05). The coefficient of variation (CV) of 11.85% denotes high index of reliability (Gomez and Gomez 1984, Gregorio 2016).

Effects on Survival Rate

Highest survival rate was observed in treatment 3 of 88.99% followed by treatment 2 of 87.40 % and lowest was obtained from treatment 1 of 81.25%. The survival rates obtained in every treatment are relatively higher than the recorded survival rates of mangrove crabs of 60-83% obtained from trials (SEAFDEC 2013). It was also higher than survival rates of 63.8% when reared in floating cages and 44.9% in bottom cages (Mwaluma J.M. & Arara B.K. 2021). Furthermore, survival rates taken from all treatments were within the range of 80-100% which was considered ideal survivability (Miya M. Y. and Alam M. J. 2006; Kuntiyo, 1992). There were no significant difference survival rates of all treatments (f=3.35, p>0.05). There were also no interaction effects attributed by size and imbedding depth (f=1.26, p>0.05). The obtained CV of 16.08 % implies very high index of reliability (Gomez and Gomez 1984, Gregorio 2016).

Effects on Physical Qualities

The following are the observed values on physical qualities of harvested crabs. Completeness of appendages – all treatments obtained mean value of 5.0. Meat content – treatment 1 and 2 were 4.7 and 4.9 in treatment 3. Meat color – treatment 1 and 2 were 4.8 and 4.9 in treatment 3. Meat taste – treatment 1 was 4.9, treatment 2 was 4.7 and 4.8 in treatment 3. Meat odor was 4.7 in treatment 1 and 2, and 4.9 in treatment 3. These obtained ratings collectively generated a grand mean of 4.82 in treatment 1, 4.80 in treatment 2 and 4.9 in treatment 3. These were all verbally described as excellent.

CONCLUSION AND RECOMMENDATIONS

The conclusions drawn from the findings are: growth and survival rates of mud crabs in three treatments obtained a mean value higher than the published growth and survival rates of the different cultural practices and research conducted. There were no significant differences on the growth and survival rates achieved by different treatments. The cage size and imbedding depth have not attributed any interaction effects on the growth and survival rates of mud crabs. The three sizes and imbedding depths of net cages produce mangrove crabs with excellent physical qualities. The adoption of this cultural innovation in growing mud crab is recommended to aquaculture entrepreneurs. The conduct of further studies on determining and improving of economic viability and scaling up of this method were also recommended.

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