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Study of Mud Crab Fattening in Earthen Pen Pond with Different Stocking Density

Chakraborty BK* and Sarker S

Department of Fisheries, Dhaka, Bangladesh

***Corresponding author:** Binay Kumar Chakraborty, Department of Fisheries, Dhaka, Bangladesh, Tel: 0088 01715 470855; Email: bborty@gmail.com

Research Article

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Abstract

The effect of stocking densities on the growth, survival and production of mud crab (*Scylla spp.*) was tested in a pen culture rearing system. The experiment was conducted for a rearing period of 90days in nine earthen pen culture ponds having an area of 1052 m^2 with an average depth of 0.98±0.14 m each. Mud crabs stocked at the rate of 0.02, 0.03 and 0.04 million.ha^{-1} were designated as treatment T_1, T_2 and T_3. At stocking, all crabs were with an initial mean carapace length, carapace width and weight of individual was recorded in three treatments. Highest mean carapace length, carapace width and weight gain was documented 6.60±0.51cm, 12.11±1.88cm and 330.62±7.26 g in treatment T_1 and lowest mean carapace length, carapace width and weight gain 6.18±0.36 cm, 10.02±2.28 cm and 252.52±3.44 g was in treatment T_3. Survival of individual followed the same trends as weight gain. Mud crab in treatment T_1 created significantly higher specific growth rate than treatment T_2 and T_3. Feed conversion ratio was significantly lowest in treatment T_1 followed by treatment T_2 and T_3 in that order. In despite of this, consistently higher net benefits were found from treatment T_1 than from treatment T_3 and T_2 and also significant ($P<0.05$). Overall, highest growth, survival, production and net benefit of mud crab were recorded at a stocking density of 0.02 million individual.ha^{-1}. Therefore, of the three stocking densities, 0.020 million individual. ha^{-1} appears to be most suitable stocking density for rearing of mud crab in earthen pen in pond culture system.

Keywords: Mud crab; Fattening; Stocking density; Carapace width; Growth; Survival; Benefits

Introduction

Various studies of mud crab aquaculture have been undertaken in the Indo-Pacific region [1]. In the Philippine, pond culture trial on the culture of mud crab to determine its optimum stocking density [2] and in polyculture with milkfish [3] has been practiced to yield economically viable production [4,5]. The most commonly cultured crab species is *Scylla spp.* due to its preference to estuarine habitats, less aggressive behaviour and higher value [6]. In Taiwan, *Scylla spp.* has been reared in both polyculture (together with shrimps, milkfish and rice) and monoculture ponds [6,7]. In Philippines, the species has been cultured in ponds [5,8-10] as well as in pens [2]. In East Malaysia, pen culture has been practiced where the mud crabs are allowed to grow in their natural habitat in enclosures in mangroves [11]. Pen culture is to be originated in the inland sea area of Japan in the early 1920's [12] and adopted by the People's Republic of China in the 1950's for rearing of carps in freshwater lakes [13].

From there, it has been successfully extended for the culture of tilapia and carp [14]. At present, it is commercially practiced only in the Bangladesh, Philippines, Indonesia and China [13].

Mud crab culture practice in Bangladesh is totally dependent on wild resource. Once the coastal area of Bangladesh was abundance of mud crabs. Due to over exploitation and various ecological changes in the mangrove area, the population of mud crab is decreasing day by day. The mangrove area is to be great stress and its existence is under danger because of changing aquatic ecosystems and habitat degradation. Indiscriminate destructive capturing crab practice and lower salinity have caused to destroy the aquatic biodiversity of coastal area. Mud crabs of the genus *Scylla* are importance as a source of delicious food and income throughout much of the tropical Indo-Pacific and as a consequence have been reduced, in both abundance and size, throughout much of their range [15-17]. The mud crabs of the coastal area were subjected to over fishing resulting in gradual decline in crab population [18]. To overcome the basic requirement of mud crab fry in the aquaculture field, crab hatchery should be established in the coastal region of Bangladesh. Until to establish crab hatchery, eco-friendly capture system of mud crab should be developed to continue gonad development of crab in pen and case culture [18].

The present study was under taken to evaluate the growth, survival and production of mud crabs with different stocking densities and to demonstrate the economic viability and profitability of different treatments under controlled pen culture management system.

Materials and Methods

Study Area and Experimental Design

An experiment of pen culture of mud was designed in net pens at the ponds of Kaligong, Satkhira; Morolgong, Bhagherhat and Sadar upazilla, Cox's Bazar; Bangladesh Figure 1.

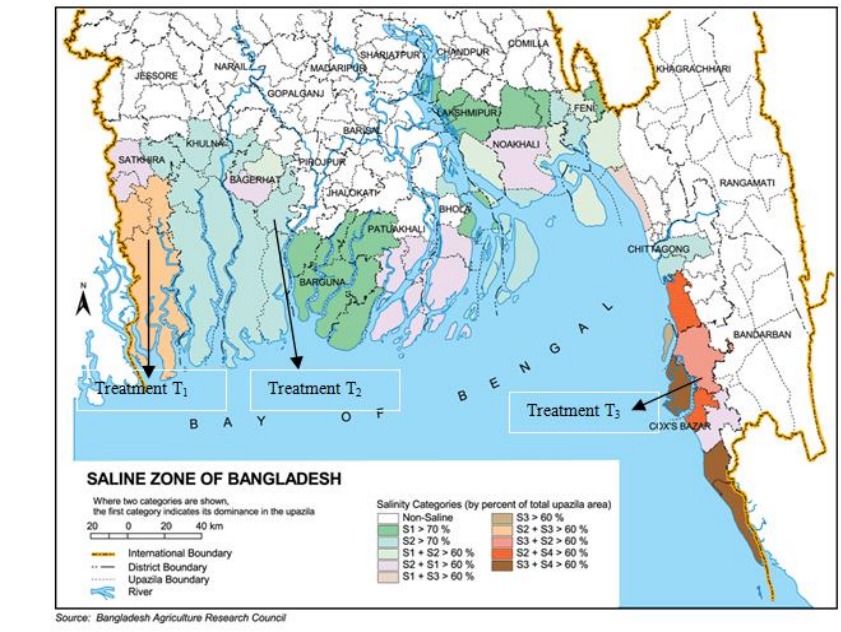

Figure 1: Location of Study area.

The study was conducted for a period of 90 days from October to December 2017 in nine pens of earthen pond. The area of pen was 1052 m^2 in each with an average depth of 0.98±0.14 m with a low turbidity, absence of pollutants, firm bottom condition and protection from high winds. The pen of ponds was encircled with bamboo slits made fence having similar rectangular size and depth. The bamboo slits was pushed into the mud up to 50cm depth to prevent escape burrowing of crabs. The pen was fenced with monofilament nets of mesh size 5 mm. The net was fixed to the bottom and supported with wooden pole. The height of the enclosures was

maintained at 1.2 m during unfavourable climatic conditions. Saline water exchange in these enclosed water bodies was connected by tidal fluctuation. Three treatments with three replicates each were designed and differing in stocking densities were 2.0 m2 (treatment T1), 3.0 m2 (treatment T2) and 4.0 m2 (treatment T3).

Pond Preparation, Stocking and Fertilization

The dyke and gate of the ponds were repaired and the ponds were exposed to full sunlight and had a well designed system of inlet and outlet. After drying, quicklime ($CaCO_3$, 250kg.ha^{-1}) was spread over the pond bottom. All the ponds were filled with saline water Figures 2a-2c. Five days subsequent to liming, the ponds were fertilized with muster oilcake at the rate of 124.0kg.ha^{-1}. The experimental ponds were stocked with an initial weight of 190.50±3.05gm old mud crab.

Figure 2a: Mud crab fattening in pen aquaculture system at Paikgacha.

Figure 2b: Mud crab fattening in pen aquaculture system at Kaligong.

Figure 2c: Mud crab fattening in pen aquaculture system at Sadar, Cox'sBazar.

Supplementary Feeding

In order to meet dietary demand, trash fish including tilapia as feed was supplied at the rate of (2-5)% of their total biomass twice daily commencing from the first day of stocking. The rate of feeding was maintained 5% depending on carapace width <7-8cm and 4% depending on carapace width <8-9cm, 3% depending on carapace width <9-10 cm and 2% depending on carapace width <10-11 cm. Daily ration was adjusted by estimating the standing crop once in each fortnightly by random sampling of the stock.

Water Quality Parameters

Physico-chemical parameters of pond water were monitored fortnightly between 9.00 and 10.00 h. A caliper was used to measure the carapace width. Water temperature was recorded using a Celsius thermometer and salinity of water was measured by Refactometer. Dissolved oxygen and pH were measured directly using a digital electronic oxygen meter (YSI, Model 58, USA) and an electronic pH meter (Jenway, Model 3020, UK).

Development of Habitat

To control cannibalism of crab a well established shelter was developed. Plastic pipe and grass culture acted as crab shelters, minimizing mortality and loss of stock due to cannibalism [19]. Point out that the application of crab shelters increased survival by minimizing antagonistic encounters.

Estimation of Growth, Survival, Production and Feed Utilization

Total yield (kg) and number of crabs harvested from each pen of the pond were recorded. Ten percent of the population from each pond was randomly sampled and

individually weighed with the help of a portable sensitive balance (Model HL 400 EX) and measured for carapace length (CL) and carapace width (CW) with a measuring scale until they attained marketing size. The growth, apparent feed conversion ratio (FCR), survival, average daily gain (ADG) and specific growth rate (SGR) was estimated. SGR and FCR were calculated according to Brown [21]; Castell & Tiews [22] and Gangadhara, et al. respectively [23]. After 90 days, the crabs were harvested by trap and draining or drying the ponds. The number of species were counted and weighed. Survival (%) and production (wt.ha^{-1}) of crabs were then calculated and compared among the treatments.

Economic Analysis

The cost analysis was in terms of hectare to maintain a standard unit. Cost-return and partial budgeting analyses were done to compare the viability and profitability of the various treatments used [24].

Analysis of Experimental Data

The data were analyzed through one way analysis of variance (ANOVA) using MSTAT followed by Duncan's New Multiple Range test to find out whether any significant difference existed among treatment means [25,26,27].

Results

Water Quality Parameters

Pond water quality did not vary much among the three treatments. Values recorded for the duration of the experiment were: temperature, 18.30 to 29.5^{0}C; salinity, 8.6 to 18.4 ppt; DO. 4.8 to 6.2 ppm; pH, 7.7 to 8.8. The values were within the ranges reported by Trino, et al. [10] and were generally within the acceptable ranges of mud crab culture [28].

Growth, Feed Utilization and Production of Fish

The growth and production of crabs in term of gain in weight under three treatments were investigated and monitored fortnightly. The results obtained are presented in Table 1, Figures 3-5 which indicated that the growth in terms of weight showed much variation in different treatment and continued till final harvesting. No formulated feed was used in this experiment. During the study, final weight of crab was recorded to be 330.62±7.26, 291.22±4.01and 252.52±3.44g in treatment T_1, T_2 and T_3, respectively. The increase in weight mud crab was the highest in T_1 followed by T_2 and T_3, respectively. The initial carapace length, carapace width and weight (4.04±0.43 cm, 7.12±0.34 cm and 190.50±3.05 g) of crab stocked in all the ponds were the same. The crab in treatment T_1 showed the highest gain in carapace length, carapace width and weight (6.60±0.51 cm, 12.11±1.88 cm and 330.62±7.26 g) compared to the treatments T_2 and T_3, where stocking density of mud crabs was 0.020 million.ha^{-1}. However, the mean final weights of mud crab in different treatments were significantly different (*P<0.05*). SGR in treatment T_1 was significantly higher than in T_2 and T_3 (*P<0.05*). Food conversion ratio was significantly lower in T_1 than T_2 and T_3. Therefore, best SGR (1.39±0.04) and FCR (2.05±0.02) were recorded in treatment T_1 where lowest number of juvenile of crab was reared. The highest survival rate (79.10±4.35) was also observed in T_1 and the lowest (51.52±1.67) in T_3. There was a significant variation (*P<0.05*) in the survival rate of crabs among different treatments. The net production of crab was (5231.00 ±2.28 kg), (5280.00±5.75 kg) and (5204.00 ±6.85kg) ha^{-1}.days^{-90} in treatment T_1, T_2 and T_3 respectively. Total production of mud crab was recorded to be more or less in three treatments. On the other hand, highest number of crabs was stocked in treatments T_3 where lowest survival rate was recorded. But no significant (*P<0.05*) different was recorded in case total production in three treatments Table 1.

Parameters	Treatments		
	T_1	T_2	T_3
Initial carapace length (cm)	4.04±0.43 (3.50-4.52)	4.04±0.43 (3.50-4.52)	4.04±0.43 (3.50-4.52)
Final carapace length (cm)	6.60±0.51 (6.20-7.12)	6.32±0.32 (6.11-6.58)	6.01±0.36 (5.98-6.14)
Initial carapace width (cm)	7.12±0.34 (7.00-.11)	7.12±0.34 (7.00-8.11)	7.12±0.34 (7.00-8.11)
Final carapace width (cm)	12.11±1.88 (11.50-12.60)	11.22±2.10 (10.80-12.02)	10.02±2.28 (9.77-11.22)

Initial body weight (g)	190.50±3.05 (181.50-210.60)	190.50±3.05 (181.50-210.60)	190.50±3.05 (181.50-210.60)
Final body weight (g)	330.62±7.26^{a} (280.18-360.64)	291.22±4.01^{b} (240.14-311.18)	252.52±3.44^{c} (218.02-282.22)
Net weight gain (g)	140.12±3.01^{a} (132.10-162.22)	100.72±3.228^{b} (91.10-112.32)	52.02±3.34^{b} (46.01-61.82)
Average daily gain(g)	1.56±0.03^{a} (1.50-1.64)	1.12±0.04^{b} (1.01-1.32)	0.58±0.05^{c} (0.50-0.65)
Specific growth rate	0.61±0.01^{a} (0.55-0.62)	0.47 ±0.01^{b} (0.45-0.48)	0.31 ±0.01^{c} (0.30-0.32)
Survival rate (%)	79.10±4.35^{a} (75.20-83.80)	60.44±2.67^{b} (58.80-63.52)	51.52±1.67^{c} (50.12-53.36)
FCR	2.05±0.02^{a} (1.90-2.20)	2.34± 0.04^{b} (2.05-2.44)	2.62±0.05^{c} (2.50-2.80)
Production (kg.ha^{-1})	5231.00 ±2.28^{a} (5228.02-5232.35)	5280.00 ±5.75^{b} (5269.22-5290.66)	5204.00 ±6.85^{c} (5200.10-5207.8)

.61 0.47 0.31

Figure in the same row having the same superscript are not significantly different (P>0.05). Values in the parenthesis indicate the range.

Total crop of crabs harvested after 90 days.

Average daily gain (g) = (mean final weight - mean initial weight) / time interval (days).

Specific growth rate (SGR) = Ln mean final weight - Ln mean initial weight)/time interval (days) × 100.

FCR (Feed conversion ratio) = Total diet fed (kg) / total wet weight gain (kg).

Table 1: Survival, feed conversion ratio (FCR), Growth performance and production of *Scylla* spp. after 90 days of rearing; mean ± S.D. with ranges in parentheses.

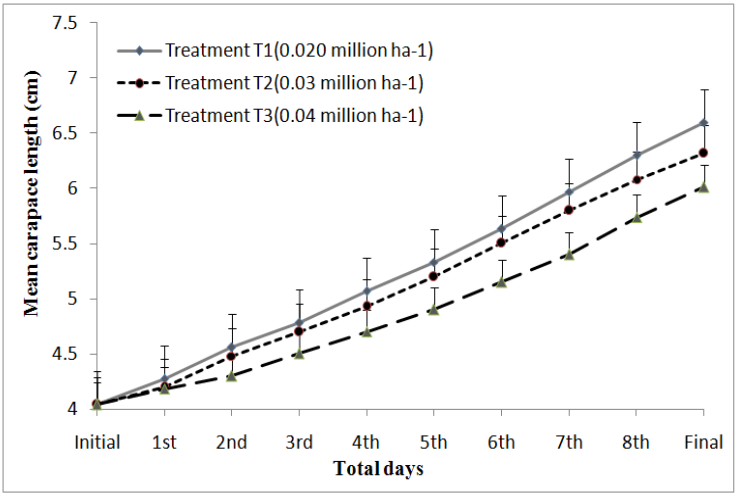

Figure 3: About 10 day's interval means carapace length (cm) of mud crab genera *Scylla* under different density.

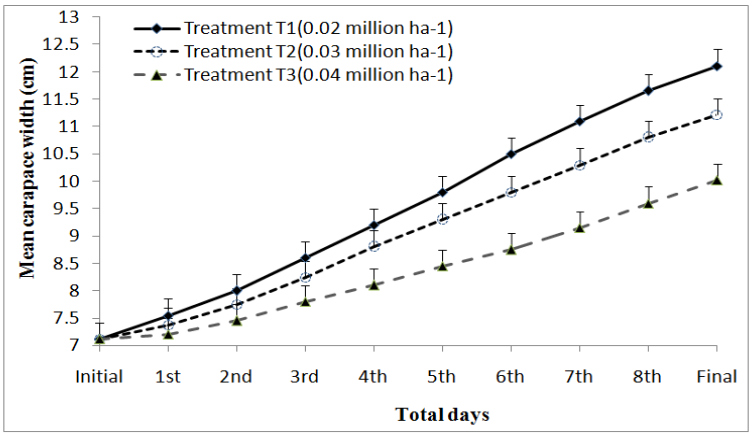

Figure 4: About 10 day's interval means carapace width (cm) of mud crab genera *Scylla* under different density.

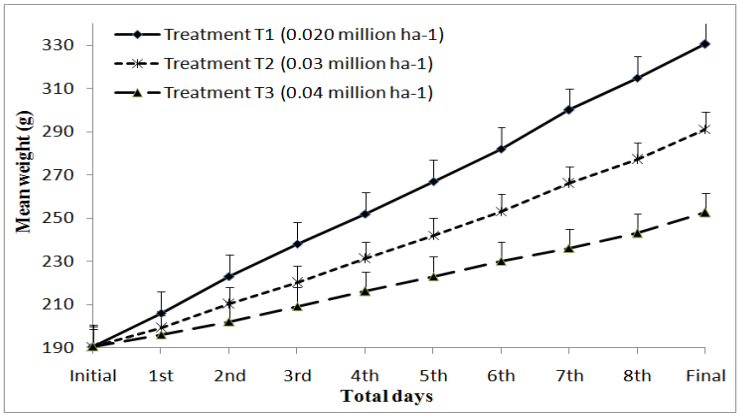

Figure 5: About 10 day's interval means weight gain (g) of mud crab genera *Scylla* under different density.

In Table 2, it is evidence that about 45.02, 50.55 and 52.43 % male was recorded and total production of male was 2606.00±2.28, 2789.00±4.88 and 2936.00±3.99 kg in treatment T_1 T_2 and T_3, respectively. On the other hand, female percentage was 54.98, 49.45 and 47.57% and total production of female was recorded at 2625.00±2.58, 2491.0±5.63 and 2268.00±3.58kg in treatment T_1, T_2 and T_3.

Species Name	Treatment T_1			Treatment T_2			Treatment T_3		
	Number (#)	Percentage (%)	Production (kg)	Number (#)	Percentage (%)	Production (kg)	Number (#)	Percentage (%)	Production (kg)
Male	7122	45.02	2606.00±2.28	9166	50.55	2789±4.88	10804	52.43	2936±3.99
Female	8698	54.98	2625±2.58	8966	49.45	2491±5.63	9804	47.57	2268±3.58
Total	15820	100	5231.00±2.28	18132	100	5280.00±5.75	20608	100	5204.00±6.85

Table 2: Identification of mud crab species, number, percentage and production of genera *Scylla* in three treatments *Scylla serrata Scylla olivacea*.

Total cost production in treatment T_1, T_2 and T_3 was recorded BDTk. 2799626, 2727932 and 4633931 respectively. On the other hand, cost of production in treatment T_3 was consistently higher than those treatments T_2 and T_1 (Table 3). Highest net return (in term of Bangladeshi Tk.ha^{-1} and one US$ = Bangladeshi TK. 84) was obtained in treatment T_1 (2954474) followed by T_2 (1132672) and T_3 (49669) in that order.

Item	Amount TK•ha^{-1}•day^{-90}			Remarks
	Treatment T_1 (Tk)	Treatment T_2 (Tk)	Treatment T_3 (Tk)	
Total return (TR)	5754100	4752000	4683600	Price is related with different grade (size and weight)
a. Variable cost:				
Price of crab	1524000	2286000	3048000	Tk. 400.kg^{-1}
Feed (Trash fish)	927600	990440	1070132	Tk. 60.kg^{-1}
Fertilizer, lime etc.	10015	10015	10015	
Human labour cost	40500	40500	40500	01 labor Tk.400.day^{-1}
Chemicals	5000	6380	6018	
Miscellaneous	20000	20000	20000	With netting
Total Variable cost (TVC)	2527115	3353335	4194665	
b. Fixed cost :				
Pond rental value	19800	19800	19800	Tk. 200.00 dec.$^{-1}$ according to local rate
Interest of operating capital	252711	246193	419466	10% interest according to BKB, Bangladesh
Total fixed cost (TFC)	272511	265993	439266	
Total cost (TC=TVC+TFC)	2799626	3619328	4633931	
Gross margin (GM= TR-TVC)	3226985	1398665	488935	
Net return (TR-TC)	2954474	1132672	49669	

[a]1 US$ = BDTk. 84.00

BKB = Bangladesh Krishi Bank

Figures with different superscripts in the same row varied significantly (*P<0.05*). Figures in the parenthesis indicate range. [b]Sale price Tk.1100.00 kg^{-1} (T_1), Tk.1000.00 kg-1 (T_2) and Tk.900.00 kg-1 (T_3).

Table 3: Cost and benefits from the mud crab of genera *Scylla* in 1-ha earthen pen of ponds for a period of 90 days.

Discussion

The stocking densities of the crab were 0.02 million.ha^{-1} (treatment T_1), 0.03 million.ha^{-1} (treatment T_2) and 0.04 million.ha^{-1} (treatment T_3), respectively; which were significantly compared to other trial cultures conducted in Taiwan by Chen, 1990. Cannibalism was found in different treatments which are agreed by [2,29,30]. They found common in mud crab culture when high stocking densities and mixed sex culture are practiced.

Survival of mud crab for the present study was recorded at the range from 50.12 to 83.80% which is agreed by Trino, et al. [10,31]. He reported that the loss of crabs grown in ponds can be relatively high, from 40% to 60%, if the stocking rates are high. The three stocking densities (0.02, 0.03 and 0.04 million ha^{-1}) for mud crab used in the study were within the range recommended by Trino, et al. [10]. In this study, the survival was comparatively lower due to higher stocking density and highly cannibalisom of mud crab during molting and post-molt crabs [20,19,32]. The pen in three treatments had a sandy and muddy bottom with pieces of plastic pipe and grass. In this study, plastic pipe and grass culture acted as crab shelters, minimizing mortality and loss of stock due to cannibalism [19]. Fielder, et al. point out that the application of crab shelters increased survival by minimizing antagonistic encounters [20].

Growth in terms of length, weight, weight gain and SGR of crab was significantly higher in T_1 where the stocking density was low compared to those of T_2 and T_3 although same food was supplied in all the treatments at an equal ratio. The low growth rate crab in treatment T_2 and T_3 appeared to be related with higher densities and increased competition for food and space and an inverse relationship with in the stocking density provided that space-limiting effects operate on the population [11,33,34]. In this study, at higher stocking densities, presence of abundant food substances could produce a comparative interaction among the population causing a stressful situation [35].

This experiment has shown that the crabs were able to grow in the pen, as indicated by the increase in SGR values in three treatments. Similar growth rates is recorded by Bensam [36] who found increase in weight ranging from 2.3 times to 3.5 times in a period of 90 days culture.

However the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities. Significantly higher survival was noted in treatment T_1, where, the stocking density was lower than T_2 and T_3. The reason for reduced survival rate in these treatments was due to higher stocking density of population as well as competition for food and space in the experimental ponds [36].

In the present study, a significant lower number of populations were stocked in treatment T_1 with 0.02 million.ha^{-1} than those of from the treatment T_2 and T_3 stocked with 0.03 and 0.04 million.ha^{-1}, respectively. Despite this, consistently higher net benefits were obtained from ponds stocked with 0.02 million.ha^{-1} than those from the treatment T_2 and T_3. The higher grade of mud crab was produced in treatment T_1 with 0.02 million.ha^{-1}, substantially increased the net benefit compared to smaller grade of crab that produced in other treatments with higher stocking densities [18,36]. Overall, highest growth, survival and benefits of pen culture were recorded at a density of 0.0.02 million.ha^{-1}.

The mangrove crab is omnivorous and feeds on raw crushed fish, crustaceans, bivalves, molluscs, penaeids and detrital matter. The application of trash fish as feed, the presence of naturally occurring food and muddy nature favoured the growth of mud crab [37]. Growth of crab to a greater extent depended on the quality of food available. No formulated feed was supplied in this study. Because price of formulated feed is more or less double of price of trash fish. In the present experiment, the amount of trash fish given in different treatments was based on the weight of crab stocked and amount of feed provided per individual was kept at the same level. Hence, the observed low growth at higher stocking densities could be due to availability of cannibalism character and some variations in environmental parameters [8]. The results in the present experiment are very similar to those of Escritor, Samonto & Agbayani, Mwaluma and Bensam and Chakraborty [5,18,30,36,37].

Partial budget analysis showed an increase in revenues and decreases in working capital when lower stocking density and monosex female crabs are used for culture. This resulted in a substantial net benefit can be earned from treatment T_1 [10]. Prices of mud crab in the Bangladesh are not stable and fluctuate depending on season and sex. The price is relatively higher during the months of November to March. The trend in market price indicates that female crabs are offered a much higher price, thus, widening the price margin between female and male [38].

Finally, it can be concluded that the survival, growth, production of *S. serrata* were inversely related to the stocking densities of crabs. Stocking density of 0.02 million.ha^{-1} (02 individual.m^{-1}) may be advisable for rearing of mud crab for 90 days culture period. The present study was undertaken to evaluate the growth, survival and production of crabs and to demonstrate the economic viability and profitability of the different densities [39,40].

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