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Growth and production performance of indigenous threatened cat fish, *Clarias batrachus* (Linn. 1758) based on stocking density in North Western Bangladesh

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Abstract
An experiment was conducted to assess the suitable stocking density of walking cat fish (*Clarias batrachus* Linn. 1758) for 90 days in nine earthen ponds situated at the hatchery complex, Department of Fisheries, University of Rajshahi. Each trial has three treatments. The fingerlings were stocked at 61750, 49400 and 37050 individual/ha in T_1, T_2 and T_3, respectively. The initial weight of fingerlings was 9.2±0.05g. The diets and feeding rates were same for all treatments. The net weight gain, SGR% and survival rate were found 21.78±0.15, 1.34±0.01 and 89.75±2.40% in T_1, 28.65±0.09, 1.57±0.02 and 90±1.58% in T_2 and 29.14±0.25, 1.58±0.01 and 92±2.41%, respectively in T_3, which were significantly (P>0.05) different among the treatments except survival performance. The highest net production was recorded from T_2 (1786.28 kg/ha) where the stocking densities were 49400 individuals/ ha^{-1}, and significantly lowest net production in T_3 (1498.2), due to low stocking densities. The net profit (Tk./ha/90 days) were significantly higher (P<0.05) in T_2 (337535). Water quality parameters such as temperature (^{0}C), transparency (cm), pH, dissolved oxygen (mg l^{-1}) and NH_3-N (mg l^{-1}) were monitored fortnightly. Mean values of the water quality parameters showed no significant differences (P>0.05) among the treatments in two trials except NH_3-N in trial one. Cost and benefit ratio were significantly highest (P<0.05) in T_3 (1:1.05) and lowest in T_1 (1:0.67). Present findings indicated that the production and net profit was significantly higher with treatment T_2 (49400 individuals/ha).

Keywords: Growth, stocking density, indigenous, *Clarias batrachus*

1. Introduction

Cat fish is one of the most important fish group in our country. It is getting increasingly popular showing future for commercial culture [1]. Cat fish is highly popular, delicious table fish. Due to its easy digestibility it is often recommended as diets for patients and convalescents. Cat fish is important due to its faster growth, easy culture system, disease resistance and tolerance to a wide range of environmental parameters [2]. Moreover, possession of accessory respiratory organs enable to breath in atmospheric air make the fish very hardy and could be cultured in swamps and derelict pond [3].

C. batrachus is a high valued, demandable marketing species having good nutrient values. In Bangladesh C. *batrachus* is commonly known as “Magur” and is available in all types of freshwater habitats such as rivers, canals, beels swamps and ponds. It breeds in shallow marginal waters of ponds, ditches and natural depressions [4-7]. and inundated paddy-fields during summer monsoon and rainy season, usually between May and August [8, 9]. *C. batrachus* inhibits in the fresh water of Bangladesh, India, Myanmar, Srilanka and Malayasia [10]. So this species may be suitable in seasonal ponds of Barind area of north western region in Bangladesh.

Commercially the culture of this fish is very much popular in South Asian countries viz. Thailand, Vietnam and India. However, in Bangladesh, very little attempt has been made for its commercial aquaculture, although, the hatchery techniques C. *batrachus* species has already developed. So it is appropriate time to explore the suitable culture technique of *C. batrachus* based on stocking density. Modern fish culture means improvement of culture practices through adopting different measures such as proper doses of fertilizer application, regular feeding, optimum stocking density, maintenance the physico-chemical factors, disease prevention and various control measures.

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It is very important to increase the production in pond fisheries with controlled water bodies as ponds and tanks through the introduction of modern and intensive culture method based on optimum stocking density.

During the grow out production, the stocking density of fry is an important for high survival and growth. Preliminary results indicated that density could be a factor during fingerling production of this fish species [10]. As such, it is important to investigate the optimum density of *C. batrachus* for better growth and survival during fingerling production. The density of fish during stocking determines the economic viability of all types of production systems. Several studies have addressed the issues of optimum stocking density for carps in Bangladesh. Reports on the stocking density of *C. batrachus* production are scarce. Hence this study was conducted to determine the optimum stocking size and density of *C. batrachus* based on growth, survival and biomass gain.

2. Materials and Methods

2.1Study location and Pond facilities

The experiment was performed in six earthen ponds of 45-48m^2 in the hatchery complex, Department of Fisheries, University of Rajshahi for a period of 90 days. The ponds were similar in shape, depth, basin configuration including water supply facilities. The water depth was maintained around 1.2-1.5 m.

2.2.Experimental design:

The experiment was conducted in a completely randomized design with two trial groups each having three treatments namely T_1, T_2, T_3, with three replications. The additional feed (commercial pellet feed; 27% protein level) provided to the fishes was same in first trial for each treatment, variation only in stocking density as shown in table-1. On the other hand; stocking density of *Clarias batrachus* in second trial for each treatment was same. The differences of different treatments were in providing feed quality as shown in table-1.

Table 1: Layout of the experiment

	Treatments
1st trial	T_1: 61,750 Individuals /ha^{-1} (6 Individuals /m^2)
	T_2: 49,400 Individuals / ha^{-1} (5 Individuals /m^2)
	T_3: 37,050 Individuals / ha^{-1} (4 Individuals /m^2)

After the completion of 90 days the fish was harvested and the result was analyzed.

2.3 Pond Preparation

All undesirable fish were completely eradicated by applying rotenone at a rate of 2.5 g m^{-3}. Aquatic weeds were removed manually. Lime (Calcium carbonate) was applied at the rate of 300 g ha^{-1} after one week of rotenone application. Lime was liquefied into an aluminum bucket and then applied by spreading homogenously in the ponds. Ponds were fertilized with urea and triple super phosphate (TSP) each at a rate of 25 kg ha^{-1} and cowdung at a rate of 1000 kg ha^{-1} after three days of liming. TSP was applied after dissolving in plastic buckets for 10 to 12 hours before application. Fertilizers were applied by spreading methods.

2.4 Collection of fishes

The Fingerlings of *C. batrachus* were collected from a private hatchery of the Madhupur Upazila of Tangail district in Bangladesh. The average weights of the fingerlings were 9.20±1.68 g Fingerlings were brought to the experimental site through plastic barrels with proper aeration.

2.5 Fry Stocking

Fingerlings were stocked at 61,750, 49,400, 37,050 Individuals / ha^{-1} respectively as shown in the Table-1. The fingerlings were transferred into plastic bucket and released into the experimental pond. The length and weight of around 10% of all fingerlings of each pond was measured and recorded for estimating initial stocking biomass and to adjust initial feeding rate for fishes.

2.6 Feeding of fishes

For the first trial the fishes were fed with homemade pellet feed (containing 27% crude protein) daily at a rate of 10% of body weight for 1st month, 8% of body weight for 2nd month and 6% of body weight for 3rd month. Half of the required feed for a day was supplied in the morning and rest half in the afternoon.

The inclusion rate and proximate composition of feed ingredients and experimental diets was analyzed according to the methods given in association of official analytical chemists [12] in table 2 and 3.

Table 2: Composition of feed used in the experiments

Ingredients	Protein percentage (%)	Inclusion rate (%)
Fish meal	55	25
Rice bran	12	15
Wheat bran	13	15
Mustard oil cake	31	20
Maize bran	12	15
Wheat flour	14	10

Table 3: Composition of feed used in the experiments

Components	Diets
Moisture	9.7%
Crude protein	26.9%
Crude lipid	12.6%
Crude fiber	15.5%
Ash	10.85%
NFE	28.85%

* Nitrogen free extract (NFE) calculated as
100-% (Moisture + Crude protein+ Crude lipid+ Crude Fiber+ Ash)

2.7. Fertilization

Urea and triple super phosphate (TSP) each were applied to the ponds at the rate of 6.25 kg ha^{-1} and cowdung 125 kg ha^{-1} at 7 days intervals throughout the cultured period.

2.8. Growth sampling of fish

Fishes were sampled fortnightly using seine net to assess their growth and health condition. At least 10 fish from each pond were taken to make assessment of growth trends and to readjust feeding rate. Length and weight of sampled fish were measured using a measuring scale and digital electronic balance (OHAUS, MODEL no. CT-1200-S) as shown in plate 1 and 2. Fishes were handled carefully to avoid stress during sampling. In the month of July after completing the first trial all the fishes were harvested by netting repeatedly with a seine net from each pond.

Plate 1: Measuring length of fish

Plate 2: Measuring weight of fish

2.9. Water Quality Monitoring

A number of water quality parameter such as temperature (^{0}C), transparency (cm), pH, dissolve oxygen (mg l^{-1}) alkalinity, ammonia-nitrogen (mg l^{-1}), were measured fortnightly at 9:00-10:00 am at the pond site to assess the physico-chemical condition of the pond.

2.10. Measurement of Physical Parameters

The transparency of water was measured by a Secchi disc of 20 cm diameter. The secchi disc was sunk into the water to the view of naked eye and then the length was measured in cm by a measuring scale. Water temperature was recorded from different layers of the pond by an ordinary Celsius thermometer (O^{o}C to 120^{o}C)

2.11. Methods of Chemical Analysis

pH of pond water was measured by a direct reading pH meter (HACH) at the pond site. The dissolved oxygen, total alkalinity and ammonia-nitrogen of water were measured by using a HACH Kit (DR/2010 model, HACH, Loveland, CO, USA, a direct reading spectrophotometer) at the pond site.

2.11. Growth Parameters

Several parameters (Weight gain, specific growth rate, survival rate, production of fishes) were used to evaluate the performance of fishes under different treatments.

2.12. Analysis of experimental data

The growth performance of the individuals were assessed in terms of length and weight. Mean weight gain, average daily gain (ADG), specific growth rate (SGR), Food conversion factor (FCR), Survival rate (%) and mean values($\pm$SD) for each parameter were computed. The term of conditioning factor (K) was calculated according to Ricker. Average daily gain (ADG) and (%) Survival were followed according to De silva [13]. SGR and FCR were calculated according to Brown [14], Ricker [15], Castell and Tiews [16], Hepher [17] and Gangadhara *et al.* [18] respectively. After three months, the fishes were harvested by repeated netting, followed by drying the ponds. The individual s were counted and weighed. Survival and production (number.ha^{-1}) of fishes were then calculated and compared among the treatment.

2.13 Statistical analysis

For the statistical analysis of data collected, one-way analysis of variance (ANOVA) was performed using the SPSS (Statistical Package for Social Science, evaluation version-15.0). Significance was assigned at the 0.05% level.

2.14. Economics analysis

A simple economic analysis was done to estimate the economic return in each treatment. The total cost of inputs was calculated and the economic return was determined by the differences between the total return (from the current market prices) and the total input cost. The cost in taka per unit yield (CPY) was calculated and was expressed as the cost in Tk/kg of fishes produced

3.Results

Water quality parameters of a large number of samples were analyzed in this experiment to observe any appreciable changes that might have occurred in response to different treatments. The overall mean values of each water quality parameter in different treatments are presented in table 4.

3.1 Transparency

The value of transparency ranged from 27.5±3.53 to 41.5±4.94 cm in treatment T_1, 32.5±3.53 to 42.5±3.53 cm in T_2 and 32.5±3.53 to 42±1.41 cm in T_3. The mean values of secchi depth (cm) were more or less similar among the treatments and those were 34.83±5.68, 35.75±3.68 and 37.17±3.68cm in T_1, T_2 and T_3 respectively, which were within the suggested value. There was no significant difference in the mean values among the treatments. Variation of water transparency among treatments is shown in table-4.

3.2 Temperature

The temperature of pond water was found to be more or less similar in different treatments. The mean values of temperature (^{o}C) were 34.92±1.81, 34.86±1.85 and 34.9±1.81^{o}C in T_1, T_2 and T_3, respectively. There was no Significant difference (P>0.05) in mean values among the treatments. The range of temperature varies from 33.2±0.28 to 37.12±0.03^{o}C in T_1, 32.15±0.07 to 37.25±0.07^{o}C in T_2 and from 32.22±0.03 to 37.05±0.07^{o}C in T_3.

3.3 Dissolved oxygen

The dissolved oxygen concentrations under different treatments were found to fluctuate from 4.26±0.08 to 5.57±0.14, 4.19±0.33 to 5.70±0.10 and 4.2±0.31to 5.90±0.5 mg l^{-1} in the treatment T_1, T_2 and T_3, respectively. The mean values of DO in treatments T_1, T_2 and T_3 were 5.02±0.45, 5.27±0.60 and 5.19±0.63mgl^{-1}, respectively. There was no significant difference among the mean values.

3.4 pH

The pH value fluctuated from 7.4±0.14 to 8.3±0.42, 7.85±0.21 to 8.4±0.42 and 7.7±0.42 to 8.9±0.14 in treatments

T_1, T_2 and T_3 respectively with the lowest value (7.3) observed on 30th June in T_1 and the highest value (9.0) was observed on 30th July in T_3. Mean values of pH did not show any significant difference (P>0.05) among the treatments. The mean values of pH in treatments T_1, T_2 and T_3 were 7.8±0.32, 8.03±0.21 and 8.25±0.44, respectively.

3.5 Total Alkalinity
Irregular fluctuations of total alkalinity were observed during the experiment. Mean values of total alkalinity were 122.6±10.82, 149.1±4.33 and 121.19± 19.87mgl^{-1} in T_1, T_2 and T_3, respectively. The mean values among the treatments were not significantly different. Total alkalinity of water was found to range from 109.95±6.29 to 141.5±28.99, 145±9.9 to 151.8±16.69 and 87.95±13.36 to 136±8.48mgl^{-1} in T_1, T_2 and T_3 respectively.

3.6 Ammonia-nitrogen
The mean values of ammonia nitrogen were 0.010±0.003, 0.013±0.003 and 0.020±0.002 mg l^{-1} in T_1, T_2 and T_3, respectively. The mean values were significantly different (P>0.05) among the treatments. It ranges from 0.006±0.007 to 0.015±0.007mg l^{-1} in T_1, 0.008±0.011 to 0.015±0.014mg l^{-1} in T_2 and 0.019±0.008 to 0.025±0.028mg l^{-1} in T_3.

Table 4: Mean values (±se) and ranges of water quality parameters of the ponds under three treatments. The range of observed values is given in the parentheses.

Parameters	Treatments		
	T_1	T_2	T_3
Transparency (cm)	34.83±5.68 ^{a} (25-45)	35.75±3.68 ^{a} (30-45)	37.17±3.78 ^{a} (30-43)
Temperature (^{0}C)	34.92±1.81^a (32.3-37.15)	34.86±1.85 ^{a} (32.1-37.3)	34.9±1.81 ^{a} (32.2-37.1)
pH	7.8±0.32 ^{a} (7.3-8.6)	8.03±0.21 ^{a} (7.6-8.7)	8.25±0.44 ^{a} (7.4-8.9)
DO (mg l^{-1})	5.02±0.45^a (4.2-5.67)	5.27±0.60 ^{a} (3.95-6.01)	5.19±0.63 ^{a} (3.98-6.25)
Total alkalinity (mg l^{-1})	122.6±10.82 ^{a} (103-162)	149.1±4.33 ^{a} (136-163.6)	121.19±19.87 ^{a} (78.5-142)
NH_3-N (mg l^{-1})	0.010±0.003 ^{c} (0.0-0.021)	0.013±0.003 ^{b} (0.0-0.025)	0.020±0.002 ^{a} (0.0-0.045)

Figures in the same row having same superscripts are not significantly different

3.7 Growth and production of *C. batrachus*
Growth performances, production and survival of *C. batrachus* in different treatments are presented in table 5 and 6. No significant variation was recorded in initial weight of fishes among the treatments. In the present experiment the average final weight were 30.98±1.21, 37.85±1.35 and 38.34±2.31g in T_1, T_2 and T_3 respectively. Weight increments were (P>0.05) statistically significant among the treatments. The highest growths in weight were observed in T_3 (38.34±2.31g) and the lowest in T_1 (30.98±1.21). The average The recorded specific growth rate of treatments T_1, T_2 and T_3 were 1.34±0.01, 1.57±0.02 and 1.58±0.01 respectively, which were significantly (P>0.05) different among the treatments. The average daily gain was found highest in T_3 (0.32±0.64) whereas, the lowest was found in T_1 (0.24±1.25). The average daily gain of treatments T_1, T_2 and T_3 were 0.24±1.25, 0.31±0.89 and 0.32±0.64 respectively, which were significantly different among the treatments. The survival net weight gain in T_1, T_2 and T_3 were 21.78±0.15, 28.65±0.09 and 29.14±0.25g, respectively.

Similarly, No significant (P>0.05) variation was recorded in initial length of fishes among the treatments. The average length was increased in T_1, T_2 and T_3 from 11.3±0.79 to 14.42±0.74, 11.03±1.01 to 16.2±1.23 and 11.3±0.96 to 16.35±0.96 cm respectively. The highest growths in length were observed in T_3 and lowest in T_1. The average net length gain in T_1, T_2 and T_3 were 3.12±0.55, 4.9±0.34 and 5.05±0.14 cm respectively.

rates during the experiment period were 89.75%, 90% and 92% in the treatment T_1, T_2 and T_3 respectively, which were not significantly different among the treatments. The mean net production recorded was 1689.4±389.2, 1786.28±295.4 and 1498.2±345.2 kg/ha in T_1, T_2 and T_3 respectively, with the highest net productions were observed in T_2 and lowest in T_3. The net productions are significantly different among the treatments.

Table 6: Growth, survival and production performance of *C. batrachus* among the treatments

Parameters	Treatments		
	T_1	T_2	T_3
SGR % (g. day^{-1})	1.34±0.01 ^{b}	1.57±0.02 ^{a}	1.58±0.01 ^{a}
DWG (g. day^{-1})	0.24±1.25 ^{b}	0.31±0.89 ^{a}	0.32±0.64 ^{a}
Survival rate (%)	89.75±2.40 ^{a}	90±1.58 ^{a}	92±2.41 ^{a}
Net production(kg/ha)	1,689.4±389.2 ^{a}	1,786.28±295.4^a	1,498.2±345.2 ^{b}

Figures in the same row having same superscripts are not significantly different

3.8. Economic analysis
The cost of different inputs and economic return from the sale of fishes in different treatments are summarized in table 7. The cost of inputs and economic return were calculated according to the local price of the inputs used and farm gate price of the fishes produced. The total cost of inputs and economic return per hectare were significantly different (P>0.05) among the treatments. The cost of input was lowest in T_3 and highest in T_1 and the net economic return was highest in T_2 and lowest in T_1. The cost per unit of yield ranged from 185.34 to 226.32 Tk/kg, which was significantly (P>0.05) different among the treatments the lowest was in T_3 (185.34 Tk/kg) and highest was in T_1 (226.32 Tk/kg). Similarly, the net profit per unit of yield was highest in T_3 (194.65 Tk/kg) and the lowest in T_1 (152.4 Tk/kg), which was significantly different among the treatments.

Cost and benefit ratio were calculated and it was 1: 0.67, 1: 0.98 and 1: 1.05 in T1, T_2 and T_3, respectively. Price of fry constituted highest operational cost. The cost of feed constituted the second highest and showed positive relationship with the stocking density.

Table 7: Input cost and economic return in *C. batrachus* for 90 days in ponds of three different treatments.

Components	Treatments		
	T_1	T_2	T_3
Fingerlings (Tk/ha)	184,880	1,61,349	1,10,928
Feed cost (Tk/ha)	1,35,730	1,18,152	105,006
Miscellaneous (Tk/ha)	61,750	61,750	61,750
Total cost (Tk/ha)	3,82,360 [a]	3,41,251 [a]	2,77,684 [b]
Total return (Tk/ha)	6,41,972 [a]	6,78,786 [a]	5,69,316 [b]
Net profit (Tk/ha)	2,59,612 [b]	3,37,535 [a]	2,91,632 [b]
Cost per unit of yield (Tk/kg)	226.32 [a]	191.04 [b]	185.34 [b]
Net profit per unit of yield (Tk/kg)	152.4 [b]	188.95 [a]	194.65 [a]
Cost and benefit ratio	1:0.67 [b]	1:0.98 [a]	1:1.05 [a]

Figures in the same row having same superscripts are not significantly different

4. Discussion

4.1. Water quality parameters:

Aquaculture, culture of fish and other commercial important aquatic organisms, depends almost completely on the qualities of water, i.e. qualities of aquatic environment. Growth, survival and feed consumption of prawn are normally governed by few environmental factors [19, 20] which is equally true for fish.

Water transparency is a gross measure of pond productivity. It has an inverse relationship with the abundance of plankton. Boyd [21] recommended a transparency between 15 to 40 cm as appropriate for fish culture. Wahab *et al*. [22] suggested that the transparency of productive water should be 40 cm or less. The mean values of secchi depth (cm) were more or less similar among the treatments and those were 34.83 ± 5.68, 35.75 ± 3.68 and 37.17 ± 3.68 cm in treatments T_1, T_2 and T_3 respectively. Viveen *et al.* [23] and Haque [24] recorded transparency 17-32 and 20-35cm, respectively in catfish rearing ponds. The transparency values of different treatment in the present study indicated that pond water seemed to be within the productive range for catfish culture.

In Bangladesh fish grows all the year round and there is no problem of very low temperature but sometimes extremely high temperature kills fishes especially in a shallow and turbid waterbody [25]. Quddus and Banerjee [26] denoted that the water temperature between 29 °C and 32 °C is suitable for the faster growth of fish spawn and aquatic organisms under natural conditions. Rahman *et al.* [27] found water temperature ranged 25.5 °C to 30.0 °C, which is favorable for fish culture. The mean values of temperature (ºC) were 34.92± 1.81, 34.86 ± 1.85 and 34.9 ± 1.81 ºC in treatment T_1, T_2 and T_3 respectively, which were slightly high from the recommended suitable range. Britz and Hecht [28] obtained higher growth rates between 25 ºC and 33 ºC the best was at 30ºC. However, Viveen *et al.* [29], Sarkar [30] and Haque [31] recorded temperature 20-30 ºC, 28-31 ºC and 24-33.9 ºC respectively in catfish ponds, which is comparatively lower than the present study; this might be due to low rainfall and the experiment conducted in summer season.

The circum-neutral pH or slightly alkaline pH is most suitable for fish culture. An acidic pH reduces the growth rate, metabolic rate and other physiological activities of fish [32]. pH 6.5 to 9.0 is suitable for pond fish culture more than 9.5 is unsuitable because free CO_2 is not available in this situation. Fish becomes easily attacked parasites and diseases when pH is less than 6.5 and at pH 11 fish dies. In the present experiment pH was around neutral to highly alkaline and it was due to local soil condition and heavy photosynthesis. The pH ranges from 7.3-8.6 in T_1, 7.6-8.7 in T_2 and 7.4-8.9 in T_3, which is in suitable range for fish culture. The pH value recorded from the experiment agreed with the findings of Sarkar *et al.* [33] and Haque *et al.* [34].

The DO concentration in the present study ranged from 3.95 to 6.25. During the period of investigation, the DO content was found sometimes lower which caused for respiration of plankton, heavy temperature and other aquatic organisms, as also reported by Sharma *et al.* [35]. The mean value of DO of was recorded 5.02±0.45, 5.27±0.60 and 5.19±0.63 mg/l^{-1} in T_1 T_2 and T_3 respectively. In the experiment the DO concentration ranged from 3.95 to 6.25 mg/l^{-1} which is fairly close with the findings of Sarkar *et al.* [36] and Haque *et al.* [37] who recorded the DO ranges from 3.87-5.85 mg/l^{-1}, 2.15-6.74 mg/l^{-1} and 1.10-6.80 mg/l^{-1} respectively under different treatments. The concentration of dissolved oxygen was fairly well as stocked fish did not show any sign of oxygen deficiency throughout the study period. In the present study the mean value of total alkalinity were recorded 122.6±10.82, 149.1±4.33 and 121.19±19.87 mg/l^{-1} in T_1 T_2 and T_3 respectively and it ranged from 78.5-163.6 mg l^{-1} which is more or less similar with the findings of Sarkar *et al.* [38] and Haque *et al.* [39] and Rahman [40] who recorded the values ranges from 81.25 to 147, 87.33-114.0 mg/l^{-1}, 41.0-208.0 mg/l^{-1} and 71.0- 175.0 mg/l^{-1} respectively. According to Boyd [41] total alkalinity should be more than 20 mg l^{-1} in natural fertilized ponds. The mean values of ammonia-nitrogen were 0.010±0.003, 0.013±0.003 and 0.020±0.002 mg l^{-1} in T_1, T_2 and T_3 respectively. The value ranged from 0.0-0.045 mg/l^{-1} which is more or less similar to Alam *et al.* [42], Ali *et al.* [43], Rahman [44] and Asaduzzaman *et al.* [45] who recorded ammonia nitrogen value ranged from 0.2 to 0.4, 0.2 to 0.37, 0.01 to 0.82, 0.203 to 0.569 mg l^{-1}, respectively. So, in the present study ammonia-nitrogen value was suitable for catfish culture.

4.2Growth and production performances of *C. batrachus*

Weight increments were (*P*>0.05) statistically significant among the treatments. The highest growths in weight were observed in T_3 (38.34g) where the fingerlings were stocked at the rate of 37050 individuals/ ha^{-1} and the lowest in T_1 (30.98g) due to highest stocking densities (61750 individuals/ ha^{-1}). The average net weight gain in T_1, T_2 and T_3 were 21.78±0.15, 28.65±0.09 and 29.14±0.25g, respectively. The highest growths in length were observed in T_3 and lowest in T_1.

The present experiment showed the highest growth rate in treatment T_3, which was stocked with lower densities although same food was supplied in all treatments at an equal ratio. This phenomenon indicated that there was a low community feeling among the fishes which influenced them to take food properly. Similar observation was also noted by various authors; Ahmed *et al.* [46] Haque *et al.* [47], Das *et al.* , [48] Sahoo *et al.* [49] and Chakrabarti *et al.* [50] who found maximum growth at low stocking densities. Whereas, Sarder and Mollah [51] gave a different opinion in case of *P. pangasius* that growth rate increased at higher stocking densities (6 and 9 fish /m^3) when compared with the lower one (3 fish /m^3). However, the reduced growth rate of higher stocking densities might be due to over crowed conditions or presence of water-brone, fish produced substances [52, 53]. Moreover, at higher stocking densities, presence of abundant food substances could produce a comparative interaction among the fish causing a stressful situation [54].

The specific growth rates (% per day) of *C. batrachus* were significantly influenced by the stocking density. The SGR value (1.34) in T_3 was very low and significantly higher (P<0.05) SGR (1.58) were found in T_3. The average daily gain was found highest in T_3 (0.31g) whereas, the lowest was found in T_1 (0.21g), which were significantly (P>0.05) different among the treatments.

The water quality in ponds of all treatments was within the acceptable limit and the size of and the health of the fingerlings at stockings was good that made high survival rate. The survival rates were 89.75%, 90% and 92% in T_1, T_2 and T_3 respectively, which were not significantly different among the treatments. The present study showed comparatively highest survival rates in lowest stocking densities. These findings have similarities with the findings of Samad *et al*. [55], Alam *et al.* [56]. Their study had 87 to 90% and 80 to 84% survival rate, respectively of *H. fossilis* during the different feeding trial. Similar observations are also made by Mollah [57] Barua [58] and Ita *et al.* [59] for *C. batrachus.*

The mean net productions were ranged from 1498.2 to 1786.28 kg/ha among the treatments. The highest net production was recorded from T_2 (1786.28 kg/ha) where the stocking densities were 49400 individuals/ ha^{-1}, and significantly lowest net production in T_3 (1498.2), due to low stocking densities. Samad *et al.* [60] found highest net production of 1710.00 kg/ha during the *H. fossilis* culture period of three months in earthen ponds. The net production obtained from the present study more or less similar with the author Haque *et al.* [61] who got total production of fish ranged from between 1398.08 and 2145 kg/ha after six month rearing through providing commercial pellet feeds.

Economics and profitability:

The cost of feed constituted the second highest and showed positive relationship with the stocking density. The cost of input was significantly highest (P<0.05) in T_1 (3, 82,360) and lowest in T_3 (2, 77,684 Tk/ha) and. The net profit was significantly highest (P<0.05) in T_2 (3, 37,535) and lowest in T_1 (2, 59,612 Tk/ha). Haque *et al.* [62] gained net profit ranged between 1, 15,047 to 2, 71,178 Tk/ha. The net profits, obtained from the present study are much higher than the author which might be due to uprising market price of *C. batrachus*. Cost and benefit ratio were significantly highest (P<0.05) in T_3 (1:1.05) and lowest in T_1 (1:0.67). Samad *et al*. [63] recorded the CBR of *Clarias batrachus* culture was higher (1:1.24) when feed containing 30% protein used. Samad *et al.* [64] also reported the CBR of *Heteropneustes fossilis* culture was higher (1:1.91) in 31% protein level of the feed in earthen ponds of Bangladesh.

5. Conclusion

An experiment was carried out to evaluate the growth survival and production of *C. batrachus* on different stocking density of *C. batrachus* for a period of three months in earthen ponds with three treatments group each with three replications. Therefore, on the basis of growth performance, production of fishes and profitability of culture system, it can be concluded that the stocking density at 49400 individuals/ h^{-1} might be recommended as the best density for culture of air breathing walking catfish in north western region. The unutilized seasonal small ponds in different areas of Bangladesh can be used for culturing this threatened species, which will ultimately change the livelihood of the rural people.

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