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Growth and yield performance of a sustainable aquaculture of Cuchia, *Monopterus cuchia* (Hamilton) under semi intensive aquaculture in Bangladesh

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ABSTRACT

Production potential of Monopterus cuchia in semi-intensive monoculture system was studied at a stocking density of 51 fingerlings m^{-2}, 42 fingerlings $m^{-2}$and 33 fingerlings m^{-2} fingerlings, in the treatment $T_{1,}$ T_2 and T_3 for a period of 240 days at Bharhatta, Netrokona; sadar, Gopalgonj and Jinaigati, Sherpur, Bangladesh to find out a new culture technology on a sustainable aquaculture method of cuchia fish. About eight small ditches with an area of 33.45 m^{-2} were selected for the experiment accommodating two replications for each treatment. At stocking, all fingerlings were of same age with a mean weight of M. cuchia 99.20±10.98g production in treatment $T_{1,}$ T_2 and T_3 were 352.0±6.66, 377.0±5.24 and 376.0±3.82 kg.ditch^{-1} respectively after 240days. Food conversion ratio was significantly lower in T_1 (2.16±0.06) than T_2 and T_3. Relative growth (RG) was significantly higher in treatment T_3(2.56±1.02) than treatment T_2 and $T_{1.}$ The mean differences of gross yield among different treatments were significant (P<0.05). The net monitory profit of treatment $T_{1,}$ T_2 and T_3 were -3670, 18566 and 34890 Tk.ditch^{-1}.after 240 day, respectively. The mean differences of net monitory profit among different treatments were also significant (P<0.05). Despite the yield values, it is advocated that M. cuchia culture is a sustainable aquaculture technology to meet up the protein deficiency, earn foreign currency and socio-economic status of the general people of Bangladesh and extremely helpful towards the protection of M. cuchia from extinction as well as for its conservation.

Keywords: Cost and return, ditch, growth, monopterus cuchia, net monitory profit, production, stocking density, survival

Monopterus cuchia is an important freshwater air breathing, swamp mud eel fish. It commonly occurs in the freshwater of Bangladesh, Pakistan, Northern and Northeastern India and Nepal. Once, indigenous *M. cuchia* was abundant throughout the Bangladesh, plenty in mud holes in shallow "beels" and 'boro' paddy field particularly in old Sylhet, Mymensingh and Tangail Districts (Rahman, 1989). But now a day this fish is often found in the open water area. ICUN, Bangladesh (2000) enlisted *M. cuchia* as vulnerable species in this country. The biodiversity, natural ecosystem of natural water bodies are being decreased due to global warming and climate change. *M. cuchia* is enlisted as threatened species (Diaster, 1990; Chakraborty *et al.,* 2010) in Bangladesh because of destruction of the natural habitats, horizontal expansion of agriculture and aquaculture, use of chemicals, fertilizer and pesticide, infrastructure development and over exploitation and various ecological changes in its natural habitat. *M.cuchia* is exported to many countries of south East Asia and Europe. Cuchia is an important fish for the livelihood of Adivasi people in the terms of both for home consumption and trade. The tribal people belonging to the Garo, Hajong, Shawtali and Koch-Rajbongshi community believes this fish to be therapeutic one and traditionally use for treatment of various ailments, Viz. weakness, anemia, asthma, hemorrhoids and diabetes. Direct consumption of fresh blood of the fish is reported to cure weakness, anemia and asthma (Jamir and Lal, 2005; Kakoti *et al.*, 2006). Consumption of gall bladder of the fish either fresh or sun dried is believed to have anti-asthmatic and anti-rhinitic properties (Lohani, 2012). Curry prepared by cooking the flesh along with certain herbs or soup prepared from cooking the flesh alone are known to cure anemia, piles and diabetes (Saikia and Ahmed, 2012; Chakravorty and Kalita, 2012).

M. Cuchia fish is considered to be rich in nutrient contents. The average protein content per 100 gm of raw flesh is 18.7 gm, while the concentrations of other nutrients are 0.8 gm fats, 2.4 gm carbohydrate and 185 gm calcium (www.mcgill.ca). The caloric value of eel flesh is reported to be as high as 303Kcal.100 gm^{-1} (Nassar, 1997). 100 gm of fish flesh contains 1400 µgm of Retinol (Vitamin A_1), >450 µgm of Dehydroretinol (Vitamin A_2) and >3500µgm of Provitamin A[11] (www.genderaqua.fish.files). Plasma composition of cuchia fish reported the presence of 3.304-3.745 gm, 67.34-72.46 mg and 224.747-257.027 mg of protein, glucose and triglyceride per 100 ml blood, respectively. Presence of amino acids viz. Alanine, Arginine, Glycine, Histidine, Leucine and Methionine has also been reported from this species (Mishra *et al.*, 1977). For such nutritional importance, there is a tremendous demand of cuchia in the national and international market.

The production of cuchia can be increased through improvement and better management of shallow unused

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swamps and reservoirs. Development and extension of sustainable aquaculture technology can play a positive role in food security of the *Adivasi* people.

It is very important to update Indigenous Technical Knowledge (ITK) with science based knowledge to assess habitat, food and feeding habit, management of fry and fingerling and cuchia fish production and developed value chain; it will be a new horizon to develop a sustainable aquaculture of cuchia production.

Considering the importance of this species in nutritional, medicinary, economic and biodiversity point of view, its culture system should be sustained; and conservation and propagation in nature are considered through fisheries regulation. Reproductive biology of fish is essential for evaluating the commercial potentialities of its stock, life history, cultural practice and actual management of indigenous fishes (Lagler, 1956; Doha and Hye, 1970).

MATERIALS AND METHODS

Study area and experimental design

The experiment was conducted at the different prepared ditches (small ponds) with treatment T_1, T_2 and T_3, respectively. Treatment T_1 was designed as ditches of Bharhatta, Netrokona; treatment T_2 sadar, Gopalgonj and treatment T_3 Jinaigati, Sherpur, respectively. The volume of every ditch was 33.45 sq.m. Cuchia fingerlings were stocked into six ditches on 1 May 2016. Two replicate ponds were randomly assigned to each of three treatments. Culture of cuchia *was* tested for a period of 240 days.

Construction of cuchia culture ditch habitat

The volume of the ditch was 9.14 × 3.66 × 1.07m and selected in a higher place of farm or other area. Measuring volume 30cm was constructed firstly. After completion of 30cm depth, 61cm Berm (A berm is a mound of earth with sloping sides that is located between areas of approximately the same elevation) was built. Then the volume of 7.92 × 2.44 × 0.76m of ditch was constructed upto 0.46m. A fence was prepared and established it around the ditch to control the movement of cuchia fish. After construction and placing the fence of ditch, the ditch was covered with polythene and “Triple” upto the fence level.

The bottom of the ditch was prepared by four layers. First layer was filled with 80 per cent clay and 20 per cent loamy which will be 15cm in density, second layer was covered with compost (cowdung, straw and water hyacinth as per requirement, lime 6.0 kg, urea 3kg and TSP 6.0 kg); third layer was filled with 5-7 days dry banana leaf of 2cm and fourth layer was filled as same as first layer. Volume of 61cm berm was covered with 80 per cent clay and 20 per cent loamy. The level of outside and berm level of ditch was same. Now berm of the ditch was covered with grass and bamboo made chatai for shelter and protection from higher temperature (Figure 1). Cuchia usually make holes in the clay layer inside the ditch. Now 0.47m of the ditch was filled with water and the berm (embankment) of the ditch was always higher than the water level. Now carp or tilapia fry (Dhani pona) was released in the ditch to observe the water quality for 3 days.

Stocking

Fingerlings of cuchia was stocked in treatment T_1, T_2 and T_3 at a stocking density of per ditch 1700 (51 fingerlings.sq.m^{-1}), 1400 (42 fingerlings.sq.m^{-1}) and 1100 (33 fingerlings.sq.m^{-1}) fingerlings for a period of 240 days. At stocking, all fingerlings were of same age with a mean weight of *M. cuchia* 99.20±10.98g.

Supplementary feeding

In order to meet up the increasing dietary demand, different types of live feeds were used to achieve targeted production (Table 1). Cuchia consume fry of tilapia or carp, gutum fish, snail, tadpole, earthworm, apple snail of paddy field. Cuchia is nocturnal fish. It likes to feed at night. The feeds were supplied in a tray or plastic pipe 2.5 inch diameter and put it in the bottom of the water. Proximate composition of the feeds was analyzed according to AOAC (1995) method, nitrogen free extract (NFE) by subtraction (Castell and Tiews, 1980). Proximate composition (% dry matter) of the supplementary feeds (crude protein, crude lipid, crude fiber, ash and nitrogen-free extract) of dry fish or fishmeal was 32.31, 7.70, 10.17, 18.18 and 31.64 per cent, respectively. Feeds were supplied to the fish at the rate of (3-5)% of their total biomass twice daily in the early morning and evening commencing from the first day of stocking. Daily ration was adjusted by estimating the standing crop once in each fortnight by random sampling of the stock.

Water Quality Parameters

Physico-chemical parameters of pond water were monitored fortnightly between 9.00 and 10.00h. Water temperature was recorded using a Celsius thermometer and transparency (cm) was measured by using a Secchi disc of 20 cm diameter. 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). Total alkalinity was determined by titrimetric method (Clesceri *et al.*, 1989).

Table 1 : A chart of feeds item

Type of feed	Rate	Application method
Carp/Tilapia fry	5.00%	Between10 days
Dry fish (Fish meal)	1.50%	Alternative day
Earthworm, tadpole, insect, apple snail	1.50%	Alternative day

Table 2: Physico-chemical parameters of experimental ponds under three monoculture treatments of *Monopterus cuchia.*

Parameters	Treatment		
	T_1	T_2	T_3
Temperature (°C)	23.67±6.12(14.10-32.90)	23.94±6.11(14.15-33.4)	24.101±6.44(14.20-32.88)
Transparency (cm)	32.22±5.22[c](30.44-36.22)	26.22±4.88[b](24.18-29.55)	22.33±4.11[a](20.15-26.66)
pH	8.01±1.08(7.60-8.75)	8.06±1.06(7.70-8.80)	8.11±1.14(7.60-8.70)
Dissolved oxygen (mg l^{-1})	4.08±1.22(3.40-5.88)	4.01±1.44(3.51-5.55)	4.22±1.02(3.22-5.66)
Total alkalinity(mg l^{-1})	140.34±6.24[c](134.50-150.34)	148.52±6.05[b](143.44-155.08)	156.02±6.15[a](149.15-162.30)

Figures with different superscripts in the same row varied significantly (P<0.05). Figures in the parenthesis indicate range

Table 3: Survival and production of *Monopterus cuchia* species as obtained under three treatments during 240 days study.

Parameters	Treatments		
	T_1	T_2	T_3
No. of fish stocked ha^{-1}	1700	1400	1100
Initial length (cm)	29.20±8.98	29.20±8.98	29.20±8.98
Final weight (cm)	41.40±14.96[c]	42.80±13.69[b]	44.40±12.17[a]
Initial weight (g)	99.20±10.98	99.20±10.98	99.20±10.98
Final weight (g)	238.22±14.92[c]	296.25±13.69[b]	356.55±12.17[a]
Mean weight (g)	139.02±9.26[a]	197.55±8.06[b]	257.35±6.86[a]
Average daily gain (g)	0.58±03.	0.82±0.03	1.07±0.02
Relative growth (RG)	1.40±2.22	1.98±1.66	2.59±1.02
FCR	2.16±0.04	2.19±0.06	2.21±0.05
SGR (% $bw.day^{-1}$)	3.55±0.02	3.78±0.01	3.96±0.01
Survival rate (%)	87.0±2.28[c]	91.0±1.33[b]	96.0±1.47[a]
Total production ($kg.ditch^{-1}.day^{-240}$)	352.0±6.66[c]	377.0±5.24[b]	376.0±3.82[a]

Note: *Values in the same row having the same superscript are not significantly different (P>0.05). Values in the parenthesis indicate the range;Total number of fish harvested after 240 days;Relative growth (RG) = (mean final weight-mean initial weight)/ mean initial weight;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 (Food conversion ratio) = Total diet fed (kg)/ total wet weight gain (kg);Volume of one ditch = 33.45 sq.m*

Table 4: Cost and return of fish production under a monoculture management of *Monopterus cuchia* during 240 days study.

Item	Amount TK.ditch^{-1}.day^{-240}			Remarks
	Treatment T_1 (Tk)	Treatment T_2 (Tk)	Treatment T_4 (Tk)	
Total return (TR)^{b}	110880^{c}	126295^{b}	135360^{a}	Price related with size and weight
a. Variable cost: 1. Price of fingerlings	28900	23800	18700	
2. Feed	30600	29500	28000	
3. Human labour cost(Tk. 2500.00 month^{-1})	25000	25000	25000	
4. Habitat development	8000	8000	8000	
5. Miscellaneous	5000	5000	5000	
Total Variable cost (TVC)	97500	91300	84700	
b. Fixed cost : 1.Pond rental value	300	300	300	Tk. 400.00 dec^{-1}
2.Interest of operating capital	9750	9130	8470	10% interest according to BKB
3. Price of polythin and Threpol	7000	7000	7000	
Total fixed cost (TFC)	**17050**	**16430**	**15770**	
Total cost (TC= TVC+TFC)	**114550**	**107730**	**100470**	
Gross margin (GM= TR-TVC)	**13380^{c}**	**34995^{b}**	**50660^{a}**	
Net return (TR-TC)	**-3670^{c}**	**18565^{b}**	**34890^{a}**	

Note: *Values with different superscripts in the same row varied significantly ($P<0.05$). Values in the parenthesis indicate range. [a]1 US$ =Tk. 78.00; BKB= Bangladesh Krishi (Agricultural) Bank;Sale price of T_1 Tk. 315.00 kg^{-1}, T_2 Tk. 335.00 kg^{-1} and T_3 Tk. 360.00 kg^{-1};Volume of one ditch = 33.45 sq.m;Remarks: 2nd year production cost is 64000.00. So, total benefit would be increased.*

Fig. 1. A prepared Ditch of Cuchia, *Monopterous cuchia*.

Estimation of growth, survival, production and feed utilization

Harvest was conducted March through December, 2016 for 240 days. Total yield (kg) and number of cuchia harvested from each pond were recorded. About 10 per cent of the population from each pond was randomly sampled and individually weighed and measured for total length (TL) with the help of a portable sensitive balance (Model HL 400 EX) and a measuring scale until they attained marketing size. Growth in terms of weight, Relative growth (RG), Average daily gain (ADG), Specific Growth Rate (SGR) and Food conversion ratio (FCR) was estimated. SGR and FCR were calculated according to Brown (1957); Castell and Tiews (1980) and Gangadhara *et al.*, 1997, respectively. After 240 days, the table size fishes were harvested by trapping, followed by drying the ponds. Both the number of species were counted and weighed. Survival (%) and production (number/ditch) of fishes were then calculated and compared among the treatments.

Economic analysis

The cost analysis was in terms of hectare to maintain a standard unit. In calculating the cost, the variable (only material inputs) was used. The gross return from the pond was the sale proceeds of the total fish production.

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 (Duncan, 1955; Zar, 1984). In all statistical analysis, the difference was considered to be significant when $P<0.05$.

RESULTS AND DISCUSSION

Mean levels of physico-chemical parameters over the 300 days culture of *M. cuchia* is presented in table 1. The mean water temperatures in treatment T_1, T_2 and T_3 were not statistically significant ($P>0.05$) among different treatments during the study period. Mean Secchi

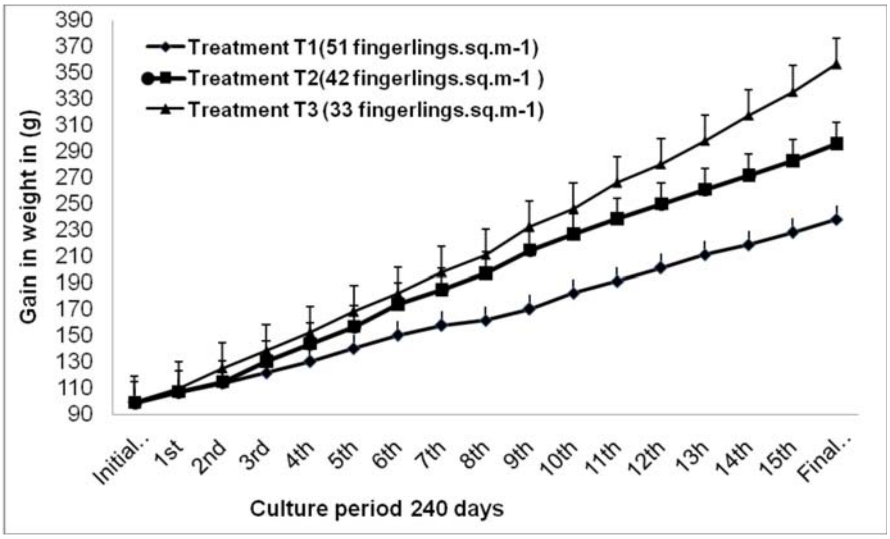

Fig. 2. Fortnightly mean length (cm) gain of Cuchia, *Monopterous cuchia* under three treatments during 240 days study

disk transparency was recorded suitable range in the treatment T_3 (22.33±4.11 cm) and differed significantly (P<0.05) among different treatments. The highest pH was recorded in treatment T_3 (8.11±1.14) and pH decreased from T_3 to T_1 but did not differ significantly (P>0.05). Highest range of dissolved oxygen was recorded in treatment T_3 (4.22±1.02 mg.l^{-1}) and lowest range of dissolved oxygen was recorded in treatment $T_{2.}$ However, there were no significant variations (P>0.05) in the value of dissolved oxygen among the treatments. Total alkalinity was found to be highest in treatment T_3 (156.02±6.15 mg.l^{-1}) and lowest in treatment T_1 (140.34±6.24 mg.l^{-1}) and differ significantly (P<0.05). Suitable range of total alkalinity was recorded in different treatment. Despite these variations, water quality parameters in all the experimental treatments were within the normal range for eel fish culture.

The growth and production of fishes in term of gain in length and weight under three treatments were investigated and monitored fortnightly. The results obtained are presented in table 2, which indicated that the growth in terms of weight showed much variation in each treatments and continued till final harvesting. During the investigation, final weight of *M. cuchia* was recorded to be 238.22±14.92, 296.25±13.69 and 356.55±12.17 g in treatment $T_{1,}$ T_2 and T_3, respectively. The increase in weight *M. cuchia* was the highest in T_3 followed by T_2 and T_1, respectively. The initial weight (92.20±10.98 g) of fingerlings, stocked in all treatments was same. The fish in treatment T_3 showed the highest gain in weight (356.55±12.17 g) compared to the treatments T_2 and T_1, where stocking density of fingerlings was 33 fingerlings.sq.m^{-1} (Figure 2 and 3). However, the mean final weight of fingerlings in different

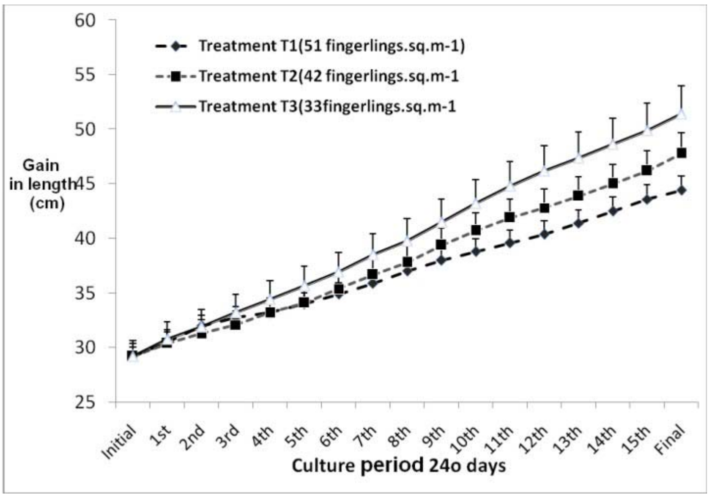

Fig. 3. Fortnightly mean weight (g) gain of Cuchia, *Monopterous cuchia* under three treatments during 240 days study.

treatments were significantly different ($P<0.05$). RG and SGR in treatment T_3 was significantly higher than in T_2 and T_1 ($P<0.05$). Food conversion ratio was significantly lower in T_1 than T_2 and T_3. Therefore, best RG, SGR and FCR were recorded in treatment T_3 where lowest number of fingerlings of *M. cuchia* (33 fingerlings m^{-2}) was reared. The highest survival rate was also observed in T_3 and the lowest in T_1. There was a significant variation ($P<0.05$) in the survival rate in cuchia individuals among different treatments. The net productions of eel were 352.00±6.66, 377.0±5.24 and 376.00±3.82 kg.dith^{-}1 days^{-240} in treatment $T_{1,}$ T_2 and T_3, respectively. Production was higher in treatment T_3 and lowest in treatment T_1. The growth rate of *M. cuchia* was relatively higher in treatment $T_{3,}$ which seemed be lower density of *M. cuchia* with sufficient food and space. Intermediate fish production results were obtained in treatments T_2, where second highest fingerling of *M. cuchia* was stocked. Highest number of fingerlings was stocked in treatments T_1, where lowest production was recorded and differed significantly ($P<0.05$) from T_3 and $T_{2.}$

A cost-benefit analysis was performed to estimate the amount of profit that has been generated from these three types of density operations. The results of the analysis are shown in $T_{1,}$ T_2 and T_3, respectively (Table 3). The cost of production in treatment T_3 was consistently higher than those of treatments T_1 and T_2. Highest net benefit (in term of one US$ = Bangladeshi TK. 78.00) was obtained in treatment T_3 (34890.00) followed by T_2 (18565.00). In second year to third year the production cost would be only Tk. 64000.00. So, total benefit of the all treatments would be increased.

According to Brett, 1979, growth, feed efficacy and feed consumption of fish are normally governed by a few environmental factors. The primary productivity of water body is dependent on physico-chemical factors of water, which are governed by environmental factors (Rahman *et al.*, 1982). The temperature of the experimental ponds was within the acceptable range for fish culture that agrees well with the findings of Boyd (1979). Transparency was consistently higher in T_3, possibly due to the reduction of the plankton population by higher density of fish. The close variation in transparency might be due to application organic manure and grazing pressure of stocked fishes (Boyd, 1979). The pH values agree well with the findings of APHA, 1998 and Chakraborty *et al.*, 2004. The dissolved oxygen in the morning was low in ponds stocked with a high density of fish compared to ponds stocked with a low density. Similar results were observed by APHA (1998). Alkalinity levels indicate productivity of the ponds was medium to high (Bhuiyan, 1970). Higher total alkalinity values might be due to application of higher amount of lime doses during the experimental period (APHA, 1998; Boyd, 1982; Jhingran, 1991).

In this experiment, same supplementary feeds were supplied for the growth of *M. cuchia* which is very much similar study of Chakraborty *et al.*, 2010. Growth in terms of weight, weight gain, RG and SGR of individuals of *M. cuchia* was significantly higher in T_3 where the stocking density was low compared to the treatments of T_2 and T_1 although same food was supplied in all the treatments at an equal ratio. The low growth rate of *M. cuchia* in treatment T_2 and T_1 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 (Johnson, 1965). In this experiment, at higher stocking densities, presence of abundant food could produce a comparative interaction among the population causing a stressful situation (Houde, 1975).

Cuchia often spend their day time hiding under stones and mud or having a burrowing habit (Nasar1997). Cuchia is a nocturnal carnivorous species, which normally feeds on live fishes, mollluscs and aquatic organism which is agreed by Narejo *et al.*, 2003.

During the experimental period, ecological factors, ditch preparation, feed quality, healthy fish and stocking rate was influenced the high percentage of survival rate of *M. cuchia* (Choudhury *et al.*,1978). Highest survival rate was recorded in treatment T_3 (Munshi, 1996; Chakraborty *et al.*, 2004, 2005). The FCR values of T_{-3} are significantly higher than those T_2 and T_3, respectively. The FCR values are reported by Das and Ray (1989) and Islam (2002). De Silva and Davy (1992) stated that digestibility plays an important rule in lowering the FCR value by efficient utilization of food. Digestibility, in turn, depends on daily feeding rate, frequency of feeding and type of food used (Chiu *et al.*, 1987). 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_3, where, the stocking density was lower than T_2 and T_1. The reason for reduced survival rate in these treatments was due to higher stocking density of individuals as well as competition for food and space in the water area (Tripathi *et al.*, 1979; Haque *et al.*, 1994 and Chakraborty *et al.*, 2006).

In this experiment, a significantly higher production (376.0±3.82 kg.ditch^{-1}.day^{-240}) were produced in treatment T_3 where stocked with 1100 fingerlings. ditch^{-1} of *M. cuchia* monoculture practice than those of from the treatment T_2 and T_1 stocked with 1400 and 1700 fingerlings.ditch^{-1}, respectively. Despite this, consistently higher net benefits (Tk.34890.00/-.ditch^{-1}.day^{-240}) were obtained from treatment T_3 than those from the treatment T_2 and T_1. Overall, highest growth, survival and benefits of *M. cuchia* monoculture practice were obtained from the treatment T_3. In the present investigation, the amount of supplementary feeds given in different treatments was based on the number of fingerlings 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 less availability of food and some variations in environmental parameters. The results in the present experiment are very similar to those of Munshi (1996), Vijayakumar *et al.* (1998), Usmani *et al.* (2003) and Chakraborty *et al.* (2005, 2010).

In conclusion, this study demonstrated that a sustainable monoculture technology of treatment T_3 is advisable for 300 days culture of *M. cuchia*. Production technology of *M. cuchia* fish through application of present findings might be developed the aquaculture field of Bangladesh, meet up the protein deficiency and earn foreign currency to develop socio economical condition of the general people of Bangladesh and extremely helpful towards the protection of *M. cuchia* from extinction.

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