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DEVELOPMENT OF SUSTAINABLE CAGE CULTURE TECHNIQUE OF STINGING CATFISH (*HETEROPNEUTES FOSSILIS*) IN SOUTHERN COASTAL REGION OF BANGLADESH

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ABSTRACT
A research work was conducted during two separate times in three treatments with three replications to develop a sustainable cage culture technique of stinging catfish (*Heteropneutes fossilis*) in southern coastal region of Bangladesh. Two treatments (T_1 & T_2) were set-up in the Angaria khas khal during the time of 133 days (04 May to 14 September) in 2014 and another treatment (T_3) was installed in the pond at PSTU campus for similar duration (25 February to 07 July) in 2015 at Dumki in Patuakhali, Bangladesh. Hatchery produced fingerling was stocked at the rate of 600 and 750 in each cage of T_1 and T_2 while natural fingerlings was stocked in T_3 at the rate of 600 in each cage. Industrial pellet feed was applied as the demand of fish once in a day at 1600 to 1700 hrs for all treatments. Some physico-chemical parameters were recorded and analyzed which were suitable ranges during the study period. Production performance especially growth rate, weight gain, survival rate, FCR and SGR were measured and the average productions were recorded 4.504 $kgcage^{-1}$, 3.86 $kgcage^{-1}$ and 25.987 $kgcage^{-1}$ while survival rate were calculated 18.40 %, 16.66% and 94% in T_1, T_2 and T_3 respectively during the study period. The growth rate and production, survival rate, weight gain and FCR were found significantly higher in T_3 due to facilitate supporting materials as shelter and resting place in all cages before stocking fish. Therefore, T_3 is an advisable technique for sustainable cage culture of *H. fossilis*.

KEY WORDS: Development, Cage culture, Stinging catfish, Shelter, Production

INTRODUCTION

There is a common phenomenon to create fissures naturally in the ponds and water reservoirs where tidal water entrance and up-down two times daily which is an immense problem for stinging catfish (*Heteropneutes fossilis*) culture in ponds in the southern coastal region of Bangladesh. Moreover, this fish can escape from the aquaculture ponds to the natural open water through these types of fissures. Stinging catfish can survive in semi-liquid and semi-dry mud during the dry season, and even when the mud dried up they conceal their bodies to the bottom mud, fissures of embankment and crevices formed by the cracking mud (Rahman *et al.* 2013) and make problems during harvesting. Among the air-breathing fishes, stinging catfish *Heteropneutes fossilis* (Bloch) belongs to the family Heteropneustidae is a very popular and commercially important fish species in Bangladesh. It is primarily a fish of ponds, ditches, beels, floodplains, swamps and marshes, though sometimes it is found in muddy rivers (Jha and Rayamajhi, 2010; Froese and Pauly, 2012). In recent years, the availability of wild *H. fossilis* has declined due to destroy of aquatic bio-diversity (Hussain and Mazid, 2001), over exploitation, application of pesticides in rice fields, release of chemical effluents from industrial plants and ecological changes in its natural habitats (Khan *et al.*, 2003; Kohinoor *et al.*, 2012); and now it is one of the threatened fish in Bangladesh (IUCN Bangladesh, 2000).

This fish is locally known as shing and it can tolerate slightly brackish water. This fish is considered to be highly nourishing, palatable and tasty and well preferred due to its less spine, less fat and high digestibility (Khan *et al.*, 2003). It contains high content of protein, iron (226 mg 100g-1), calcium and low amount of fat compared to many other freshwater fishes (Saha and Guha, 1939; Alok *et al*, 1993; Kohinoor *et al.* 2012); and it is recommended in the diet of sick and convalescents. It is considered as an ideal fish species for aquaculture due to its fast growth, high market value, ability to survive in low oxygen content and high stocking densities, adapts well to hypoxic water bodies, high protein and iron content, low fat and high medicinal values (Dehadrai *et al.*, 1985; Alok *et al.*, 1993; Vijayakumar *et al.*, 1998; Haniffa and Sridhar, 2002; Froese and Pauly, 2012). It is a very hardy fish, can respire aerially by gulping in air (Munshi, 1993) and can survive for quite a few hours outside the water due to presence of accessory respiratory organs (Kohinoor *et al.*, 2012). Aquaculture of *H. fossilis* has not been well flourished in Bangladesh due to lack of appropriate culture techniques, though this fish has enormous aquaculture potential and it could be easily grown in ponds and small ditches. Although the market demand of this air breathing fish is extremely high, nevertheless very little attention has been paid to develop culture techniques of this species. Even though, there is no cage culture technique available in the world for this popular fish species. Earlier accounts on this fish species comprises seasonal morphology of gonads in relation to the biology (Azadi and Siddique, 1986; Kuddus *et al*., 1995), induced breeding (Thakur *et al*., 1977; Saha, 1998; Rahman *et al*. 2013; Ali *et al*., 2014), food and feeding habits (Kuddus *et al*., 1995), nutrition (Hossain *et al*., 1993; Anwar and Jafri, 1995); and growth and production in ponds and cistern (Khan *et al*., 2003; Narejo *et al*., 2005; Kohinoor *et al.*, 2012; Rahman *et al.* 2014). None at all published literature is available on cage culture technique of *H. fossilis*. Considering the lack of information on these lines, the present study was carried out to develop sustainable cage culture technique of *H. fossilis* in the southern coastal region of Bangladesh.

MATERIALS AND METHODS

Experiment set-up and design: This research work was conducted during two separate times in three treatments including three replications in each treatment. Two treatments (T_1 & T_2) were set-up in the Angaria khas khal during the time of 133 days (04 May to 14 September) in 2014 and a further treatment (T_3) was installed in the pond at PSTU (Patuakhali Science and Technology University) campus for the same duration (25 February to 07 July) in 2015 at Dumki in Patuakhali, Bangladesh. Hatchery produced fingerling of *H. fossilis* (4.1 to 7.3 g) was stocked at the rate of 600 and 750 each cage in T_1 and T_2 respectively while natural juvenile of *H. fossilis* (5.1 to 12.2 g) was stocked in T_3 at the rate of 600 in each cage.

0.5 cm meshes of knotless polyethylene net were used to prepare all cages for T_1 and T_2. But 1mm meshes knotless polyethylene net (filter net) was used to prepare the cages of T_3. The size of the cage was $9m^3$ (length 2.5m, width 2m and depth 1.8m) for all treatments. Bamboo was used to make frame of cages and plastic drums were used for floating the frame with upper portion of net in T_1 and T_2 in Angaria khas khal. On the other hand, upper portion of the cases of T_3 were fixed 20 cm above from the water surface with the support of bamboo poles. 5 piece of plastic pipes (1.5 m long and 10 cm diameter) were horizontally placed in the cage for shelter of fish while additional 5 piece of plastic cover (50 cm diameter) filled-up with mud by using polyethylene paper on the cover were also hanged into water column by using plastic rope for resting of fish on it in each cage for all treatments.

Preparation and setting of pipes and cover: 1.5 m long and 10 cm diameter plastic pipes were collected from local market. Similarly, 50 cm diameter round shape plastic cover (which normally used in the households for covering cooked food on the dinning table) was also collected from the market. After collection of these materials, mud was packed narrow-long by using polyethylene bags to entrance into the pipe-hole and closed-fitting inside the pipes by using plastic rope. At least 50% free space was kept inside the pipe for moving of shing through the pipes. Thereafter pipe was settled onto the bottom of net as a shelter for shing. Four plastic pipes were placed and fixed onto the bottom of four side of each cage and rest one was installed and fixed in the middle of the cage. Likewise, Plastic cover was also used as shelter for shing by arranging another way such as mud was filled-up by using polyethylene paper on the plastic cover to hold the mud within it and then hanged into water column by using plastic rope. Four plastic cover were hanged and fixed of four corners of each cage with the bamboo poles into 0.8m depth from the surface of water and rest one was hanged into middle portion of the cage in the same depth by using bamboo and rope like traditional balance.

Fingerling collection and stocking: Hatchery produced fingerlings were collected from Jessore (a district of Bangladesh where have stinging catfish hatchery and nursery) through the vender. Collected fingerlings (4.1 to 7.3 g) were stocked at the rate of 600 in T_1 and 750 in T_2 in each cage. Small size of natural *H. fossilis* (5.1 to 12.2 g) were collected from local market and stocked in T_3 at the rate of 600 in each cage. Weight of fingerlings was recorded by using portable weight balance (Model: M-ACS015G/C) during stocking of all treatments.

Feed supply: Industrial pellet feed (Mega Fish sinking feed pellets; www.spectragroup.com.bd) was applied once in a day at 1600 to 1700 hrs for all treatments as the demand of fish during the study period. Feed was applied in the plastic cover (50 cm diameter) which had been used as feeding tray. For the preparation and setting of feeding tray, polyethylene paper was fixed and closed-fitting onto the upper portion of the cover to contain feeds on it and sinker was fixed and tight-fitting with the lower portion of the cover to sink and stay it entirely into the water column with feed.

Physico-chemicals properties: Some physico-chemical parameters such as water temperature (^oC), transparency (cm), dissolved oxygen (mgl^{-1}), pH, alkalinity (mgl^{-1}) and ammonia (mgl^{-1}) were measured fortnightly during the study period from all treatments by using a celsius thermometer, a secchi-disk, a dissolved oxygen meter (DO 5509, Taiwan), a portable pH meter (HI 96107, Hanna Instruments, Italy), alkalinity test kit (HI 3811, Hanna Instruments, Romania) and ammonia test kit (HI 3824, Hanna Instruments, Romania) respectively.

Harvesting: All of the fishes were harvested from all treatments at the end of 133 days of cage culture. The harvested fishes were counted and weights were recorded by using electric balance (Model: M-ACS015G/C) to find out the weight gain, production, estimation of growth and specific growth rate (SGR), survival rate, and FCR (Food Conversion Ratio) respectively. SGR was estimated as: SGR (% body weight day^{-1}) = [In (final weight) – In (initial weight)]/culture period (days) × 100 and FCR was calculated as: Feed Conversion Ratio (FCR) = Dry weight (g) of feed supplied /Live weight (g) of fish gained according to Ricker, 1975.

Data analysis: The final data of water quality parameters, growth rate, survival rate, production, SGR and FCR were expressed as mean ± standard deviation (SD) and analyzed by one-way analysis of variance (ANOVA), followed by testing of pair-wise differences using Duncan's Multiple Range Test. Significance was assigned at the 5% level (P>0.05). All statistical analysis was done by using the SPSS (Statistical Package for Social Science) version-16.

RESULTS AND DISCUSSION

Some physico-chemical parameters of environmental factors were recorded (Table 1) during the study period which were in suitable and acceptable range for fish culture (Boyd 1982; Haque *et al*. 1984; Kohinoor *et al*. 1994, 1998, 2007; Rahman *et al.*, 2014) and observed there were no significant variation (P>0.05) among the parameters in different treatments except transparency. The transparency was found to be lower (23.88±4.42) in T_3 compare to other treatments (36.70±5.11 in T_1 and T_2) and it was significantly different (P<0.05) due to might be two diverse environment e.g. T_3 was in aquaculture pond and standing water while T_1 and T_2 was in running water which was opened by sluice gate. The findings of physic-chemical parameters of this study are similar which observed by different authors during their experiments in different times of stinging catfish culture in ponds of Bangladesh e.g. Marginal analysis of culture of stinging catfish (Khan *et al.*, 2003); culture potentials of stinging catfish under different stocking densities (Kahinoor *et al.*, 2012); effects of stocking density on growth and production performance of indigenous stinging catfish (Rahman *et al.*, 2014) and effect of stocking density on growth, survival and production of shing fingerlings (Monir and Rahman, 2015).

The level of ammonia was found to be higher in Angaria khal (T_1 and T_2) compare to PSTU pond (T_3) during the study period though, there was no significant different (P>0.05) among the treatments. The T_1 and T_2 were installed in Angaria khas khal which has connection to the Paira River through the sluice gate and upper portion of it carry on wastes of several drainage system such as some residential hostel of PSTU campus and sewage of Dumki bazaar those directly linked-up through this khas khal. Moreover, there are some food providing restaurants of Dumki bazar established on the bank of this khal and all of their wastes openly throw down to this khal. As a result, the amount of wastes and pollutants are highly present before rainy season in winter, and these pollutants are diluted by rain water and tidal water during summer season that was the reason to observe higher level (1.21 ±0.49 mgl^{-1}) of ammonia in T_1 and T_2 than T_3 (0.63 ±0.05 mgl^{-1}) during the study period.

Table 1: Physico-chemicals parameters (Mean±SD) of fortnightly samples during the study period in Angria Khas khal and PSTU pond

Parameters	Treatment- 1 & 2 (04 May to 10 September 2014)	Treratment-3 (25 February to 10 July 2015)
Temperature (°C)	28.75±1.44	28.15±2.29
Transparency (cm)	36.70±5.11^{a}	23.88±4.42^{b}
pH	6.98.0±0.15	6.88±0.17
Dissolved oxygen (mgl^{-1})	5.40±0.47	5.00±0.33
Alkalinity (mgl^{-1})	90.88±22.24	98.63±43.38
Ammonia (mgl^{-1})	1.21±0.49	0.63±0.05

*Mean± SD (Standard deviation); Figures in the same row having the same superscript are not significantly different (P> 0.05).

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Table 2: Growth performance and production (Mean±SD) of stinging catfish (*Heteropneutes fossilis*) during the study period in Angria Khas khal and PSTU pond

Treatments	Mean initial wt (g)	Mean final wt (g)	Mean wt gain (g)	Survival rate (%)	Production ($kgcage^{-1}$)	SGR (% per day)	FCR
T_1	5.55±1.34	31.63±6.88 [b]	26.08±6.68[b]	18.40±2.79 [b]	4.50±0.77[b]	1.31±0.19	2.77±0.19 [b]
T_2	5.83±1.33	30.98±7.70 [b]	25.15±6.54[b]	16.66±1.85 [b]	3.86±0.31[b]	1.25±0.08	2.99±0.10 [b]
T_3	8.50±3.14	55.75±9.35 [a]	47.25±10.94[a]	94.00±1.23 [a]	25.98±1.23[a]	1.44±0.37	3.70±0.11 [a]

*Mean± SD (Standard deviation); Figures in the same row having the same superscript are not significantly different (P> 0.05).

Table 3: Cost benefit ratio of stinging catfish (*Heteropneutes fossilis*) during the study period in Angria Khas khal and PSTU pond

Items	Treatments		
	T_1	T_2	T_3
A. Cost per cage			
Cost of net (BDT @ 60 per meter for T_1 and T_2; and @ 80 per meter for T_3)	1260	1260	1680
Cage preparation cost	150	150	150
Cost of bamboo (BDT @ 300 per piece)	600	600	600
Cost of dram (BDT @ 800 per piece)	2100	2100	-
Rope ((BDT @ 400 per kg)	100	100	100
Cost of fingerling (BDT @ 7.0 per piece for T_1 and T_2; and @ 3.0 per piece for T_3)	4200	5200	1800
Plastic pipe (BDT @ 100 per meter)	750	750	750
Plastic cover (BDT @ 75 piece)	300	300	300
Polyethylene paper (BDT @ 100 meter)	50	50	50
Cost of feed (BDT @ 55 per kg)	686	635	5283
Total cost	11145	11145	10713
B. Gross sell			
Sell price of shing (BDT @ 600 per kg)	2700	2316	15588
Gross benefit (B-A)	(-) 8445	(-) 8829	4475

Details of initial weight, final weight, weight gain, survival rate, FCR, SGR, and production of *H. fossilis* in the three treatments during the study period are shown in Table 2. The mean production of *H. fossilis* in three treatments were recorded 4.504 $kgcage^{-1}$ (range: 3.580 to 5.462 $kgcage^{-1}$), 3.86 $kgcage^{-1}$ (range: 3.806 to 4.260 $kgcage^{-1}$) and 25.987 $kgcage^{-1}$ (range: 24.771 to 27.676 $kgcage^{-1}$) in T_1, T_2 and T_3 respectively. The mean production of all treatments was 11.446 $kgcage^{-1}$ whereas 27.676 kg production was found in one cage in T_3. The production of *H. fossilis* was observed significantly different (P<0.05) among the treatments and it was higher in T_3.

The mean survival rate of *H. fossilis* in three treatments were 18.40 % (range: 15.2 to 22 %), 16.66% (range: 14.40 to 18.93 %) and 94% (range: 92.6 to 96.6 %) in T_1, T_2 and T_3 respectively during the experiment. The mean survival rate of all treatments was 43.02% while apporximately 95% survival rate was observed in T_3. The mean production and survival rate were observed different in three treatments and that was significantly (P<0.05) higher in T_3 (25.98±1.23 $kgcage^{-1}$ and 94.00±1.23 %) due to facilitate supporting materials (plastic pipes and plastic cover) as shelter in T_3 before stocking of fish in the cages. Fish was stocked in the cages of T_1 and T_2 before facilitated supporting materials (plastic pipes and plastic cover) as shelter in this two treatments and as a result approximately 65% fish died within 15 days of stocking. Fishes did not get shelter as well as any resting place in the cages of T_1 and T_2 and consequently their movement was restless and irrupted their body with the newly setting net, subsequently mucus eradicated from the skin, fish was severely injured and finally happening death. Another important matter here, the hatchery produced fingerlings were stocked in T_1 and T_2 while natural fingerlings and juveniles were stocked in T_3 which might also be somewhat effect on abrupt mortality in T_1 and T_2 though, body mucus was eliminated and fish were severely wounded. After observation (physical condition) of dead fish in T_1 and T_2, plastic pipes and plastic cover with mud (plastic cover filled-up with mud) were provided as shelter as well as resting place for fishes after 15 days of stocking in the cages of T_1 and T_2. After providing of these materials in this two treatments, those abrupt mortality of fish was reduced and consequent 15 days additional 15% fish died those were very weak and injured severely due to lose of mucus from skin. Rest of the 20% *H. fossilis* survived for subsequent culture period in T_1 and $T_{2,}$ but ultimate effect on growth and production which were very low. Afterward, in treatment T_3 these similar supporting materials (plastic pipes and plastic cover) were set-up before stocking of fish in the cages and as a result fish had no physical stress there. *H. fossilis* enjoyed convenient environment like natural to conduct their life in T_3 and subsequently the growth, survival rate, weight gain and production of fish were observed significantly ($P<0.05$) higher in T_3 than other two treatments.

FCR is one of the most important factors of aquaculture to succeed agro-business and it is directly related to cost-benefit ratio of aquaculture. In this study, FCR was observed 2.77 (range: 2.52 to 2.98), 2.99 (range: 2.88 to 3.12) and 3.69 (range: 3.55 to 3.82) in T_1, T_2 and T_3 respectively which were found to be different significantly ($P<0.05$) and it was higher in T_3. The observed FCR were more or less similar to observe in other stinging catfish culture in ponds in Bangladesh e.g. on-farm experiment in earthen ponds to evaluate the growth and production potentials of stinging catfish (2.13 to 2.33; Kahinoor *et al.,* 2012), an experiment in ponds to assess the growth performances, production potentials and highest net benefit of stinging catfish (2.51 to 3.93; Rahman *et al.*, 2014), an experiment in earthen nursery ponds to assess the growth performances, survival and production of *H. fossilis* (2.8 to 3.3; Monir and Rahman, 2015). Specific growth rate (SGR), survival rate and weight gain were observed significantly different ($P<0.05$) among the treatments and those were recorded higher in T_3 due to affix resting place and shelter (plastic pipes and plastic cover) before stocking of fish in T_3; and as a result fishes enjoyed suitable environment for resting on mud and shelter in pipes which were crucial requirement of *H. fossilis* culture. The production cost, net return and benefit in each cage of stinging catfish (*H. fossilis*) excluding labour cost among three treatments are shown in Table 3. Materials that are possible to reuse for subsequent culture period reduce the production cost which increases the net benefit.

CONCLUSION

From this experiment, it can be concluded that treatment T_3 (Provided sufficient resting place and shelter before stocking) is advisable for cage culture of *H. fossilis*. On condition that resting place and shelter in the cage before stocking of fish confirmed positive effect for increasing survival rate and growth of *H. fossilis.* As survival rate was about 95%; and growth and FCR were satisfactory when provided appropriate shelter in T_3 therefore, cage culture of stinging catfish (*H. fossilis*) may be a profitable business especially in the southern coaster region of Bangladesh. More research will be required for appropriate stocking density, culture period, feeding frequency and requisition of shelter and resting place compare to stocking density to develop sustainable cage culture technique of stinging catfish.

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