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EFFECTS OF FEEDING RATE ON GROWTH AND PRODUCTION OF STINGING CATFISH, *HETEROPNEUSTES FOSSILIS* (BLOCH 1974) IN CAGE MONOCULTURE SYSTEM

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Abstract

The present study evaluated the potentiality of cage culture of stinging catfish (*Heteropneustes fossilis*) under different feeding regimes. Fish experiments were consists of three treatments (T1, T2 and T3), each with three replicates, and lasted for 90 days. The stocking density was 300 fry (~1.5 g) per cage. Fish were given commercial floating feed (28% crude protein) twice daily (in the morning and evening) at 5% (T1), 7% (T2) and 9% (T3) of body weight. Water quality parameters were monitored fortnightly. Mean values of water quality showed no significant difference among the treatments. Survival of stinging catfish was comparatively higher with T2 (83.1%) compared to T1 (81.6%) and T3 (79.3%). The specific growth rate was significantly higher in fish reared underT2 treatment than T1 and T3, corresponding to 1.91, 1.85 and 1.87% bwd^{-1}, respectively. The net yield was also highest with T2 (1.74 kg) than those with T1 (1.57 kg) and T3 (1.60 kg). These data together with cost-benefit analysis among three treatments suggests that 7% feeding rate positively influence growth and production offish. Therefore, a daily feeding at 7% of body weight can be suitable for culturing stinging catfish in cages.

Key words: Cage culture, feeding rate, growth, *Heteropneustes fossilis*, stinging catfish

Introduction

Bangladesh is endowed with vast inland water bodies of rivers, tributaries, estuaries, beels, baors and ponds, with about 46.99 lakh hectares. Fisheries sector contributed 3.57% to national GDP and 25.30% to the agricultural GDP and 1.5% to foreign exchange earnings by exporting fish and fish products in 2017-2018 (DoF 2022). It employs approximately 1.2 million full-time and 12 million part-time fishers and others associated with the fisheries sector. Fishes also contribute about 60% of animal protein to our daily diet. Due to the increasing population, the demand for fish has increased. Our per capita annual fish demand is 21.90 kg, but we are getting only 19.30 kg. In Bangladesh, both fish production and catch were estimated to be 4.38 million tons in the 2018-2019 fiscal year, of which 2.49 million tons (57%) were yielded from aquaculture, 1.23 million tons (28%) from inland capture fisheries, and 0.66 million tons (15%) from marine fisheries, while the total annual demand for fish is 4.79 million tons (DoF 2020).

However, the present rate of increasing fish production in Bangladesh is lesser than that of the population boom. So, it's strongly felt that all sorts of efforts have to use to extend the fish production in all available

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inland water bodies to satisfy the protein demand of the people. So, culture system development is one of the foremost essential factors to extend fish production. Among the various culture systems, cage culture is more suitable in the context of Bangladesh (Ali et al. 2016). The cage fish culture technique has gained popularity as a compatible technology worldwide due to its advantages over conventional fish farming methods. The cage culture is a system where highly valued fish species are fed with artificial diets in cages. Through cage fish culture, the scope of increasing fish production in inland waters is highly expected in Bangladesh. Unfortunately, cage cultures on a commercial basis have not yet been popularized in Bangladesh for various reasons where feed cost is a primary hindrance. Anomalies feeding rates can be one of the main reasons to increase feed cost.

The stinging catfish, *Heteropneustes fossilis*, commonly known as "Singhi" is a popular and high valued fish in Bangladesh. It might play a vital role in the rural economy, providing a nutrient source for the poor. This fish can tolerate adverse ecological conditions obtaining swamps, mashes, and derelict water bodies. *H. fossilis* can easily survive in captive conditions, even in a small quantity of water. It has a paired sac-like pharyngeal lung as accessory respiratory organs (Das 1927). However, the culture of this fish has largely been restricted to land-based pond aquaculture systems. Stinging catfish can also be raised in cage aquaculture because the fish grows well with diets, tolerate high stocking densities, and be easily spawned (Kohinoor et al. 2012; Rahman et al. 2017). Earlier, studies were mainly conducted on the effects of stocking density on the growth and production of *H. fossilis* (Narejo et al. 2005; Kohinoor et al. 2012; Rahman et al. 2014; Rahman et al. 2017; Ali et al. 2018; Roy et al. 2019). However, there is no information available about the optimum feeding rate for this species in cage aquaculture. Considering the lack of information, the present investigations were carried out to ascertain an optimum feeding rate for *H. fossilis* fed with formulated pelleted feed.

Materials and Methods

The experiment was conducted at the Department of Fisheries, University of Rajshahi. The average depth of pond used for the fish culture was 1.50 m. The pond was rectangular in shape, well exposed to sunlight, free from aquatic vegetation and the dam was well protected and covered with grasses.

Design of the experiment

The experiment was designed with three treatments (T_1, T_2 and T_3) and three replications (R_1, R_2 and R_3) under each treatment. The pond was introduced with cages and then stinging catfish were stocked at 300 fish cage^{-1}. The mean initial weights of fish were 1.503±0.230, 1.523±0.217 and 1.527±0.180 g in T1, T2 and T3, respectively. Feeding was done at 5% of body weight in T1, 7% in T2 and 9% in T3, respectively.

Construction and submersion of cages

Nine cages each of 1.81 m^3 size were made for the experiment (Fig. 1). The frame of the cages was made of wood with bamboo slices and covered by a black synthetic net. The net's mesh size (5 mm bar) was selected as it was required to prevent the fishes from escaping from the cage and keeps water passing effortlessly through the cage. An opening was kept at the top of each cage for supplying feed and handling of the fishes. The cages were submerged 20 cm above the pond bottom. Two vertical and horizontal bamboo poles were used to hang each cage. Nylon rope was used to tie the cages to make them float with the help of the bamboo poles. The cages were located six feet away from the nearest bank of the pond.

Fig. 1: Setup of experimental cages made of wood with bamboo slices in the pond.

Fish stocking and feeding

Catfish fries were collected from the fish farm of Shantahar in Bogra and stocked in cages for the experiment. Fish were conditioned and brought by oxygenated polythene bags. The total length and body weights of fry were measured and then the fries were released in the cages. Caged fish were fed twice a day at 10 AM and 4.30 PM with commercial floating feed containing 28% protein at the rate of 5% body weight in T1, 7% in T2 and 9% in T3 for 90 days.

Sampling of fish

Fish were sampled monthly and caught by the scoop net. Then the body weight of fish was recorded by an electric balance and length was measured using a scale.

Water quality parameters

Water quality parameters such as temperature (°C), transparency (cm), pH, dissolved oxygen (mg/l) and total alkalinity (mg/l) were measured fortnightly. A Celsius thermometer was used for water temperature measurement. Transparency was measured with a Secchi disc of 20 cm diameter. Dissolved oxygen of water sample was measured by portable digital DO meter (Lutron, DO-5509). The pH of pond water was measured by using digital pH meter (CORNING pH meter 445) in the laboratory. Total alkalinity was determined titrimatrically by using 0.02 N sulfuric acid and methyl orange as an indicator.

Harvesting of fish

At the end of the experimental period (90 days), cages were brought out on the embankment of the pond and all fishes were recovered. The individual body weight and total fish weight were taken by using an electric balance.

Study of growth and production of fish

The following parameters were used to evaluate the growth rate of fish.

a) Weight gained = Mean final fish weight - mean initial fish weight.

b) Survival rate = No. of fish harvested/ Initial No. of fishes × 100.

c) Specific Growth Rate (SGR %) = [Ln {(final weight) – Ln (initial weight)} / culture period (day)] × 100.

d) Feed conversion ratio (FCR) = dry weight of feed (g)/ wet weight gain (g).

e) Net yield = No. of fish caught × Average weight gained.

f) Net benefit = Total revenue (Tk.) – Total cost (Tk.).

Benefit-cost ratio

$$(\text{BCR}) = \frac{\text{Total revenue}}{\text{Total cost}}$$

Statistical analysis

All the data collected during the experiment were recorded and preserved in a computer spreadsheet. The data obtained in the experiment were analyzed statistically. One-way analysis of variance was done using statistical software (SPSS, version 11.0, SPSS Inc., Chicago, USA).

Results and Discussion

Water quality parameters

The suitable water quality parameters are a prerequisite for a healthy aquatic environment and for producing sufficient fish food organisms (Rumpa et al. 2016). Various water quality parameters with their minimum and maximum values, including mean and standard deviation are showed in Table 1. Water temperature values were ranged from 25.0 to 32.7°C (mean 28.09±0.55 to 28.77±0.61°C) among all treatments, which are almost similar to the findings of Oké and Goosen (2019) who obtained higher growth between 25°C to 33°C. Boyd (2000) stated that, water temperature of 25 to 32°C is considered suitable for fish culture. The result was also supported by Mollah and Haque (1978) who recorded the water temperature ranges from 26.0 to 32.44°C. In the present experiment, transparency values of the studied cages were 18 to 50 cm (mean 27.57 ±1.45 to 27.61 ±1.58 cm) supported by Uddin (2002), Kohinoor (2000) and Raihan (2001), who recorded more comprehensive ranges of transparency values that were 11-63.5 cm, 15-58 cm and 11-50 cm respectively. Dissolved oxygen levels among treatments varied from 4.5 to 8.0 mg/l, although average DO levels were almost the same in all treatments, around 5.5 mg/l. Several studies reported this present DO level within the suitable range for fish culture (Uddin 1998; Hussain et al. 2000; Chakraborty et al. 2003; Rahman et al. 2017; Roy et al. 2019). Like temperature and DO, the pH values observed from the present experiment were not significantly varied among treatments and were within the suitable range (6.51 to 8.45). During the study period, the lowest average alkalinity level was found in T1 (122.59±4.5 mg/l), and the highest was in T2 (127.19±4.8 mg/l), although there was no significant variation among treatments. A study showed that the acceptable total alkalinity range should be within 40 to 200 mg/l (Boyd 1990) which support our alkalinity values. Jiwyam (2012) also obtained the alkalinity value of 156.75±19.16 mg/l in cage culture. From the observation of water quality parameters in the present study, it is clear that all parameters were suitable for stinging catfish culture in the cages and did not influence the production.

Table 1. Mean (±SE) with minimum-maximum values of water quality parameters as recorded fortnightly from all the cages.

Parameters	T1	T2	T3	Level of significance
Temperature	28.09±0.55	28.50 ±0.65	28.77±0.61	NS*
(°C)	25.1-32.5	25.0-32.6	25.3-32.7	
Transparency	27.57 ±1.45	27.61 ±1.38	27.59±1.51	NS
(cm)	21-50	18-48	19-49	
Dissolved oxygen	5.42 ± 0.11	5.37 ±0.19	5.40±0.20	NS
(mg/l)	4.5-8.0	4.9-7.6	4.5-7.1	
pH	7.18 ±0.87	7.38 ±0.16	7.28±0.12	NS
	6.51-8.31	6.58-8.45	6.53-8.20	
Total alkalinity	122.59±4.5	127.19±4.8	126±4.39	NS
(mg/l)	72-166	64-162	66-162	

*NS: Non-significant. T = Treatment, First row indicates mean value with standard deviation and second row indicates range value for every parameters.

Growth, yield and economic analysis

In terms of initial weight, average final weight, weight gain, survival rate (%), SGR (%/ day), FCR as well as Net yield (g/cage), the growth parameters of catfish, *H. fossilis* in cage culture system are shown in Table 2. Fish fry body weight significantly increased when fish were fed with a 7% body weight rate in T2 compared to those fed with a 5% body weight rate in T1. Mean final weight (8.52 g) and mean weight gain (6.99 g) was highest in T2. Although, the survival rate of *H. fossilis* fries did not significantly vary with the different feeding rates, but showed a better survival rate in T2 (83.11%). Specific growth rate (SGR, % bwd^{-1}) and net yield of *H. fossilis* significantly increased in T2. In addition, FCR values in T1 (1.71) and T2 (2.12) showed no significant difference, whereas T3 exhibited significantly increased FCR value (2.80) over the experimental period. The mean initial weight of *H. fossilis* was 1.50±0.23, 1.52±0.22 and 1.52±0.18 g in T_1, T_2 and T_3, respectively, where it was raised into 7.93±0.45, 8.52±0.30 and 8.25±0.57 g within 3 months. The result was lower than the findings obtained by Chakraborty and Nur (2012) and Roy et al. (2019), perhaps due to a shorter culture period, variation of stocking density and smaller initial weight of fish. Rahman et al. (2017) found a lower survival rate (48.0±1.20 to 59.50±1.73%) of *H. fossilis* in cage culture. The survival rate of *H. fossilis* in the present study was higher than the previous study and it was within the range reported by Syeead et al. (2017).

Table 2. Mean values of growth parameters and yield of *H. fossilis* fewer than three different treatments during 90 days of experimental period.

Parameters	Treatments		
	T1	T2	T3
Initial weight (g)	1.50±0.23[a]	1.52±0.22[a]	1.52±0.18[a]
Final weight (g)	7.93±0.45[a]	8.52±0.30[b]	8.25±0.57[b]
Weight gain (g/90 days)	6.42±0.45[a]	6.99±0.29[b]	6.72±0.56[ab]
SGR (% bwd^{-1})	1.85±0.06[a]	1.91±0.03[b]	1.87±0.07[a]
Survival rate (%)	81.56±9.29[a]	83.11±5.67[a]	79.33±3.00[a]
FCR	1.71±0.00[a]	2.12 ±0.00[a]	2.80±0.00[b]
Net yield (kg/$cage^{-1}$/3 month)	1.57±0.17[a]	1.74±0.11[b]	1.60±0.14[a]

Values are means ±SE of triplicates. Different superscripts denote significant statistical differences ($p<0.05$).

FCR value of the present study ranged between 1.71 to 2.80, which was more or less similar to the result of Chakraborty and Nur (2012). SGR of the current experiment was agreed by Rahman et al. (2017) but lower than that achieved by Chakraborty and Nur (2012) and Roy et al. (2019) may be due to variation of feed utilized, feeding rate etc.

Simple economic analysis showed in Table 3 revealed that the net income of this culture system was higher in T2. Total cost was most increased in T3 and lowest was in T1. The income from selling the catfish was more than the cost of catfish seeds and other operational costs i.e. feed, labor etc. So, the culture system is profitable and may be sustainable. Syeead et al. (2017) reported the benefit-cost ratio of Shing farm was 0.89 in Sabuj farm using cherish feed which showed more or less similarity to the present study. Different studies suggested that net return may vary and depend on factors like stocking density, disease prevalence, feed and fish fry price etc.

Table 3. Economic analysis of fish yield of *H. fossilis* reared in different feeding rates in cages.

Particulars	Treatments		
	T1	T2	T3
Cage preparation (Tk. $cage^{-1}$)	250.00	250.00	250.00
Feed apply for 90 days (Kg)	2.69	3.70	4.48
Feed cost (Tk./kg)	45.00	45.00	45.00
Feed cost for 90 days (Tk.)	121.05	166.50	201.60
Seed (Tk. $cage^{-1}$)	200.62	200.62	200.62
Labour (Tk. $cage^{-1}$)	150.00	150.00	150.00
Total cost (Tk. $cage^{-1}$)	721.67	767.12	802.22
Return (Tk. $cage^{-1}$)	1281.85	1402.24	1296.05
Net profit (Tk. $cage^{-1}$)	560.18	635.12	493.83
Benefit-cost ratio	0.78	0.83*	0.62

* Significant difference at $p<0.05$.

The feeding rate is an essential factor affecting the growth of fish. This assists producers to grow healthy fish as efficiently as desired and using optimal ratio averts overfeeding, which is pricey and impairs water quality. Determination of optimal values for this factor is necessary to the success of aquaculture production. In the present study, the feeding rate had significant effects on the growth *H. fossilis*. Similar studies by Khan and Abidi (2010) on *H. fossilis*, Ahmed (2007) on *Labeorohita*, Oberg et al. (2014) on pigfish revealed that ration levels affected the growth, survival, feed intake and conversion efficiencies of reared fish. However, in the present study, significant growth improvement was observed with increasing the ration level up to 7%, indicating that feeding *H. fossilis* at the rate of 7% of body weight results in maximum growth and production. Growth improvement was also observed in *Cirrhinus mrigala* (Khan et al. 2004) and hybrid sturgeon (Luo et al. 2015), when fish were reared with increasing feeding ration up to a certain level. Hassan and Jafri (1994) reported an optimum feeding rate of 3.0% body weight per day for the walking catfish using a purified diet (40% protein). Due to differences in experimental conditions and methodology, it is hard to compare the results obtained from the present study with those obtained in studies carried out on other catfish species. However, it can be implied that the optimum benefits of altering the feeding regime of *H. fossilis* can be achieved by feeding two times at 7% feeding rate.

Conclusion

The stinging catfish is a high valued species and has the potentiality for cage culture system. In the present study, the feeding rate applied in the experiment affected the growth and production of *H. fossilis*. The results reveal that feeding at the rate of 7% of body weight per day is the most efficient feeding strategy for *H. fossilis* as it provides better growth and production. The cost-benefit analysis of the present culture of *H. fossilis* in cages suggests that 7% of the bodyweight feeding rate can be suitable for catfish aquaculture. However, further research is needed to determine the optimum feeding rate in different stocking density and in different culture system of *H. fossilis*.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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