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Impacts of stocking density and economic returns on the cage culture of stinging catfish, *Heteropneustes fossilis*

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Abstract
An experiment was conducted to assess the effect of stocking density in cages (1 m^3size) on the growth performances of stinging catfish *(H. fossilis)* within a closed pond system. There were three different stocking densities (T1: 100 fish/cage, T2: 200 fish/cage and T3: 300 fish/cage). The experiment was conducted in triplicates under a completely randomized design. Fish fries with a mean weight of 3.53±0.10 g was reared for 144 days in different cages fed with commercial pellets. The water quality parameters were within suitable range for fish culture during the experimental period. At the end of the rearing period, the higher mean weight gain, better FCR and BCR obtained 15.20±0.2g, 7.13±0.05 and 1.00±0.01, respectively that showed a significant difference ($p<0.05$). It was concluded that by considering profitability 200 fish/cage produced the best production and farm economics among the densities tested in this experiment.

Keywords: Cage culture, *Heteropneustes fossilis***,** stocking density, Cost Benefit Ratio

1. Introduction
Stinging catfish (*Heteropneustes fossilis*), an air-breathing catfish is a very popular and high valued fish in Bangladesh. This fish is locally known as Shing or Shingi. Having high palatability, fewer spines, and less fat, *H. fossilis* is well preferred in many parts of the indian subcontinent by the consumers [1]. Considering high nutritive value, the fish is recommended in the diet of sick and convalescents. Due to its high market value (Market price 500-800 Tk/KG *H. fossilis;* 3-4 times higher than carp fishes, 1USD is equal to 72 Tk) and high consumer demand, the culture of *H. fossilis* has been started in many parts of the country for last few years. The culture of stinging catfish relatively in deeper and larger ponds is not practiced since the ponds are needed drying for harvesting due to its dwelling nature in bottom mud. In this circumstance, cage culture is an alternative way to overcome such a problem. *H. fossilis* is very much suitable for cage culture due to a massive pair of sac-like pharyngeal lungs as an accessory respiratory organ which supports in captivity even in a small quantity of water [2]. The management of cages is easy those produces fish of high quality and utilize existing water bodies [3]; therefore, cage aquaculture provides a viable earning source for the landless farmers.

Stocking density as compared to the food ration and extent of managing greatly affect the successful aquaculture [4]. It is mentioned stocking density as a vital parameter in fish culture as the survival, health, and growth of fish depend upon these factors [5]. Higher stocking density within a cage can raise the yield per unit area; however, high densities may cause stress in fish which may result reduce the growth and survival rates [6, 7]. Both under and overstocking affect economics and profitability of the farm. However, the optimum stocking density identification is the crucial factor for the successful cage culture of *H. fossilis*. By considering all these things the major objectives of this study are to figure the effect of different stocking density on growth and a simple economic analysis.

2. Materials and method
The experiment was conducted in the experimental pond of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh has an area of 3 acres with an average depth of 2m.

The pond was rectangular in shape, exposed to available sunlight and free from aquatic vegetation. The study period of the trial was 144 days from 26 June to 22 November 2014.

2.1. Design of the experiment
The study was performed in completely randomized design with a total of three treatments with triplicate where three different densities were used in the experiments which were 100 fish m^{-3} (T1), 200 fish m^{-3} (T2) and 300 fish m^{-3} (T3). Twelve square shaped cages having an area of $1m^3$ were constructed to conduct this experiment. The frame of cages was made of a bamboo pole which was covered by black nylon net with the help of nylon twine. The mesh size of the net was 1 cm which did not allow the experimental fish fry to escape but allowed water to pass easily. An opening was kept on the upper side of the cage to supply feed and handling of the fishes whenever necessary. A floating feeding frame and a plastic sheet were set inside cages that prevented the passing out of feed outside cages (i.e. misuse of feeds). The cages were tied using nylon rope to the bamboo platform so that they remain fixed near to the platform. This platform was used to supply feed easily and monitoring the fish of the cages. Plastic bottle floats were used for suspension of the cages.

2.2. Fry collection and stocking
Fries of stinging catfish were collected from a nursery farmer in Shomvuganj upazilla under Mymensingh district, Bangladesh. The fish fries were carried by oxygenated polyethelene bag to the experimental site. Then the fries were kept into a *hapa* for one week for conditioning. On 26th June 2014, the fries were released into the cages randomly according to the experimental design without considering male and female ratio.

2.3. Feeding of fish
In order to meet the dietary requirement artificial commercial floating feed (30% protein) were provided to the fries twice daily. Initially the feeding rate was 20% of their body weight (Up to 3-10g body weight) then decreased to 10% (Up to 3-10g body weight). Feed ration was adjusted forth-nightly by sampling the weight and considering the mortality. To confirm good water exchange and aeration into the cages were lifted and checked during sampling to clean the nets. In the experimental pond, no extra feed and fertilizer were applied.

2.4. Monitoring water quality
Water quality parameters were measured monthly in the morning at 8 am. A portable Celsius thermometer (Digi-thermo WT-2), DO meter (Lutron, DO-5509) and pH meter (Eco Test r pH2) were used to determine temperature, dissolved Oxygen, and hydrogen ion concentrations, respectively. The ammonia-nitrogen concentrations of the caged water were determined by using HANNA instrument Test Kit.

2.5. Growth, Yield, and economic analysis
At the end of the experiment, on 22nd November 2014 the fish were harvested by taking out cages from the pond. The harvested fish were counted and weighed to determine the mortality and production, respectively. The final average weight (g) of the individual fish in each cage was estimated by dividing the total final biomass in the cage by the number of survivors. Total weight increments (net yield) were estimated by deducting the biomass stocked from the biomass harvested and was expressed as kg m^{-3}. The specific growth rate (SGR, % day^{-1}) was calculated as $(\ln W_2 - \ln W_1) / t \times 100$, where W_1 is the initial live body weight (g), W_2 is the final live body weight (g), and t is the time in days. Survival rate was calculated as: (no. of fish harvested/ no. of fish stocked) ×100. Weight gain was calculated based on mean weight increments during the rearing period of 144 days. The feed-conversion ratio (FCR) was calculated as feed consumption/weight gain.

To choose the best result, Benefit Cost Ratio (BCR) was conducted to determine economic returns of different treatments based on the sale price of the fish after harvest and the costs of fingerlings and feed. The fish fries and pelleted feed were purchased at the rate of Tk 2.00/piece and Tk 40.00/Kg, respectively (1USD=72Tk). The market price of adult stinging cat fish was considered as Tk 600.00/Kg in this analysis.

The formula used for determining Benefit Cost Ratio (BCR) was as below:

BCR: Gross income / Total cost

2.6 Statistical analysis
All the collected data were analyzed statistically by one-way ANOVA using statistical software Statistix 10. Means were given with ± standard error (SE). This analysis was then followed by a Tukey-HSD test where significant differences were observed. Differences were considered significant when $P<0.05$.

3. Results
3.1 Water quality parameters
The water quality parameters were recorded monthly from the middle of the cages that measured at 8:00am-9:00 am. The mean values (±SEM) of water temperature, pH and ammonia-nitrogen didn't show any significant difference ($P>0.05$). Dissolved oxygen concentration showed a significant difference ($p<0.05$) among the treatments. The mean ± S.E. (range) values of the water quality parameters are presented in Table 1.

Table 1: Monthly recorded water quality parameters (Mean±SEM) from different treatments (Values are means of 6 sampling dates; N=6)

Parameters	Treatments			Level of significance
	T1	T2	T3	
Temperature	27.55±0.04	27.55±0.04	27.60±0.06	NS
pH	7.40±0.01	7.42±0.01	7.42±0.01	NS
DO (mg/l)	5.90±0.03^{a}	5.80±0.02^{ab}	5.95±0.08^{b}	*
Ammonia-nitrogen (mg/l)	0.73±0.05	0.78±0.02	0.73±0.04	NS

NS: Not significant

* Mean values with different superscript letters in cells indicate significant difference ($P<0.05$).

3.2. Growth, yield, and economic analysis
The growth parameters of *H. fossilis* in terms mean initial length, mean final length, mean length gain, mean initial weight, mean final weight, mean weight gain, SGR (%/day), FCR, Survival rate (%), Net yield (g/cage/144days) as well as the BCR value were given in Table 2. The results of growth performances of *H. fossilis* in cages showed variation in different stocking densities. In the treatment T3 where 300

fish was stocked, found lower mean final weight, mean weight gain, SGR (%/day) and survival rate compared to T1 (100 fish/cage) and T2 (200 fish/cage) which showed a significant difference (*P<0.05*). The lowest net yield (g/cage/144days) was obtained in T1 (100 fish/cage) which was significantly different (*P<0.05*) then T2 and T3 treatments. In the cass of FCR and BCR, T2 (200 fish/cage) showed better performance which was 7.13±0.05 and 1.00±0.01, respectively.

Table 2: Growth parameters of the catfish, *Heteropneustes fossilis* with different stocking densities

Parameters	Treatments			Level of significance
	T1	T2	T3	
Mean initial length (cm)	5.03±0.1	5.06±0.2	5.13±0.1	NS
Mean final length (cm)	14.93±0.5	14.77±0.4	14.23±0.1	NS
Mean length gain (cm)	9.90±0.6	9.70±0.2	9.10±0.2	NS
Mean initial weight (g)	3.53±0.13	3.47±0.15	3.59±0.11	NS
Mean final weight (g)	18.49±0.3^{a}	18.67±0.1^{a}	17.57±0.2^{b}	*
Mean weight gain (g)	14.96±0.4^{a}	15.20±0.2^{a}	13.97±0.3^{b}	*
SGR (% /day)	1.88±0.01^{a}	1.88±0.01^{a}	1.83±0.01^{b}	*
FCR	7.57±0.15^{b}	7.13±0.05^{c}	8.13±0.05^{a}	*
Survival rate (%)	57.33±4.73^{a}	59.50±1.73^{a}	48.0±1.20^{b}	*
Net yield (g/cage/144days)	857.66±70^{b}	1857.42±58^{a}	1891.18±147^{a}	*
BCR	0.83±0.03^{b}	1.00±0.01^{a}	0.75±0.02^{b}	*

NS: Not significant

* Mean values with different superscript letters in cells indicate significant difference (*P<0.05*).

4. Discussion

Water quality is one of the most important factors determining growth and survival of fish in cage culture. Measurement of water quality parameters is a pre-requisite for maintaining a healthy aquatic environment and better production for aquatic organisms. It is reported that growth, feed efficiency and feed consumption of fish were greatly affected by the water quality parameters [7, 8]. Though the DO concentration significantly differs among the treatments, the range of all water quality parameters was in suitable condition for fish culture [9].

In cage culture of *H. fossilis* lower survival rate was observed in all the treatments which ranged 48.0±1.20 to 59.50±1.73%. As the stocking density increased, the survival rate was decreased as well as the mean weight gain and SGR (5/day). More space, food and less competition were observed in lower stocking densities that reported by various authors [10, 11, 12]. In case of

H. fossilis farming, lower stocking densities showed the best growth performance [13]. This result indicated that lower stocking density influenced them to consume feed properly and it might be absent in the treatments with higher stocking densities. On the other hand, the yield was strongly affected by the stocking density. As the stocking density decreased in T1 (100 fish/cage) treatments the lower yield was obtained. It is like another study that the higher yield can achieve from higher stocking densities (80 fish/m^3) compared to lower ones (15, 50 fish/m^3) [14].

The Cost Benefit Ratio (BCR) value was comparatively higher in T2 (200 fish/cage) treatments were yield, FCR, survival rate and mean weight gain were higher. Though the net yield of T2 and T3 treatments did not significantly differ, BCR value was obtained lower in T3 (300 fish/cage) treatments due to higher production cost.

5. Conclusion

Stocking density had significant positive effects on production, suggesting that higher stocking densities may be used to obtain higher biomass but it is wise to use optimum density by considering the profitability. It is suggested for cage culture of *H. fossilis* that 200 fish/cage is preferable for getting good economic returns. This study was carried out in a captive pond so further investigation should be conducted in open water body as well as a concern should be taken to increase survival rate.

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