E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(2): 315-320

www.fisheriesjournal.com
Received: 15-01-2020
Accepted: 19-02-2020

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Determination of suitable species for cage fish farming in Chalan *beel*, Bangladesh

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Abstract
4 treatments with Pangas, Magur, Pabda and Gulsa Tengra at T_1, T_2, T_3 and T_4 at a stocking density of 100 fish/m^3 were evaluated during the study period. The fishes were fed with commercial feed containing 32% protein and feeding was done at the rate of 5% of body weight. After the culture period, significantly (P<0.05) higher growth and production performance were recorded for Pangas at T_1 and lower for Pabda at T_3. However, calculation of cost-benefit analysis revealed a significantly (P<0.05) higher total net return and benefit cost ratio (BCR) for T_4 (BDT 13692.01±1741.13 and 0.73±0.09). The present study, therefore, recommended Gulsa Tengra for cage farming in running water of Chalan *beel* area.

Keywords: Cage culture, Gulsa Tengra, economic analysis, running water, wetland

Introduction

Fish production in cages became highly popular among the small or limited resource farmers who are looking for alternatives to traditional agricultural crops. Cage culture is an aquaculture production system where fish are held in floating nets. Cage culture of fish utilizes existing water resources but encloses the fish in a cage or basket which allows water to pass freely permitting water exchange and waste removal into the surrounding water. Cages are used to culture several types of shell fish and finfish species in fresh, brackish and marine water habitats. Cage production is possible in ponds, lakes, reservoirs, strip pits, rivers and streams. Moreover, cage culture provides an intensive culture system of fishes, whereas it is possible to apply intensive technology and to get higher biomass production [1]. Technical simplicity, lower capital investment, intensive feeding and health monitoring, and ease of harvesting make the cage culture system more preferable then other aquaculture system [2]. A widespread and profitable culture of fish and prawns in cages has already been developed successfully in Asia, Europe and America [3, 4]. However, the challenges faced by cage culturist are to maintain the environmental condition favourable for cultured fish species as because uneaten parts of supplied feed, feces and metabolic products can create noxious condition for fish [5, 6].
Water bodies in Bangladesh including rivers, irrigation canals, oxbow lakes and haors offer potential sites for cage culture [7] as it affords a prospect for small-scale farmers to use their limited resources and to include high-valued species in their cage to generate more income and improve their livelihood. Till now several studies on cage fish culture have been conducted by several researcher in Bangladesh [2, 8, 9, 10], however, most ponds are standing waters which receives little or no addition of water. Moreover, there is no stratification and circulation of water column in pond water and thus nutrient enrichment is a common phenomenon which often makes the waterbody unfavourable for fish culture. Although some studies have also been done on cage fish culture in lakes [11, 12], haors [13] and rivers [14], the amount is too low to mention. In the present situation, the scope for increasing fish production in running water through cage culture is highly expected in Bangladesh and it would be a very profitable industry like Japan, Thailand, Cambodia, Philippines, Malaysia, USA, and UK [15]. Cage culture can also help in conservation of wild fisheries as providing alternative livelihood option during the ban period. But, unfortunately cage culture on commercial basis are yet to be popularized in Bangladesh due to many reasons such as, lack of knowledge about proper management, determination of appropriate stocking densities, unavailability of cage materials

and socio-economic constraints. Furthermore, for cage culture or any other intensive culture system, selection of species is also important since not all species are suitable for all culture system.

Fish species cultured in cage fish culture of Bangladesh are mainly; Climbing Perch *Anabas testudineus* [2, 10, 11], Tilapia *Oreochromis niloticus* [2, 9, 12, 13, 14] and Walking Catfish *Clarias batrachus* [8]. However, in Bangladesh, among the various fish species catfishes are particularly important for their fast growth, lucrative size, good taste, and high market demand. Catfishes are also popular for most essential vitamins and minerals, including; vitamin A, vitamin C, calcium, iron manganese etc. Not only are those, catfishes are very popular air-breathing fish species can survive even at low oxygen levels in water. Therefore, catfish can be grown more successfully in cages and these are more desirable species for cage culture. Moreover, conservation of catfishes are now in danger due to the destruction of natural breeding and feeding grounds because of anthropogenic pressure on inland water habitats [16, 17] and cage culture can be a solution for extinction of these fish species from natural water habitat. Therefore, many commercially important indigenous catfishes such as Pabda *Ompok pabda*, gulsha Tengra *Mystus cavasius* are highly susceptible and on the limit of extinction [18, 19].

Under the above circumstances, the present study was designed to evaluate the performance of cage fish farming in running water of Atrai River in *Chalan beel* area of Bangladesh through the selection of suitable catfish species for better economic performance.

Materials and Methods

Selection of study location

The study location was selected on the channel of Atrai river that flows through the Chalan *beel* of Singra upazila under Natore district (Fig. 1). The present experiment was conducted as a part of a project on "Techniques adoption and formulation of guidelines for sustainable management of Haor and Beel fisheries", where the cage fish farming was introduced as an alternative approach to reduce the fishing pressure during ban on fishing for successful management of established fish sanctuaries. Therefore, connectivity of floodplain to the river channel and the subsequent water flow were given major emphasis during the selection of cage farming location. The chosen river channel was also deeper from other locations and as a result it was possible to maintain the optimal depth for cage fish farming. The present experiment was conducted from October to January 2019.

Fig 1: Location for cage fish farming in Atrai River at Singra upazila, Natore district

Description of cages

Medium sized cage (6 m x 3 m x 2 m) was used for this trial. Metals and plastic barrels were used as frame and float, respectively. The entire frame was wrapped with a net of 0.5 cm mesh size which was again covered with a net of 1 cm mesh size. The distance between the two different meshed net was 5 inch as because to save the inner net from the attack of crab. A total of 12 cages have been installed in a row for this experiment.

Experimental design

The project was to develop alternate livelihood option through appropriate cage fish farming to reduce the fishing pressure during ban on fishing for sanctuary operation, whereas in the first year experiment, 4 catfish species (Pangus *Pangasius hypophthalmus*, Magur *Clarias batrachus*, Pabda *Ompok pabda* and Gulsha Tengra *Mystus cavasius*) were selected for trial of cage culture. The treatments T_1, T_2, T_3 and T_4 were assigned for Pangus, Magur, Pabda and Gulsha Tengra, respectively. Fry of selected fishes were released in experimental cages at a stocking density of 100 fish/m^3 and growth monitoring was done. The fishes were fed with commercial feed containing 32% protein and feeding was done at the rate of 5% of body weight.

Monitoring of water quality parameters

Water temperature (°C) was recorded with the help of a Celsius thermometer. Dissolved oxygen (mg/l) was recorded with digital oxygen meter and pH with a portable pH meter. Ammonia-nitrogen (mg/l) was determined by the help of a HACH kit (FF2, USA).

Fish growth monitoring

Fish has been sampled monthly to assess the growth and to adjust the feeding ration. 50 fishes from each cage of the stocked fishes were measured in each sampling using scope net in each experimental cage. The following growth parameters were assessed:

Initial weight (g) = Weight of fish at stock

Final weight (g) = Weight of fish at harvest

Weight gain (g) = Mean final weight- Mean initial weight

$$\text{Per cent weight gain (\%)} = \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}} \times 100$$

$$\text{SGR (\%/day)} = \frac{\ln[\text{Final weight} - \ln[\text{Initial weight}]}{\text{Culture period}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stock}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Weight of feed fed}}{\text{Fish weight gain}}$$

Yield (Kg/cage): Fish biomass at harvest – Fish biomass at stocking

Economics of fish farming

At the end of the culture period, fishes were harvested and sold to the local market. Cost-benefit analysis of different treatments was calculated on the basis of the cost of inputs and labor to be used; and the income from the sale of fishes. The following equation was used for the calculation of net return:

$R = I - (Fc + Vc + Ii)$

Where *R* refers to net return; *I*, total income from fish sold; *Fc* for Fixed costs, *Vc* for variable costs and *Ii* for interests on input costs.

The prices were expressed in Bangladesh Taka (BDT). All inputs and fish fingerlings were correspond to wholesale market prices of the project areas. Net benefit was calculated by deducting the total cost from total income from fish sale. The cost-benefit ratio (CBR) was also calculated using following formula:

BCR = Total revenue / Total cost

Statistical analysis

Water quality parameters, fish growth and production performance and economic performance were analyzed by one-way ANOVA. When a mean effect was significant, the ANOVA was followed by Duncan New Multiple Range Test (Duncan, 1955) at 5% level of significance (Gomez and Gomez, 1984). The percentages and ratio data were analyzed using arcsine transformed data. All analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corporation, Armonk, NY, USA).

Results

Water quality parameters of cages

Water quality parameters of the studied cages at different treatments are shown in Table 1. There was no significant differences ($P > 0.05$) were observed in all the water quality parameters among the treatments. Temperature ranged between 21.11±0.33 (T_3) to 21.21±0.39 ºC (T_1). The higher value of pH was recorded at T_4 (7.54±0.13) followed by T_3 (7.51±0.16), T_1 (7.49±0.06) and T_2 (7.41±0.02). DO level was also higher at T_4 (7.19±0.11 mg/l) and lowest at T_3 (7.09±0.08 mg/l). NH_3-N content of the water was more or less similar in all the treatments and ranged between 0.001±0.000 (T_4) to 0.002±0.000 mg/l (T_1).

Table 1: Water quality parameters of cages after the culture period of 120 days

Parameters	T_1	T_2	T_3	T_4
Temperature (ºC)	21.21±0.39^a	21.17±0.33^a	21.11±0.33^a	21.20±0.24^a
pH	7.49±0.06^a	7.41±0.02^a	7.51±0.16^a	7.54±0.13^a
DO (mg/l)	7.15±0.04^a	7.18±0.10^a	7.09±0.08^a	7.19±0.11^a
NH_3-N (mg/l)	0.002±0.000^a	0.001±0.001^a	0.001±0.001^a	0.001±0.000^a

Values in each same raw having different superscripts are significantly different (P<0.05)

Growth performance of fish in cages

At the end of 120 days of fish rearing in cages, biological performances and production of fishes at different treatments were presented in Table 2. All growth parameters in terms of final weight, weight gain, per cent weight gain, average daily gain (ADG) and specific growth rate (SGR) were significantly varied among the treatments. Significantly (P<0.05) higher final weight, weight gain, per cent weight gain, average daily gain (ADG) and specific growth rate (SGR) were the highest at T_1 followed by T_3. Significantly ($P<0.05$) higher survival was observed at T_1 and lowest at T_4. There was also significant difference in the FCR value among the three treatments, whereas best performance of FCR was found at T_1 with the fish species Pangas and the lowest performance of FCR was recorded at T_3 where the fish species was Pabda. Significantly ($P<0.05$) higher total and net production per cage were also recorded at T_1 where the fish species was Pangas and lowest at T_3 with the species was Pabda.

Table 2: Growth performance of fishes in cage culture period of 120 days

Parameters	T_1	T_2	T_3	T_4
Initial weight (g)	5.50±0.05^a	5.60±0.10^a	5.25±0.05^a	5.10±0.10^a
Final weight (g)	101.19±2.46^a	58.58±0.92^b	17.56±0.27^d	22.67±1.07^c
Weight gain (g)	95.69±2.48^a	52.98±0.95^b	12.31±0.32^d	17.57±1.11^c
% weight gain	1740.21±50.85^a	946.33±26.79^b	234.46±8.30^d	344.66±25.72^c
ADG	0.80±0.02^a	0.44±0.01^b	0.10±0.01^d	0.15±0.01^c
SGR (%/day)	2.43±0.04^a	1.96±0.02^b	1.01±0.02^d	1.24±0.05^c
Survivability (%)	91.16±1.54^a	80.10±3.53^b	89.94±0.20^a	90.67±2.00^a
FCR	1.21±0.09^d	1.30±0.06^c	2.50±0.04^a	1.81±0.13^b
Total production (kg/cage)	332.92±5.57^a	164.16±4.84^b	55.27±0.88^d	71.95±4.20^c
Net production (kg/cage)	303.67±5.56^a	144.56±4.65^b	36.89±1.05^d	54.10±4.22^c

Values in each same raw having different superscripts are significantly different (P<0.05)

Economics of cage culture

The cost-benefit analysis of fish culture under different treatments is given in Table 3. The analysis revealed that total cost was significantly (P<0.05) higher in T_1 followed by T_2, T_3 and T_4. However, total income from fish sale was highest at T_2, which was not significantly different from T_4. But, when comparing total net return, the value was higher for T_4 followed by T_2 and T_3. Significantly higher BCR was recorded at T_4 (0.73±0.09) followed by T_2 (0.19±0.04), T_3 (0.12±0.01) and T_1 (0.03±0.01). However, after conducting the economic analysis it was observed that Pangas at T_1 showed significantly lower net income and BCR.

Table 3: Economic performance of fishes at different treatments under cage culture system after 120 days of culture period

Parameters	T_1	T_2	T_3	T_4
Feed cost	17196.30±1236.50^a	18743.40±155.67^b	9217.20±139.56^c	9768.30±162.85^c
Fry cost	4200.00	5250.00	5950.00	5250.00
Cage cost	2000.00	2000.00	2000.00	2000.00
Labour cost	1666.00	1666.00	1666.00	1666.00
Total cost	25062.30±1236.50^a	27659.40±155.67^b	18833.20±139.56^c	18684.30±162.85^c
Total income	25833.49±361.96^c	32833.13±967.41^a	21002.07±334.28^b	32376.31±1889.53^a
Net income	771.19±1593.78^d	5173.73±1110.30^b	2168.87±204.43^c	13692.01±1741.13^a
BCR	0.03±0.01^c	0.19±0.04^b	0.12±0.01^b	0.73±0.09^a

Values in each same raw having different superscripts are significantly different ($P<0.05$)

Discussion

During the study period, the water quality parameters of the studied cages did not varied significantly among the treatments, which might be due to the running waterbody chosen for cage farming. The factors affecting the water quality of cage farming are wastes from uneaten feed and faecal materials of cultured fishes as previously reported by Shahidul [20]. Being the running water, these factors were eliminated successfully by the water current in the present experiment, therefore, maintained the uniformity of the water quality parameters among the treatments. The ranges of water temperature (21.11±0.33 to 21.21±0.39 ºC) recorded during the study period were not within the suitable level recommended by Boyd [21] as because of the seasonal effect. The present study was conducted within October to January which is characterized by low water temperature in Bangladesh. However, taking the seasonal effect into consideration, the range of water temperature was within the suitable range according to the findings of Mondal *et al.* [2], whereas they reported the range of water temperature from 15.3 °C to 28.5 °C during their study period. pH and DO were within the suitable range for fish culture in cage environment and coincide with the findings of Uddin *et al.* [11], Moniruzzaman *et al*. [12] and Rahman & Marimuthu [22] where they reported a pH ranged between 6.3 to 7.4 and DO 5.8 to 7.8 mg/l. Selection of study site in running water decreased environment degradation during the present study. In cage culture system, higher stocking density of fish, uneaten feed materials and feces of fishes are common phenomena which cause deterioration of water quality in terms of lower dissolved oxygen, higher ammonia and excessive algal blooms due to nutrient build up [5, 6]. Sangma *et al.* [8], Begum *et al.* [9] and Habib *et al.* [10] reported pH and DO ranged between 7.2-7.4 and 4.91-4.92 mg/l, 7.18-7.38 and 5.37-5.42, 7.50-7.90 and 4.90-6.70 mg/l, respectively in pond cage culture system, which were lower than the findings of the present study. NH_3-N ranged between 0.010-0.07 mg/l was also reported by Sangma *et al.* [8] and Begum *et al.* [9] in water of cage cultured in pond, which was also higher than the findings of the present study. Results of the present study were mainly influenced by water currents that constantly sweeping out the uneaten feed and feces of cultured organisms, which highlighted the suitability of cage fish farming in running water system.

Significantly higher growth and production performance was recorded at T_1 for Pangus followed by Magur at T_2, Gulsa Tengra at T_4 and Pabda at T_3. The variations in growth performance in the present study might be due to the variation of species specific inherent differences in genetic makeup and feeding behaviour [23, 24, 25]. Different fish species have different protein and amino acid absorption ability [26], which might responsible for the variation of growth performance of fishes in the present study. On the other hand, maximum weight is also a factor responsible for growth variations in different catfish species. Pangas is well-known for its faster growth [27] and can achieve a maximum weight of 872 g in pond culture [28]. Moreover, Magur also have potential to grow larger in size in culture condition. Therefore, higher increment of growth performance for Pangas and Magur was common than Pabda and Gulsa Tengra. The final weight obtained by Pabda and Gulsa Tengra was lower than the findings of Kohinoor *et al*. [29], whereas they reported mean final weight of 35.33 and 28.21 g for Pabda and Gulsa Tengra, respectively during the culture period of six months. During the study period, the higher survival rate of Pangas was coincided with the finding of Mian *et al*. [30], who have reported the survival of Pangas ranged between 87-93% in their study period. Moreover, SGR and FCR of treatment T_1 were also more or less similar with the findings of Sayeed *et al*. [28] and Azad *et al*. [31], respectively. Lower survival for Magur during the study period was due to their escaping tendency from the cage, which causes physical injury and much mortality.

During the study period, voracious feeding habit of Pangas resulted in significantly higher feed cost at T_1. Therefore, total cost was also varied significantly among the treatments and the highest total cost was recorded from treatment T_1. On the other hand, although growth performance of the studied fishes was found better for Pangas, significantly (P<0.05) higher net return was recorded for Gulsa Tengra T_4, and finally benefit cost ratio also showed higher economic performance for Gulsa Tengra. This was due the fact that the market price of Gulsa Tengra was comparatively higher than other fish species selected in the present experiment. Not only that, cage culture of catfish species was more profitable than Tilapia [12].

Conclusion

It was evidenced from the present study that cage fish farming in running water could minimizes the negative environmental effect on water quality. Pangas responded towards higher growth performance and higher total production. However, overall economic analysis revealed the efficacy of Gulsa Tengra as a potential catfish species to be cultured in net cages of running water habitat.

Acknowledgement

This research work was funded by Bangladesh Agricultural Research Council (BARC), Dhaka PIU-BARC, NATP-2 Project (ID-035).

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