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Marginal Analysis of Culture of Stinging Catfish (*Heteropneustes fossilis*, Bloch): Effect of Different Stocking Densities in Earthen Ponds

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Abstract: A culture experiment was conducted to see the effect of different stocking densities on production of stinging catfish (*Heteropneustes fossilis*) in earthen ponds for a period of four months. Four different stocking densities were tested, namely treatments T_1 (40,000 individuals ha^{-1}), T_2 (60,000 individuals ha^{-1}), T_3 (80,000 individuals ha^{-1}) and T_4 (1,00,000 individuals ha^{-1}) and each have two replications. The initial length and weight of the fish were 5.13 cm and 0.7 g respectively. Significantly ($P<0.05$) highest weight was found in T_1 and T_2 (52.64 and 51.84 g respectively). Best survival (98.81%) was found in T_1, which was also significant ($P<0.05$). Whereas significantly ($P<0.05$) highest production was obtained in case of T_3 and T_4 and it was 3189 kg ha^{-1} and 3364 kg ha^{-1} respectively. Marginal analysis was done for economic analysis. Marginal rate of return for changing from T_1 to T_2 was 74%, T_2 to T_3 was only 1% and T_4 was a *dominated treatment*. So among the treatments in four months of culture experiment of stinging catfish (*Heteropneustes fossilis*), 60,000 individuals ha^{-1} stocking density (T_2) would be the best recommendation for farmers.

Key words: Stinging catfish, *Heteropneustes fossilis*, stocking density, marginal analysis and *dominated treatment*

Introduction

Among the air-breathing catfishes, stinging catfish (*Heteropneustes fossilis*) is very popular and high priced fish in Bangladesh. This fish is locally known as Shingi. It is considered to be highly nourishing, palatable and tasty and well preferred because of its less spine, less fat and high digestibility in many parts of Indian subcontinent. Owing to its taste, medicinal values and as can be marketed as live fish, it fetch a high price. It occurs in all types of ponds and can survive for a very long time when kept in captivity even in a small quantity of water, for it has massive paired sac-like pharyngeal lungs as accessory respiratory organs (Das, 1927). So, Shingi (*H. fossilis*) is a promising species for culture in such types of water bodies due the accessory respiratory organs that allows it to thrive well in waters with low oxygen levels.

During the last few years, the natural abundance of this fish has been rapidly decreased due to various manmade and natural causes. Moreover, natural breeding grounds of this fish also under threat due to drying up and indiscriminate use of fertilizers and pesticides. If the situation continues this endemic catfish will be endangered in near future.

Culture of *H. fossilis* has not yet been flourished in Bangladesh due to lack of appropriate culture technology, scarcity of fry and fingerlings and non-availability of low cost supplementary feed for the fish. Timely supply of adequate quantity of fry and fingerlings will facilitate the development of commercial farming of this fish.

Earlier accounts on this species include general remarks on the fish (Deraniyagala, 1930), seasonal histology of gonads (Ghosh and Kar, 1952), seasonal morphology of gonads in relation to the pituitary (Sunderaraj, 1959), biology (Bhatt 1968, Sufi and Bakeya, 1985, Azadi and Siddique, 1986, Kuddus *et al.,* 1997), induced breeding for fry production (Pal and Khan, 1969, Sundararaj and Goswami 1969, Khan, 1972a and 1972b, Thakur *et al.,* 1974 and 1977; Saha *et al.,* 1998), food and feeding habits (Kuddus *et al.* 1995) and nutrition (Molla *et al.,* 1973, Asadur Rahman *et al.*1982, Sufi and Begum, 1986, Akand *et al.,* 1989 and 1991, Hossain *et al.,* 1993, Anwar and Jafri, 1995). Only Haque *et al.* (1988) reported on cultural prospects of Shingi in floating cages.

The present investigation was undertaken to find out appropriate stocking density in pond culture and its economics of *H. fossilis* production in Bangladesh.

Materials and Methods

Source of fish: The fingerlings of *H. fossilis* used in this experiment were produced in the hatchery of Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh.

Experimental design: The experiment was conducted for four months (August to November, 2000) with 30 days old

H. fossilis fingerlings to see the effect of different stocking densities on growth, survival and production. Twelve ponds were used; size of each pond was 0.032 ha. Four different stocking densities were tested with three replications in each. Stocking densities were 40000, 60000, 80000 and 100,000 individuals ha^{-1} as T_1, T_2, T_3 and T_4 respectively. All the ponds were situated at the campus of FS, BFRI, Mymensingh. The average water depth was 1.5 m in all the ponds.

Pond preparation and release of fingerlings: All the eight experimental ponds were dried for several days and then those were filled up by fresh under ground water. Lime was used at a rate of 1 kg $decimal^{-1}$. Fertilizers such as Urea, TSP and cow dung were used after three days of liming at a rate of 100 g $decimal^{-1}$, 200 g $decimal^{-1}$ and 20 kg $decimal^{-1}$ respectively. Fingerlings were released 3 days after the application of fertilizers and manures.

Methods of feeding: A commercial fish feed named Saudi Bangla Fish Feed (Grower-1) were used as supplementary feed at a rate of 4% of total body weight of stocked fish twice daily at 9:00 and 17:00 hrs. The amount of feed was adjusted fortnightly on the basis of sampling of experimental fish. Proximate composition of the feed was determined following the standard methods given by AOAC (1984) in the Nutrition Laboratory of Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. The proximate composition of the feed is shown in Table 1.

Sampling procedure: Sampling was carried out fortnightly; random samples of 50 *H. fossilis* from each of each replication of all the treatments were caught by cast net (mesh size ½”). Total length was recorded using a stainless steel scale and weight was measured by using a three-pin balance (accuracy upto 0.1 g). The fishes were released in the respective places after recording length and weight.

Physico-chemical parameters: Water quality parameters such as temperature, pH and dissolved oxygen were monitored during the experimental period. Temperature was recorded everyday using a Celsius Thermometer; dissolved oxygen and pH were measured weekly by a portable digital DO meter (WPA OX 20) and a portable digital pH meter (WPA CD 70).

Survival rate and production: At the end of the experiment all the ponds were dewatered and all the fish were caught by hand and counted and weighed to find out the survival rate and production respectively.

Statistical analysis: All the structured designs and data were analyzed using a one-way ANOVA. This included significant results ($P<0.05$) were taken as rejection of the null hypothesis-significant differences between the treatments. Significant results were further analyzed using Duncan’s Multiple Range Test in order to determine ranking and significant differences between treatment means. These results are displayed as superscripts against each respective value. All statistical analyses were carried out using the computer package MSTAT-C (version 2.10).

Marginal analysis

Calculation of total cost that vary: Cost of seed: In different Treatments cost of seed were calculated on the number of fish stocked per hectare. The price of fingerlings was Tk. one per piece.

Cost of feed: Total amount of feed required in different treatments was varied due to different densities. At the time of the experiment the price of fish feed was Tk. 19 per kg.

Cost of labour required for fish harvest: At the end of the experiment the required labor for harvest of fish, varied because of the different survival rate in different treatments. A labour can pick roughly at the rate of 200 fish per hour from mud. Price of labor was Tk. 55 per day and they work 8 hours daily. So, for harvesting of 1600 fish it needed Tk. 55 and in this way total cost of labor was calculated in different treatments on the basis of total numbers of fish collected.

Gross field benefits: The adjusted yield for a treatment was calculated by average yield adjusted downward by 80%. The gross field benefits for each treatment were calculated by multiplying the field price by the adjusted yield. The field price of Stinging Catfish was considered Tk. 150 per kg.

Net benefits: Net benefits were calculated by subtracting the total that varies from the gross field benefits for each treatment.

Dominated treatment: Any treatment that has net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated.

Marginal rate of return: Marginal rate of return is the marginal net benefit (i.e., the change in net benefit) divided by the marginal cost (i.e., the change in costs), expressed as percentage.

Results

The growth parameters, survival rate and yield of *H. fossilis* in four treatments viz. T_1, T_2, T_3 and T_4 have been reported in (Table 2). Significantly (P<0.05) highest length (19.43 cm), weight (52.64 g) and survival rate (98.81%) were obtained in T_1 but in case of weight there was no significant (P<0.05) difference between T_1 and T_2. Lowest length (18.36 cm), weight (44.20 g) and survival rate (76.13%) were found in T_4 (Table 2). The highest yield was observed in T_4 (3364 kg ha^{-1}), but no significant (P<0.05) difference was observed with T_3. Whereas significantly (P<0.05) lowest yield was found in T_4 and it was 2080 kg per hectare (Table 2). Month wise weight increments have been shown in Fig.1. Here one exception was noticed that the average weight gained in 3rd month of T_3 was higher than T_4, may be it was occurred due to sampling error. Data on physico-chemical parameters of water i.e., temperatures, pH and dissolved oxygen during the experimental period has been summarized in Table 3. Temperature, pH and DO of water in ponds under different treatments ranged between 18.7-32.5°C, 6.9-8.1 and 5.2-6.5 mg l^{-1} respectively.

Partial Budget of the experiment has been summarized in Table 4. The adjusted yields were 1664 kg ha^{-1}, 2293 kg ha^{-1}, 2551 kg ha^{-1} and 2691 kg ha^{-1} in case of T_1, T_2, T_3 and T_4 respectively (Table 4). The highest gross field benefit was found in T_4 and it was Tk. 403,650 per hectare, the lowest gross field benefit was studied in T_1 and it was Tk. 249,600 per hectare (Table 4). In case of Total Costs That Vary was highest (Tk. 256,358 ha^{-1}) in T_4 and lowest (Tk. 125,316 ha^{-1}) in T_1 (Table 5). Net benefits were found Tk. 124284, Tk. 164531, Tk. 164896 and Tk. 147292 in T_1, T_2, T_3 and T_4 respectively (Table 5). The net benefit of T_4 was lower than T_3 and that is why it is a *Dominated Treatment* (Table 5). Net benefit curve has been shown in Fig. 2. Marginal rate of return for changing T_1 to T_2 was 74%, T_2 to T_3 was only 1% and T_4 was a *dominated treatment* (Table 6 and Fig. 2).

Discussion

The success of intensive fish culture depends on the fish feed that contains an optimum level of protein and energy necessary for the growth of the fish. Earlier studies suggested that a crude protein level of 40% was the requirement of the *H. fossilis* (Rahman *et. el.*, 1982; Niamat 1985). Akand *et al.* (1989) concluded that the protein requirement of *H. fossilis* at an average temperature of 29°C was 27.73-35.43% when casein was the source of protein. The feed used in this experiment contains 38.92% protein, which was in between the range of suggested protein requirement.

Table 1: Proximate analyses of the feed used (% dry matter basis)

Dry matter	Protein	Lipid	Ash	Crude fibre	NFE*
81.52	38.92	3.61	19.25	11.10	27.12

*Nitrogen Free Extract calculated as: 100 - % (Protein + Lipid + Ash + Crude fibre)

Table 2: Growth and survival of *H. fossilis* (Shingi) under different Treatments after four months culture period in earthen pond

Parameters	T_1(40,000 ha^{-1})	T_2(60,000 ha^{-1})	T_3(80,000 ha^{-1})	T_4(1,00,000 ha^{-1})
Initial Length (cm)	5.13	5.13	5.13	5.13
Initial Weight (g)	0.7	0.7	0.7	0.7
Final Length (cm)	19.43^a	19.04^{ab}	18.82^{ab}	18.36^b
Final Weight (g)	52.64^a	51.84^a	48.31^b	44.20^c
Survival (%)	98.81^a	92.16^b	82.53^c	76.13^d
Yield (kg ha^{-1} per 4 months)	2080.00^c	2866.00^b	3189.00^a	3364.00^a

Means in the same row with different superscripts are significantly different (P<0.05)

Table 3: Physico-chemical parameters of water during the rearing period of *H. fossilis*

Parameters	T_1	T_2	T_3	T_4
Ranges of average temp.(°C)	18.7-32.1	18.9-32.5	18.9-32.3	19.1-32.1
Ranges of average p^H	7.1-7.9	7.3-8.0	7.1-8.1	6.9-7.8
Ranges of average DO (mg l^{-1})	5.5-6.5	5.4-6.5	5.4-6.4	5.2-6.1

Table 4: Partial Budget: density experiment of Shingi

Parameters	T_1	T_2	T_3	T_4
Average Experimental Yield (kg ha^{-1})	2,080	2,866	3,189	3,364
[1]Adjusted Yield (kg ha^{-1})	1,664	2,293	2,551	2,691
[2]Gross Field Benefits (Tk. ha^{-1})	249,600	343,950	382,650	403,650
Costs:				
[3]Seed (Tk. ha^{-1})	40,000	60,000	80,000	100,000
[4]Feed (Tk. ha^{-1})	83,958	117,517	135,486	152,736
[5]Labor Required for Harvest	1,358	1,902	2,268	3,622
Total Costs That Vary (Tk. ha^{-1})	125,316	179,419	217,754	256,358
Net benefits (Tk. ha^{-1})	124,284	164,531	164,896	147,292

[1]Adjusted Yield = 80% of the Average Experimental Yield,
[2]Shingi field price = k. 150 kg
[-1,3]Seed cost = Tk.one per piece,
[4]Feed cost = Tk. 19 kg^{-1} (Saudi Bangla Fish Feed – Grower 1/Pungus),
[5]Labor cost = Tk. 55 day^{-1} (8 hours per working day),
*Feed was applied @ 4% of the total body weight twice daily,
*US $ 1.00 = Tk. 58.40

Table 5: Dominance analysis: effect of different stocking densities of the culture of Shingi

Treatments	Density (fish ha^{-1})	Total Costs That Vary (Tk. ha^{-1})	Net Benefits (Tk. ha^{-1})
T_1	40,000	125,316	124,284
T_2	60,000	179,419	164,531
T_3	80,000	217,754	164,896
T_4	100,000	256,358	147,292 D

Table 6: Marginal analysis: effect of different stocking densities of the culture of Shingi

Treatment	Total costs that vary (Tk. ha^{-1})	Marginal costs (Tk. ha^{-1})	Net benefits (Tk. ha^{-1})	Marginal net benefits	Marginal rate of return
1	125,316		124,284		
		54,103		40,247	74%
2	179,419		164,531		
		38,335		365	1%
3	217,754		164,896		

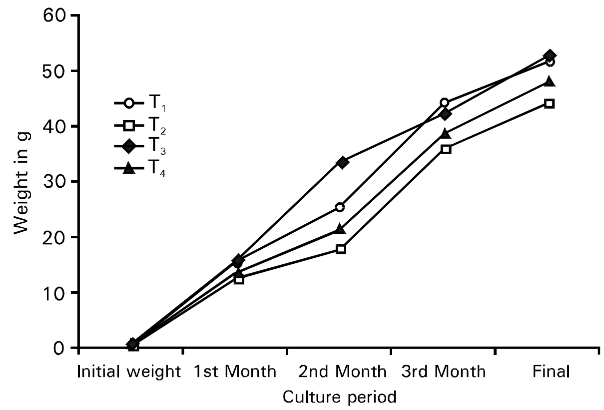

Fig. 1: Month wise weight increment of *Heteropneustes fossilis* in pond culture

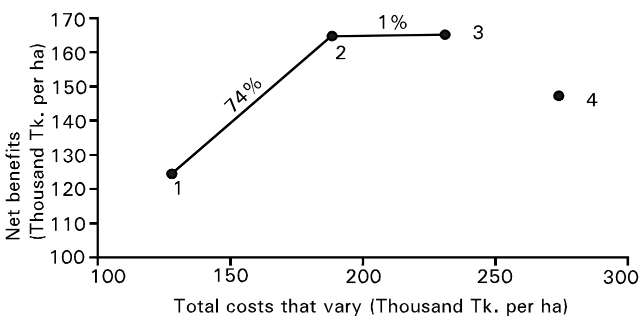

Fig. 2: Net benefit curve, density experiment of Shingi

Stocking density has been considered as an important parameter in aquaculture practices. Backiel and Le Cren (1967) described that stocking density has direct effect on growth and survival of fish. The harmful affects that higher stocking density has on the culture of fish are the reduction of growth and survival rate (Powell, 1972). Growth performance of *H. fossilis* in earthen ponds revealed that T_1 and T_2 produced significantly ($P<0.05$) better growth than other treatments. In case of survival T_1 is significantly ($P<0.05$) better than T_2. But the production scenario was different, where T_3 and T_4 were significantly ($P<0.05$) better than T_1 and T_2. Haque *et al.* (1988) found that stocking density has direct effect on growth and production in case of cage culture of *H. fossilis*. In their experiment *H. fossilis* were reared for a period of 180 days in floating cages at the stocking density of 25, 50, 75 and 100 fish m^{-3}. They reported that cages stocked with 100 fish m^{-3} (highest density) gave the lowest individual growth, but highest production was also observed in the same density. In this experiment too, effect of stocking density has been observed on growth and survival rate; in higher stocking density lower growth and survival rate have been found. Hussain *et al.* (2001) found better growth and production but lower survival rate than our experiment in pond culture of *Clarias batrachus* for eight months, the stocking density was 160, 240 and 320 individuals decimal^{-1}; which is equal to 40000, 60000 and 80000 individuals ha^{-1}. The reason behind it may be due to longer culture period than ours.

The ranges of water temperature, pH and dissolved oxygen during the experimental period were found to be in the desirable range according to Boyd (1982).

In case of marginal analysis, T_4 was a dominated treatment, that means the yields of T_4 is the highest than those of the other treatments, but the dominance analysis showed that the value of the increase in yield was not enough to compensate for the increase in costs. To improve the farmer's incomes it is important to pay attention to net benefits, rather than yields. The purpose of marginal analysis was to reveal just how the net benefits from an investment increase as the amount invested increase. In this case, the marginal rate of return for changing from T_1 to T_2 was 74%. It means that for every Tk. 100 invested in density 60,000 ha^{-1} rather than density 40,000 ha^{-1} of Shingi culture for a period of four months, farmers can expect to recover the Tk. 100 and obtained an additional Tk. 74. For T_2 to T_3 the marginal rate of return was only 1%; for every Tk. 100 invested in the higher density (80,000 ha^{-1}), they will recover the Tk. 100 and an additional Tk. one.

So, the stocking density of 60,000 individuals ha^{-1} for culture of Shingi for a period of four months is the best recommendation for farmers.

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