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Stocking density of threatened cat fish *Heteropneustes fossilis* (Bloch, 1792) in seasonal ponds of Rajshahi, Bangladesh

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Abstract

An attempt was made to evaluate the effect of stocking density on the growth of *Heteropneustes fossilis* for a period of six months reared in earthen ponds at Rajshahi University Campus. H. fossilis fingerling were stocked at the rate of 320, 280, 240/dec in treatment T_1, T_2 and T_3, respectively, The treatments had significant effects on the weight gain, length gain, ADG, SGR parameters among the treatments. Highest weight gain (45.90g) was observed in T_3 and lowest (36.97g) in T_1. Significant ($P<0.05$) highest yield was obtained in case of T_2 and T_3 and it was 2686.80 kg/ha and 2343 kg/ha, respectively. Higher net benefits (5,18519.91TK/ha) were obtained from treatment T_2, than from treatments T_1 and T_3, water temperature, transparency, pH and dissolved oxygen did not differ significantly ($P>0.05$) among the treatments depicting the suitable range for fish culture. The plankton levels in all the treatments were found to be at optimum state. Final length, final weight and survival of fingerlings followed the same trends of weight gain. Cost benefit ratio was also highest (1:0.93) in T_2 followed by T_3 and T_1. Overall, highest growth, fish yield survival (95.67%) rate and net benefits of fingerlings were obtained at a density of 280/dec (69, 160 individuals/ha) in treatment T_2 were recorded.

Keywords: Stocking density; Yield; *Heteropneustes fossilis* and cost benefit ratio

Introduction

The catfish, *Heteropneustes fossilis* (Bloch, 1792) is one of the best known cat fishes in Bangladesh. The flesh and skeleton of the fish supply a high percentage of protein and minerals like calcium, phosphorus, iron etc. (Basu and Gupta, 1939). It is found that the food value of 100g flesh of *H. fossilis* contains protein 23g, fat 0.5g, calcium 0.67g and phosphorus 0.65g (Siddiqui and Chaudhury, 1996). This type of composition is not found in any other fish groups available in fishery culture. So, the fish has a good nutritive value and physicians prescribe the fish for the convalescents and fast growing children.

The fish inhabits in both fresh and brackish waters but abundant in all types of freshwater bodies. It can be cultured in shallow ponds, canals, cemented cisterns, paddy fields and sewage waters. So commercial large-scale production of *H. fossilis* can play a vital role in the country economy. Polyculture failed to fulfill the demand of farmers and therefore they were looking for new species which could be cultured with high stocking density. Introduced African catfish *(C. gariepinus)* and Thai pangas were not accepted by consumers because of their predatory nature, black spots and poor taste in comparison with the local *H. fossilis* (Khan *et al*., 2005). So, the air-breathing indigenous stinging catfishes are the species which can fulfill the requirement of the people and farmers in Bangladesh. Catfishes are an important group of fishes in our country. According to Pal and Khan (1969), shing *(Heteropneustes fossilis,* Bloch) is a commercially important air breathing catfish which is one of the high ranking valuable fishes of Bangladesh. It is a highly popular, delicious table fish. Catfish is important due to its faster growth, easy culture system, disease resistant and tolerant to a wide range of environmental parameters. *H. fossilis* can survive at a reduced oxygen level (Stickney, 1979). Moreover, possession of accessory respiratory organs enable it to breathe in atmospheric air. The fish is very hardy and can be cultured in seasonal ponds of northern Bangladesh where carp culture is not possible. They require relatively small area for culture and can be stocked at higher density than any other species.

The stinging catfish *(H. fossilis)* is commercially as well as aqua culturally an important species in many Asian countries (Akand *et al*., 1991). It occurs in all types of inland water bodies and can survive for a long time when kept in captivity even in a small quantity of water as it has a massive pair of sac-like structures as accessory respiratory organ (Das, 1972). Stocking density is an important parameter in fish culture operation in nursery and rearing ponds because, it has direct effects on growth, survival and production (Backiel and LeCern, 1978). For the development of culture technique of

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catfish *(H. fossilis)* stocking density on grow-out rearing might play a very important role.

The growth of fish is also dependent on the population density (Backiel and LeCren, 1978). Higher density may cause crowding effects and reduction in growth rate. So, it is necessary to determine a suitable stocking density for fry rearing of *H. fossilis* and *C. batrachus*.

Successful aquaculture requires not only careful selection of species, appropriate feeding and water quality management but also a great extent, the density to which the fishes are stocked as compared to the food ration and extent of management. Backiel and LeCren (1978) described stocking density as an important parameter in fish culture as the health, growth and survival of fishes depend upon this factor. Higher stocking density reduces the growth and survival rates during fish culture (Shugunan, 1997). Earlier very few studies were made on the biology of *H. fossilis* like Mia (1984) reported length-weight relationship, Das *et al*. (1989) calculated fecundity and Singh and Goswami (1989) studied the age and growth. Few published information is available on the effect of stocking density on growth and survival rate of *H. fossilis*. Considering the lack of information on these aspects, the present investigations were carried out to ascertain the optimum stocking density and enhanced yield of *H. fossilis* in Rajshahi, Bangladesh.

Materials and methods

Location of the study area

The experiment was performed in earthen ponds of 40.4m^2 in the hatchery complex, Department of Fisheries, University of Rajshahi for a period of six months .The ponds were similar in shape, depth, basin configuration including water supply facilities. The water depth was maintained around 1.2-1.5 m. To maintain the water level and to keep the good water quality, water was added to the ponds at regular intervals using pump machine.

Experimental design

The experiment was designed in a completely randomized design with three treatments namely T_1, T_2, and T_3, each having three replications. Three different stocking densities were maintain in the experimental ponds as 320/dec (79,040 individual/ha) in the T_1, 280/dec (69,160 individual/ha) in the T_2 and 240/dec (59,280 individual/ha) in the T_3, respectively. The same size of *H. fossilis* fry were stocked to serve this purpose. Low cost indigenous feed (27% protein level) provided to the fishes was same in this trial for each treatment, variation being only in stocking density as shown in Fig. 1.

Pond preparation

Control of undesirable species and aquatic weeds: Aquatic weeds and undesirable species were completely removed from all the experimental ponds by draining out of water. Lime (Calcium carbonate) was applied at the rate of 240 kg ha^{-1}. Lime was liquefied into an aluminum bucket and then applied by spreading homogenously in the ponds.

Fertilization

Ponds were fertilized with urea and triple super phosphate (TSP) each at a rate of 25 kg ha^{-1} (Mazid, 2002) and cowdung at a rate of 1000 kg ha^{-1} after three days of liming. TSP was applied after dissolving in plastic buckets for 10 to 12 hours before application. Fertilizers were applied by spreading methods.

Collection of fishes

The fingerlings *H. fossilis* were collected from a private

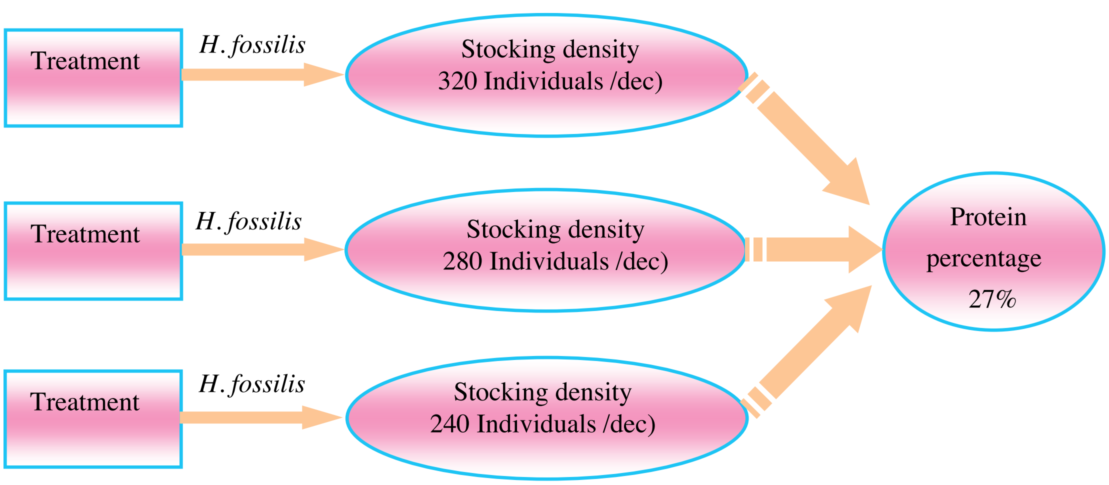

Fig. 1. Layout of the experiment on stocking density

hatchery of the Madhupur Upazila of Tangail district in Bangladesh. The average weights of the fingerlings were 9.20±1.68 g Fingerlings were brought to the experimental site through plastic barrels with proper aeration. After completion of the first trial the fingerlings were again collected from the same place.

Stocking

Fingerlings were stocked at densities of 320/dec, 280/dec and 240/dec in T_1, T_2, T_3, respectively. The fingerlings were transferred plastic bucket and released the experimental ponds. The length and weight of around 10% of all fingerlings of each pond were measured and recorded for estimating initial stocking biomass and to adjust initial feeding rate for fishes. The fishes were stout and naturally moving at the time of releasing in the ponds.

Feeding of fishes

The supplemental feed was given to *H. fossilis* at the rate of 5% of their body weight for proper growth of fishes at the beginning. The fishes were fed (containing 27% crude protein) daily at a rate of 5% of body weight for the first three months and 3% of body weight for next three months. Half of the required feed per day was supplied in the morning and rest half in the afternoon. The feeding was adjusted on the basis of fish weight. Feed requirements were calculated and adjusted after sampling of fishes once in a month. The composition of feed has been given in Table I. The ingredients were analyzed for their proximate composition and the results are shown in Tables-II & III. The proximate composition of feed ingredients and experimental diets was analyzed according to the methods given in Association of Official Analytical Chemists (AOAC, 1980).

Table I. Composition of feed used in the experiments

Ingredients	Percentage
Fish meal	22
Mustard oil cake	25
Rice bran	15
Wheat bran	28
Wheat flour	10

Growth sampling of fishes

Fishes were sampled fortnightly using cast net to assess their growth and health condition. At least 10 fishes from each pond were taken to make assessment of growth trends and to readjust feeding rate. Length and weight of sampled fishes were measured using a measuring scale and digital electronic balance (OHAUS, MODEL no. CT-1200-S). Fishes were handled carefully to avoid stress during sampling.

Table II. Proximate composition of the feed ingredients used (% dry matter basis)

Ingredient	Dry matter	Protein	Lipid	Ash	Crude fibre	NFE[a]
Fish meal	90.21	56.5	16.34	20.57	1.58	5.01
Mustard oil cake	91.65	31.5	10.85	8.94	10.53	38.18
Rice bran	89.32	12.50	14.76	12.45	15.23	45.06
Wheat bran	89.24	13.8	4.12	3.87	13.67	64.54
Wheat flour	88.74	16.5	5.4	10.3	11.4	56.4

a Nitrogen free extract calculated as 100% -(moisture+protein+ lipid + ash + crude fibre)

Table III. Analyzed proximate composition of the experimental diet (% dry matter basis)

Components	Diet
Dry matter	89.86
Protein	27.02
Lipid	11.26
Ash	10.83
Crude fibre	11.34
NFE	39.55
Gross energy (kj/g) 1	17.422
PE ratio (mg/kj) 2	15.5091

[1]Gross energy was calculated according to Hasan *et al*., 1989; Tacon, 1990
[2]Protein to energy ratio in mg protein per kJ of gross energy

Water quality monitoring

Study of water quality variables: A number of water quality parameter such as temperature (°C), transparency (cm), pH, dissolved oxygen (mg l^{-1}) alkalinity, ammonia-nitrogen (mg l^{-1}), were measured fortnightly at 9:00-10:00 am at the pond site to assess the physico-chemical condition of the pond.

Estimation of growth, survival, production and feed utilization

Twenty individuals from in each pond were sampled every ten days interval until they attained the marketing size. The growth performance of the individual were evaluated in terms of length and weight. Mean weight gain, average daily gain (ADG), specific growth rate (SGR), Food conversion factor (FCR), Survival rate (%) and mean values(SD) for each parameter were computed. Average daily gain (ADG) and (%) Survival were followed according to De silva (1989). SGR and FCR were calculated according to Brown (1957), Castell and Tiews (1980), Hepher (2009) respectively. After six month, the fishes were harvested by repeated netting, followed by drying the ponds. The individuals were counted and weighed. Survival and production (number.ha^{-1}) of fishes were then calculated and compared among the treatment.

Economic analysis

Economic analysis was done to estimate the economic return in each treatment from the mono culture of *H. fossilis*. The cost of each ingredient was calculated on the basis of Rajshahi whole sale market price. The total cost of inputs was calculated and the economic return was determined by the differences between the total return (from the current market prices) and the total input cost. The cost in taka per unit yield (CPY) was calculated and was expressed as the cost in Tk/kg of fishes produced.

Statistical analysis

The data were analyzed through one-way analysis of variance (ANOVA) using SPSS (Statistical Package for Social Science, version-11.5) followed by Duncan Multiple Range test to find out whether any significant difference existed among treatment means (Duncan, 1955). The level of significance was evaluated. The results are displayed as superscripts against each respective value.

Results and discussion

Water quality variables

The physico-chemical characteristics of water in earthen ponds where the fingerlings of *H. fossilis* were reared did not show significant variation (Table-IV). Suitable water quality parameters are prerequisite for a healthy aquatic environment and for production of the adequate fish food organisms.

Water transparency is a gross measure of pond productivity. It has inverse relationship with the abundance of plankton. Water transparency ranged from 18.10±0.12 to 31.43±0.12, 20.63±0.09 to 27.63±0.30 and 21.47±0.18 to 28.17±0.07 cm in the treatments T_1, T_2 and T_3. Boyd (1990) recommended a transparency between 15 to 40 cm as appropriate for fish culture. Wahab *et al*. (1994) suggested that the transparency of productive water should be 40 cm or less. The mean values of secchi depth (cm) were more or less similar among the treatments and those were 22.94±2.02, 23.63±0.99 and 23.40±1.09 cm, in treatments T_1, T_2 and T_3 respectively. Viveen *et al*. (1985) and Haque *et al*. (2005) recorded transparency 17-32 and 20-35 cm, respectively in catfish rearing ponds. The transparency values of different treatment in the present study indicated that the pond water seemed to be within the productive range for catfish culture.

Table IV. Variation in the mean (±SE) values and ranges of water quality variables in different treatments during the study period

Water quality variables	Treatments		
	T_1	T_2	T_3
Transparency (cm)	22.94±2.02^a	23.63±0.99^a	23.40±1.09^a
Water temperature (°C)	28.38±1.91^a	28.28±1.85^a	28.20±1.96^a
*p*H	7.17±0.04^a	7.22±0.04^a	7.24±0.03^a
DO (mg/l)	5.54±0.10^a	5.52±0.16^a	5.50±0.14^a
Alkalinity (mg/l)	104.50±2.18^a	109.61±2.06^a	107.42±2.81^a
NH_3-N (mg/l)	0.0190±0.0023^a	0.0145±0.0002^b	0.0182±0.0005^{ab}

Values in the same row having the same superscript are not significantly different (P>0.05)

The maximum temperature (32.67°C) was found in treatment T_1 in July and that of minimum was (19.27°C) in T_3 in December. In Bangladesh, fish grows all the year round and there is no problem of very low temperature but sometimes extremely high temperature kills fishes especially in a shallow and turbid waterbody (Rahman *et al*., 1982). Quddus and Banerjee (1989) stated that the water temperature between 29°C and 32°C is suitable for the faster growth of fish spawn and aquatic organisms under natural conditions. Rahman (1992) found water temperature ranging from 25.5°C to 30.0°C, which is favorable to fish culture. The mean values of temperature (°C) were 28.38±1.91, 28.28±1.85 and 28.20±1.96°C in treatment T_1, T_2 and T_3 respectively, which were slightly high from the recommended suitable range. Britz and Hecht (1987) obtained higher growth rates between 25°C and 33°C the best was at 30°C. However, Viveen *et al*. (1985), Sarkar et al. (2005) and Haque *et al*. (2005) recorded temperature 20-30°C, 28-31°C and 24-33.9°C respectively in catfish ponds.

Most water bodies have *p*H within the range of 6.5 to 8.5. The circum-neutral *p*H or slightly alkaline *p*H is most suitable for fish culture. An acidic *p*H reduces the growth rate, metabolic rate and other physiological activities of fish (Swingle, 1967). pH 6.5 to 9.0 is suitable for pond fish culture. More than 9.5 is unsuitable because free CO_2 is not available in this situation. In the present experiment *p*H was around neutral to highly alkaline and it was due to local soil condition and heavy photosynthesis. The mean values of *p*H in treatments T_1, T_2 and T_3 were 7.17±0.04, 7.22±0.04 and 7.24±0.03, respectively. The *p*H value recorded from the experiment agreed with the findings of Sarkar *et al*. (2005) and Haque *et al*. (2005).

DO concentrations in water depend on many variables including temperature, sunlight, atmospheric pressure, salinity, plant life, and water turbulence. Fishes can survive at low levels of dissolved oxygen (1 mg l^{-1} or less) for few hours but not for long time. The DO concentration in the present study ranged from 3.95 to 6.25 mgl^{-1}. During the period of investigation, the DO content was found sometimes lower which caused for respiration of plankton, heavy temperature and other aquatic organisms, was also reported by Sharma *et al.* (1978). In the experiment the DO concentration ranged from 3.95 to 6.25 mg/l^{-1} which is fairly close with the findings of Sarkar *et al.* (2005) and Haque *et al.* (2005) who recorded the DO ranges from 3.87-5.85 mg/l^{-1}, 2.15-6.74 mg/l^{-1} and 1.10-6.80 mg/l^{-1}, respectively under different treatments. The concentration of dissolved oxygen was fairly well as stocked fish did not show any sign of oxygen deficiency throughout the study period. According to Rahman (1992), DO content of a productive pond should be 5 mg/l or more. Banerjee (1967) and Bhuiyan (1970) reported 5.0 to 7.0 mg/l of DO content of water as fair or good in respect of productivity and water having DO less than 5 mg/l to be unproductive.

In alkaline waters essential nutrients were found in higher quantities and this was the most important reason for higher biological productivity in alkaline waters than in acidic waters. But highly alkaline condition is not favourable for biological production (Rahman, 1992). Total alkalinity may be several hundred mg l^{-1} in natural waterbodies. In the present study mean values of total alkalinity were 104.50±2.18, 109.61±2.06 and 107.42±2.81 mg l^{-1} in treatment T_1, T_2 and T_3, respectively and The highest value of total alkalinity was 116.33 mg l^{-1} in T_2 on December and the lowest value was 97.08 mg l^{-1} in T_1 on October agreeing with the findings of Hossain *et al.* (2007), Sarkar *et al.* (2005), Haque *et al.* (2005) recorded the values ranging from 81.25 to 147, 87.33-114.0 mg/l^{-1} and 41.0-208.0 mg/l^{-1}, respectively. According to Boyd (1982), total alkalinity should be more than 20 mg l^{-1} in natural fertilized ponds. Rath (2000) stated that calcareous water with alkalinity more than 50 ppm was most productive. He also described the range of alkalinity 0-20 ppm as low productive, 20-40 ppm as medium productive and 40-90ppm as high productive. On the basis of findings it can be said that the total alkalinity recorded from the present study is within productive range. The highest value of ammonia-nitrogen (0.0287 mg l^{-1}) was found in treatment T_1 on 3 October and the lowest value was found 0.0137 in T_2 on October. Chen (1988) found that lower than 1 mg l^{-1} of NH_3 gas content in pond was good for fish culture. However, he concluded that the permissible level was higher than the value of 0.012 mg l^{-1}. The mean values of ammonia-nitrogen were 0.0190±0.0023, 0.0145±0.0002 and 0.0182±0.0005 mg l^{-1} in T_1, T_2 and T_3, respectively. Alam *et al.* (1997) recorded ammonia nitrogen value 0.2 to 0.4 mg l^{-1}. So, in the present study ammonia-nitrogen value was suitable for catfish culture.

Plankton population

Boyd (1973) reported that fish excreta and uneaten portion of feed in catfish ponds supply large quantities of nutrients. Six planktonic groups were identified out of which 4 were from phytoplankton and 2 were from zooplankton. Similarly, Khan *et al.* (2005) recorded 4 group of phytoplankton and 2 groups of zooplankton. A total 29 genera of plankton, of which 20 were phytoplankton belonging to Bacillariophyceae (4), Chlorophyceae (9), Cyanophyceae (5) and Euglenophyceae (2) and 9 of zooplankton belonging to Rotifera (3) and Crustacea (6) were identified. More or less similar results were also obtained by Khan *et al.* (2005) and Dewan *et al.*

Table V. Mean abundance (±SE) of plankton (x10^3 cells/l) recorded from the ponds under the three treatments

Groups	Treatments		
	T_1	T_2	T_3
Bacillariophyceae	8.33±0.73[a]	7.58±0.80[a]	7.24±0.52[a]
Chlorophyceae	35.38±2.37[a]	33.77±1.81[a]	33.71±1.14[a]
Cyanophyceae	21.22±1.64[a]	18.90±1.25[a]	18.97±0.92[a]
Euglenophyceae	4.14±0.56[a]	3.31±0.49[a]	2.83±0.41[a]
Total Phytoplankton	69.06±4.55[a]	63.56±3.85[a]	62.74±1.83[a]
Percentage	94.20	93.14	94.54
Rotifera	1.91±0.23[a]	2.27±0.29[a]	1.58±0.22[a]
Crustacea	2.34±0.26[a]	2.41±0.37[a]	2.04±0.32[a]
Total zooplankton	4.25±0.26[a]	4.68±0.50[a]	3.62±0.43[a]
Percentage	5.79	6.85	5.45
Total plankton	73.31±4.52[a]	68.24±3.85[a]	66.36±2.12[a]

Means followed by same superscripts did not differ significantly at 5% level.

(1991). Thus the recorded planktonic communities of the present experiment reflect the typical feature of plankton in tropical fish pond.

Total plankton

The mean abundance of total phytoplankton was 69.06±4.55×10^3/l in T_1, 63.56±3.85×10^3/l in T_2 and 62.74±1.83×10^3/l in T_3. Chlorophyceae was dominant among the phytoplankton group and Euglenophyceae was the least dominant group. The mean zooplankton concentration was 4.25±0.26, 4.68±0.50 and 3.62±0.43×10^3/l in treatment T_1, T_2 and T_3, respectively. There was no significant difference (P>0.05) among the treatments. Crustacea was the dominant group among zooplankton. Statistical analyses showed no significant difference (P>0.05) in the mean abundance of total phytoplankton. Percentage composition of phytoplankton and zooplankton are shown in Table-5. Total phytoplankton and zooplankton comprised 94.20% and 5.79%, respectively in T_1 and 93.14% and 6.85%, respectively in T_2, 94.54% and 5.45% T_3. The mean value of total plankton was 73.31±4.52, 68.24±3.85 and 66.36±2.12×10^3/l in T_1, T_2 and T_3, respectively. The mean values showed no significant difference (P>0.05) among the treatments. The phytoplankton abundances were consistently higher than that of zooplankton. Similar results have also been recorded in various food fish and fry or fingerling rearing ponds (Wahab *et al.,* 1994; Haque *et al*., 1998; Kohinoor *et al.,* 1999; Chakraborty *et al*., 2003). The mean value of total plankton was ranged from 66.48×10^3/l to 72.15×10^3/l among the different treatments which is more or less similar to the findings of Mumtazuddin and Khalique (1987). Total plankton was not significantly (P>0.05) different among the treatments which might be due to the same stocking density and combination of the cultured species. The abundant planktonic population throughout the study period might be due to regular application of feed.

Growth and production performances of H. fossilis

Stocking density is recognized as an important factor which directly affects the growth, survival and production of fish (Backiel and LeCren, 1978). Generally highest stocking density results in reduction of growth and survival and increase in the food conversion ratio (FCR), and severe competition for food and space (Powell, 1972). During the study period, the average final weight was found to be 40.47±0.38, 44.27±0.09 and 45.90±0.42g in T_1, T_2 and T_3 respectively (Table-6). Weight increments were (P>0.05) statistically significant among the treatments. The highest growths in weight were observed in T_3 (45.90 g) where the fingerlings were stocked at the rate of 37050 individuals/ha^{-1} and the lowest in T_1 (40.47g) due to highest stocking densities (61750 individuals/ha^{-1}). The average net weight gain in T_1, T_2 and T_3 were 36.97±0.38, 40.77±0.09 and 42.40±0.42 g, respectively. Decline in fish growth rate and feed utilization with increasing levels of stocking densities has been observed in several studies (Vijayan and Leatherland, 1988; Suresh and Lin, 1992).

The average length increased in T_1, T_2 and T_3 from 18.5±0.79, 18.77±1.01 and 19.03±0.96cm, respectively. The highest growths in length were observed in T_3 and lowest in T_1. The average net length gain in T_1, T_2 and T_3 were 11.70±0.10, 11.97±0.03, 12.23±0.12cm, respectively. Singh and Goswami (1989) observed that the fish *H. fossilis* attained a length of 143-175 mm in 1st year, 195-209 mm in second year, and 223-235 mm in third year and 249-253 mm in the fourth year. The growth rate of H. fossilis under the present study was within the range reported by Singh and Goswami (1989). The present result coincided with the findings of Kawamoto *et al*. (1957), Narejo *et al*. (2005), who achieved best growth at lower stocking densities. The specific growth rates (%, per day) of *H. fossilis* were significantly influenced by the stocking density. The SGR value (1.36±0.01) in T_1 was very low and significantly higher (P<0.05) SGR (1.43±0.01) were found in T_3. The average daily gain was found highest in T_3 (0.24 g) whereas, the lowest was found in T_1 (0.21g), which were significantly (P>0.05) different among the treatments. Growth in terms of ADG and SGR of *H. fossilis* was higher T_3 where the stocking density was low compared to those of T_2 and T_1, although same food was supplied in all treatments at an equal ratio. This phenomenon indicated that there was a low community feeling among the fishes which influenced them to take food properly. Similar observation was also noted by various authors; LeCren (1965), Powell (1972), Clay (1979), Das *et al*. (1992), Sahoo *et al*. (2002) who found maximum growth at low stocking densities. Whereas, Sarder and Mollah (1991) gave a different opinion in case of *P.* pangasius that growth rate increased at higher stocking densities (6 and 9 fish/m^3) when compared with the lower one (3 fish/m^3). However, the reduced growth rate of higher stocking densities might be due to over crowed conditions or presence of water-borne, fish produced substances (Francis *et al*., 1974; Rose and Rose, 1975). Moreover, at higher stocking densities, presence of abundant food substances could produce a comparative interaction among the fish causing a stressful situation (Houde, 1975). The water quality in ponds of all the treatments was within the acceptable limit and the size and and the health of the fingerlings at stockings was good that furnished high survival rate.

Significant variation in the survival rate of *H. fossilis* was observed among different treatments. Highest survival rate (95.67%) of *H. fossilis* in treatment-T_2 appeared to be related to the low stocking density. Survival rate dropped to (88.00%)

in treatment T_1 where the *H. fossilis* fishes were maintained at (79040 fry/ha). Therefore, stocking density-dependent effect was pronounced (P<0.05) on the survival rate of *H. fossilis*. The present study showed comparatively higher survival rates in lowest stocking densities. Similar observations were also made by Mollah (1985), Ita *et al*. (1989). The survival rate of present study also agreed with the findings of Samad *et al*. (2004) in *H. fossilis* ponds. Narejo *et al*. (2005) reported the highest survival rate of *H. fossilis* in lower stocking density. *H. fossilis* exhibited FCR of 3.80±0.09 for treatment T_1, 3.93±0.02 for treatment T_2 and 3.77±0.04 for treatment T_3 under different stocking densities among the treatments. The highest (3.93±0.02) FCR were observed with T_2 while the lowest (3.77±0.04) value was recorded with T_3. The FCR values which were slightly higher than the values reported by Islam *et al*. (2002). De Silva and Davy (1992) stated that digestibility played an important role in lowering the FCR value by efficient utilization of food. The highest fish yield was recorded from T_2 (2686.80 kg/ha/6 months) where the stocking densities were 69,160 individuals/ha^{-1}, and significantly lowest yield in T_3 (2343.00 kg/ha), due to low stocking densities. The net production obtained from the present study is more or less similar with the author Haque *et al*. (2005) who recorded total production of fish ranging from 1398.08 to 2145 kg/ha after six month rearing through providing commercial pellet feeds. The present result agrees with the finding of Mollah (1985) and Ita *et al*. (1989) who obtained higher production in higher density.

Economics and profitability

Similarly the net profit per unit of yield was the highest in T_2 and the lowest in T_1, which was significantly (P>0.05) different among the treatments. Cost and benefit ratio were significantly highest (P<0.05) in T_2 (1:0.93) and lowest in T_1 (1:0.66) (Table-7). The cost of feed constituted the highest and showed positive relationship with the stocking density. The net profit was significantly highest (P<0.05) in T_2 (5,18519.91) and lowest in T_1 (4,02609.60 Tk/ha). Haque *et al*. (2005) gained net profit which ranged from 1, 15,047 to 2, 71,178 Tk/ha. The net profits obtained from the present study are much higher which might be due to uprising market price of *H. fossilis*. Considering the growth, survival, net production and profit the results of the present study indicated that a stocking density of 69,160 individuals/ h^{-1} was suitable for fish culture and can earn more benefit. Considering the increase in growth rate, survival, net production and profit catfish *H. fossilis* of stocking density of the treatment T_2 provided better result when compared with the higher densities. Thus a stocking density of 69,160 individuals/ h^{-1} could be recommended to culture in earthen ponds in Rajshahi region.

Table VI. Variation in the mean (±SE) values of different growth parameters of *H. fossilis* during the study period under treatments

Growth parameters	Treatments		
	T_1	T_2	T_3
Initial weight (g)	3.50±0.00[a]	3.50±0.00[a]	3.50±0.00[a]
Final weight (g)	40.47±0.38[c]	44.27±0.09[b]	45.90±0.42[a]
Weight gain (g)	36.97±0.38[c]	40.77±0.09[b]	42.40±0.42[a]
Length gain (cm)	11.70±0.10[b]	11.97±0.03[ab]	12.23±0.12[a]
SGR	1.36±0.01[c]	1.41±0.02[b]	1.43±0.01[a]
ADG	0.21±0.003[b]	0.23±0.002[a]	0.24±0.003[a]
FCR	3.80±0.09[a]	3.93±0.02[a]	3.77±0.04[a]
Survival rate (%)	88.00±0.58[b]	95.67±0.33[a]	93.00±1.53[a]
Fish yield (kg/ha/6 months)	2538.37±44.57[a]	2686.80±15.82[a]	2343.00±62.68[b]

Means followed by same superscripts did not differ significantly at 5% level by DMRT

Conclusion

Considering increase in growth rate, survival, net production and profit of *H. fossilis*, the stocking density of the treatment T_2 produced better result when compared to the higher densities. Thus a stocking density of 69160 individuals/ h^{-1} (280/dec.) could be recommended to culture in earthen ponds in Rajshahi region. Stinging cat fish is an important and threatened high valued fish species which will definitely play an important role for livelihood upliftment of the rural fish farmers. So, the farmers may come forward for adapting *H. fossilis* culture techniques from which they will be able to make more profit than other fish species.

Table VII. Input cost and economic return in *H. fossilis* for six months in the ponds under three different treatments

Economical parameters	Treatments		
	T_1	T_2	T_3
Investment			
Cost of seed (Tk./ha)	237120.00[a]	207480.00[b]	177840.00[c]
	(±0.00)	(±0.00)	(±0.00)
Feed cost (Tk/ha)	332869.06[a]	309914.26[a]	284597.35[b]
	(±11505.31)	(±777.49)	(±1025.48)
Operational cost (Tk/ha)	42749.18[a]	38804.57[b]	34682.80[c]
	(±862.90)	(±58.31)	(±76.91)
Total Cost(Tk/ha)	612738.24[a]	556198.83[b]	497120.15[c]
	(±12368.20)	(±835.80)	(±1102.39)
Total return (Tk/ha)	1015347.84[a]	1074718.74[a]	929455.07[b]
	(±17828.93)	(±6326.35)	(±24867.11)
Net Profit per unit of yield (Tk/kg)	158.60[c]	192.98[a]	184.52b
	(±0.55)	(±0.39)	(±0.64)
Net Profit (Tk/ha)	402609.60[b]	518519.91[a]	432334.92[b]
	(±6451.42)	(±6950.81)	(±24823.80)
CBR	0.66b	0.93[a]	0.87[a]
	(±0.01)	(±0.01)	(±0.05)

Mean values in the same row having same superscripts are not significantly different
Seed cost=3.00, Feed cost=Tk 30/-, Market price of *H. fossilis* T1 =400/-, T2= 425/-, and T3=475/-
Price is related with size and weight of *H. fossilis*, Leasing cost of pond is not included.
Operational cost is considered as 7% of the total cost.

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