ISSN: 2347-5129
IJFAS 2015; 2(3): 81-86

www.fisheriesjournal.com
Received: 01-11-2014
Accepted: 02-12-2014

Md. Shirajum Monir
Head Quarter, Bangladesh Fisheries Research Institute Mymensingh-2201, Bangladesh.

Shafiqur Rahman
Marine Fisheries and Technology Station Bangladesh Fisheries Research Institute Cox's Bazar, Bangladesh.

Correspondence
Md. Shirajum Monir
Head Quarter, Bangladesh Fisheries Research Institute Mymensingh-2201, Bangladesh.

Effect of stocking density on growth, survival and production of shing (*Heteropneustes fossilis*) fingerlings under nursery ponds in Northern region of Bangladesh

Md. Shirajum Monir, Shafiqur Rahman

Abstract
An experiment was carried out in nine earthen nursery ponds to assess the growth performances, survival and production of *Heteropneustes fossilis* fingerlings for the period of 8 weeks from June to July 2012. Three stocking densities were tested for each, viz., 2 million fry ha^{-1} (T_1), 2.5 million fry ha^{-1} (T_2) and 3 million fry ha^{-1} (T_3). The growth performances and survival of *H. fossilis* fingerlings were significantly ($P<0.05$) higher in T_1 than those obtained from T_2 and T_3, respectively. Significantly ($P<0.05$) the lowest feed conversion rate (FCR) was in T_1 then followed by T_2 and in T_3. The highest number fingerlings was produced in T_1 than those in T_2 and T_3 but showed no significant ($P>0.05$) difference. However, the highest net benefit was in T_1 where the stocking density was 2 million fry ha^{-1}. Therefore, 2 million fry ha^{-1} (T_1) is the most suitable stocking density for nursing of *H. fossilis* for better production as well as higher net benefits.

Keywords: *Heteropneustes fossilis*, Fingerling, Growth, Survival, Production, Net benefits.

1. Introduction

Heteropneustes fossilis (Bloch) is an indigenous air-breeding catfishes, stinging catfish of South-East-Asia which is locally known as Singi or Shing in different parts of Bangladesh. Among the catfishes, Shing (*H. fossilis*) is very popular and high valued fish in Bangladesh. It is not only recognized for its delicious taste and market value but is also highly venerated for nutritional and medicinal aspect. The species is very high content of iron (226 mg per 100 g) and fairly high content of calcium compared to many other freshwater fishes [1]. It is a very hardy fish that can survive for quite a few hours outside the water due to presence of accessory respiratory organs [2, 3]. This fish was abundantly available in our open water system of floodplains, canals, beel and haors of Bangladesh. But due to over exploitation and various ecological changes in its natural habitat; this species is threatened. *H. fossilis* is one of the threatened fish in Bangladesh [4]. Considering its status of threatened, high market value and high consumer demand it is essential to develop an appropriate breeding, nursing and rearing technology of fry and fingerlings of *H. fossilis*.

The major constraint for the development of aquaculture system for any species is the availability of stocking material fingerlings. Growth performances and survival of fingerlings mostly depend on stoking densities, application of appropriate fertilizers and adequate amount of supplementary feeds as well as proper nursery ponds management. Although, *H. fossilis* nursing and culture technology have been developed mainly in Mymensingh region of Bangladesh but its culture have not yet been flourished in northern regions of Bangladesh due to lack of appropriate nursing and culture technologies, scarcity of fry and fingerlings. Timely supply of good quality and adequate quantity of fry and fingerling will be facilitated the development of commercial farming of this species especially in northern region. No work has yet been undertaken to evaluate the effects of stocking density on the growth and survival of *H. fossilis* fingerlings in nursery ponds in northern region of Bangladesh. Therefore, the present experiment has been carried out to develop an appropriate and economically feasible technology for mass seed production of *H. fossilis* in northern region of Bangladesh.

2. Materials and methods

2.1 Description of the study area and duration

The present experiment was conducted in Freshwater Sub-station, Bangladesh Fisheries Research Institute, Saidpur, Nilphamari located at 25° 46′ 41″ N, 88° 53′ 51″ E of Bangladesh for a culture period of eight weeks during June to July 2012. Nine experimental nursery ponds of 0.012 ha with an average depth of 1.2 m were selected for three treatments each with three replicates.

2.2 Nursery ponds preparation

Prior to stocking, the nursery ponds were dried and cleaned for unwanted weeds and species. All the dried nursery ponds were kept to sunlight for 10 days and the bottom soil was treated with quicklime (Ca_2O) at the rate of 250 kg ha^{-1} and enclosed by fine nylon mosquito net. After seven days, all the treated ponds were filled up with underground water and fertilized with cow dung at the rate of 100 kg ha^{-1}. After ten days of manuring, the treated nursery ponds were sprayed with sumitheone 2500 ml ha^{-1} to kill harmful insects and predatory zooplankton.

2.3 Sources and stocking of fry

The fry of Shing (*H. fossilis*) used in this experiment were produced in the hatchery of Freshwater Sub-station, Bangladesh Fisheries Research Institute, Saidpur, Nilphamari. After 24 hours of applying sumithone into the ponds water, 5 days old fry with an average length of 1.40±0.09 cm and weight of 0.0007±0.0002 g *H. fossilis* were stocked at the rate of 2, 2.5 and 3 million fry ha^{-1} under treatment-1 (T_1), treatment-2 (T_2) and treatment-3 (T_3), respectively on 01 June 2012. Before stocking the initial mean weights of the fingerlings were measured using sensitive balance (OHAUS Model CS-2000).

2.4 Feed supply in the nursery ponds

After stocking the fry were not fed for the first day in order to acclimatize them to the new nursery ponds. Then they were fed four times daily with MEGA nursery feed (38% crude protein) for the first 15 days and starter-I feed (35% crude protein) up to 60 days. The feeding rate was 14% of the estimated body weight of fry for the first two weeks, 12% for the second two weeks, 10% for the third two weeks and 8% for the last week. After 7 days of fry stocking, the nursery ponds were manure with organic fertilizer (100 kg ha^{-1}) at fortnight interval.

2.5 Growth measurement of the fry

The growth performances of the experimental *H. fossilis* fry/fingerlings was observed weekly for each pond random sampling method. At least 75 fry/fingerlings were sampled with the help of a seine net to measure the growth to assess the health status and for feed adjustment.

2.6 Physico-chemical parameters

Physico-chemical parameters such as surface water temperature (°C), transparency (cm), dissolved oxygen (mgl^{-1}), pH, total alkalinity (mgl^{-1}) and ammonia (mgl^{-1}) were weekly monitored at intervals between 8.30 to 9.30 am using a Celsius thermometer, a Secchi-disk, a portable dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal), a portable pH meter (HI 8424, Hanna Instruments, Portugal) and a portable ammonia test kit (Hanna), respectively. Total alkalinity was determined following the titrimetric method according to the standard procedure and methods [5].

2.7 Plankton population

Plankton from the nursery ponds was collected in every week for quantitative and qualitative estimation. Ten liters water samples was collected from each replicate experimental ponds and then filtered through bolting silk plankton net (25 μm) to obtain a 50 ml sample. The collected samples were preserved immediately with 5% buffered formalin. Plankton was expressed as cells per liter of water of each pond. The quantitative and qualitative analysis of phytoplankton and zooplankton was done according to Stirling [6] and Needham [7], respectively.

2.8 Harvesting of fingerlings

After 8 weeks of nursing, *H. fossilis* fingerlings were harvested by dewatering the nursery ponds. The harvested fingerlings were counted for estimated survival rate as well as production and at least 75 fingerlings individually weighted to assess final growth in terms of length and weight, specific growth rate (SGR %day) and feed conservation ratio (FCR). Specific growth rate (SGR %day) and feed utilization efficiency were calculated according to Ricker [8] respectively as follows:

SGR (%/day) = In [W.sub.2] - In[W.sub.1]/[T.sub.2] - [T.sub.1] x 100

Where,
[W.sub.1] = initial live body weight (g) at time [T.sub.1] (day) and
[W.sub.2] = final live body weight (g) at time [T.sub.2] (day).

Feed Conversion Ratio (FCR) = Dry weight (g) of feed supplied / Live weight (g) of fish gained

2.9 Data analysis

The final data were expressed as mean value±Standard deviation (SD) and analyzed by one-way analysis of variance (ANOVA). Percentage data were arcsine transformed before analysis of variance. Duncan's multiple range tests were analyzed among different group means. Significance was assigned at the 5% level (P>0.05). All statistical analysis was done by using the SPSS (Statistical Package for Social Science) version-11.5.

3. Results

3.1 Physico-chemical parameters

During the study period, the mean water temperature were 30.05±0.61, 30.04±0.41 and 29.89±0.87 ºC in T_1, T_2 and T_3, respectively but did not differ significantly (P>0.05) among the treatments. The transparency of water were significantly (P<0.05) higher in T_1 (34.50±3.02 cm) than those obtained in T_2 (42.17±5.70 cm) and T_3 (50.50±5.47 cm). The observed Dissolved Oxygen (DO) content ranged from 2.8 to 6.5 mgl^{-1} with mean values was 6.08±0.33 (T_1), 4.50 ±0.25 (T_2) and, 3.07±0.28 mgl^{-1} (T_3) and showed significant difference (P<0.05) among the treatments. The mean values of pH were 8.10±0.43, 8.28±0.25 and 8.13±0.19 recorded in T_1, T_2 and T_3, respectively but did not differ significantly (P>0.05). The highest mean value of total alkalinity was recorded in T_2 (148.83±0.9.28 mgl^{-1}) and the lowest was in T_1 (135.00±12.65 mgl^{-1}) but the variations among the treatments were not statistically significant (P>0.05). The mean values of ammonium-nitrogen (NH_4-N) in T_1 (0.01±0.01 mgl^{-1}) was significantly (P<0.05) lower than other treatments. However, there was no significant (P>0.05) variation between the T_2 (0.02 ± 0.02) and T_3 (0.05 ± 0.02 mgl^{-1}). (Table 1)

Table 1: Physico-chemical properties of weekly samples over the 8 weeks experiment.

Parameters	T_1(2 million fry ha^{-1})	T_2 (2.5 million fry ha^{-1})	T_3 (3 million fry ha^{-1})
Water temperature (°C)	30.05±0.61^a (29-32)	30.04±0.41^a (29-31)	29.89±0.87^a (28- 32)
Transparency (cm)	34.50±3.02^a (30-38)	42.17±5.70^b (37-52)	50.50±5.47^c (44-58)
Dissolved oxygen (mgl^{-1})	6.08±0.33^a (5.8-6.5)	4.50±0.25^b (4.2-4.9)	3.07±0.28^c (2.8- 3.4)
pH	8.10±0.43^a (7.6-8.6)	8.28±0.25^a (7.9-8.6)	8.13±0.19^a (7.9- 8.3)
Total alkalinity (mgl^{-1})	135.00±12.65^a (120-150)	148.83±9.28^a (135-160)	137.52±10.25^a (105-160)
Ammonia-nitrogen (NH_4-N) (mgl^{-1})	0.01±0.01^a (0-0.02)	0.02±0.02^a (0-0.04)	0.05±0.02^b (0.03-0.07)

Mean± SD (Standard deviation) and range in parentheses; Figures in the same row having the same superscript are not significantly different (*P* > 0.05).

3.2 Plankton population

The phytoplankton population in the experimental nursery ponds was mainly found four groups- Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae whereas the zooplankton population were composed only two groups- Crustacea and Rotifera (Table 2). Phytoplankton of Chlorophyceae group was the most dominant and Euglenophyceae group was the least abundant as observed during the study period. Zooplankton of Rotifera group was the most dominant in terms of both numbers and genera compared to Crustacean group among the treatments. The total phytoplankton ranged from (3640 to 18540) X 10^3 units l^{-1}) with mean abundance were 14790±1240 (T_1), 11203±1680 (T_2) and 8914±1450 X 10^3 units l^{-1} (T_3), respectively and showed significant (P<0.05) difference among the treatments. The mean abundance of total zooplankton were 7437±986, 5107±1059 and 3701±987 X 10^3 units l^{-1} in T_1, T_2 and T_3, respectively and also showed statistically significant (P<0.05) among the treatments.

Table 2: Plankton abundance (units l^{-1}) of pond water of weekly samples over the 8 weeks experiment.

Plankton group	T_1 (2 million fry ha^{-1})	T_2 (2.5 million fry ha^{-1})	T_3 (3 million fry ha^{-1})
Phytoplankton			
Bacillariophyceae	3850±411^a (2670-4540)	2920±580^b (1640-3654)	2574±479^c (1425-3415)
Chlorophyceae	5412±547^a (3297-7410)	3987±724^b (3145-5821)	2875±498^c (1750-3245)
Cyanophyceae	2987±542^a (1982-3800)	2542±854^b (1982-4582)	2240±654^c (1235-2895)
Euglenophyceae	2541±542^a (1641-4235)	1754±564^b (1254-2987)	1254±564^c (897-1875)
Total	14790±1240^a (5520-18540)	11203±1680^b (4420-17650)	8914±1450^c (3640-14565)
Zooplankton			
Crustacea	3987±754^a (1687-5200)	2887±564^b (1542-3750)	2154±538^c (1100-2875)
Rotifera	3450±678^a (2340- 5130)	2285±445^b (1470-3540)	1547±540^c (1254-3210)
Total	7437±986^a (4506-12310)	5107±1059^b (2840-7562)	3701±987^c (2340-5420)

Mean± SD (Standard deviation) and range in parentheses; Figures in the same row having the same superscript are not significantly different (*P* > 0.05).

3.3 Growth and production of *H. fossilis* fingerling

The length and weight of *H. fossilis* fingerlings under different stocking densities at the end of the experiment in weekly sampling is shown in Figs 1 & 2 which indicates that the improvement of length and weight were always higher in T_1 than T_2 and T_3. The mean final length attained under T_1, T_2 and T_3 were 8.48±0.10, 6.36±0.47 and 4.23±0.31 cm, respectively (Table 3).

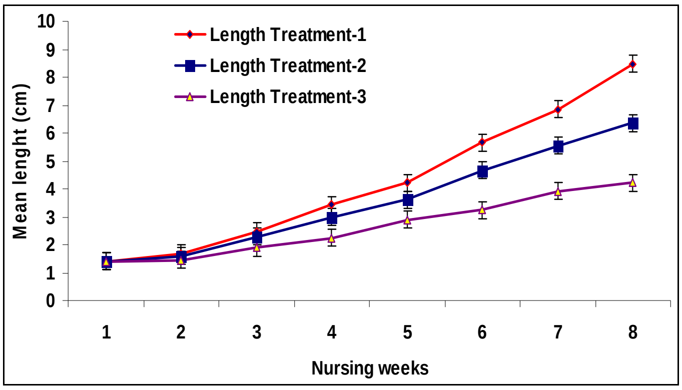

Fig 1: Improvement of the length of Shing (*H. fossils*) fingerlings at different stocking densities over the nursing period of 8 weeks.

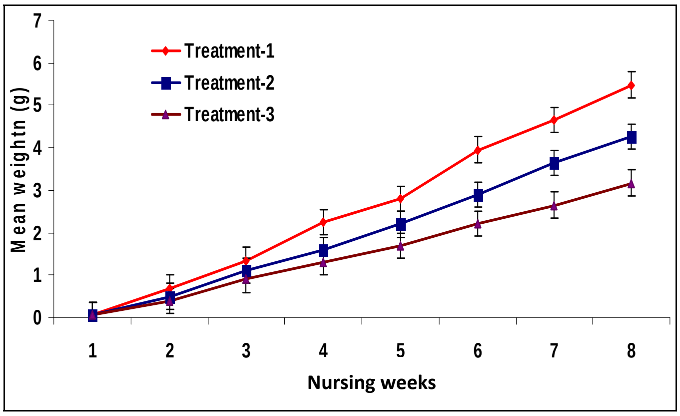

Fig 2: Improvement of the weight of Shing (*H. fossils*) fingerlings at different stocking densities over the nursing period of 8 weeks.

The highest mean final weight was also obtained in T_1 (5.48±0.37 g) and lowest in T_3 (3.17±0.31 g). However, the mean final length and weight were showed significant difference (P<0.05) in T_1 followed by T_2 and T_3, when ANOVA was performed. The Specific growth rate (SGR % day) were significantly (P<0.05) higher in T_1 (14.88±0.26) than those obtained in T_2 (14.46±0.61) and T_3 (14.00±0.43). The highest survival rate (68.67±5.68%) was also observed in T_1, where the stocking density was 2 million fry ha^{-1} whereas the lowest was 33.33±7.57% in T_3, where the stocking density was 3 million fry ha^{-1} and there were significantly differences among the treatments. The Food Conversion Ratio (FCR) of T_1 (1.47±0.25) was found to be significantly lower than T_2 (2.27±0.40) and T_3 (3.10±0.25). However, the highest number of fingerlings was recorded in T_1 (1373333) and the lowest was produced in T_3 (1000000 fingerlings ha^{-1}) but the variations among the treatments were not statistically significant (*P*>0.05).

Table 3: Growth performances, survival, feed utilization and production of Shing (*H. fossilis*) fingerlings after 8 weeks of nursing.

Parameters	Treatments		
	T_1(2 million fry ha^{-1})	T_2 (2.5 million fry ha^{-1})	T_3(3 million fry ha^{-1})
Initial length (cm)	1.40±0.09^a (1.32-1.51)	1.40±0.09^a (1.32-1.51)	1.40±0.09^a (1.32-1.51)
Final length (cm)	8.48±0.10^a (8.38-8.58)	6.36±0.47^b (5.90-5.6.84)	4.23±0.31^c (3.90-4.50)
Initial weight (g)	0.0007 ±0.0002^a (0.0006-0.0009)	0.0007 ±0.0002^a (0.0006-0.0009)	0.0007 ±0.0002^a (0.0006-0.0009)
Final weight (g)	5.48±0.37^a (5.17-5.89)	4.27±0.49^b (3.70-4.60)	3.17±0.31^c (2.90-3.50)
Length gain (cm)	7.07±0.16^a (6.96-7.26)	4.96±0.56^b (4.39-5.52)	2.84±0.27^c (2.58-3.12)
Weight gain (g)	5.48±0.37^a (5.16-5.88)	4.27±0.49^b (3.69-4.60)	3.17±0.31^c (2.8-3.5)
Specific growth rate (SGR) (% day)	14.88±0.26^a (14.64-15.16)	14.46±0.61^{ab} (14.64-15.16)	14.00±0.43^b (13.58-15.16)
Feed conversion ratio (FCR)	1.47±0.25^a (1.2-1.7)	2.27±0.4^b (1.9-2.7)	3.10±0.25^c (2.8-3.3.3)
Survival (%)	68.67±5.68^a (64-75)	51.33±7.76^b (45-60)	33.33±7.57^c (28-42)
Production of fingerlings (No. ha^{-1})*	1373333±113724^a (1280000-1500000)	1283333±194186^a (1125000-150000)	1000000±227156^a (840000-1500000)

Mean± SD (Standard deviation) and range in parentheses; Figures in the same row having the same superscript are not significantly different ($P > 0.05$). *Total number of fingerlings that produced after a rearing period of 8 weeks.

3.4 Cost-benefit analysis

Among the treatments, the total cost of production was the lowest in T_1 (BDT 2, 44, 200 ha^{-1}) than those in T_2 (BDT 2, 96, 450 ha^{-1}) and T_3 (BDT 3, 49, 200 ha^{-1}). The net benefits generated from 8 weeks nursing period was calculated as BDT 11,29,133, 6,66,050 and 4,00,800 ha^{-1} for T_1, T_2 and T_3, respectively. However, the highest net benefits of BDT 11, 29, 133 ha^{-1} was obtained from T_1 where Shing (*H. fossilis*) fry stocked in 2 million fry ha^{-1} (Table 4).

Table 4: Costs and benefits for of Shing (*H. fossilis*) fingerlings production in 1ha earthen ponds for a nursing period of 8 weeks.

Items	Treatments		
A. Cost	T_1 (BDT)*	T_2 (BDT)	T_3 (BDT)
Pond lease (BDT 65,000.00/ha/yr)	21,700 (4 months)	21,700 (4 months)	21,700 (4 months)
Lime (BDT 20.00/kg)	5,000	5,000	5,000
Cow dung (BDT 6/kg)	15,000	15,000	15,000
Dipterex (BDT 1,000.00/kg)	8,000	8,000	8,000
Fry (BDT 30,000.00/million)	60,000	75,000	90,000
Feeds:			
a. Nursery (BDT 44.00/kg)	4,500	6,750	9,500
b. Starter-1 (BDT 40.00/kg)	75,000	1,10,000	1,45,000
Labour (2 labour @ BDT 250/day)	45,000	45,000	45,000
Miscellaneous	10,000	10,000	10,000
Total costs	2,44,200	2,96,450	3,49,200
B. Gross benefit			
Selling price of fingerlings**	1,37,3333	9,62,500	7,50,000
Net benefits (B-A)	11,29,133	6,66,050	4,00,800

* 1 US$ = BDT 80.00

** Price of *H. fossilis* fingerlings fixed by the institute was BDT 1.00/piece (T_1) and BDT 0.75/piece (T_2 and T_3).

4. Discussion

Growth, feed efficiency and feed consumption of fish are normally governed by a few environmental factors [9, 10]. The mean range of water temperature (28 to 32 °C) in the nursery ponds is within suitable range for nursing of Shing (*H. fossilis*). Rahman [11] observed almost similar types of temperature variation in nursery rearing of *Ompok pabda* fingerlings. The mean transparency level was significantly ($P<0.05$) higher in T_3 and consistently lower in T_1, which might be due to the reduction of the plankton population by higher density of fish [12, 13]. The recorded pH values of water ranging from 7.6 to 8.6 which indicates slightly alkaline. However, the pH range was found to be suitable for fish culture that agrees well with the findings of Rahman [12] and Kohinoor [10]. The dissolved oxygen (DO) in the morning was low in the experimental nursery ponds where stocked with a high density of fish compared to low stocking density ponds. This might be due to the higher consumption rate of oxygen by the higher density of fish and other aquatic organisms that agree with Boyd [14]. However, the DO level is within the acceptable ranges in all the experimental nursery ponds. The mean values of ammonium-nitrogen (NH_4-N) in T_1 (0.01± 0.01 mgl^{-1}) was significantly ($P<0.05$) lower from the other treatments. Ammonia-nitrogen contents in T_2 and T_3 were higher than T_1 that might be due to higher stocking density fry of Shing (*H. fossilis*). Boyd [14] reported that the suitable range of ammonia-nitrogen in fish culture less than 0.1 mgl^{-1}. However, in the study the level of ammonia-nitrogen content in the experimental nursery ponds is not lethal to the *H. fossilis* fry [13].

The plankton abundance in the present experiment was significantly higher in T_1 which might be due to the lower density fry/fingerlings than those in T_2 and T_3. It seems likely that in the nursery ponds where stocking density was high, consumption of plankton by the fry/fingerlings was also high. Rahman and Monir [13] obtained phytoplankton range 8500 to 15500 x10^3 units l^{-1} in nursery ponds located in Saidpur, Nilphamary. However, the plankton population in the study showed to be more or less similar with the findings of Rahman [11].

Growth performances (final length, length gain, final weight, weight gain and specific growth rate) and survival rate of Shing (*H. fossilis*) in nursery ponds revealed that T_1 was significantly higher ($P<0.05$) where the stocking density of fry (2 million fry ha^{-1}) was low compared to those of T_2 (2.5 million fry ha^{-1}) and T_3 (3 million fry ha^{-1}) although the same fish feed with equal ratio was applied among all the treatments. The lower growth performances were in T_2 and T_3 than T_1 that might be due to competition for food and habitat for higher number of fingerlings. Stocking density is known to be one of the important parameters in fish culture, since it directly effects growth and survival, and hence production [15]. Haylor [16] revealed that the growth and survival rate of African catfish (*Clarias gariepinus*) larvae was significantly influenced by the density at which they were stocked. More or less similar results also were obtained by Rahman [12], Kohinoor [17] and Kohinoor [18] from their fry/fingerlings rearing experiments with various carp, barb and catfish species. However, higher stocking density with abundance with sufficient feed might produce a stressful situation if the feed is not used for growth [19, 20].

The Food conversion ratio (FCR) in T_1 during the study period was significantly lowest followed by T_2 and T_3. In the present study, the FCR values are lower than the FCR values reported by many workers [21, 22, 13]. The causes might be due to the smaller ration size, higher digestibility and proper utilization of feed. Reddy and Katro [23] and Das and Ray [24] observed increasing trends of FCR values with increasing ration size in the growth trials of air breathing catfish (*Heteropneustes fossilis*) and Indian major carp (*Labeo rohita*), respectively. However, the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities.

After completion of the experiment, the highest number of fingerlings were in T_1 (1373333) compared to those in T_2 (1283333) and T_3 (1000000 ha^{-1}). Rhaman [11] reported that production of pabda (*Ompok pabda*) were 127333 to 147670 fingerlings ha^{-1} for a 8 weeks nursing. In addition, Rahman and Monir [13] reported that production of Thai *Anabas testudineus* fingerlings was ranged from 640000 to 700000 of 7 weeks nursing. However, the production of *H. fossilis* was higher than those reported by Rahman [11] and Rahman [13].

A simple cost-benefits analysis showed that the net benefits was higher in treatment T_1 (where *H. fossilis* stocking density was 2 million fry ha^{-1}) than T_1 and T_3. Rahman [25] analyzed the cost and benefits of Reba Carp (*Cirrhinus ariza*) nursing and got the net benefits of BDT 69,277.32 ha^{-1} for 8 weeks nursing where fish were fed formulated feed. Rahman and Monir [13] got the net benefit BDT 2, 40, 757 to 5, 71, 112 ha^{-1} for 7 weeks nursing of Thai koi (*Anabas testudineus*). In this experiment, the net benefits was higher than the above findings. Therefore, it could be concluded that 2 million fry ha^{-1} is the most suitable stocking density for nursing of *H. fossilis* in the nursery ponds for better production as well as higher net benefits.

5. Conclusion

The growth, survival, production and net benefits of Shing (*H. fossilis*) fingerlings were inversely related to the stocking densities of fry in the experimental nursery ponds. In all respects, 2 million fry ha^{-1} was the highest performances than those obtained at higher stocking rates. However, stocking density of 2 million fry ha^{-1} may be suggested for rearing of Shing (*H. fossilis*) fingerlings over 8 weeks in single stage nursing rearing system in northern region of Bangladesh.

6. Acknowledgment

The authors would like to extend gratitude to the Director General, Bangladesh Fisheries Research Institute (BFRI) and Chief Scientific Officer, Freshwater Station, BFRI, Mymensingh for their kind assistance and co-operation as well as for allocating fund to complete the research smoothly. The authors also wish to thanks to the staffs of Freshwater sub-station, Bangladesh Fisheries Research Institute, Saidpur, Nilphamari who were participated the experimental activities.

7. Reference

1. Saha KC, Guha BC. Nutritional investigation on Bengal fish. Indian J Med Res 1939; 26:921-927.
2. Das BK. The bionomics of certain air-breathing fishes of India, together with an account of the development of their air-breading organs. Phil Trans 1927; 216:1-41.
3. Khan MN, Saiful Islam AKM, Hossain MG. Marginal analysis of culture of stinging catfish (*Heteropneustes fossilis*, Bloch): Effect of different stocking densities in earthen ponds. Pak J Biol Sci 2003; 6(7):666-670.
4. IUCN. Red book of threatened fish of Bangladesh. The world Conservation Union. Bangladesh, 2000, Appendix-I, 61.
5. Clesceri LS, Greenbarg AE, Trussell RR. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association and Water Pollution Control Federation. Edn 18, 1015 Washington DC, USA, 1992, 10- 203.
6. Stirling HP. Chemical and biological methods of water analysis for aquaculturists. Institute of Aquaculture, University for Stirling Scotland. 4LA FK9, 1985,119.
7. Needham JG, Needham PR. A guide to study of freshwater biology. Edn 5, Holden- day Inc, San Francisco, 1963,106.
8. Ricker WE. Computation and interpretation of biological statistics of fish population. Bull Fisheries Res Board of Canada 1975; 191:1-382.
9. Brett JR. Environmental factors and growth. In: Hoar WS, Randal DJ, Brett JR (Eds.) Environment relations and behavior, Fish Physiology, Academic press, New York, 1979; 6:599-677.
10. Kohinoor AHM, Khan MM, Yeasmine S, Mandol P, Islam MS. Effects of stocking density on growth and production performance of indigenous stinging catfish, *Heteropneustes fossilis* (Bloch). Int J Agril Res Innov and Tech 2012; 2(2):9-14.
11. Rahman MA, Yeasmine S, Khan MM. Growth, survival and production of a threatened silurid catfish, O*mpok pabda* (hamilton) fingerlings in nursery ponds. Malays Appl Biol 2008; 37(1):47-56.
12. Rahman MA, Mazid MA, Rahman MR, Khan MN, Hossain MA, Hussain MG. Effect of stocking density on survival and growth of critically endangered mahseer, *Tor putitora* (Hamilton) in nursery ponds. Aquaculture 2005; 249:275-284.
13. Rahman S, Monir MS. Effect of stocking density on survival, growth and production of Thai *Anabas testudineus* (bloch) fingerlings under nursery ponds management in northern regions of Bangladesh. Journal of Experimental Biology and Agricultural Sciences 2013; 1(6):465-472.
14. Boyd CE. Water quality management for fish culture. Elsevier Science Publisher, the Netherlands, 1982, 318.
15. Backiel T, ED Le Cren. Some density relationship for fish population parameters. In: Gerking SD (Editor). The Biological Basis of Freshwater Fish Production. Blackwell Scientific Publication. Oxford 1967; 27-36:261-293.
16. Haylor GS. Controlled hatchery production of *Clarias gariepinus* (Burchell): Growth and survival of larvae at high stocking density. Aquacult Fish Manage 1992; 23(3): 303-314.
17. Kohinoor AHM, Islam AKMS, Jahan DA, Zaher M,

Hussain MG. Monoculture of climbing perch, Thai koi, *Anabas testudineus* (Bloch) under different stocking densities at on-farm. Bangladesh Journal of Fisheries Research 2007; 11:173-180.

18. Kohinoor AHM, Jahan DA, Khan MM, Ahmed SU, Hussain MG. Culture potentials of climbing perch, *Anabas testudineus* (Bloch) under different stocking densities at semi-intensive management. Bangladesh Journal of Fisheries Research 2009; 13:115-120.
19. Haque MZ, Rahman MA, Hossain MM, Raman MA. Effect of stocking densities on the growth and survival of mirror carp, *Cyprinus carpio* var. *specularis* in rearing ponds. Bangladesh Journal of Zoology 1994; 22:109-116.
20. Rahman MA, Rahman MR. Studies on the growth and survival of sharpunti (*Puntius sarana* Ham.) spawn at different stocking densities in single stage nursing. Progressive Agriculture 2003; 14(1-2):109-116.
21. Islam MS. Evaluation of supplementary feeds for semi-intensive pond culture of mahseer, *Tor putitora* (Hamilton). Aquaculture 2002; 212:263-276.
22. Islam MS, Dewan S, Hussain MG, Hossain MA, Mazid MA. Feed utilization and wastage in semi-intensive pond culture of mahseer, *Tor putitora* (Ham.). Bangladesh Journal of Fisheries Research 2002; 6:1-9.
23. Reddy SR, Katro S. Growth rate and conversion efficiency of air breathing catfish, *Heteropneustes fossilis* in relation to ration size. Aquaculture 1979; 18:35-50.
24. Das I, Ray AK. Growth performance of Indian major carps *Labeo rohita* (Ham.) on duckweed incorporated pelleted feed: a preliminary study. Journal of Inland Fisheries 1989; 21:1-6.
25. Rahman MA, Zaher M, Azimuddin KM. Development of fingerling production techniques in nursery ponds for the critically endangered Reba Carp, *Cirrhinus ariza* (Hamilton, 1807). Turkish Journal of Fisheries and Aquatic Sciences 2009; 9:165-172.