E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2019; 7(5): 194-199

www.fisheriesjournal.com
Received: 09-07-2019
Accepted: 13-08-2019

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Studies on the growth, survival and production of endangered mahseer, *Tor putitora* (Hamilton, 1822) at different stocking densities in primary nursing

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Abstract
The research work was conducted in six nursery ponds of 0.01 ha each with 4 days old mahseer, *Tor putitora* spawn at three different stocking densities viz., 1.50, 1.75 and 2.00 million spawn/ha each having two replicates. Fries were fed same diet of MEGA fish feeds in three different treatments containing 40.57% crude protein (pre-nursery feed) for the first 14 days and 35.52% crude protein (nursery feed) for the second 14 days. The feeding rate was 20 kg/ million spawn/ day for the first 2 weeks and 24 kg/ million spawn/ day for the second 2 weeks. The physico-chemical characteristics of pond water were measured weekly. The mean values of some water quality parameters such as temperature (°C) were 22.50±0.35 (T1), 22.69±0.39 (T2), 22.81±0.37 (T3); transparency (cm) 28.38±2.00 (T1), 41.88±2.45 (T2), 52.25±1.93 (T3); dissolved oxygen (mg/l) 4.90±0.21 (T1), 4.42±0.15 (T2), 3.72±0.07 (T3); pH 7.34±0.22 (T1), 7.21±0.23 (T27.53±0.21 (T3) and alkalinity (mg/l) 92.38±3.06 (T1), 112.13±6.48 (T2), 117.38±5.75 (T3) from 28 days, respectively. The ranges of water quality parameters were suitable for fry and fingerling rearing. The highest weight gain was recorded in T1 (1.79±0.03) and the lowest in T3 (1.46±0.04). The mean value of final weight (g) was 1.81±0.02, 1.71±0.02 and 1.52±0.03 in T1, T2 and T3, respectively. Significantly lower specific growth rate was found in T3 (7.23±0.04) than T1 (7.54±0.02) and T2 (7.45±0.02). Fingerlings in T3 produced significantly higher food conversion ratio (0.61±0.10) than T1 (0.44±0.07) and T2 (0.48±0.04). The survival rate of mahseer was 63.05±0.59% (T1), 60.38±0.51% (T2) and 55.19±0.70% (T3), respectively. Significantly higher number of fingerlings was produced in T3 (1103700±10608) than T1 (945675±9320) and T2 (1056650±10314), respectively. But the simple cost benefit analysis showed that higher net benefits were obtained in T2 (TK. 13, 09,968) where the ponds stocked with 1.75 million spawn/ha. Hence, it seems that, among the three tested stocking densities, 1.75 million spawn/ha is the most efficient stocking density for primary nursing of mahseer spawn.

Keywords: *Tor putitora*, primary nursing, densities, growth, survival, production

1. Introduction
About 260 freshwater fish species and 475 marine species are found in Bangladesh [1]. Among the freshwater species, *Tor putitora* [2] commonly known as 'mohashol' or as "mahseers" belongs to the family cyprinidae of the order cypriniformes is a highly sought after group due to their high commercial and recreational values and also a famous sport fish in Bangladesh, Nepal and India [3, 4]. It is the most valuable and ranks high as a popular food. Because of its desirable and tasty flesh, as a considered delicacy by all classes of people in Bangladesh [5]. It is also a highly attractive species to anglers particularly in Nepal and India [6, 7].
Although a significant proportion of natural stock of *Tor* spp. of mahseer are contributed in Bangladesh, India, Nepal and Pakistan but only *T. tor* and *T. putitora* are found in the hilly streams of Sylhet, Mymensingh, Dinajpur and Kaptai reservoir of Chittagong Hill Tracts in Bangladesh [8, 9, 4]. As an omnivorous fish, mahseer eats plants, insects, shrimp and mollusks as feed [10, 11, 4]. Spawning behaviour and breeding biology of mahseer have striking similarities with that of carps coinciding with monsoon as main breeding period. Various workers have carried out their research on reproductive biology of mahseer species and observed that there is almost similar breeding mechanism and behaviour depending on aquatic ecological factors. The spawning habit of mahseer involves migration towards upstream

during the southwest monsoon in search of crystal clear water for maturation and also in search of food. Spawning grounds of mahseer have specific features. The physico-chemical parameters such as temperature, pH, velocity, turbidity and rains are some of the important factors for triggering spawning in hill-stream fishes [12]. Sandy bottom having aquatic weeds and depth of 2-2.5 cm, highly flooded and turbid water, rocky beds of the river with intermittent deep pools act as potent site for spawning of mahseer [13]. Highly oxygenated water is most crucial for spawning of mahseer with optimum water temperature ranging between 21- 26 °C. In Bangladesh, the breeding season of mahseer initiate at the early November and continue upto the end of January [14]. The maximum fecundity of *T. putitora* was recorded 12,000 eggs per kg body weight of female [15, 16]. According to Ahmed [5], mahseer attains nearly 3 m in length and 45 kg in weight but the maximum size recorded from Cauveri River weighed 54 kg [14].

In recent years natural fish stocks have been declined due to natural and man-made degradation of environments and reduction of wetlands resulting in the loss of suitable habitats for a large number of indigenous fish species has been threatened or endangered including mahseer. As a result, mahseer has been enlisted as one of the most endangered fish species of Bangladesh [14, 17, 18]. So, it is very much essential to protect this fish from extinction and conserve the natural stocks. In this situation, it is crucial that appropriate measures be taken to reduce habitat loss and breeding, nursing and culture technique of the mahseer will be developed [14, 19, 4]. Bangladesh Fisheries Research Institute at Mymensingh has been introduced this species in Bangladesh from Nepal and have successful in artificially breeding [4]. But there is no sufficient information about on growth and survival of fry and fingerling rearing of *T. putitora* in earthen ponds. So, the present study has been undertaken to establish an appropriate culture technology for nursing and rearing of *T. putitora* to ensure quality and regular supply of fingerlings.

2. Materials and Methods

2.1 Study area and experimental design

The experiment was conducted in farmer's ponds of Baraigoan under Trishal Upazila, Mymensingh for a period of 4 weeks from 4 January 2017 to 31 January 2017 in six earthen nursery ponds. All the ponds were rectangular in size and shape and the surface area of each pond was 0.01 ha with an average water depth of 3 feet. Three treatments differing in stocking densities of spawn viz., 1.50 million spawn/ha (T1), 1.75 million spawn/ha (T2) and 2.00 million spawn/ha (T3) were tested with two replicates each.

2.2 Pond preparation, stocking and management

At first, water of the experimental ponds was drained out and all fish species and aquatic vegetations were removed. After drying, pond bottoms were treated with quicklime (CaO) at the rate of 250 kg/ha to kill harmful animals and pathogens. All the ponds were then filled with ground water at a depth of about 3 feet. The pond water was sprayed with dipterex (1.0 ppm) to eradicate harmful insects and predatory zooplankton. One day after the application of dipterex, 4-day-old spawn having an average length of 1.15±0.13 cm and weight of 0.014±0.02 g were stocked in the experimental ponds. Spawn were fed three times (8:30 am BDT, 1:00pm BDT and 5:00pm BDT) daily with MEGA pre nursery feed for the first 14 days and nursery feed for days 15 to 28. The rate of feeding was 20 kg/million spawn/ day for the first 2 weeks and 24 kg for the second 2 weeks. Spawn were sampled weekly by seining with a fine-meshed net for the assessment of growth and health condition.

2.3 Physico-chemical parameters of pond water

Physico-chemical parameters of pond water were monitored weekly between 09.00 and 10.00 hr. Temperature (°C) and dissolved oxygen (mg/l) were determined directly by a digital water quality analyzer Hanna DO meter (Model-HI 9146, Romania), pH by a digital pH-meter (Milwaukee pH meter, Model-PH55/PH56, USA) and transparency (cm) by a secchi disc. Total alkalinity was estimated following the standard method [20, 21].

2.4 Growth performance, survival, production and feed utilization of *T. putitora*

After 4 weeks of nursing, the spawn were harvested by repeated netting, followed by drying the ponds. The live fingerlings were counted and weighed individually. Survival (%) and production (kg/ha) of spawn were then estimated and compared among the treatments. The following formulae have been used to determine the specific growth rate (SGR% per day), survival rate (%), food conversion ratio (FCR) and production of *T. putitora* fry.

$$\text{SGR (\% per day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

Where, W_1 = Initial live body weight (g) at time T_1 (day).
W_2 = Final live body weight (g) at time T_2 (day).

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

$$\text{Food conversion ratio (FCR)} = \frac{\text{Feed fed (dry matter)}}{\text{Live weight gain}}$$

Statistical analysis

The mean values for growth, survival, production and water quality parameters of different treatments were tested using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test [22]. The statistical analysis was performed by SPSS software 19 (SPSS, USA). The level for significance was set at 0.05%. A simple cost-benefit analysis was done to estimate the net benefits from different treatments.

3. Results

3.1 Physico-chemical parameters of pond water

The ranges and mean values of physic-chemical parameters recorded during the experimental ponds were recorded and presented in Table 1.

Table 1: Physico-chemical characters of water in the earthen nursery ponds during the experimental period

Parameter	Treatments		
	T1	T2	T3
Water temperature (°C)	22.50±0.35^{a} (21.00-24.00)	22.69±0.39^{a} (21.50-24.00)	22.81±0.37^{a} (21.00-24.00)
Transparency (cm)	28.38±2.00^{c} (22.00-38.00)	41.88±2.45^{b} (32.00-50.50)	52.25±1.93^{a} (41.50-59.00)
Dissolved oxygen (mg/L)	4.90±0.21^{a} (4.31-5.41)	4.42±0.15^{b} (3.98-5.09)	3.72±0.07^{c} (3.49-4.01)
pH	7.34±0.22^{a} (6.90-8.10)	7.21±0.23^{a} (6.80-7.60)	7.53±0.21^{a} (6.90-8.20)
Total alkalinity (mg/L)	92.38±3.06^{b} (75.50-102.50)	112.13±6.48^{a} (80.50-138.50)	117.38±5.75^{a} (94.00-140.50)

Values in the same row having the same superscript are not significantly different ($p > 0.05$).
Values in the parenthesis indicate the range.

During the experimental period, the water temperature ranged from 21.00 to 24.00 ºC with a mean values were 22.50±0.35, 22.69±0.39 and 22.81±0.37 ºC in T1, T2 and T3, respectively. The mean values of water temperature among the treatments did not differ significantly (P>0.05). The transparency of water were significantly (p<0.05) higher in T3 (52.25±1.93 cm) than those obtained in T1 (28.38±2.00 cm) and T2 (41.88±2.45 cm). The ranges of Dissolved Oxygen (DO) was 3.49 to 5.41 mg/l with a mean values were 4.90±0.21 (T1), 4.42±0.15 (T2) and 3.72±0.07mgl/l (T3) and showed significant difference (p<0.05) among the treatments. The mean values of pH were 7.34±0.22, 7.21±0.23 and 7.53±0.21 recorded in T1, T2 and T3, respectively but did not differ significantly (p>0.05). The highest mean value of total alkalinity was recorded in T3 (117.38±5.75 mg/1) and the lowest was in T1 (92.38±3.06 mg/1). The mean value of total alkalinity in T1 was statistically differed from T2 and T3. However, there was no significant (p>0.05) variation between the T2 (112.13±6.48 mg/1) and T3 (117.38±5.75 mg/1).

3.2 Growth performance, feed utilization and production of *T. putitora*

Weekly growth in length and weight under three different treatments was recorded during this study period which is shown in Figs. 1 and 2 and summarized in Table 2.

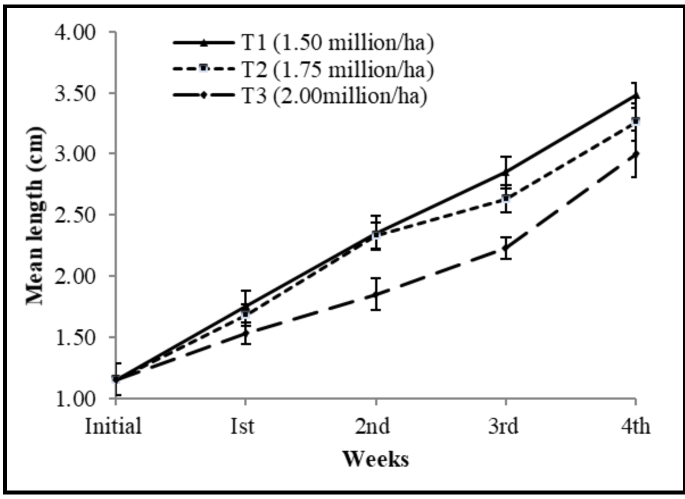

Fig 1: Weekly mean length (cm) gain of *T. putitora* under different stocking densities

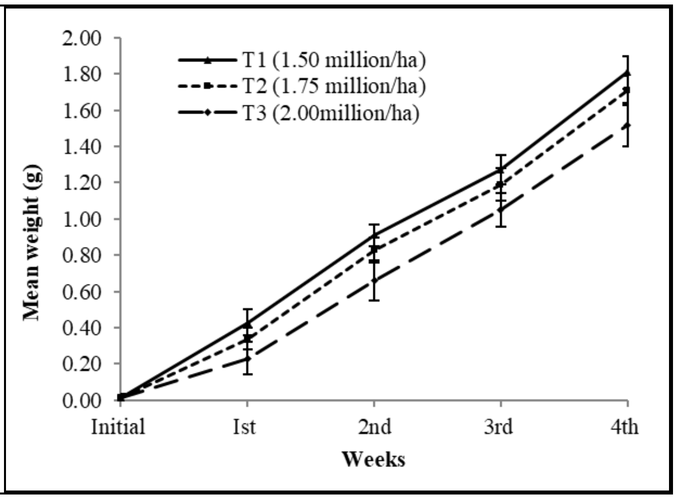

Fig 2: Weekly mean weight (g) gain of *T. putitora* under different stocking densities

The initial length and weight of spawn stocked in all the ponds were same i.e. 1.15±0.13 cm and 0.014±0.02 g. The mean final length and weight attained under T1, T2 and T3 were 3.48±0.03 cm and 1.81±0.02 g, 3.16±0.06 cm and 1.71±0.02 g and 3.00±0.10 cm and 1.52±0.03 g, respectively (Table 2).

Table 2: Growth performance, survival and production of *T. putitora* fry or fingerlings after 4 weeks of rearing; mean ± SE with ranges in parentheses.

Parameters	Treatments		
	T1	T2	T3
Initial length (cm)	1.15±0.13^{a} (1.10-1.20)	1.15±0.13^{a} (1.10-1.20)	1.15±0.13^{a} (1.10-1.20)
Final length (cm)	3.48±0.03^{a} (3.45-3.51)	3.16±0.06^{b} (3.10-3.22)	3.00±0.10^{c} (2.90-3.10)
Initial weight (g)	0.014±0.02^{a} (0.013-0.015)	0.014±0.02^{a} (0.013-0.015)	0.014±0.02^{a} (0.013-0.015)
Final weight (g)	1.81±0.02^{a} (1.78-1.83)	1.71±0.02^{a} (1.68-1.73)	1.52±0.03^{b} (1.49-1.55)
Weight gain (g)	1.79±0.03^{a} (1.77-1.82)	1.69±0.03^{a} (1.67-1.72)	1.46±0.04^{b} (1.43-1.50)
Specific growth rate (SGR) (%/day)	7.54±0.02^{a} (7.52-7.56)	7.45±0.02^{a} (7.43-7.47)	7.23±0.04^{b} (7.19-7.26)
Food conversion ratio (FCR)	0.44±0.07^{b} (0.42-0.45)	0.48±0.04^{b} (0.47-0.48)	0.61±0.10^{a} (0.58-0.64)
Survival rate (%)	63.05±0.59^{a} (64.02-62.07)	60.38±0.51^{a} (61.12-59.64)	55.19±0.70^{b} (56.55-53.82)
Production (number/ha)	945675±9320^{c} (960300-931050)	1056650±10314^{b} (1069600-1043700)	1103700±10608^{a} (1131000-1076400)

Values in the same row having the same superscript are not significantly different ($p > 0.05$). Values in the parenthesis indicate the range.

The mean final length of fingerlings in different treatments were significantly different (p<0.05). But the mean lowest final weight, weight gain, specific growth rate (% per day) and survival rate of fingerlings were recorded in T3 which was differed significantly (p<0.05) than T1 and T2. But there was no significantly differed (p<0.05) among these parameters between T1 and T2. FCR was significantly higher in T3 (0.61±0.10) than in T1 (0.44±0.07) and T2 (0.48±0.04). The mean productions (number/ha) of fingerlings were 945675±9320, 1056650±10314 and 1103700±10608 in T1, T2 and T3, respectively (Table 3).

Table 3: Cost and benefits from the nursing of mahseer, *T. putitora* fingerlings in 1-ha earthen ponds for a nursing period of 4 weeks.

Item	Amount (TK)/ha/ 2 months			Remarks
	Treatments			
	T1 (TK)[a]	T2 (TK)	T3 (TK)	
Total Return (TR)[b]	18,91,350	21,13,300	16,55,550	Price is related with size and weight
A. Variable cost:				
1. Price of hatchlings (@ TK. 0.30/piece)	4,50,000	5,25,000	6,00,000	
2. Feeds				
a. Pre-nursery (@Tk. 80.00/kg)	53,760	62,720	71,680	
b. Nursery (@Tk. 55.00/kg)	44,440	51,700	59,180	
3. Human labour cost (@TK. 250.00/day)	15,000	15,000	15,000	02 labour/day
4. Lime (250 kg, @TK. 22.00/kg)	5,500	5,500	5,500	
5. Miscellaneous	12,000	12,000	12,000	Dipterex, Oxy flow, carrying, netting etc
Total Variable Cost (TVC)	5,80,700	6,71,920	7,63,360	
B. Fixed Cost:				
1.Pond lease value	64,220	64,220	64,220	Tk. 260.00/decimal/year (Local rate, Mymensingh region)
2.Interest of operating capital	58,070	67,192	76,336	10% interest according to Bangladesh Krishi Bank, Bangladesh
Total Fixed Cost (TFC)	1,22,290	1,31,412	1,40,556	
Total Cost (TC= TVC+TFC)	7,02,990	8,03,332	9,03,916	
Gross Margin (GM= TR -TVC)	13,10,650	14,41,380	8,92,190	
Net benefit (TR-TC)	11,88,360	13,09,968	7,51,634	

[*a]TK 80.00 =1 US$

[b]Selling price of fingerlings Tk. 2.00/ piece (size 1.81 g and 1.71 g in T1 and T2, respectively) and Tk. 1.50/piece (size 1.52 g in T3).

The production of fingerlings was recorded highest in T3 and lowest in T1 which was differed significantly (p>0.05) among the three treatments. On the other hand, production cost of fingerlings in T1 was consistently lower than those in T2 and T3 (Table 2). Highest net benefits (Tk. /ha) was obtained in T2 (13, 09,968) followed by T1 (11, 88,360) and T3 (7, 51,634).

4. Discussion

The water quality parameters greatly influence on the maintenance of a healthy aquatic environment and production of food organisms. Growth, feed efficiency and feed consumption of fish are normally governed by a few environmental factors [23, 24]. The mean range of water temperature (21 to 24 °C) in the nursery ponds is within suitable range for nursing of fry and fingerlings of fishes that agrees well with the findings of Rahman *et al.* [4, 25] and Monir and Rahman [26]. The mean transparency level was significantly (p<0.05) higher in T3 and consistently lower in T1, which might be due to the reduction of the plankton population by higher density of fish [4, 27]. The dissolved oxygen (DO) was lower in T3 during the study period where stocked with a high density of fish compared to lower stocking density. This might be due to the higher consumption rate of oxygen by the higher density of fish and other aquatic organisms. Similar results were observed by Rahman and Rahman [28], Rahman *et al.* [4, 25, 29] and Monir and Rahman [26]. However, the DO level is within the acceptable ranges in all nursery ponds during the study period. The recorded pH values of water of experimental nursery ponds ranging from 6.8 to 8.2 which indicates slightly alkaline but suitable ranges for fry and fingerlings rearing of fishes that agrees well with the findings of Rahman *et al.* [4, 29] and Monir and Rahman [26]. The mean values of total alkalinity was significantly (p<0.05) higher in T1 followed by T2 and T3 but no significant differences (p>0.05) were recognized between the values of T2 and T3. Higher total alkalinity values might be due to higher doses of lime used during pond preparation [30]. Similar results were also found in the studies of Chakraborty and Mirza [31], Ahmed [32], Monir and Rahman [26] and Samad *et al.* [33].

Statistical analysis (Table 2) showed that the growth parameters of weight, weight gain and SGR of mahseer fry was significantly lower in ponds where the stocking density was 2.0 million spawn/ha than the socking density of 1.50 and 1.75 million spawn/ha. Although in all ponds applied same type of food and feeding rate was also similar. This might be happened as the stocking density has a direct effect on the growth of fish. Similar results were observed by Rahman *et al.* [25, 29], Rahman and Rahman [28] and Islam *et al.* [34]. In the present study the FCR value was comparatively lower than the values reported by many author [19, 29, 34]. The survival rate of mahseer fry was significantly lower (p>0.05) in T3 where the stocking density was higher than T1 and T2. Here the data clearly indicate that the maximum survival was found at the lowest stocking density but there is no information available in Bangladesh on the effect of different stocking densities on the growth and survival rate of fry/fingerling of mahseer. Rahman *et al.* [35] found 95.80% survival of mahseer spawn after 56 days when reared at 0.6 million/ha. Uddin *et al.* [36] obtained a maximum survival of 73.3% of rohu spawn after 21 days of rearing at 3 million/ha. Saha *et al.* [37] got 82.5% survival of silver carp spawn after 60 days of rearing at 6 million/ha. The above results were more or less in similar with those of the present study. In the present study, the recorded number of fingerlings in T1 was significantly higher

(p<0.05) than T1 and T2, respectively. But the simple cost-benefit analysis in table 3 showed higher net benefits obtained in T1 than T2 and T3, respectively. Although initial stocking size of fry in all ponds were more or less similar. Survival and growth of fry were inversely related to the stocking density. From Table 2 and 3, it clearly indicated that the highest growth, survival and net benefits of fingerlings were obtained in ponds where the stocking density was 1.75 million spawn/ha. The physico–chemical parameters of pond water during the experimental period were within acceptable limits. The results in the present study are very similar to those of Kohinoor *et al*. [38], Hossain [39], Rahman and Rahman [28], Chakraborty *et al*. [40] and Rahman *et al*. [4, 29].

The presented study revealed that the survival, growth and production of fry were inversely related to the stocking densities of spawn but the net benefits recorded in the ponds where the stocking density was the lowest than other ponds. So, it can be concluded that the stocking density of 1.75 million spawn/ha may be advisable for rearing of mahseer fry for 4 weeks in primary nursing. On the other hand, production of sufficient and quality fingerlings through application of our present findings might have important implications towards the protection of mahseer from extinction.

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