Turkish Journal of Fisheries and Aquatic Sciences 9: 165-172 (2009) DOI: 10.4194/trjfas.2009.0207

Development of Fingerling Production Techniques in Nursery Ponds for the Critically Endangered Reba Carp, *Cirrhinus ariza* (Hamilton, 1807)

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Received 09 April 2008
Accepted 13 May 2009

Abstract

Growth, survival and production performances of *Cirrhinus ariza* fingerlings were evaluated for 8 weeks in nine earthen nursery ponds having an area of 0.012 ha each with an average depth of 1.0 m. Three stocking densities of hatchlings each with two replications were tested in treatments. Four-day-old hatchling stocked at 0.8 million ha^{-1} was defined as treatment-1 (T_1), 1.0 million ha^{-1} as treatment-2 (T_2) and 1.2 million ha^{-1} as treatment-3 (T_3), respectively. Hatchlings in all the experimental ponds were supplemented with wheat flour for the first 7 days, finely ground mustard oilcake for the next 7 days and a mixture of rice bran and mustard oilcake (1:1) for days 15 to 56. Feeding was done at the rate of 15 kg/million hatchling day^{-1} for the first two weeks, 20 kg for the second two weeks, 25 kg for the third two weeks and 30 kg for the fourth two weeks. The physico-chemical and biological parameters of pond water were within the suitable range for fish culture. Growth in terms of final weight, final length, weight gain, length gain and specific growth rate, and survival of fingerlings was significantly higher in T_1 where stocking density were 0.8 million hatchling ha^{-1} than those obtained from T_2 (1.0 million ha^{-1}) and T_3 (1.2 million ha^{-1}), respectively. Feed conversion rate was the lowest in T_1 followed by T_2 and the highest in T_3 ($P<0.05$). Gross and net productions of fingerling were higher in T_1 than T_2 and T_3, respectively ($P<0.05$). Higher number of fingerlings was produced in T_3 than those in T_2 and T_1 ($P<0.05$). Even then, consistently higher net benefits were obtained from T_1 than those from T_3 and T_2. Among the treatments evaluated, 0.8 million hatchling ha^{-1} (T_1) was the best stocking density considering the highest growth, survival, production and net benefits of the fingerlings of *C. ariza* in nursery ponds.

Keywords: *Cirrhinus ariza*, hatchling, stocking density, fingerling, growth, production, benefits.

Introduction

Cirrhinus ariza (Hamilton, 1807) is an important food fish, which is distributed over Indian Sub-continent (Jhingran, 1991; Talwar and Jhingran, 1991; Rahman, 2005). It is locally known as reba carp, bhagna bata, raik or tatkini, and considered as one of the most important indigenous minor carp species in Bangladesh. The fish is easily recognized by medium-sized silvery scales, the upper body is deep bluish or darkish and the lower body is shiny and silvery. The lateral line has 38 or 39 scales, most of them appearing as a black mark elongated from the base margin of the operculum to the tail during the early stage of life. The black mark becomes shorter and remains between the operculum and the end of the belly during the adult stage (Talwar and Jhingran, 1991; Hussain and Mazid, 2001; Rahman, 2005).

The fish is highly popular to the consumers due to its oily flesh and taste qualities. The natural distributions of reba carp included most of the rivers, small creeks, natural depressions and floodplains of Bangladesh (Kohinoor *et al*., 1998; Hussain and Mazid, 2001). Reba carp is a water column feeder and omnivore in nature and grows to a maximum size of 40 to 50 cm in length (Rahman, 2005; Felts *et al*., 1996; Akhteruzzaman *et al*., 1998). Males and females attain sexual maturity by the end of first year. The spawning season of reba carp stars in April and ends in August with peak spawning occurring during the rainy months in flowing flood waters (Akhteruzzaman *et al.*, 1998; Hussain and Mazid, 2001). Relative fecundity of reba carp was recorded between 200,000 and 250,000 egg kg^{-1} body weight of female (Hussain and Mazid, 2001).

During the last 14 years, the population of reba carp has declined considerably due to increased fishing pressure, and various anthropogenic activities leading to siltation, aquatic pollution, and loss of natural habitat for spawning and growth (Akhteruzzaman *et al.*, 1998; Hussain and Mazid, 2001). These factors not only destroyed the breeding grounds but also caused havoc to the availability of brood fish including fry and fingerlings (Hussain and Mazid, 2001). As a result, recently the fish is considered as one of the most endangered species in Bangladesh (IUCN, 1998). To maintain this fish population as well as its conservation and rehabilitation, development of a suitable technology for breeding, and rearing of fry and fingerlings in nursery ponds is urgently needed.

Webber and Riordan (1976) stated that one of the main obstacles in the development of aquaculture is the availability of fry/fingerlings. Growth and survival of fry and fingerlings in nursery ponds depend on stocking density, type and quantity of fertilizers and supplementary feeds. To obtain maximum economic returns, it would be necessary to stock the ponds at appropriate stocking densities for optimum growth and survival of fingerlings. No work has yet been undertaken on stocking density of reba carp for rearing in nurseries. Good quality fingerlings are needed to establish a successful fish culture package of *C. ariza*. The present work has therefore been undertaken to develop a practical and economically viable methodology for mass seed production of *C. ariza* in earthen nursery ponds.

Material and Methods

The present experiment was carried out at the Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh. The experiment was conducted for 8 weeks from 15 June to 11 August, 2005 in nine earthen nursery ponds. The ponds were rectangular in shape and the surface area of each pond was 0.012 ha with an average depth of 1.0 meter. The ponds were pump-fed, free from aquatic vegetation, well-exposed to sunlight and had a well designed inlet and outlet system. The ponds were similar in size, shape, depth, basin conformation, contour, and bottom type (sandy-loam soil). After drying, quicklime (CaO, 250 kg ha^{-1}) was spread over the pond bottom. Ponds were then filled with ground water at a depth of about one meter and a more or less similar depth was maintained for the whole experimental period. Five days subsequent to liming, the ponds were fertilized with organic manure (cattle dung, 2,500 kg ha^{-1}). Seven days after manuring, the pond water was sprayed with dipterex (one ppm) to eradicate harmful insects and predatory zooplankton such as copepods and cladocerans. Hatchlings of reba carp were produced by artificial breeding following the technique of Akhteruzzaman *et al.* (1998). Three treatments differing in stocking densities of hatchlings viz., 0.8 million ha^{-1} (treatment 1, T_1), 1.0 million ha^{-1} (treatment 2, T_2) and 1.2 million ha^{-1} (treatment 3, T_3) were employed each of which was replicated. In each treatment, 1 ml aliquots of the larval samples were first counted and then adjusted to the stocking densities. These densities were selected on the basis of the results obtained from the previous studies (Rahman unpub. data). Four-day-old hatchlings having an average length of 0.41±0.06 cm and weight of 0.0004±0.00001 g were then stocked in the experimental ponds. Fifty randomly selected individual hatchlings were sampled for length and weight before stocking.

The hatchlings were not fed for the first day in order to acclimatize them to the new environment. From the second day of stocking, hatchlings were fed twice daily with wheat flour for the first 7 days, finely ground mustard oilcake for the next 7 days and a mixture of rice bran and mustard oilcake (1:1) for days 15 to 56. The rate of feeding was 15 kg/million hatchling day^{-1} for the first two weeks, 20 kg for the second two weeks, 25 kg for the third two weeks and 30 kg for the fourth two weeks. The feed was distributed on the pond water surface. In addition, the ponds were manured with cattle dung (1000 kg ha^{-1}) at weekly intervals. Fingerlings were sampled weekly by dragging a fine-meshed (hapa) net for the studies of growth performances.

Physico-chemical parameters of pond water were monitored weekly between 09.00 and 10.00 h. Temperature (ºC) and dissolved oxygen (mg L^{-1}) were determined directly by a digital water quality analyzer (YSI, model 58, USA), pH by a digital pH-meter (Jenway, Model 3020, UK) and transparency (cm) by a Secchi disc and ammonia nitrogen by a HACH water analysis kit (DR 2000, USA). Total alkalinity was measured following the standard method (Stirling, 1985; APHA, 1992).

Quantitative and qualitative estimates of plankton in the experimental ponds were also taken weekly. Ten litres of water, collected from different locations and depths of each pond were filtered through fine-meshed plankton net (25 µm) to obtain a 50 ml sample. The samples were preserved immediately with 5% buffered formalin in plastic bottles. Plankton density was estimated by using a sub-sampling technique. A Sedgwick-Rafter (S-R) cell was used under a calibrated compound microscope for plankton counting. Plankton cells in 10 randomly chosen squares were counted for quantitative estimation using the formula proposed by Rahman (1992).

To estimate the growth of fish, 30 randomly selected fingerlings from each pond were sampled weekly. Growth was studied in terms of increase in length and weight, specific growth rate (SGR) and feed conservation ratio (FCR). Length and weight gain were calculated simply by deducting the mean initial length and weight values from that of the final. SGR, the instantaneous change in weight of fish calculated as the percentage increase in body weight per day over any given time interval (Brown, 1957). The FCR was calculated according to Castell and Tiews (1980).

After 8 weeks of rearing, the fingerlings were harvested by repeated netting, followed by drying the ponds. The live fingerlings were counted and weighed individually. Survival rates were calculated on the basis of the number of fish harvested (no. of fish harvested/no. stocked x 100). Gross production was calculated by multiplying the average final weight of fish by the total number, while net production was estimated by multiplying the average final weight increment of fish by the total number and was expressed as kg/ha.

The mean values for growth, survival, production, water quality parameters and plankton abundance of different treatments were tested using one-way analysis of variance (ANOVA). A "Bartlett's test" was used to analyze the homogeneity of variances (Bartlett, 1937). When variances were not significantly heterogeneous and no major departures from normality, a one way analysis of variance (ANOVA) was done followed by Duncan's New Multiple Range test (Duncan, 1955). All statistical analyses were performed with the aid of a computerized statistical package, 'Stat View' version 4.0. Standard deviation in each parameter and treatment was calculated and expressed as 'mean±SD'. The level for statistical significance was set at 0.05%. A simple cost-benefit analysis was performed to estimate the net benefits from each of the three treatments.

Results

Water Quality and Plankton Monitoring

The results of the physico-chemical parameters over the eight-week nursing of *C. ariza* fingerlings are summarized in Table 1. The mean water temperatures in T_1, T_2 and T_3 did not differ significantly (P>0.05). Mean secchi disc transparency levels were differed significantly (P<0.05), increasing from T_1 to T_3. The mean dissolved oxygen (DO) obtained in the morning hours was significantly different (P<0.05), decreasing from T_1 to T_3. pH decreased from T_1 to T_3 but did not differ significantly (P>0.05). Total alkalinity was decreased from T_1 to T_3; but no significant differences (P>0.05) were recognized among the treatments. Ammonia-nitrogen contents in T_1, T_2 and T_3 showed increasing trends but the variations were not statistically significant (P>0.05).

The plankton populations recorded from the pond water are summarized in Table 2. The phytoplankton comprised of 28 genera under four groups viz., Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Among the phytoplankton population, Chlorophyceae was the most dominant group in all the treatments followed by Bacillariophyceae, Cyanophyceae and

Table 1. Mean values (± SD) and ranges of water quality parameters of weekly samples over the 8-week experiment

Parameters	Treatments		
	T_1 (0.8 million ha^{-1})	T_2 (1.0 million ha^{-1})	T_3 (1.2 million ha^{-1})
Water temperature (°C)	30.84±1.32^a	30.80±1.35^a	30.96±1.26^a
	(29.20–32.30)	(29.10–32.20)	(29.30–32.40)
Transparency (cm)	33.62±3.48^c	44.16±3.89^b	52.73±3.35^a
	(30.50–42.50)	(38.50–48.50)	(45.50–58.50)
Dissolved oxygen (mg L^{-1})	4.84±0.78^a	4.29±0.69^b	3.82±0.72^c
	(3.70–6.00)	(3.40–5.30)	(3.10–4.90)
pH	7.68±0.27^a	7.49±0.22^a	7.46±0.25^a
	(7.30–8.10)	(7.20–8.00)	(7.20–7.90)
Total alkalinity (mg L^{-1})	134.52±25.33^a	130.83±28.50^a	129.85±27.78^a
	(88.50–171.50)	(65.50–162.50)	(70.50–160.50)
Ammonia-nitrogen (mg L^{-1})	0.28±0.19^a	0.32±0.20^a	0.35±0.22^a
	(0.01–0.80)	(0.01–0.90)	(0.01–1.00)

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

Table 2. Mean values (±SD) and ranges of plankton abundance (cells/L) of pond water of weekly samples over the 8-week experiment

Plankton group	Treatment-1	Treatment-2	Treatment-3
Phytoplankton			
Bacillariophyceae	3,989±218^a	3,524±207^b	2,943±240^c
	(3,625–4,250)	(3,250–3,850)	(2,650–3,350)
Chlorophyceae	4,784±165^a	4,261±255^b	3,497±268^c
	(4,450–4,950)	(3,850–4,650)	(3,225–4,050)
Cyanophyceae	3,241±239^a	2,894±253^b	2,394±284^c
	(2,975–3,650)	(2,575–3,250)	(2,150–2,850)
Euglenophyceae	2,803±224^a	2,500±235^b	2,266±298^c
	(2,575–3,175)	(2,225–2,850)	(1,850–2,650)
Total	14,817±871^a	1,3179±770^b	11,100±564^c
	(13,625–16,025)	(11,900–14,600)	(9,875–12,900)
Zooplankton			
Crustacea	8,897±457^a	7,538±590^b	6,241±640^c
	(8,450–9,750)	(6,950–8,575)	(5,475–7,250)
Rotifera	10,694±496^a	9,547±524^b	7,925±558^c
	(10,075–11,575)	(8,875–10,350)	(7,125–8,775)
Total	19,571±1,271^a	17,085±1,421^b	14,166±1,191^c
	(18,525–21,325)	(15,825–18,925)	(12,600–16,025)

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

Euglenophyceae in that order. However, the abundance of each group differed significantly ($P<0.05$) among treatments, increasing from T_3 to T_1. The mean abundance of total phytoplankton was significantly higher ($P<0.05$) in T_1 than those in T_2 and T_3. The zooplankton population consisted of 12 genera including nauplius in two major groups viz., Crustacea and Rotifera. Rotifera were dominant over Crustacea during the entire experiment in all treatments. However, the abundance of Rotifera and Crustacea in T_1 was significantly higher ($P<0.05$) than those recorded in T_2 and T_3. Total zooplankton abundance differed significantly ($P<0.05$) among the treatments, decreasing from T_1 to T_3.

Growth, Survival, Food Conversion and Production of Fingerlings

Growth in terms of length and weight of fingerlings at weekly intervals is depicted in Figures 1 and 2. The increase in length and weight was the highest in T_1 (0.8 million ha^{-1}) followed by T_2 (1.0 million ha^{-1}) and the lowest in T_3 (1.2 million ha^{-1}). The detailed growth and production performances of fingerlings under different treatments over the 8-week experiment are summarized in Table 3. The initial length and weight of hatchlings, stocked in all the experimental ponds were the same. The highest increase in length and weight was observed in T_1 and the lowest in T_3. However, the mean final length and weight of fingerlings among different treatments were significantly different ($P<0.05$). The highest weight and length gains were also found in T_1 and the lowest in T_3. Specific growth rate (SGR) in T_1 was significantly higher than T_2 and T_3. Food conversion ratio (FCR) was significantly lower in T_1 than in T_2 and the highest in T_3. Therefore, the best SGR and FCR values were obtained in T_1 where the lowest number of hatchling (0.8 million ha^{-1}) was attained in nursery ponds. The mean survival rate was also the highest in T_1 and the lowest in T_3 ($P<0.05$).

The mean gross and net productions (kg ha^{-1}) of fingerlings after 8 weeks of rearing were 1,576.08 and 1,568.88, 1,448.50 and 1438.90, and 1,099.19 and 1,078.19 in T_1, T_2 and T_3, respectively. Production was the highest in T_1 and the lowest in T_3. However, gross and net productions differed significantly ($P<0.05$) among the three treatments (Table 3). Despite this, significantly higher number of fingerlings per hectare was produced in T_3 (814,320) than those in T_2 (778,433) and T_1 (686,080) (Table 4). Total cost of production (Tk/ha) was consistently

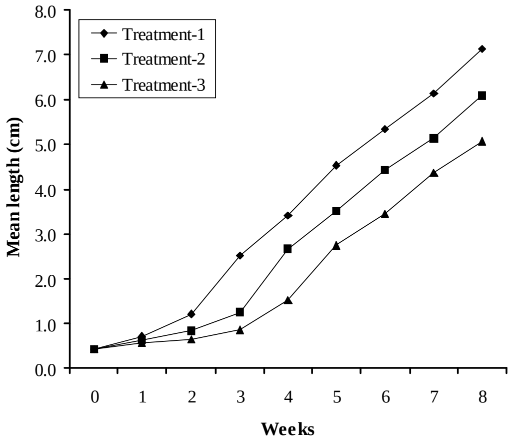

Figure 1. Mean length increment of *C. ariza* fingerlings at different stocking densities during the rearing period of 8 weeks.

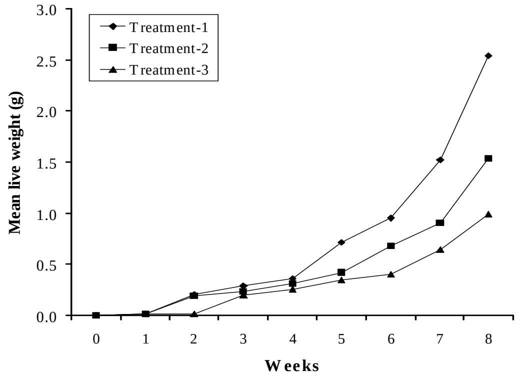

Figure 2. Mean weight increment of *C. ariza* fingerlings at different stocking densities during the rearing period of 8 weeks.

Table 3. Growth performances, survival, feed utilization and production of reba carp (*Cirrhinus ariza*) fingerlings after 8 weeks of rearing; mean±SD with range in parentheses

Parameters	Treatments		
	T $_1$ (0.8 million ha^{-1})	T $_2$ (1.0 million ha^{-1})	T $_3$ (1.2 million ha^{-1})
Initial length (cm)	0.41±0.06^a	0.41±0.06^a	0.41±0.06^a
	(0.30-0.50)	(0.30-0.50)	(0.30-0.50)
Final length (cm)	7.12±0.27^a	6.08±0.17^b	5.06±0.15^c
	(6.80-7.50)	(5.80-6.40)	(4.80-5.30)
Initial weight (g)	0.0004±0.0001^a	0.0004±0.0001^a	0.0004±0.0001^a
	(0.0003-0.0006)	(0.0003-0.0006)	(0.0003-0.0006)
Final weight (g)	2.54±0.16^a	1.54±0.14^b	0.99±0.08^c
	(2.21-2.69)	(1.34-1.72)	(0.85-1.12)
Weight gain (g)	2.54±0.16^a	1.54±0.14^b	0.99±0.08^c
	(2.21-2.69)	(1.34-1.72)	(0.85-1.12)
Specific growth rate (SGR) (%/day)	15.64±0.06^a	14.73±0.11^b	13.96±0.07^c
	(15.59-15.71)	(14.62-14.83)	(13.90-14.04)
Food conversion ratio (FCR)	0.56±0.01^a	0.81±0.01^b	1.17±0.04^c
	(0.55-0.56)	(0.80-0.81)	(1.14-1.20)
Survival (%)	85.76±2.09^a	77.84±2.92^b	67.84±2.71^c
	(83.81-87.97)	(74.95-80.78)	(64.96-70.35)
Gross production (kg ha^{-1})	1,576.08±13.93^a	1,448.34±8.65^b	1,099.19±34.03^c
	(1,566.23-1,585.93)	(1,442.38-1,454.62)	(1,075.12-1,123.25)
Net production (kg ha^{-1})	1,568.88±13.93^a	1,438.90±8.65^b	1,099.17±34.03^c
	(1,559.03-1,578.73)	(1,432.78-1,445.02)	(1,063.12-1,111.25)
Production of fingerlings (No. ha^{-1})*	686,080±16,737^c	778,433±29,152^b	814,320±32,614^a
	(670,480-703,760)	(749,500-807,800)	(789,520-844,200)

Figures in the same row having the same superscript are not significantly different (P>0.05).
*Total number of fingerlings that produced after a nursing period of 8 weeks.

Table 4. Costs and benefits from the nursing of reba carp (*Cirrhinus ariza*) fingerlings in 1 ha earthen ponds for a rearing period of 8 weeks

Items	Treatments		
	T $_1$ (Tk.)*	T $_2$ (Tk.)	T $_3$ (Tk.)
A. Cost			
Pond lease (Tk. 30,000.00 ha^{-1} yr^{-1})	4,615	4,615	4,615
Lime (Tk. 6.00 kg^{-1})	1,500	1,500	1,500
Cowdung (Tk. 0.35 kg^{-1})	2,975	2,975	2,975
Dipterex (Tk. 800.00 kg^{-1})	6,848	6,848	6,848
Hatchlings (Tk. 10,000.00 million^{-1})	8,000	10,000	12,000
Feeds:			
a. Wheat flour (Tk. 25.00 kg^{-1})	1,134	1,418	1,701
b. Mustard oilcake (Tk. 12.50 kg^{-1})	6,300	7,875	9,450
c. Rice bran (Tk. 8.00 kg^{-1})	3,360	4,200	5,040
Labor (Tk. 70.00 day^{-1})	7,840	7,840	7,840
Miscellaneous	1,000	1,000	1,000
Total costs	43,572	48,271	52,969
B. Gross benefit			
Fingerlings**	686,080	389,217	407,160
Net benefits (B-A)	642,508	340,946	354,191

* 1 US$ = Tk. 60.00.
** Price of fingerlings fixed by the Institute was Tk. 1.00/piece (T_1) and Tk. 0.50/piece (T_2 and T_3).

lower in T_1 (43,572) than those in T_2 (48,271) and T_3 (52,969). The highest net benefit (Tk/ha) was obtained in T_1 (642,508) followed by T_3 (354,191) and T_2 (340,946) in that order.

Discussion

Physico-chemical parameters play a significant role in the maintenance of a healthy aquatic environment and production of natural food organisms. Growth, feed efficiency and feed consumption of fish are normally governed by environmental factors (Fry, 1971; Brett, 1979). The range of temperature (29.1–32.4°C) in the experimental ponds are within the acceptable range for nursing of fry and fingerlings of warm water fishes that agree well with the findings of Haque *et al.* (1993; 1994), Kohinoor *et al.* (1994) and Rahman *et al.* (2005). Consistently higher transparency depth was recorded in T_3, which might be due to the reduction of the plankton population by higher density of fish (Haque *et al.*, 1993; 1994). Dissolved oxygen level was low in ponds stocked with a high density of fish compared to ponds where stocking density was low. Saha *et al.* (1988), Ahmed (1993), Rahman and Rahman (2003), and Rahman *et al.* (2005) also reported similar trends of dissolved oxygen in various carp nursery ponds. Fluctuations in DO concentrations might be due to alteration in the rate of photosynthesis caused by altering cloudy and sunny weather of the monsoon and also due to variation in the rate of oxygen consumption by fish and other aquatic organisms (Boyd, 1982). However, the DO level was within the acceptable range for fish culture. The observed pH values agree well with the findings of Kohinoor *et al.* (1994), Chakraborty *et al.* (2003), and Rahman *et al.* (2005) and are within the range of good water quality for rearing of fry/fingerlings in nursery ponds. Total alkalinity levels indicating the productivity of the ponds were medium to high (Bhuiyan, 1970). The findings of the present study are in agreement with those of Islam (2002), Rahman and Rahman (2003), and Rahman *et al.* (2004, 2005). The level of ammonia-nitrogen recorded from the experimental ponds was lower than that which was reported by Dewan *et al.* (1991). Kohinoor *et al.* (2001) recorded ammonia-nitrogen ranging from 0.01 to 1.55 mg/L in monoculture ponds. However, the present level of ammonia-nitrogen content in the experimental ponds is not lethal to the fish (Kohinoor *et al*., 1998; Kohinoor *et al*., 2001).

Significantly higher plankton abundance was recorded in T_1 which might be due to the lower density of fish than those in T_2 and T_3. It seems that in the ponds where stocking density was high, consumption of plankton by the fish was also high. Generally, higher plankton concentrations in pond water normally indicate higher productivity. It was also found in all the ponds that zooplankton abundance was higher than phytoplankton, which might be due to heavy manuring with organic fertilizer (cattle dung). This coincides with the findings of Saha *et al.* (1988), Haque *et al.* (1994), Kohinoor *et al.* (1994; 1997) and Rahman and Rahman (2003) in various carp and barb nursery ponds.

Growth in terms of final length, length gain, final weight, weight gain and specific growth rate of fingerlings of *C. ariza* was significantly higher in T_1 where the stocking density of hatchlings (0.8 million ha^{-1}) was low compared to those of T_2 (1.0 million ha^{-1}) and T_3 (1.2 million ha^{-1}) although the same food was applied at an equal ratio in all the treatments. The causes might include competition for food and habitat due to higher number of fish. Stocking density had previously been observed to have a direct effect on the growth of fish (Haque *et al.*, 1993; 1994; Kohinoor *et al.*, 1994; Islam, 2002; Islam *et al.*, 2002; Rahman and Rahman, 2003; Rahman *et al.*, 2004; 2005). High stocking density of larvae in combination with abundant food in the rearing system might produce a stressful situation if not from the build-up of metabolites than from competitive interaction (Houde, 1975; Haque *et al.*, 1994; Rahman and Rahman, 2003). FCR values of T_1 are the lowest followed by T_2 and T_3 in that order ($P<0.05$). The FCR values of the present study are lower than those reported by many workers (e.g., Reddy and Katro, 1979; Das and Ray, 1989; Islam, 2002; Islam *et al.*, 2002; Rahman *et al.*, 2005 etc). The causes might be smaller ration size, higher digestibility and proper utilization of feed. Das and Ray (1989) observed increasing trends of FCR values with increasing ration size in the growth trial of Indian major carp (*Labeo rohita*). Ghosh *et al.* (1984) found increasing FCR values with increasing ration size by feeding common carp (*Cyprinus carpio*) with supplementary feeds. De Silva and Davy (1992) stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. The digestibility in turn, depends on daily feeding rate, its frequency, and the type of feed used (Chiu *et al.*, 1987). However, the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities. Significantly higher survival rate of fingerlings was obtained in T_1, where the stocking density was low compared to those in T_2 and T_3. The causes for decreasing survival rates in these treatments were accounted for higher stocking density of hatchlings as well as competition for food and space in the experimental ponds. This agrees well with the findings of Uddin *et al.* (1988), Saha *et al.* (1989), Haque *et al.* (1993; 1994), Kohinoor *et al.* (1994), Rahman and Rahman (2003) and Rahman *et al.* (2005) during fry/fingerling rearing experiments of various indigenous/exotic carp and barb species.

In the present study, significantly higher gross and net productions of fingerlings were obtained from ponds stocked with 0.8 million hatchling ha^{-1} than those from the ponds stocked with 1.0 and 1.2 million hatchling ha^{-1}, indicating that the growth and percentage of survival decreased with increasing stocking density. The results in the present experiment are very close to those of Saha *et al.* (1988) who obtained a gross production of 1385.15 to 1995.60 kg ha^{-1} by 8 weeks rearing of rohu (*Labeo rohita*) fingerlings at 0.6 to 0.8 million ha^{-1} stocking densities. Rahman *et al.* (2003) also found 1663.48-2476.77 kg ha^{-1} productions after 8 weeks nursing of local sharpunti (*Puntius sarana*) hatchlings at stocking densities of 1.25 to 1.75 million ha^{-1}. Similar to the present study, Rahman *et al.* (2004) obtained a production of 1869.1 kg ha^{-1} by rearing of *Labeo calbasu* fingerlings for 8 weeks at a stocking density of 0.8 million hatchlings ha^{-1}. Significantly higher numbers of fingerlings were produced in T_3 where the stocking density was higher than those in T_2 and T_1. Despite this, consistently higher net benefits were obtained from the ponds stocked with 0.8 million hatchling ha^{-1} than those from 1.0 and 1.2 million ha^{-1}. The higher market price of the larger fingerlings produced in ponds with 0.8 million hatchling ha^{-1}, substantially increased the net benefits compared to those obtained from the smaller fingerlings produced at higher stocking densities. Similar results were obtained by Rahman *et al.* (2005) from the fingerling rearing experiments with critically endangered mahseer (*Tor putitora*) in earthen nursery ponds. Overall, the highest growth, survival, production and benefits of fingerlings were obtained in ponds with 0.8 million hatchling ha^{-1} compared to the ponds with higher stocking densities. Physico-chemical parameters of pond water during the study were within the acceptable range for nursery management, the growth of fingerlings to a greater extent was dependent on the quality and quantity of food available. However, availability of plankton varied among the ponds, being more abundant in ponds stocked with lower densities. In the present experiment, amount of feeds supplied in different ponds were based on the number of hatchlings stocked and the amount provided per fry was kept at the same level. Hence, the observed low growth at higher stocking densities could be due to less availability of natural food and some unfavourable changes in environmental parameters (Kohinoor *et al.*, 1997). The findings in the present study are in a very close agreement with those reported by Kohinoor *et al.* (1994), Rahman and Rahman, (2003) and Rahman *et al.* (2004, 2005).

Finally, it could be concluded that the growth, FCR, survival, production and net benefits of reba carp fingerlings were inversely related to the stocking densities of hatchling and in all respects 0.8 million hatchling ha^{-1} showed the highest values compared to higher stocking rates. Hence, stocking density of 0.8 million hatchling ha^{-1} may be recommended for rearing of *C. ariza* fingerlings over 8 weeks in single stage nursing. Due to the environmental changes and manmade intervention in aquatic ecosystem, spawning and feeding grounds of this important fishery have been severely degraded. In this situation, production of adequate quality seeds through application of our present findings might immensely be helpful towards the protection of gene pool of reba carp from extinction as well as for its conservation and rehabilitation.

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