

Effects of Seasonal variation on Growth Performance of Mirror carp (*Cyprinus carpio* Ver. *specularis*) in Earthen Nursery Ponds

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Abstract

The experiment was conducted to determine the effect of seasonal variation on growth performance of *Cyprinus carpio* fry in six earthen ponds during December 2011 to June 2012 covering winter (WS) and summer season (SS). Stocking density was 6250 per decimal with a mean weight of 0.192±0.002 (g). This study was done with three replications for each season. During the WS, the mean values of water parameters were temperature 16.78±2.17, transparency 32.67±1.9 cm, dissolved oxygen 5.88±2.18 mg/l, pH 8.24±0.49, total alkalinity 184.72±22.72, and ammonia nitrogen 0.21±0.05 whereas the mean value of water parameters in SS were temperature 30.56±1.51, transparency 30.61±1.71cm, dissolved oxygen 4.3±1.37 mg/l, pH 8.33±0.24, total alkalinity 274.95±6.73 mg/l, and ammonia nitrogen 0.16±0.05 mg/l. Mean values of survival and specific growth rates were 58.94±0.95 and 2.45±0.03 in WS and 67.85±4.27 and 4.00±1.03, in SS respectively. Mean gross and net productions in WS were 1581.94±71.55 kg ha⁻¹ 60 d⁻¹ and 1285.03±69.84 kg ha⁻¹ 60 d⁻¹ and, 4262.74±147.81 kg ha⁻¹ 60 d⁻¹ and 3964.74±145.74 kg ha⁻¹ 60 d⁻¹, in SS respectively. Therefore, it can be concluded that mirror carp fry production was better in SS than in WS.

Key words: Seasonal variation, Growth performance, *Cyprinus carpio*, Water quality parameter

Introduction

Being cold-blooded animal, fish is affected by the temperature of the surrounding water which influences the body temperature, growth rate, food consumption, feed conversion and other body functions (Houlihan *et al.*, 1993; Britz *et al.*, 1997; Azevedo *et al.*, 1998; Kausar and Salim, 2006). Therefore, water temperature is a driving force in the fish life because its effects are more than any other single factor. Growth and livability in fishes are optimum within a defined temperature range (Gadowaski and

Caddell, 1991; Begum *et al.*, 2003). Although short-term changes, such as weather conditions, may influence a fish for a day or two, but temperature has more predictable and seasonal effect.

Each fish species has an ideal temperature range within which it grows quickly. However, fish move into more favorable areas of a stream to regulate their body temperature. In warmer environment fish have a longer growing season and faster growth rate but tend to have a shorter life

span than in cool water. High water temperature increases the metabolic rate, resulting in increased food demand (Begum *et al.*, 2007; Hossain *et al.*, 2013a). Although, fish can generally function in a wide range of temperature, but they do have an optimum range, as well as lower and upper lethal temperature, for various activities (Beschta *et al.*, 1987).

Freshwater fish have an optimum growing temperature in the range of 25-30°C (El-Shebly *et al.*, 2007; Shah *et al.*, 2008; Hossain *et al.*, 2013b) at which they grow quickly. During winter, temperature falls, thus influencing biological functions in fish. Mirror carp is an important freshwater fish cultured in Asia, particularly in Bangladesh, India and Pakistan. Therefore, growth rate of this fish and other cultured freshwater carps decreased during the low water temperature period.

Keeping in view the information given above, it can be envisaged that by understanding how temperature affects the performance of fish, particularly during winter season, a farmer can maximize his profit by exploiting maximum production potential of local fish species. However, information regarding the effect of water temperature on various species of fish in Bangladesh is limited. Therefore, an experiment was designed to investigate the effect of seasonal variation (especially changing water temperature during winter and summer) on the growth performance of Mirror carp fry.

Materials and methods

Study area and experimental design

The research was carried out for a total period of 6 months (3 months in winter and

3 months in summer) from December, 2011 to June, 2012 in six nursery ponds located at Banbelgharia, the Government fish seed production farm, Natore Sadar Upazila under Natore district, Bangladesh. The ponds were rectangular in shape and the surface area of each pond was 0.15 hectare (38 decimal) with an average depth of 1.07 meter. Each pond had inlet for watering but no outlet, freed from aquatic vegetation, well-exposed to sunlight and sandy loam bottom soil types. Stocking density of mirror carp fry was 1543750/ha both in winter and summer season.

Pond preparation, stocking and fertilization

Before starting the experiment the ponds were dried and freed from aquatic vegetation. After drying, liming (CaO) was done in all the ponds at the rate of 1 kg/decimal. Ponds were then filled with ground water at a depth of about 1.07 meter. Seven days after liming, Urea and triple super phosphate (TSP) were applied at the rate of 100 g/decimal each as basal dose. Seven days after fertilization, Sumithion was applied in all the ponds at the rate 100 ml/decimal after watering. Fry of *Cyprinus carpio* var. *specularis* were stocked in the ponds both in winter and summer season at the density of 6250 fish/ decimal after 7 days of fertilization.

Fertilization

Fertilization of the ponds in winter and summer seasons was done with Urea (200 gm/decimal) and TSP (100 gm/ decimal) at fortnightly basis. TSP was dissolved in water for 24 hours before and Urea was dissolved in a bucket in the morning and

then applied by spreading with a mug on the pond surface. Fertilization was done fortnightly.

Supplementary feeding

The fish was fed with a mixture of rice bran (50%), mustard oil (30%) cake and wheat bran (20%) at the rate of 50% of their body weight from day 1 to 90.

Study of water quality parameters

The physico-chemical parameters of pond water were recorded fortnightly throughout the experimental period between 10 A.M. and 12 A.M. Physical parameters such as; water temperature (°C), transparency (cm), and water depth (m) were measured at the pond site on each sampling day. Depth of water of the experimental ponds was estimated with the help of a graduated wooden scale. Water transparency of the experimental ponds was measured by a Secchi-disk, it was immersed into the water and then the visible and invisible depths under the water to the naked eye were measured in cm. water temperature was recorded with a Celsius thermometer at 15-20 cm depth. The dissolved oxygen concentration of water was determined by the aid of a water quality test kit (HACH kit model FF-2, made in USA). The negative logarithm of the hydrogen ion concentration or pH of water was measured by using HACH kit (model FF-2, cat. No. 2430-01, made in USA) and total alkalinity of water sample was determined by titrimetric method using methyl orange indicator. Ammonia-Nitrogen was measured by using a HACH kit (model FF-2, cat. No. 2430-01, made in USA). Rochelle salt solution and Nessler reagent were used to measure the

NH₃-N. A colour comparator (value ranging from 0 to 3.0 mg/l) also used for the same.

Harvesting of fish

At the end of the experiment the water of the ponds were pumped out and all the fishes were harvested. The growth of fish was recorded by measuring the length (cm) and weight (g) of the harvested fishes by using a measuring scale and a balance respectively.

Estimation of survival rate, growth and production of fish

(i) The survival rate was estimated by the following formula:

$$\text{Survival Rate (\%)} = \frac{\text{No. of harvested fishes}}{\text{Initial no. of fishes}} \times 100$$

Fish production

At the end of the experiment, all fish were harvested and following parameters were used to determine production of fishes in different seasons.

Individual stocking weight (g)

Individual fish weight was taken using electric balance as gram (g) during stocking.

Individual final weight (g)

It was taken at the time of harvest and was expressed as gram (g).

Weight gain (g)

(i) The weight gain was calculated through the following equation-
Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

(ii) Specific growth rate (SGR %) was estimated by the following formula:

$$\text{SGR}(\% \text{ per day}) = \frac{\text{In (final weight)} - \text{In (initial weight)}}{\text{Culture period (days)}} \times 100$$

(iii) Calculation of gross fish production (ton/ha/yr):

Gross fish production =

$$\frac{\text{Gross weight (kg) of fish per decimal per month}}{1000} \times 247 \times 12$$

(iv) Calculation of net fish production (ton/ha/yr)

$$\text{Net fish production} = \frac{\text{Net weight (kg) of fish per decimal per month}}{1000} \times 247 \times 12$$

Statistical analysis

All data were analyzed using GraphPad Prism 5 statistical software (GraphPad Software, Inc., San Diego, CA) after they were checked for normal distribution and homogeneity of variance. Tests for normality of each group were conducted by visual assessment of histograms, box plots and confirmed using the Kolmogorov-Smirnov test. Only percent data had to be arcsine transformed before analysis; however, non-transformed data are presented in tables. Where the normality assumption was not met, the non-parametric Mann-Whitney U-test was used to check the effects on weight gain, survival, growth and production between WS and SS. All statistical analyses were considered significant at 5% ($p < 0.05$).

Results and discussion

Physical parameters and Chemical parameters

The mean values of water depth of the ponds in winter and summer were 0.90 ± 0.03 m and 0.88 ± 0.02 m respectively (Table 1). Water depth has great influence

on the productivity of a water body. In shallow water bodies sunlight penetrates up to the bottom and thus increases the productivity. During the experimental period, fortnightly fluctuations of water depth ranged from 0.79 to 0.99 m. Jhingran (1975) stated that a depth of about 2 m of a pond is suitable from the biological point of productivity. Rahman (1992) and Hossain et al. (2001) stated that pond should not be shallower than 1 m and deeper than 5 m and optimum depth should be 2 m.

The mean values of water transparency, dissolved oxygen (DO), pH, total alkalinity and ammonia-nitrogen of the ponds in winter were 32.67 ± 1.9 cm, 5.88 ± 2.18 mg/l, 8.24 ± 0.49 , 184.72 ± 22.72 mg/l, 0.21 ± 0.05 mg/l, whereas, the above parameters in summer were 30.61 ± 1.71 cm, 4.3 ± 1.37 mg/l, 8.33 ± 0.24 , 274.95 ± 6.73 mg/l and 0.16 ± 0.05 mg/l, respectively (Table 1). Azam (1996), Nahar (1997), Kawser (1998), Tasneem (1998), Rashid (1999), Israfil (2000), Kabir (2003), Khatun (2004), Chowdhury (2005), Uddin (2005) and Hossain et al. (2007) recorded almost similar transparency, DO and pH values of

pond water in similar experiments. Fortnightly variations of water transparency during the experimental period ranged from 27.00 to 38.00 cm. Rahman (1992) stated that the transparency of productive water-bodies should be 40 cm or less (turbidity resulting from plankton). Kohinoor (2000) recorded transparency values ranging from 15 to 58 cm. According to Kamal et al. (2012) transparency fluctuated between 19 cm and 49 cm in the seasonal ponds at Natore, Bangladesh. Dissolved oxygen content of the ponds were found between 2.75 to 8.9 mg/l. Hossain (2012) found the DO content ranged from 4.8-8.7 ppm.

Kamal et al. (2012) recorded DO content varied from 1.80 mg/l to 9.8 mg/l in the seasonal ponds of Natore, Bangladesh. Banerjea (1967) stated that 5-7 ppm of dissolved oxygen of a water body is good for biological productivity. The fluctuations of pH values during the experimental period in winter and summer ranged from 7.0 to 9.0 and 8.0 to 9.0 respectively. According to Swingle (1967) and Hossain et al. (2006), pH 6.5 to 9.0 is suitable for pond fish culture and pH more than 9.5 is unsuitable because free CO₂ is not available in this situation. Kamal et al. (2012) found the pH values ranged from 6.88 to 9.22 at the seasonal ponds of Natore, Bangladesh. Fortnightly fluctuations of total alkalinity in the experimental ponds ranged from 128.00 to 188.00 mg/l. Mairs (1966) stated that water bodies having total alkalinity 40 mg/l or more are considered more productive than the water bodies of lower alkalinity. Fortnightly fluctuations of ammonia-nitrogen in the experimental ponds ranged from 0.1 to 0.3 mg/l. Wahab et al. (1995), Kadir et al. (2007) and

Milstein et al., (2009) recorded ammonia-nitrogen (NH₃-N) of 0.09 to 0.99 mg/l, 0.11 to 0.52 mg/l and 0.6 to 0.29 mg/l, respectively.

The highest water temperature recorded was 35°C found in summer and the lowest water temperature was recorded 14°C in winter. The mean values of water temperature of the ponds in winter and summer were 16.78±2.17 and 30.56±1.51°C, respectively (Table 1). Houlihan et al. (1993), Britz et al. (1997) and Azevedo et al. (1998) observed that fish were markedly influenced by the water temperature in which they lived. However, different fish require different temperature regimes; a range between 25-30°C is being optimum for Mirror carp. The lower body weight gain of the mirror carp in low water temperature (20-22°C) may be due to less feed intake than those in higher water temperature (24-26°C). Jauncey and Ross (1982) have reported that most species cease to feed at low temperatures (below 16°C). Therefore, better growth rate at 26-35°C in Mirror carp may be attributed to the high water temperature, which increased feed intake and metabolic rate of the fish. Similar results were obtained by Kumar et al. (2000), Zaman et al. (2002), Frei and Becker (2005), Kauser and Salim (2006), Hossain (2012), Hossain et al. (2013). Kamal et al. (2012) recorded water temperature ranged from 25.5°C to 32.6°C in the seasonal ponds at Natore, Bangladesh.

Growth and production performances of mirror carp

The mean individual stocking wt (g) of mirror carp was 0.192±0.002 and

Table 1 Physico-chemical characters of water in the earthen ponds during the winter and summer season.

Parameters	Winter	Summer	Level of Significance
Water depth (m)	0.90±0.03	0.88±0.02	NS
Transparency (cm)	32.67±1.9	30.61±1.71	NS
Water temperature	16.78±2.17	30.56±1.51	NS
Dissolved oxygen (mg/L)	5.88±2.18	4.3±1.37	NS
pH	8.24±0.49	8.33±0.24	NS
Total Alkalinity(mg/L)	184.72±22.72	274.95±6.73	NS
NH ₃ -N (mg/L)	0.21±0.05	0.16±0.05	NS

NS: Not significant

Table 2 Growth performance of *Cyprinus carpio* during winter and summer season in the earthen ponds.

Parameters	Winter		Summer	
	Mean	SD	Mean	SD
Mean individual stoking wt. (g)	0.192	0.002	0.193	0.001
Survival (%)	58.94	0.949	67.85	4.27
Mean individual harvesting wt. (g)	1.74	0.060	4.08	0.12
SGR (% bw d ⁻¹)	2.45	0.030	4.00	1.03
Gross production (kg ha ⁻¹ 60 d-1)	1581.94	71.551	4262.74	147.81
Net production (kg ha ⁻¹ 60 d-1)	1285.03	69.836	3964.74	145.74

SD: standard deviation

0.193±0.001 in winter and in summer, respectively. Mirror carp reached mean individual harvesting weight of 1.74±0.06 and 4.08±0.12 in winter and in summer, respectively. The survival rates of mirror carp was 58.94±0.95 and 67.85±4.27 in winter and in summer, respectively. The gross production of mirror carp was 1581.94±71.55 kg ha⁻¹ 60 d⁻¹ and 4262.74±147.81 kg ha⁻¹ 60 d⁻¹ in winter and in summer, respectively. The net production of mirror carp was 1285.03±69.84 kg ha⁻¹ 60 d⁻¹ and 3964.74±145.74 kg ha⁻¹ 60 d⁻¹ in winter and in summer, respectively.

However, it was found that the gross and net production of mirror carp in summer was better than in winter, which was 4262.74±147.81 kg ha⁻¹ 60 d⁻¹ and 3964.74±145.74 kg ha⁻¹ 60 d⁻¹ (Table 2).

During the WS, the growth was almost similar in all the three replications. ANOVA revealed that the body weight among three replications were not significantly difference (P=0.702). However, in summer season, the significantly difference (P=0.761) among the three replications was observed. Mann-Whitney U-test indicated that the growth in summer (Median =3.78g)

was significantly higher than in winter (Median=1.78g) (Two tailed, Mann-Whitney U=3.00, P<0.001)

Survival rate, growth and producti fish

Survival rate (%)

In the present experiment, the survival rates were different in different experimental ponds. The survival rate of mirror carp was 58.94±0.95 and 67.85±4.27 in winter and in summer, respectively (Table 2). Malecha *et al.* (1981) conducted a feasibility study of raising freshwater prawn (*M. rosenbergii*) without supplemental feed in a culture system. Of the two ponds, one received fresh manure from swine and was stocked with silver carp, big head carp, grass carp, common carp (later) at the ratio of 65:1:4:12 and with prawn at the density of 7.9 /m² and the other received only effluent, was stocked with silver carp, bighead carp, grass carp, at a density of 650, 79, 10-15/ha and with prawn at 4.6 /m². They found that the gained averaged fish biomass of 14.38 kg/ha/day with the manure pond and 6.06 kg/ha/day with the effluent pond and gained averaged prawn biomass of 2.46 kg/ha/day. The study also showed that the survival: 17.4% to 48.1% with the manure and effluent ponds, respectively. In the present study, the survival rate was low because mirror carp spawn was released. In case of spawn, mortality rate was high due to the environmental factors, water quality parameters, food competition and was stocked together with high stocking rates, although the experimental ponds were prepared effectively with appropriate doses of lime, urea and TSP. Haque (2005) recorded the survival rates of 89.50% and 90% in winter and in summer season

respectively in monoculture of Thai sharpunti (*Puntius gonionotm*). Jannat *et al.* (2012) obtained survival rates of 92 to 94% in monoculture of Thai climbing perch.

Specific growth rate (SGR% per day)

In the present study, the specific growth rates of mirror carp was 2.45±0.03 and 4.00±1.03 in winter and in summer (Table 2). Hossain and Islam (2006), reported the SGR of prawn, catla, rohu and silver carp ranged from 3.99 to 4.26, 3.71 to 3.83, 2.49 to 2.55 and 2.44 to 2.59% respectively. The specific growth rate in summer season was higher because the environment is suitable for fish. The temperature, water transparency, DO, Alkalinity, Ammonium-ion, Hardness etc. are limiting factors were in suitable ranges. De silva and Davy (1992) stated the SGR of fish was high because of high feed protein and energy diet that showed high value of nutrients. Whereas the supplementary fish feeds was made in farm manually showed the SGR value between 3-4% per day. Besides this, the fish fry was comparatively small size, of which the growth and production of carps cultured in winter and summer season was not the satisfactory level.

Production of fish

In the present experiment, calculated gross and net production of fish in winter was 1581.94±71.55 and 1285.03±69.84 kg ha⁻¹ 60 d⁻¹ whereas in summer, gross and net production was 4262.74±147.81 and 3964.74±145.74 kg ha⁻¹ 60 d⁻¹ (Table 2). Net production of fish in summer was higher than that of in winter season because the environment was suitable for fish growth. The temperature, water transparency, DO, Alkalinity, Ammonium-ion, Hardness etc. the limiting factors were in suitable ranges.

Alim *et al.* (2005) found their experiment on stocking of carps in polyculture, 20% large carps stocking did not affect the survival rate and the production of rohu and catla (but not as same as common carp). Hopher *et al.* (1989) found in an experiment, the effect of fish density and species combination on the growth and utilization of natural food in ponds, the yield of all combined species in the polyculture was higher where at the density of 1300 carps/ha (2116 kg/ha in 156 days). At 2600 carps/ha density reduced the total rate of silver carp growth, as compared with the lower density. Lakshmanan *et al.* (1968) conducted an experiment to the Preliminary study on the rearing of carp fingerlings. They found that in the experiment the stocking of major carp fries in polyculture under three densities, viz. 62,500, 93,750 and 125,000 per hectare (i.e. 250, 375 and 500 per decimal). The species ratio of *Catla catla*, *Labeo rohita*, *Cirrhina mrigala* and *Cyprinus carpio var. commnis* was 3:4:1:2 respectively. The negligible difference in the growth rate of three stocking rates showed that optimum stocking does not mean under stocking. The average production rates under the three densities was ranged from 2002.28 to 3127.75 kg/ha/three months, which are considered very encouraging. The fish population densities of the present experiment were very high. Lorenzen (2001) carried out an experiment entitled "Using population models to assess culture-based fisheries: a brief review with an application to the analysis of stocking experiments" he found that population dynamics models are powerful tools for the analysis of culture-based fisheries, optimization of stocking and harvesting

regimes. Key population processes and the culture-based fisheries are briefly reviewed, and approaches to the practical assessment of management regimes are outlined. A model was developed for the analysis of stocking experiments, and was applied to mrigal (*Cirrhinus mrigala*) stocking in Huay Luang reservoir in Thailand. From this experiment it reveals that determination of suitable fish population density is very important in fish culture. Hashim *et al.* (2002) conducted an experiment on "Production of hybrid red tilapia, *Oreochromis mossambicus* × *O. niloticus*, at varying stocking densities in portable canvas tanks" the stocking rate of 79 fish/m³ resulted in the highest specific growth rate (SGR) and relative growth rate (RGR) but was not significantly different from stocking rates of 119 and 159 fish/m³. However, feed conversion ratio (FCR), condition factor (CF), and survival rate did not differ significantly among all stocking densities. Based on these findings, a maximum stocking rate of 159 fish/m³ is recommended for culture of tilapia. The five stocking densities of tilapia were 79, 119, 159, 198 and 328 fish per m³ in their experiment. Above the 5 stocking densities, 159 fish/m³ was most suitable for the culture system.

Conclusion

In the present experiment, the specific growth rate (SGR % bwd⁻¹) and the production of mirror carp fries was recorded comparatively better in summer than that of winter season while the stocking density and size of mirror carp fries were same. During this period almost all the physicochemical parameters of the experimental ponds water were found more

or less similar at summer and winter season but it was big differ in temperature. Though the stocking density and size of mirror carp fries were same but the production of fishes was recorded higher in summer season where the temperature was better than in winter. It can be concluded that the ranges of water temperature from 26-35⁰C seemed to be the most effective for rearing of Mirror carp in Bangladesh. However, the effect of water temperature on nutrient digestibility of the diet fed to the Mirror carps still remains an important factor, which might be played an important role in understanding the growth performance of the fish.

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