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Effect of different photoperiods on the growth and survival of juvenile of Indian major carp, *Catla catla*

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Abstract

The experiment was conducted to determine the effects of different photoperiods and darkness on the growth and survival of juvenile *Catla catla* in the laboratory for 90 days. Fishes were divided into four aquaria (10 fish per aquarium), and subjected to different photoperiod regimes of 8 hours light: 16 hours dark (8L:16D), 16 hours light: 8 hours dark (16L:8D), continuous light (24L:0D) and complete darkness (0L:24D). The maximum and minimum growth was observed in the group subjected to continuous photoperiod and complete darkness, respectively. The mean body weight of these groups was significantly different ($p<0.05$) from other groups which was observed from day 60. Survival rate was 100 percent in all the aquaria subjected to different photoperiods except one which was under continuous dark, where 30 percent mortality was recorded. Mean final growth rate, specific growth rate and daily feed intake were maximum in the group subjected to continuous photoperiod and their means were significantly different ($p<0.05$) from other groups of fish of different photoperiod regime. A continuous photoperiod is suggested for better growth and survival of rearing juvenile Indian major carp, *C. catla* under controlled conditions.

Keywords: Photoperiod, *Catla catla*, Growth, Mortality, Specific growth rate

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Introduction

The Indian major carp, *Catla catla* is an inland water teleost widely used as a surface feeder in polyculture in Indian sub-continent. The fish is commercially important and palatable as a table fish among the people in India, Bangladesh, Myanmar, Pakistan and Thailand. The fish is endemic to all rivers in northern India, the Indus plain and adjoining hills of Pakistan, Bangladesh, Nepal and Myanmar. *C. catla* is a eurythermal species that grows better at water temperatures ranging between 25 and 32 °C and its natural distribution seems to be governed by temperature rather than latitude and longitude.

Environmental and nutritional factors play an important role in the development of various stages of fish. The factors which affect the growth of fish are feeding rate, feeds, water quality, stock density and size (Trzebiatowwski *et al.,* 1981). In addition to these, photoperiod and temperature affect the growth and maturation of fish (Yamamoto *et al.,* 2001). Studies on the use of light intensities in different fish species has been carried out by many workers (Imsland *et al.,* 1995; Garcia, 1996; Purchase *et al.,* 2000; Ergün *et al.,* 2003; Ruchin, 2004; Rad *et al.,* 2006; Taylor *et al.,* 2006; Valenzuela *et al.,* 2006; Bonnet *et al.,* 2007; Askarian and Kousha, 2009). Simensen *et al.* (2000) pointed photoperiod as a zeitgeber which controls growth through its influence on endogenous rhythms and circulating levels of growth hormones. A number of workers reported a positive relationship between photoperiod and growth rate in fishes, and concluded that application of optimum photoperiod can raise the yield of fish in aquaculture (Saunders and Henderson, 1970; Lundqvist, 1980; Brauer, 1982; Saunders *et al.,* 1985).

The investigations on influence of photoperiod on the growth of carp were carried out by many workers such as Ruchin (2004) on the influence of colored light on growth performance of *Carassius carassius* and the effect of light on white blood cell count in *Cyprinus carpio* in the years 2004 and 2006, respectively; Davies *et al.* (1986a, b) and Davies and Hanyu (1986) on the effect of temperature and photoperiod on sexual maturation and spawning of the common carp. Yamamoto *et al.* (2001) reported that shortening of light phase during the feeding trial affected feed intake in carps. Bhattacharyya *et al.* (2005) carried out the effect of photoperiod on gonadal activity of *C. catla*. However, review literature revealed that no work has been done on the growth of juvenile of *C. catla* with respect to different photoperiod regimes. Therefore, the present study focused on the effects of photoperiod on the growth and survival of juvenile *C. catla.*

Materials and methods

Materials

Juvenile *C. catla* were procured from Howrah commercial seed market, West Bengal, and transported to the laboratory and acclimatized to local environmental conditions. A total number of 40 juveniles of *C. catla* weighing between 0.7 and 0.8 g (length: 30 mm–35 mm) were selected. The experiment was conducted in aquaria (0.45×0.22×0.30m) for 90 days. A water volume of 15 liters was maintained in each tank which was equipped with an aerator supported by an air pump and filter. Fecal matter was removed daily and water level was maintained according to required volume. Fish were fed with artificial prepared balanced food comprised of 35% fish meal, 28% mustard oil cake, 28% rice barn, 2% each sun- flower and cod liver oils, 5% carboxy methyl cellulose and multivitamin-multimineral tablets (‘Becozyme Forte’ Glaxo India Ltd, 25 tablets/kg food) throughout the investigation. Adequate amounts, equivalent to 6% body mass of food was scattered in all the tanks twice daily.

Illumination and experimental paradigm

After a brief period of acclimatization, 40 juvenile *C. catla* were randomly selected and divided into four major groups of 10 individuals each and each group was exposed to either of the following photoperiodic regime:

(a) Continuous photoperiod (24L: 0D) of 24 hours light

(b) Continuous dark (0L: 24D) of 0 hours light

(c) Short photoperiod (8L: 16D) of 8 hours light

(d) Long photoperiod (16L: 8D) of 16 hours light

The four different aquaria were separated from each other by light-proof devices. Artificial white fluorescent lamps of 40 watt each were installed at a height of 15cm above the water level. The intensity of light at the surface of the water in each tank was about 200 lux. Different switches operated by previously programmed electronic timers, separately determined the duration of illumination in different tanks. In an annual cycle, the maximum and minimum values of water temperature recorded were 32.50 °C and 21.70 °C during the summer and the winter, respectively. Physico-chemical conditions including ambient temperature, dissolved O_2 and pH of water for different groups were maintained constant throughout the study. Each rectangular aquarium with an artificial photoperiod regime was enclosed with black sheets in order to prevent the escape of light from it. All the aquaria were kept in the dark room separately to isolate them from natural light. The initial mean weight of fish exposed to the three light regimes and darkness were 0.78±0.16, 0.76±0.31, 0.74±0.20 and 0.73±0.17 for 8L: 16D, 16L: 8D, 24L and 24D, respectively. Feeding schedule and illumination timings are given in Table 1.

Table 1: Feeding schedule and illumination timing of the experiment.

Tank number	Light on	Light off	Feed time
1	10.00 HRS	18.00 HRS	10.00 HRS
2	18.00 HRS	10.00 HRS	18.00 HRS
3	Always	Never	10.00 HRS
4	Never	Always	10.00 HRS

Sampling and analysis

The weight of each individual fish used in the experiment was recorded using an electronic balance sensitive up to 0.001 g at the beginning and every fortnight during the experiment. No feed was given on the day of weighing. Feed conversion ratio (FCR), daily feed intake (DFI), growth rate (GR) and specific growth rate (SGR) of each group was calculated using equations as per Degani *et al*. (1989). The statistical significance of differences between measured parameters was computed using one way ANOVA. All calculations were done with the help of GraphPad Prism 5.

Results

The survival rate was 100 percent in the three groups of different photoperiod regimes, while 30 percent mortality was observed after 15 days of the experiment in the group which was kept in total darkness (Table 2). Mean final growth rate and SGR and DFI were maximum in the group subjected to continuous photoperiod (24L: 0D) and their means were significantly different (p<0.05) from other groups of fish of different photoperiod regimes (Table 2). Maximum value of FCR was recorded in the group subjected to 8L: 16D (Table 2), but it was not significantly different (p>0.05) from other groups of fish. Mean Body weights of carp in all the groups increased by the 90th day of experiment (Fig.1). Maximum Growth was observed in the group of fish which were exposed to continuous light (24L: 0D) followed by fish kept in 16L: 8D, 8L: 16D and 0L: 24D. No significant increase in the weight was observed in the group exposed to continuous light from other groups up to the 45th day, but after that, it was found to be significantly different and continued till end of the experiment (Table 3). Minimum growth was observed in fish kept in darkness (0L: 24D).

The weight gain in fish in all the groups was almost similar during the first 30 days of the experiment, but after that, a change in growth rate was recorded in groups of different photoperiod regimes (Fig. 1). The mean final weight recorded in all four groups of fish exposed to different light regimes and darkness were 2.01±0.52, 2.25±0.84, 3.66±1.24 and 1.82±0.52 for 8L: 16D, 16L: 8D, 24L and 24D, respectively. The growth differences between fish in the continuous photoperiod (24L: 0D) and the other two groups of photoperiod regimes (8L:

16D and 16L: 8D) was noticed after the 45th day and growth difference appeared significantly different at day 60 and this difference continued till the end of the experimental period.

Table 2: Survival, DFI, GR, SGR, FCR of carp after 90 days under different photo regimes, Mean±standard deviation, values with different subscript in the same row are significant different ($p<0.05$).

	8L:16D	16L:8D	24L:0D	0D:24D
Survival	100%	100%	100%	70%
DFI	0.02230±0.004968[a]	0.02357±0.006042[a]	0.03264±0.01651[b]	0.02194±0.005134[a]
FCR	1.32±0.38[a]	1.17±0.51[a]	0.81±0.53[a]	1.15±0.72[a]
GR	0.011733±0.005899[a]	0.014667±0.008233[a]	0.030133±0.018435[b]	0.0108±0.004908[a]
SGR	1.1733±0.5899[a]	1.4667±0.8233[a]	3.0133±1.8435[b]	1.0800±0.4908[a]

FCR: Feed Conversion Ratio, DFI: Daily Feed Intake, GR: Growth rate, SGR: Specific growth rate.

Table 3: Mean body weight (mean±standard deviation) of all groups during the trial, values with different subscript in the same row are significant ($p<0.05$).

Days	8L:16D	16L:8D	24L:0D	0D:24D
0	0.78±0.16[a]	0.76±0.31[a]	0.74±0.20[a]	0.73±0.17[a]
15	0.89±0.21[a]	0.91±0.33[a]	0.94±0.36[a]	0.91±0.24[a]
30	1.00±0.29[a]	1.03±0.47[a]	1.05±0.42[a]	1.04±0.31[a]
45	1.20±0.49[a]	1.31±0.58[a]	1.68±0.73[a]	1.10±0.31[a]
60	1.34±0.56[a]	1.45±0.65[a]	2.40±1.03[b]	1.28±0.40[a]
75	1.66±0.39[a]	1.86±0.90[a]	3.00±1.35[b]	1.54±0.32[a]
90	2.01±0.52[a]	2.25±0.84[a]	3.66±1.24[b]	1.82±0.52[a]

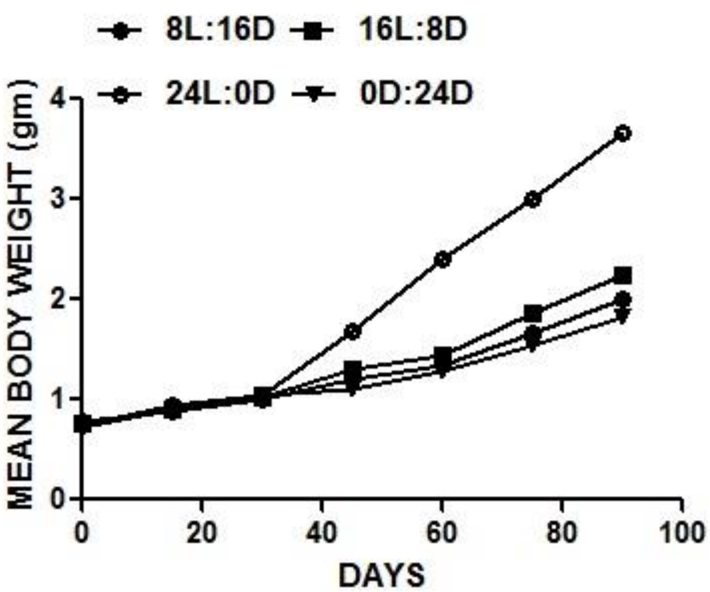

Figure 1: Mean body weight of juvenile of carp *Catla catla* exposed to different photoperiod.

Discussion

Photoperiod requirement is extremely variable and is related to environmental adaptation, species and is age specific (Britz and Pienaar, 1992; Silva-Gracial, 1996; Boeuf and Baille, 1999). The findings of the present study showed that the growth of juvenile *C. catla* is affected by photoperiod treatments and longer periods of photo regime can improve the growth of fish. Working on influence of increased photoperiods on growth, feed consumption and survival of juvenile *C. carpio*, Yager and Yigit (2009) also reported highest growth in the group subjected to continuous photoperiod. Similar results have been reported by many workers (Tandler and Helps, 1985; Folkvord and Ottera, 1993; Imsland *et al.*, 1995; Duncan *et al.*, 1999; Ergun *et al.*, 2003; Rad *et al*., 2006) in various fish species. In contrast to this, Arvedlund *et al.* (2000) reported slow growth under 24L: 0D as compared to 16L: 8D in *Amphiprion melanopus* and emphasized that their developing juveniles have a period of inactivity during darkness, their growth is compromised. A number of workers (Fuchs, 1978; Barahona-Fernandes, 1979; Boehlert, 1981; Barlow *et al.*, 1995) reported different optimum photoperiod regimes for different fish species.

The growth differences between the fishes in the continuous photoperiod and in the other two groups of photoperiod regimes were noticed after the 45th day onwards, and significant growth difference by 60th day suggested that the juvenile stage of *C. catla* requires several weeks to acclimatize to new rearing conditions. These findings are similar to those of a study carried out by Koskela *et al.* (1997) on Baltic salmon and brown trout which required several weeks to acclimatize to new rearing conditions.

Appetite, food conversion and growth energy requirement are dependent on the secretion of growth hormones in fish (Donaldson *et al*., 1979; Bjornsson *et al.*, 1989), and feeding activity is regulated by the light: dark cycle (Boujard and Leatherland, 1992). High growth rate in the group exposed to continuous light in the present study was because of increased feed conversion rate. Similar to the present findings, Yager and Yigit (2009) found high growth rates because of high feed conversion rates instead of differences in feed intake in turbot and mirror carp, respectively.

The investigations on the influence of different regimes of photoperiod on the growth of juvenile Indian major carp, *C. catla* were carried out. On the basis of the results obtained in the current study, for better growth and survival in rearing juvenile of *C.catla* under controlled conditions, the use of a continuous photoperiod is suggested. Since feeding activity is regulated by the light: dark cycle, the high growth rate under continuous photoperiod in juveniles of *C. catla* in the present study was because of increased feed intake and better feed conversion ratio.

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