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Influence of Photoperiod and Rearing Density of Fry in Production of Stunted Fingerlings of *Catla catla* (Hamilton)

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ABSTRACT

Background: Seed stunting is a process of suppressing the normal growth of fish by manipulating various factors affecting the growth process. The present study aimed at evaluating the influence of varied photoperiod and stocking density on the growth and survival of catla (*Catla catla*) during the stunting process.

Methods: Five treatments including control were used in triplicate and stocked with catla fry (0.84 g, 38.8 mm). Control, T-1 and T-2 groups were stocked with fry at 20 m^{-3} densities and maintained at 12 hours light and 12 hours darkness (12L:12D), 6L:18D and 0L:24D, respectively to study the influence of varied photoperiod. T-3 and T-4 were stocked with fry at 30 and 40 m^{-3} densities respectively to study the effect of crowding on the growth. Control at 20 m^{-3} density and 12L:12D photoperiod served as control for both the studies.

Result: There was a significant reduction in the survival, harvested body weight, total length and specific growth rate in the treatments T-1 and T-2 as compared to the control ($P<0.05$). Though these attributes were statistically similar ($P>0.05$) between T-1 and T-2, the values were relatively higher in T-1 suggesting considerable photoperiod effect on fish growth. Similarly, the HBW, total length and SGR significantly reduced from T-3 to T-4 with increased density depicting effect of crowding on growth. Such results indicated that both increased stocking density and decreased photoperiod lead to growth suppression and can be used as tools for seed stunting in catla.

Key words: Catla fingerling, Photoperiod, Rearing density, Stunting.

INTRODUCTION

Catla (*Catla catla*) is the fastest growing species in the Indian major carp group that is widely cultured in India and other south-east Asian countries. Despite its popularity among farmers and high consumer preference, its propagation in culture system is somewhat restricted mainly due to constraints in its seed availability. Poor breeding response, high mortality and non-uniform growth in nursery phase are some of the reasons for its seed scarcity. The decrease in average rainfall and occurrence of erratic monsoon in recent years has further affected the breeding behaviour of this species. Therefore, production of stunted juveniles of the species can be an ideal proposition for assured and continuous supply of assorted size stocking materials. This is particularly important for seed supply for the popular multiple stocking- multiple harvests (continuous culture) and multiple cropping methods.

Seed stunting is a process of suppressing the normal growth of fish by manipulating various factors affecting the growth process. A variety of factors has been suggested to explain the phenomenon of growth suppression or stunting in reared fish. These include overcrowding (Wedemeyer and McLeay, 1981; Pickering, 1981; Wedemeyer, 1997, Jena *et al.* 1998, Das *et al.* 2016), diet restrictions or low food availability (Abdel-Hakim *et al.* 2009; Ali *et al.* 2003), photoperiod manipulation (Boeuf and Bail, 1999; Bani *et al*. 2009; Andres *et al.* 2010), *etc*. Use of some of these factors alone or in combination can be explored for production of stunted juveniles in carps. Manipulation of stocking density has been used as a tool to optimize growth and survival during seed production and culture of many fish species (Jena *et al*. 1998; Chakraborty and Mirza, 2007; Ahmed *et al*. 2002; Moradyan *et al*. 2012). Many studies have reported growth suppression with increased stock density (Wedemeyer and McLeay, 1981; Pickering, 1981; Wedemeyer, 1997). Similarly, photoperiod has been used in growth manipulation of many finfish especially in juvenile growth of red sea bream, *Pagrus major* (Biswas *et al*. 2006), *Sparus aurata* (Gines *et al*. 2004), largemouth bass, *Micropterus salmoides* (Petit *et al*. 2003), snapper, *Pagrus auratus* (Fielder *et al*. 2002) and striped knifejaw, *Oplegnathus fasciatus* (Biswas *et al*. 2008). Photoperiod affects growth and survival by influencing the endocrine functioning (Le Bail, 1988; Falcon *et al*. 1998; Porter *et al*. 1999, 2001), feeding activity (Yağcı and Yiğit, 2009; Boeuf and Falcon, 2001) and locomotor

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activity (Veras *et al*. 2013). So, photoperiod can be another factor that can be manipulated to produce stunting effect in fish.

Use of stunted juveniles of carp for grow-out pond stocking is in practice in many regions in India (Nandeesha, 2007). Although such practice is based on the popular assumption of achieving compensatory growth response, but it lacks any systematic evidence. Only limited studies relating to seed stunting and subsequent grow-out performance of the stunted seed have been reported in Indian major carps *viz*. rohu (Prabhakar *et al*. 2008), mrigal (Singh and Balange, 2005) and catla (Kashyap *et al*. 2015). Das *et al*. (2016) reported stunted growth of rohu by employing higher stocking density and reducing the daily feed ration. However, they did not find growth compensation in the species in subsequent grow-out culture of those stunted seed. Similar information on compensatory growth response is lacking in catla, the important Indian major carp. Also no systematic study is available on the effect of photoperiod on growth in catla. The present study basically aimed at production of stunted seed of catla by employing manipulation of photoperiod and stocking density and evaluated the growth and survival during the stunting process in outdoor tank rearing system, so that the compensatory growth response of the species can further be studied in grow-out system.

MATERIALS AND METHODS

The experiment was carried out in 15 circular FRP tanks of 1000 litre capacity in outdoor condition at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India (Latitude 20°11′06″- 20°11′45″N, Longitude 85°50′52″E) for a period of 150 days from November, 2016 to April, 2017. Each tank was filled up to 800 litre level with pond water filtered through bolting silk net (No.25, mesh size 64 µ) and stabilised for three days. A total of five treatments including control were used and each treatment was triplicated. Fry of catla (0.84 g, 38.8 mm) collected from the Institute farm and acclimated for 15 days were stocked in tanks of control, T-1 and T-2 groups at 20 m^{-3} densities, to study the influence of varied photoperiod. Similarly, tanks in T-3 and T-4 were stocked with catla fry from same stock at 30 and 40 m^{-3} densities respectively to study the effect of crowding. While the normal 12 hours of light and dark period maintained in the control tanks also considered as the control for photoperiod study, T-1 and T-2 groups were manipulated to 6 hours light-18 hours dark and 24 hours dark, respectively using black and thick polythene.

Extruded floating feed pellets (3 mm diameter, 26% crude protein, 5% crude fat, 6% fibre, 11% moisture; ABIS, Indian Solvent Industry, Rajnandgaon, Chhattisgarh, India) were crushed to smaller crumbles and fed *ad libitum* in two meals daily (0900 and 1500 hr) in tanks by broadcasting on the water surface. Water samples from tanks were collected between 0700 and 0800 hr at 15 days intervals for monitoring the important physico-chemical parameters. Water temperature and pH (Elico, Hyderabad, India) were measured *in situ* while water samples were brought to laboratory for estimation of dissolved oxygen (Wrinkler's method), total alkalinity, total hardness and inorganic nutrients, *viz*., total ammoniacal nitrogen (TAN), nitrite, nitrate and phosphate, following standard methods (APHA, 2005). Fry were also sampled at 15 days intervals for assessment of their growth in terms of length and weight. Specific growth rate (SGR) of fish was calculated using the formula:

% SGR= (*ln* final weight - *ln* initial weight) × 100x (number of days of culture) $^{-1}$

The data on fish growth (length and weight), survival and specific growth rate were subjected to statistical analysis using PC-SAS programme for Windows, release v6.12 (SAS Institute, Cary, NC, USA) and Duncan's Multiple Range Test was used to compare the value of parameters among the treatments at 5% level of significance.

RESULTS AND DISCUSSION

Variation in the different water quality parameters are presented in Fig 1 and 2. The water temperature varied in a range of 23.3-33.1°C. The two treatments T-1 and T-2 with photoperiod variation showed lower pH and DO, higher CO_2 and higher levels TAN, NO_2 and NO_3, and the variation of these parameters were more pronounced with reduced photoperiod from control to T-2. In contrast, the other two treatments T-3 and T-4 stocked with higher densities did not show any marked variation of these above parameters with those of control only except the higher CO_2 and phosphorous contents. Whereas, the total alkalinity and hardness of water gradually increased with progress of rearing period in all the groups, but did not show marked variations among themselves (Fig 1).

The growth curves as depicted in Fig 3 revealed both darkness and crowding to affect adversely on the length and weight gain process in the fingerlings and the stunting effect was more pronounced with reduced photoperiod than crowding. Further, in both the cases, the stunting effect increased with reduced photoperiod from control to T-2 as well as increased density from T-3 to T-4.

With regard to photoperiod effect, there were significant reduction in the survival, harvested body weight, total length, specific growth rate as well as biomass yield per tank in the treatments T-1 and T-2 compared to the control ($P<0.05$) (Table 1). Further, the survival, harvested body weight and total length between T-1 and T-2 were statistically similar ($P>0.05$), though the values were relatively higher in T-1. Similarly T-1 showed significantly higher SGR and biomass yield than T-2.

Survival in T-3 and T-4 were similar despite their varied density, but both were significantly lower than the control ($P<0.05$) (Table 1). The average body weight (ABW) at the end of the study significantly reduced with increased density from T-3 to T-4. Similarly, the total length and SGR in control were statistically similar to those in T-3 groups, while T-4

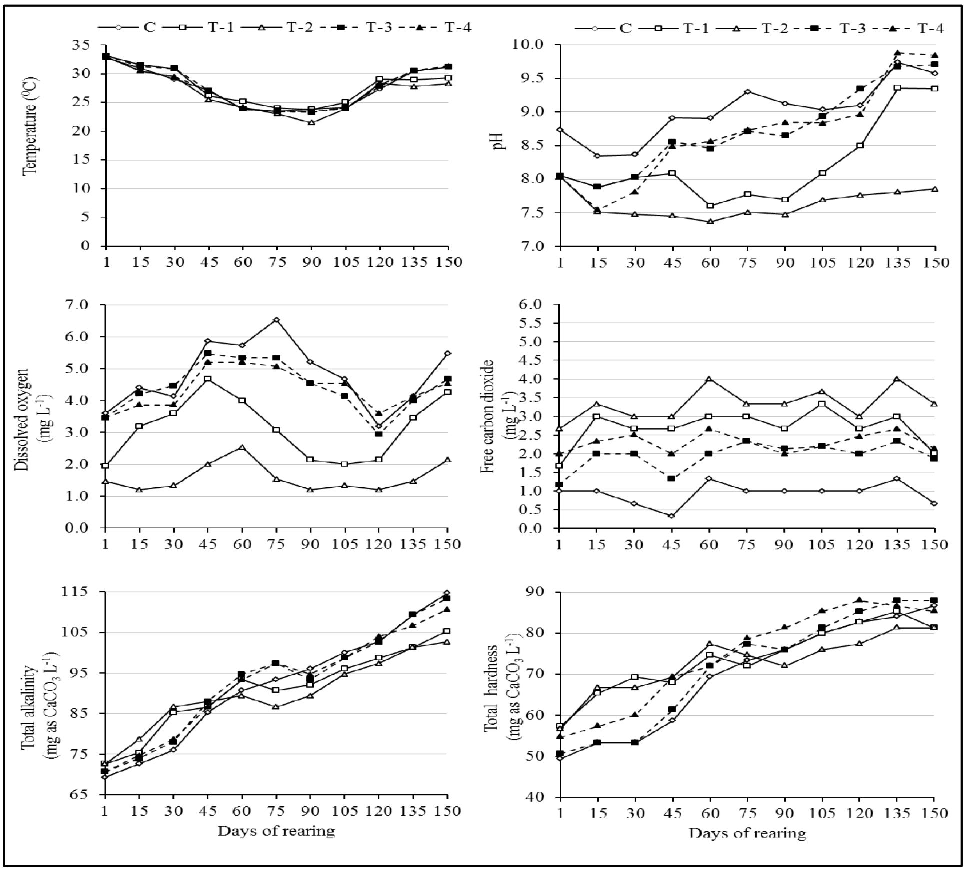

Fig 1. Water quality parameters in the tanks during the seed rearing (n=3).

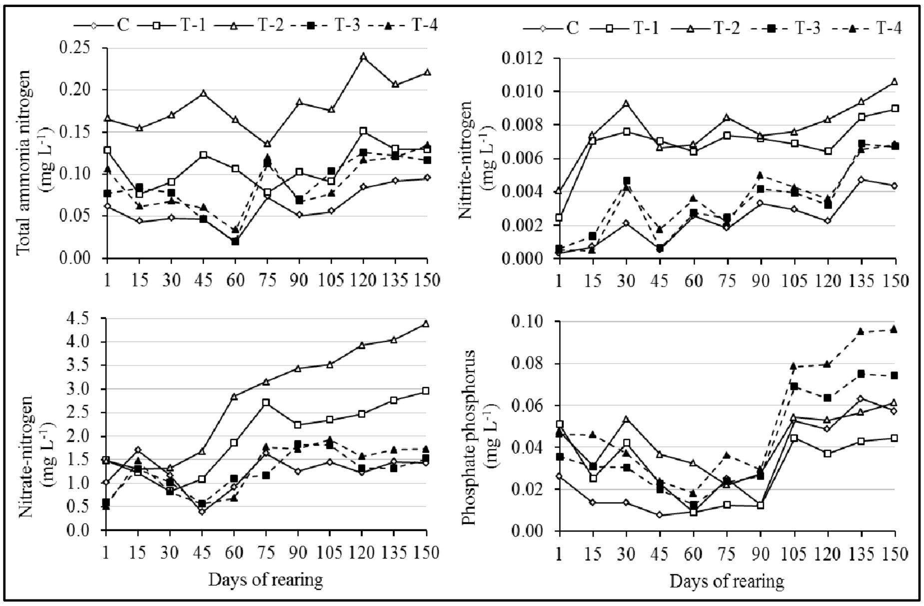

Fig 2. Different nutrient levels in tank water during the seed rearing (n=3).

recorded significantly lower values of these two attributes. Average biomass yield per tank in T-3 group was the highest among the treatments ($P<0.05$), but did not vary between control and T-4.

Incident light plays the crucial role in aquatic system through the photosynthetic activity by the planktons to generate the much wanted oxygen required for organism respiration and to fuel the decomposition process for nutrient recycling. Reduced incidence or absence of light obviously affects these processes. Reduction in DO from the Control to T-2 in the present study was obviously attributed to the reduced photosynthesis as there was reducing light incidence in

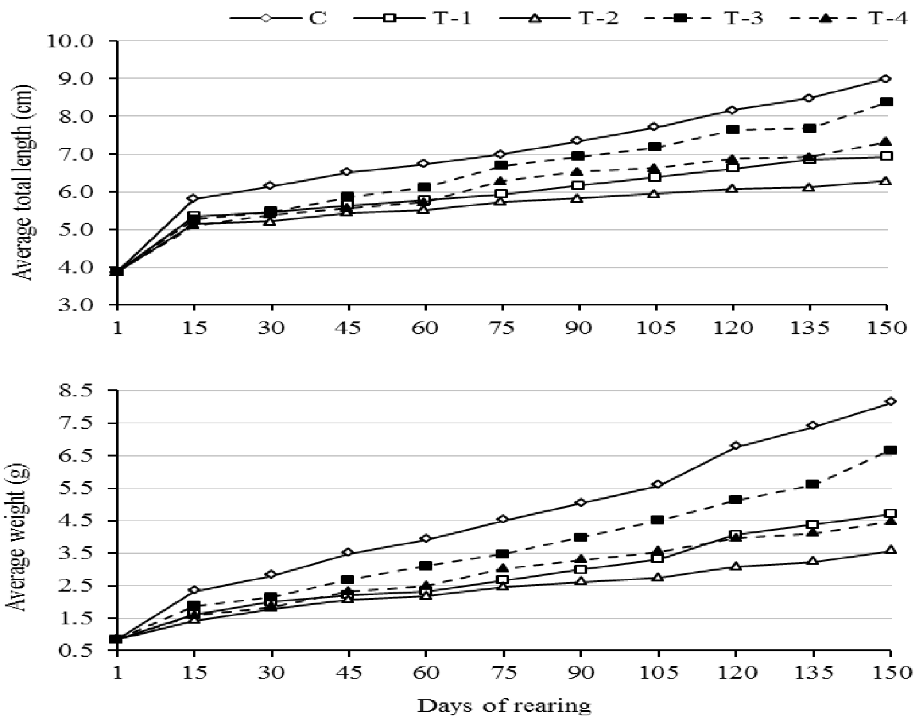

Fig 3: Growth curves of catla fingerling subjected to stunting process using varied photoperiod exposure and stocking density (n=3).

Table 1: Yield attributes of catla fingerling subjected to stunting process using varied photoperiod exposure and stocking density (n=3).

Treatment	Control (12L/12D, 20m^{-3})	T-1 (6L-18D)	T-2 (0 L-24D)	T-3 (30 m^{-3})	T-4 (40 m^{-3})
Survival (%)	91.67±3.61^{a}	85.42±3.61^{ab}	81.25±6.25^{b}	86.11±2.41^{ab}	84.38±3.13^{ab}
Harvest body weight (g)	8.13±0.78^{a}	4.70±1.32^{c}	3.57±0.24^{c}	6.67±0.16^{b}	4.47±0.20^{c}
Total length (cm)	9.0±0.24^{a}	6.93±0.73^{bc}	6.29±0.08^{c}	8.37±0.19^{a}	7.32±0.21^{b}
Specific growth rate	1.510±0.062^{a}	1.130±0.176^{b}	0.963±0.046^{c}	1.380±0.017^{a}	1.113±0.031^{bc}
Biomass/tank (g)	118.91±6.78^{b}	63.69±14.87^{c}	46.20±1.64^{d}	137.87±5.93^{a}	120.56±7.86^{b}

these tanks. Fish respiration further added CO_2 in these tanks with obvious consequence of lowering of the water pH. As a result, the lower DO and pH would have affected the organic (faeces and waste feed) decomposition process leading to prevalence of proportionately higher nitrogen species as observed in these treatments (Ghosh and Mohanty, 1981; Boyd, 1990; Das *et al*. 2005; Hargreaves and Tucker, 2004). In contrast to the tanks meant for photoperiod study, T-3 and T-4 did not show much variation in the water parameters compared to the control. Although at some points of sampling, the DO and pH in these two treatments were relatively lower, those were attributed to the fish respiration. But the decomposition process was not affected as revealed from the similar nutrient levels in these tanks as that of control.

Varied photoperiod in the treatments markedly influenced the growth and survival of catla fingerlings. Prevalence of poor water quality in terms of lower DO and pH and higher level of nitrogen species as observed in the study would have affected the fish growth and survival (Barton and Iwama, 1991; Wedemeyer, 1997; Parker, 1988; Vijayan and Leatherland, 1988). In fact, the survival reduced in the fingerlings with reduced photoperiod in the present study. Such direct relationship of survival and photoperiod has been reported earlier in many other fishes (Bani *et al*. 2009; Liu *et al*. 2015; Falahatkar *et al*. 2017; Aragon-Flores *et al*. 2017). Observation of the reduced growth (both harvested body weight and total length) in fingerling in the present study with decreased photoperiod is in concurrence with earlier reports of Kashyap *et al*. (2015) in *Catla catla*, Yagci and Yigit (2009) in *Cyprinus carpio*), Biswas and Takeuchi (2002) in *Oreochromis niloticus* and Turker (2005) in Sea turbot, *Psetta maeotica*. Such growth reduction in the fingerlings may be attributed to a slower fish activity for foraging and feed intake under short photoperiod exposure (Ali and El-Feky, 2013), reduced appetite due to hormonal effect (Karlsen *et al*. 1999) and poor feed conversion efficiency (Yagci and Yigit, 2009; Bani *et al.* 2009, Woiwode and Adelman, 1991). Indian major carps are basically planktivorous in nature. Though they are grown at higher density with supplementary feed in pond system, the natural food through plankton intake forms an important constituent in the diet, particularly in catla. The greater growth depression in the fingerlings with reduced photoperiod in the present study probably is attributed to such phenomenon as it would have restricted the plankton growth in the tanks limiting their availability for the fish. In fact, water in tanks of T-2 was remaining visibly clear during the study suggesting neglible plankton population. The pronounced growth suppression with squeezing of photoperiod indicated increasingly adverse effect of darkness on fingerling growth and can be used as a tool for seed stunting.

Observation of reduced survival with increased rearing density in the second part of this study was obvious as reported earlier in carps (Jena *et al*. 1998; Chakraborty and Mirza, 2007; Rahman and Marimuthu, 2010; Mane *et al.* 2019 and Fatima *et al*. 2018). Papoutsoglou *et al.* (1979) and Leatherland (1993) attributed the reason for such lower survival to decreased average food consumption by individual fish with increased density while Narejo *et al*. (2005) attributed it to availability of less living space in addition to food. Reduction of fingerling growth, their SGRs and biomass yields with increased density from the Control through T-3 and T-4 in the present study could also be attributed to the above reasons, as higher densities causes increased competition for food and space (Hepher and Prugnin, 1981; Haque *et al*. 1994; Jena *et al*. 1998; Gomes *et al*. 2000; Chakraborty and Mirza, 2007). Never the less, the study revealed increased stocking density to cause growth suppression and can be used as a tool for seed stunting in catla.

CONCLUSION

As a conclusion such results indicated that both increased stocking density and decreased photoperiod lead to growth suppression and can be used as tools for seed stunting in catla.

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