



Growth performance of silver carp (*Hypophthalmichthys molitrix*) in cage stocked at different densities

Rumana Akhtar Jui, Mohammad Mahfujul Haque and S. M. Rahmatullah

Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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Correspondence:

Rumana Akhtar Jui

(rumanajui@yahoo.com)

Abstract

An experiment was conducted to evaluate the growth performance of silver carp (*Hypophthalmichthys molitrix*) in cage stocking at different densities. It was expected that silver carp could grow feeding on plankton without external feeding. In this experiment, silver carps in nine cages were stocked in three different stocking densities such as 20, 30 and 40 fishes/m³ designated as treatments T₁, T₂ and T₃, which were located in the south west corner of the L-shaped pond in Field Laboratory Complex, Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh consisting of three treatments with three replications of each for a period of 90 days from 18th August to 17th November, 2015. Each cage size was 1m x 1m x 1m (length x width x height) and silver carp was cultured in the cage with natural feed which filtered phytoplankton mainly. Twenty five genera of phytoplankton were identified in pond and the average phytoplankton production was around 8.44x10⁵ cells/liter. Water quality parameters such as temperature, dissolved oxygen, pH and transparency were recorded fortnightly. At the completion of the experiment, weight showed significant difference (p>0.05) among three treatments although length didn't vary significantly. The highest length gain (18.61±0.369 cm) and the highest weight gain (62.52±2.249 g) were found in T₁. The highest SGR% for silver carp was found in T₁ and the highest total production was obtained in T₃ (5.00±0.015 kg/m³). Individual growth performance of silver carp was satisfactory. Further studies are needed with different stocking densities and duration to verify the result.

Introduction

Different types of fish species are cultured in Bangladesh like Indian major carps, Chinese carps, indigenous catfish, Thai pangus, koi, tilapia etc. Among them, silver carp (*Hypophthalmichthys molitrix*) has become one of the most important commercial culturable species and it is a freshwater cyprinid fish originated from Eurasia (FRSS, 2017). Silver carp is generally considered as a planktivorous fish (Cremer and Smitherman, 1980; Spataru *et al.*, 1983). The effect of filter-feeding fish on the plankton communities of aquatic ecosystem have been studied by Zhang *et al.* (2006); Milstein *et al.* (2008); Yan *et al.* (2009) and Wahab *et al.*, (2011). The culture of silver carp in cage has shown promising production without external feeding as this species living the cage can filter plankton horizontally from the water body (Roy, 2015). The culture of fish in cages is a promising aquaculture technology that has already proven itself in many Asian countries. However, cage culture is a relatively novel concept in Bangladesh. Cage culture is a viable alternative to traditional techniques of rearing, due to its practicability and mainly low costs (Beveridge, 1996). Cages are easy to manage, produce fish of high quality and utilize existing water bodies (Beveridge, 1996). Therefore, cage aquaculture offers a viable alternative for the landless and poor farmers in Bangladesh. Cage culture of fish consists of raising a group of fish from the

juvenile stage to the table size in a volume of water enclosed with all sides, including the bottom, while permitting the free circulation of water through the cage culture. It can be practiced intensively in low productive water bodies. It permits manipulation of harvest to fit the market whenever more profitable. Thus it could be very profitable for poor farmers (CARE, 2000).

In Bangladesh, intensive monoculture is increasingly being practiced. In this culture system, farmers stock the fish at high densities and offer large quantity of feed for getting higher profit within short time, which resulted in excessive accumulation of metabolic and feed wastes in the pond bottom. The decomposition of these metabolic and feed wastes make the pond water nutrient rich that favor the excessive growth of phytoplankton (Haque and Sarkar, 2006). Silver carp mainly phytoplanktivore and it has short food chain and higher efficiency at converting primary production into fish protein than that of carnivorous fish. Cage culture of silver carp has the potential to use phytoplankton from the ponds where primary productivity is higher and ponds have multi-ownership problems to bring into aquaculture practices. Considering above facts, the present study was carried out to assess effects of stocking density on the growth performance of silver carp in cage stocking at different densities.

Materials and Methods

Study site

The experiment was conducted in the pond at south-west side of Field Laboratory Complex, Faculty of Fisheries, BAU, Mymensingh. (Fig. 1) It is a L-shaped pond and the depth was 1 meter where the cages were set.

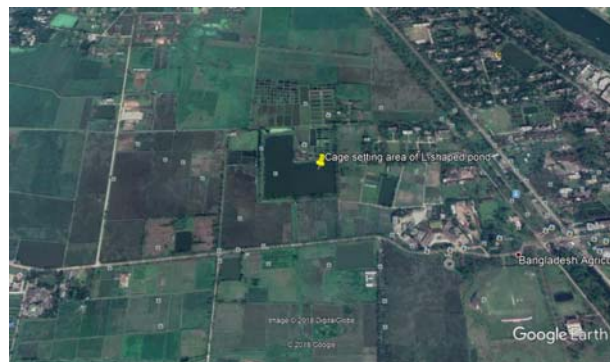


Fig. 1. Google earth map showing cage location in the L-shaped pond of Field Laboratory Complex, Faculty of Fisheries, BAU, Mymensingh

Experimental design

The experimental design comprised of three densities (20, 30 and 40 fishes/m³), carried out with three replication in each densities, using nine cages. The treatments were named as: T₁ (20 fish/m³: cage 1, 2 and 3), T₂ (30 fish/m³: cage 4, 5 and 6) and T₃ (40 fish/m³: cage 7, 8 and 9) (Table 1). The experiment was continued for 90 days from 18th August to 17th November, 2015. Fish fingerlings were collected from Bangladesh Fisheries Research Institute (BFRI).

Table 1. The layout of the experiment

Treatment Density (fish/m ³)	Replication	Cage No.	Initial body weight (g)
T ₁ (20 fish/m ³)	3	1	10.31
		2	
		3	
T ₂ (30 fish/m ³)	3	4	10.31
		5	
		6	
T ₃ (40 fish/m ³)	3	7	10.31
		8	
		9	

Study on phytoplankton

Both qualitative and quantitative observations were done to examine planktons. Phytoplankton was identified using a light microscope (Primo Star, USA). Quantitative study of phytoplankton was done by Sedge wick-Rafter cell (S-R cell).

Plankton collection and sampling procedure

Plankton samples were collected from the experimental pond where the cages were set. Five liters of water were

passed through the plankton net to get a 50 ml sample. The sample was preserved immediately with 5% formalin in a bottle. Before counting the S-R cell was allowed to stand for at least 15 minutes to settle the planktons. The cell was then set on an electric microscope. 10 fields from the total 1000 fields were randomly chosen for counting.

For counting phytoplankton, the following formula was used (Rahman, 1992).

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

Where,

N = No. of phytoplankton cells per liter

A = Total No. phytoplankton counted

C = Volume of final concentration of samples in ml

V = Volume of a field in cubic millimeter

F = Number of the fields counted

L = Volume of original water in liter

Water quality parameters

The water quality parameters were recorded during sampling. Water temperature (°C), dissolved oxygen (ppm), pH, transparency were recorded by using portable instruments.

Growth performance

Sampling was done 15 days interval by scoop net. In every sampling, 3 fishes were collected randomly from each treatment and their individual length and body weight were recorded. After harvesting of fishes final weight were recorded and following parameters were used to evaluate the growth and production of the fishes. Length gain (cm) = Mean final length (cm) - Mean initial length (cm)

Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

Percent (%) weight gain =

$$\frac{\text{Mean final weight (g)} - \text{Mean initial weight (g)}}{\text{Mean initial weight (g)}} \times 100$$

Specific growth rate SGR (% day) =

$$= \frac{\log W_2 - \log W_1}{T_2 - T_1} \times 100$$

Here,

W₂ = Mean final weight (g)

W₁ = Mean initial weight (g)

T₂ = Time at end of the experiment

T₁ = Time at start of the experiment

Average daily gain (ADG)

Average daily gain was computed by subtracting the initial body weight from the final body weight and then dividing by the number of days of culture.

$$ADG = \frac{\text{Mean final fish weight} - \text{Mean initial fish weight}}{\text{Number of days of culture}}$$

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

Total production

The production of silver carp was determined by multiplying the average gain in weight (kg) by the total number of fishes survived at the end of the experiment.

Data analysis

The data found during the investigation were entered into MS Excel 2010. The significant differences among three treatments for silver carp in cages were tested using one-way ANOVA. All the statistical tests were done by SPSS (Statistical Package for the Social Sciences) software version 16.

Results

Production of phytoplankton

As the cages were set in the same pond, during the sampling the abundance of phytoplankton groups in three treatments were more less same. Five major groups and twenty five genera of phytoplankton were identified of which included Bacillariophyceae (6 genera), Chlorophyceae (12 genera), Cyanophyceae (4 genera), Euglenophyceae (2 genera) and Rodophyceae (1 genus) (Table 2).

Table 2. Generic status with the different groups of phytoplankton

Groups	Genera
Bascillariophyceae	<i>Cyclotella</i>
	<i>Diatoma</i>
	<i>Navicula</i>
	<i>Amphora</i>
	<i>Asterionella</i>
	<i>Nitzschia</i>
	<i>Actinastrum</i>
	<i>Crucigenia</i>
	<i>Chlorella</i>
	<i>Vlovox</i>
	<i>Closterium</i>
	<i>Cosmarium</i>
Chlorophyceae	<i>Pediastrum</i>
	<i>Scenedesmus</i>
	<i>Ulva</i>
	<i>Ulothrix</i>
	<i>Tetraedron</i>
	<i>Characium</i>
Cyanophyceae	<i>Anabaena</i>
	<i>Microcystis</i>
	<i>Chlorococcus</i>
	<i>Nostoc</i>
Euglenophyceae	<i>Euglena</i>
	<i>Phacus</i>
Rhodophyceae	<i>Porphyra</i>

In the experimental period, the average phytoplankton production was around 8.44×10^5 cells/litre. Among different phytoplankton groups, Chlorophyceae was found dominating with 52% of the total count (Table 3 and Fig. 2).

Table 3. Phytoplankton content of water in cage set in the pond

Groups	Amount (cells/liter)
Bacillariophyceae	214000
Chlorophyceae	440000
Cyanophyceae	131000
Euglenophyceae	46000
Rhodophyceae	13000
Total	$=8.44 \times 10^5$ cells/liter

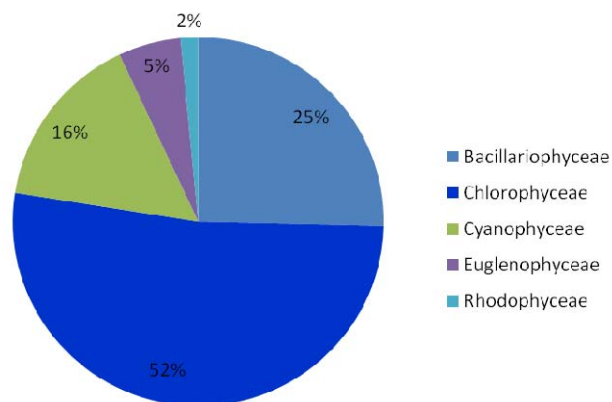


Fig. 2. Percent distribution of different phytoplankton groups in cage water

Water quality parameters

The mean values of water quality parameters are presented in the Table 4 that did not show any significant difference among the treatments.

Table 4. Average (Mean ± SE) value of water quality parameters in different treatments

Treatments	Temperature (°C)	Dissolved oxygen (mg/l)	pH	Transparency (cm)
T ₁	30.50±0.61	6.50±0.49	7.04±0.27	31±0.53
T ₂	30.34±0.44	6.00±0.47	8.27±0.03	32±0.62
T ₃	31.46±0.51	6.33±0.58	8.50±0.06	32±0.67

Growth performance and survival rate

Length gain (cm): During the study period, length gain (cm) of silver carp was higher in T₁ in comparison with T₂ and T₃ (Table 5). Statistically, there is no significant difference (p>0.05) among the treatments for length gain in silver carp (Table 5).

Table 5. Growth performance and survival rate of silver carp in cage culture under different treatments

Species	Treatment	Initial length	Final length (cm)	Length gain (cm)	Initial weight (g)	Final weight (g)	Weight gain (g)	% weight gain	Survival rate (%)
Silver carp	T ₁	10.36±0.000	18.61±0.369	8.25±0.369	10.31±0.000	62.52±2.249	52.21±2.249	455.79±19.632	79.23±1.118
	T ₂	10.36±0.000	17.79±0.336	7.43±0.336	10.31±0.000	51.75±1.596	41.44±1.596	361.77±13.928	77.67±9.200
	T ₃	10.36±0.000	17.74±0.717	7.38±0.717	10.31±0.000	49.49±0.930	39.18±0.930	341.99±0.930	70.36±0.575

Weight gain (g): During the study period, weight gain (g) of silver carp was higher in T₁ in comparison with T₂ and T₃ (Table 5). Similarly, the highest percent (%) weight gain of silver carp was found in T₁ compared to T₂ and T₃ (Table 5). There were significant differences ($p < 0.05$) among the three treatments for weight gain and % weight gain in silver carp.

Specific growth rate (SGR %) of silver carp: The specific growth rate (SGR %) of silver carp were significantly varied ($p < 0.05$) among the three treatments (Table 5 and Fig. 3).

Table 6. Specific growth rate (SGR %) of silver carp

Species	Treatment		
	T ₁	T ₂	T ₃
SGR (%)	180.20±3.561	161.31±3.100	156.85±1.881
SGR (%/day)	0.020±0.000	0.018±0.000	0.017±0.000

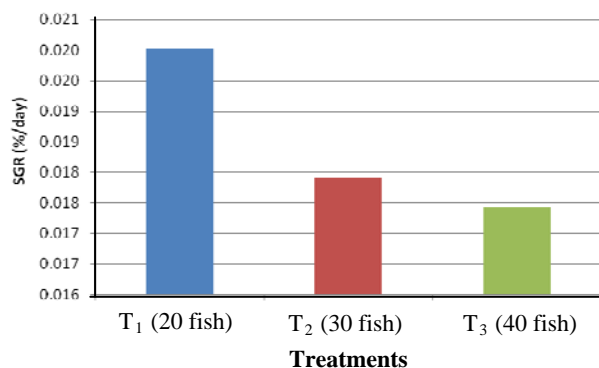


Fig. 3. Specific growth rate (SGR%) of silver carp at different stocking densities (where, T₁, T₂ and T₃ implies 20, 30 and 40 fish/m³, respectively).

Individual growth performance of weight (g) of silver carp: The weight gain of silver carp was recorded highest in T₁ (52.21±2.249 g) and lowest in T₃ (39.18±0.930 g).

Survival rate: The survival rate of silver carp in cage was highest in T₁ (79.23±1.118) and lowest in T₃ (70.36±0.575) (Table 5).

Total production

The net production of fish in treatments T₁, T₂ and T₃ were 2.16±0.01 kg/m³, 3.90±0.02 kg/m³ and 5.00±0.015 kg/m³, respectively. The highest total production was found 5.00±0.015 kg/m³ in T₃ due to higher stocking density and the lowest 2.16±0.01 kg/m³ was found in T₁ due to lower stocking density (Fig. 4).

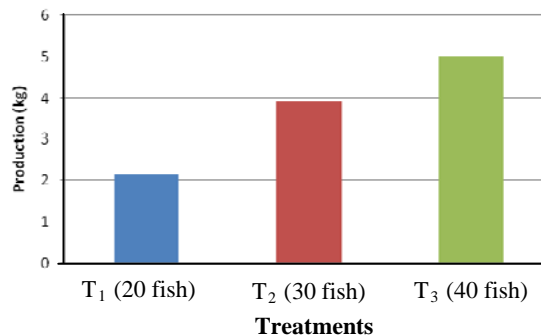


Fig. 4. Production of silver carp among three treatments in different sampling stage

Discussion

Plankton production

Phytoplankton production of the experimental pond was found to be consisted of five major phytoplanktonic groups, which included Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Rodophyceae. The most dominant group was Chlorophyceae. More or less similar results were obtained by Haque *et al.* (1998), Paul (1998), Chowdhury (1999) and Yeamin (2000).

Twenty five genera of phytoplankton were found from the experimental pond of the study. Nirod (1997) studied plankton population in nine experimental ponds of Fisheries Field Laboratory, BAU, Mymensingh and found 25 genera of phytoplankton belonging to Bacillariophyceae (3), Chlorophyceae (15), Euglenophyceae. Similar results were found by Paul (1998), Yeamin (2000), Raihan (2001), and Kohinoor (2000). These sorts of phytoplankton are good food of indigenous and exotic carps such as *Labeo rohita*, *Cirrhinus cirrhosus*, *Hypophthalmichthys molitrix*, and *Oreochromis niloticus*. The presence of such types of phytoplankton in the pond reflected higher growth of silver carp (Haque, 2007).

Water quality parameters

Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organism. Fish growth, metabolism and other biological activities are mostly dependent on water temperature so temperature is one of the vital water quality parameters for fish culture. The mean values of water temperature were 30.50±0.61°C,

30.34±0.44 °C and 31.46±0.51°C in T₁, T₂ and T₃, respectively. The maximum temperature (32°C) was recorded in T₂ on 18th August due to high intensity of sunlight and absent of cloud in the sky. The lowest temperature (18°C) was recorded in T₃ on 17th November due to low intensity of sunlight. Hasan (2007) measured water temperature in ponds of BAU campus, Mymensingh and found the range from 21 to 32.8°C which was more or less similar to this study. Another vital water quality parameter is dissolved oxygen on which fish depend on to live. Shortage of dissolved oxygen in water, fish start gulping. Sustainable fish culture depends on the optimum level of dissolved oxygen concentration. In this study the mean values of dissolved oxygen concentration were 6.50±0.49 ppm in T₁, 6.00±0.47 ppm in T₂ and 6.33±0.58 ppm in T₃. Bhatnagar and Devi (2013) reported that the desirable dissolved oxygen of 5 ppm which was slightly lower than the present study. The pH is another productivity index of water body. The circum-neutral pH or slightly alkaline pH is most suitable for fish culture. For pond fish culture, the suitable range of pH is 6.5 to 8.5 (Byod, 2008). During the experimental period the mean values of pH were 7.04±0.27, 8.27±0.03 and 8.50±0.06 in T₁, T₂ and T₃, respectively. Sarker (2000) and Maghna (2012) measured pH in ponds of BAU campus, Mymensingh and found to vary between 6.8 to 8.3 and 7.6 to 8.3, respectively which were relevant in the present study. Water transparency is a gross measure of pond productivity. When the abundance of phytoplankton in a water body, the secchi disk reading becomes lower and vice-versa. Boyd (1982) suggested a transparency (cm) ranges 15-40 cm is good for fish culture. The concentration of transparency in the present study varied from the 31±0.53 cm, 32±0.62 cm and 32±0.67 cm in T₁, T₂ and T₃, respectively that ranged corresponds to the study of Boyd (1982).

Growth parameters

Weight gain: In the present study, the length gain of silver carp were 8.25±0.369 cm, 7.43±0.336 cm and 7.38±0.717 cm for T₁, T₂ and T₃, respectively.

The weight gain of silver carp was 52.21±2.249 g, 41.44±1.596 g and 39.18±0.930 g for T₁, T₂ and T₃, respectively in cages which was slightly lower than the findings of Nazish (2011) who recorded total body weight gain was 86.2 to 124.3 g in different ponds. The total growth performance of silver carp was relatively low because in cage silver carp was grown up only with natural feed. Diana *et al.* (2004) reported that sex reversed Nile tilapia stocked in ponds at a low density showed better growth than at a higher stocking density. Similarly in cages of silver carp we found the higher weight gain at lower stocking densities. In T₁ (20 fish/m³) weight gain was higher than in T₂ (30 fish/m³) and T₃ (40 fish/m³), because the competition of phytoplankton which they feed was low in lower stocking density.

Specific growth rate (SGR %): The values of specific growth rate of silver carp were observed at 0.020±0.000, 0.018±0.000 and 0.017±0.000 in T₁, T₂ and T₃, respectively. The highest specific growth rate (0.020) was observed in T₁ and the lowest specific growth rate (0.017) was observed in T₃. In the present study, the values were lower than the finding of Ali *et al.* (2009) who recorded SGR of silver carp ranged from 0.52 to 0.53 in different treatments.

Survival rate and total production: The survivability of silver carp was observed as 79.23% in T₁, 77.67% in T₂ and 70.36% in T₃ in first two weeks. This indicates the fundamental relationship between the stocking density and survival rate in cage in ponds. The variation of production of fish was found in three treatments. Among them, the higher production of fish was observed in T₃ where stocking density was 40 fish/m³. The lowest production was observed in T₁ where stocking density was 20 fish/m³. Singh *et al.* (2013) obtained 0.214 kg/m³ production for different three stocking densities (2.5, 3.0, 4.0 fish/ m³) in carp polyculture during 120 days culture period. The fish production recorded in the present study was 2.16±0.01 kg/m³, 3.90±0.02 kg/m³ and 5.00±0.015 kg/m³ in treatments T₁, T₂ and T₃, respectively which was greater than the study of Singh *et al.* (2013). This was possibly due to following higher stocking density of silver carp in the present experiment.

Relationship between primary productivity and fish growth: Smith (1988) and Radke and Kahl (2002) reported that silver carps are effective in reducing large-sized phytoplankton biomass in aquaculture ponds. In this experiment, it was found around 8.44x10⁴ cells/liter plankton in the pond. Silver carp was grown up with filtered planktons from water body. In the cage water set in pond, the abundance of Chlorophyceae and other groups of phytoplankton indicates sufficient amount of food organisms available in the pond water for growth and production of silver carp. In this kind of water body abundant with phytoplankton, silver carp is an efficient fish species that can grow up filtering plankton. Final weight of silver carp with natural feeding (plankton) was satisfactory level in a short culture period. In fact, if it is implemented at the farmer level, this type of technique can ensure the cheaper production of fish.

Conclusion

Cage culture is one of the fastest growing methods of cultured fish which requires small amount of capital investment and make profit within some months. In this method, landless people can grow fish in cages. In cage aquaculture, the owners of the cages are the owners of the fish within the pond and this is one of the advantages where there is multiple ownership problems in traditional pond management. In cage, silver carp survived with phytoplankton and grown up. In the present study, the growth and production of silver carp was satisfactory in three different densities with natural feed phytoplankton. From the above discussion, it was

found that cage culture may have impacts in providing extra aquaculture opportunities in water body which is more beneficial for farmer as the additional feeding cost can be saved by this technique.

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