AACL BIOFLUX

Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Effects of stocking density on growth performance and yield of Thai silver barb *Barbonymus gonionotus* reared in floating net cages in Kaptai Lake, Bangladesh

[1,2]Mohammad Moniruzzaman, [1]Kazi B. Uddin, [1]Sanjib Basak, [1]Abul Bashar, [1]Yahia Mahmud, [1]Muhammad Zaher, [2]Seunghan Lee, [2]Sungchul C. Bai

[1] Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati Hill District, Bangladesh; [2] Department of Marine Bio-Materials and Aquaculture, Feeds & Foods Nutrition Research Center (FFNRC), Pukyong National University, Busan, 608-737, Republic of Korea. Corresponding author: M. Moniruzzaman, mzaman_bfri@yahoo.com

Abstract. A 120-day experiment was conducted to evaluate the effects of different stocking densities on growth, survival and yield of Thai silver barb, *Barbonymus gonionotus* reared in cage culture system in Kaptai Lake, Bangladesh. Triplicate groups of Thai silver barb with an average initial weight of 15.03±0.05g (mean±SD) were randomly stocked in 12 floating net cages (3m×3m×2m) at 30 fish m^{-3}, 50 fish m^{-3}, 70 fish m^{-3}, 90 fish m^{-3} designated as T_{30}, T_{50}, T_{70} and T_{90}, respectively. Fish in the experimental cages were fed with commercial floating pellet feed (29% protein) at 3-5 % of body weight twice daily. At the end of stocking trial, growth in terms of final weight, weight gain, specific growth rate and survival rate of fish were significantly higher in T_{30} than those in T_{50}, T_{70} and T_{90} ($P>0.05$). Feed conversion ratio was lower in T_{30} followed by T_{50}, T_{70} and T_{90} consecutively. Regression line analysis revealed that there was an inverse relationship between weight gain and stocking density, and a positive correlation between fish production and stocking density. The cages stocked with 30 fish m^{-3} have highest growth performance and 90 fish m^{-3} showed highest production performance. The results suggest that 30 fish m^{-3} could be recommended for producing larger and better quality of Thai silver barb, and 90 fish m^{-3} for highest gross production.

Key Words: stocking density, growth, production, correlation, Thai silver barb.

Introduction. Kaptai Lake (22°29'45"N, 92°13'45"E) is one of the most important inland freshwater fisheries in Bangladesh. It is the largest man-made reservoir in the South-East Asia with an average surface area of 58,300 ha, 68,800 ha when full (Fernando 1980). The lake is impounded by damming the Karnaphuli river in the Rangamati hill tracts district in 1961 (Halder et al 1991). The present annual production of Kaptai reservoir reached to 8,537 metric tons (MT) in 2012 (DoF 2013) which plays a significant role in national economy of Bangladesh. Albeit in every year a large number of Indian major carp fingerlings were stocked under fish ranching program, it is essential to increase the production by other alternative means in Kaptai Lake (Alamgir & Ahmed 2008) to meet the protein demand of huge population of the country.

Cage aquaculture in South-East Asia first started from late 1800s; since then, many countries in this area were practicing this technique both in freshwater and marine environments, including open sea, estuaries, lakes, reservoirs, ponds and river (Balcazar et al 2006; Eng & Tech 2002). This technique could effectively increase the carrying capacity of aquatic environment by releasing metabolic wastes, uneaten feeds and fecal matters from cage unit through flowing water (Beveridge 1983). In cage aquaculture, fish stocking density has great impact on growth, survival, health, water quality and production (Costa et al 2013). It is well documented that high stocking density could reduce fish growth and increase mortality (Mills & McCloud 1983; Liti et al 2005; Abou et al 2007). In contrast, increased growth, survival and feed conversion ratio were also observed in high density culture of juvenile silver perch (*Bidyanus bidyanus*) and tilapia (*Oreochromis spirulus*) (Rowland et al 2006; Cruz & Ridha 1991).

Thai silver barb or Java barb, *Barbonymus gonionotus* (Bleeker, 1850) is a fresh water and small exotic fish species in Bangladesh. It was first introduced from Thailand in 1977 because of its high yielding potential (Rahman et al 2006). It is locally known as Thai sharpunti, an herbivorous species native to South East Asia and is cultivated in freshwater ponds in Thailand, Indonesia and Vietnam (Tantong et al 1980). The breeding, culture technology and genetic improvement of this important fish species has already been developed by Bangladesh Fisheries Research Institute in Bangladesh (Hussain et al 2002). Mollah et al (2011), Moniruzzaman & Mollah (2010) and Rahman et al (2006) reported its culture potential in the seasonal ponds in mono or polyculture system. This species can withstand at high stocking densities and attains marketable size within 3-4 months (Gupta & Rab 1994). Ahmed et al (1990) studied the effect of supplemental feed and different stocking rate of major carp and silver carp in net cages in Kaptai Lake. But, growths of major carps were not found suitable and economically viable in cage culture. Thai pangasius (*Pangasius sutchi*) exhibited relatively better growth performance when reared in cages in Kaptai lake environment, fed with a mixture of rice bran, mustard oil cake and chicken offal at satiation rate (Ahmed 2001).

Adaptation of cage culture in Kaptai Lake by introducing Thai silver barb may be an appropriate option for increasing fish production in this area. It might create a great opportunity to increase the aquaculture production by using available unutilized water resources of the lake. Despite the knowledge gained, there is limited information on cage culture of this species. So, the overall objectives of this research work was to evaluate the effects of stocking density on growth, survival and yield of Thai silver barb in net cages in Kaptai Lake.

Material and Method

Experimental cages*.* The present experiment was conducted for a period of four months (120 days) from April to July 2013. Twelve cages were installed near the Riverine Sub-Station (Lake Fisheries), Rangamati of Bangladesh Fisheries Research Institute (BFRI). Experimental net cages, having an area of 3 m × 3 m × 2 m (18 m^3) made of knot-less synthetic plastic net (mesh size 1.1 cm) were installed and hanged with cage frame. The frames of cages were made by straight and rigid bamboo poles. The bamboo poles were covered with long pieces of wooden raft for easy movement, feeding and sampling of the experimental fishes on the cage structure. Empty sealed plastic drums of 250 liter size were used as cage float for buoyancy of cage structure. Each cage was covered at the top with a piece of large mesh size (4.5 cm) net to prevent escape of fish by jumping and predation of cormorants and other birds. The outer side of each experimental net was covered with a fine mesh net (20 cm depth) to inhibit floating feeds to go out from the net and to inhibit the effects of non-caged fishes from wild sources (McGinty 1991). The whole structure was tied with anchors at each corner by nylon rope to make easy movement of floating cages depending on water level.

Fish stocking and feeding*.* Juvenile Thai silver barb were collected from nearby government hatchery of Rangamati district and transported carefully to the experimental site. Prior to start of the experiment, the transported fish were acclimated with the lake environment by rearing them in hapa net for one day. In the following day, fish with an average initial weight of 15.03 ± 0.05 g (mean±SD) were randomly stocked in the net cages at 30 fish m^{-3}, 50 fish m^{-3}, 70 fish m^{-3}, 90 fish m^{-3} as T_{30}, T_{50}, T_{70} and T_{90}, respectively, in triplicates.

Commercial floating pellet feed, previously described by Moniruzzaman et al (2015), was used in the experimental period (Table 1). Feed was applied at the rate of 5% of body weight at the beginning of the experiment. Then it was reduced to 4% after one month and it was further reduced to 3% after 2nd month and thence to end of the experiment. Fish were fed twice a day at 8:00 hr and 18:00 hr with each daily ration divided into two equal halves. Feeding was done by manually to ensure ingestion of feed completely by the fish. Fortnightly, around 20% of fish in each treatment was sampled to obtain weight (TANITA digital kitchen scale, model KD-160, Japan; ± 1g) of fish and the feed amount was adjusted accordingly.

Table 1
Proximate composition of the experimental diet (% dry matter) for Thai silver barb

Component	*Composition (%)*
Moisture	9.43
Crude protein	28.76
Crude lipid	5.95
Crude fiber	6.47
Crude ash	14.23
NFE[1]	35.16
Diet size (mm)	1.8-2.2

[1]NFE = Nitrogen free extract [100% − (protein + lipid + ash + fiber + moisture)], a measure of soluble carbohydrates.

Water quality parameters*.* Water quality parameters were measured between 7:00 h and 8:00 h on each sampling day. Water quality parameters inside each cage like water temperature (Celsius glass thermometer), dissolved oxygen - DO (DO-5509; Lutron Electronic Enterprise Co. Ltd., Taipei, Taiwan), and pH (model-HI 98107 pHep® HANNA Instruments, Carrollton, TX, USA) were monitored on weekly basis. Free carbon dioxide (CO_2), total hardness, total alkalinity and ammonia (NH_3) were measured fortnightly following APHA (1992) and using chemical kits (HACH kit box, model FF-2, No. 243001; Loveland, CO, USA).

Management of cages*.* The cages were lifted from water at every 15 days interval to check the net and cleaning purpose. Cages were cleaned regularly to remove algae, sponges and other organisms. Dead fish were removed from cages immediately and disposed off in a pit. Ancillary works like mending of torn nets and replacement of sinkers and anchors were also performed for proper management of cages.

Fish harvesting and growth parameters*.* All fish were harvested at the end of 120 days of rearing period. Fish sampling was conducted in the morning between 8:00 and 9:00 hr using scoop net. At final harvest, all fish were weighed, measured and the survival rate and mean weight were determined. To determine the growth response of fish, the following parameters were calculated:

- weight gain (WG) = final fish weight (g) – initial fish weight (g);
- weight gain (%) = (final weight - initial weight) × 100 / initial weight;
- average daily weight gain (ADWG) = (final fish weight – initial fish weight)/days;
- feed conversation ratio (FCR) = weight of feed given (g) / fish weight gain (g);
- specific growth rate (SGR %) = 100 × (ln final wt. - ln initial wt.) / days;
- survival rate (SR%) = 100 × (number of fish survived / number of fish stocked).

Statistical analysis*.* All data were analyzed by one-way ANOVA test using SAS software version 9.1 (SAS Institute Inc., Cary, NC, USA). A least significant difference (LSD) test was used to compare means amongst treatments with significant effects. Treatment effects were considered with the significant level at $p < 0.05$. Regression line analyses were performed to find out relationship between stocking density with WG and fish production.

Results and Discussion

Water quality parameters*.* A summary of mean values (mean ± SD) and ranges of water quality parameters measured in the cages during the experimental period are presented in Table 2. Water quality parameters were within the suitable and safe ranges for Thai silver barb production throughout the experimental period. In the present study, water temperature ranged from 25.1°C to 30.5°C inside all experimental cages. Boyd (1982) reported that the range of water temperature from 26.06 to 31.97°C is suitable for tropical fish culture. Optimal fish growth occurs when oxygen levels are maintained above 5 ppm for warm water fish species. The concentration of DO in the experimental site ranged from 5.8 to 7.2 mg L^{-1}, which was similar to Rahman et al (2014). In this study, DO concentration was suitable for fishes throughout the study period. The value of free CO_2 ranged from 1.9 to 3.9 mg L^{-1} which supports the results of Rahman et al (2014). pH range from 6.4 to 8.3 is favorable for fish growth (Robert 1940). In the present study, pH was recorded 6.3 to 7.3 during the study period which was similar to Rahman et al (2014). The alkalinity denotes the concentration of calcium or magnesium carbonate or bicarbonate in water. On the other hand, hardness means the sum of all alkaline metal ions present in water. Both of them have significant role for maintaining pH and productivity of water body. In this experiment, the value of total hardness and total alkalinity ranged from 36.5 to 55.2 mg L^{-1} and 40.7 to 57.4 mg L^{-1}, respectively. These findings were near to Rahman et al (2014), ARG (1986) and Chowdhury & Mazumder (1981). All the water quality parameters were within the acceptable ranges as recommended for tropical aquaculture (Beveridge 1996; Boyd 1982).

Table 2

Mean values (±SD) and ranges (parentheses) of water quality parameters observed in different stocking densities in cage culture system in Kaptai Lake for 120 days

Parameters	*Stocking densities (fish/m³)*			
	T_{30}	T_{50}	T_{70}	T_{90}
Water temperature (°C)	28.3±1.4 (25.1-30.5)	28.8±1.2 (25.4-30.2)	29.3±1.4 (25.8-30.7)	30.4±1.6 (25.6-30.5)
DO (mg L^{-1})	6.9±0.2 (6.8-7.2)	6.6±0.4 (6.2-6.8)	6.8±0.3 (6.4-7.0)	6.3±0.6 (5.8-6.7)
Free CO_2 (mg L^{-1})	2.8±0.6 (1.9-3.2)	3.4±0.5 (2.6-3.7)	3.1±0.7 (2.6-3.4)	3.6±0.9 (2.8-3.9)
pH	7.3±1.2 (6.7-7.8)	6.9±0.5 (6.4-7.1)	6.8±0.5 (6.6-7.2)	6.5±0.5 (6.3-6.8)
Total hardness (mg L^{-1})	41.4±1.9 (36.5-53.2)	42.3±1.3 (39.5-55.2)	44.4±1.6 (40.5-51.2)	43.5±1.9 (38.4-48.7)
Total alkalinity (mg L^{-1})	52.4±5.2 (43.3-57.4)	51.9±4.6 (42.1-56.2)	51.3±5.5 (41.8-58.3)	48.7±5.8 (40.7-55.1)

Growth and yield parameters. The growth and production performance of Thai silver barb in four different stocking treatments are presented in Table 3. This table showed the summary of the initial and final mean weight (g) ±SD of fish, weight gain (g), percent weight gain (%), average daily weight gain (g), specific growth rate (SGR, %/day), feed conversion ratio (FCR), survival rates (%), gross and net production of Thai silver barb. After 120 days culture, the results showed that the growth parameters were significantly affected by fish stocking densities ($p < 0.05$). In the present study, fish stocked with T_{30} had the significantly higher WG than those of fish stocked with T_{50}, T_{70} and T_{90}. The highest final mean weight was recorded to be 91.33 g in T_{30} followed by 83.67, 74.67 and 66.33 g in T_{50}, T_{70} and T_{90}, respectively. Moreover, we observed an increasing trend of WG at T_{30} in relation to other treatment groups during 120 days of cage culture period (Figure 1). Consequently, percent WG also decreases from lower stocking density to higher stocking density. The reason behind this might be due to lower density stocked of fishes got more spaces and there was less competition for feeds compared to higher density treatments (Rahman & Verdegem 2010). Osofero et al (2009) found that the average final weight of individual tilapia (*Oreochromis niloticus*) ranged from 84.02, 82.74, 93.65 and 111.66 g at 50, 100, 150 and 150 fish m^{-3}, respectively, after 90 days culture in bamboo net cages. In another study, Gibtan et al (2008) suggested 219.71, 197.48, 169.20 and 147.76 g at same stocking densities with same species in a 150 day long experiment. However, in our study WG of Thai silver barb after 120 days culture was less than tilapia in cages (Table 3). Moniruzzaman & Mollah (2010) reported that WG of Thai sharpunti or silver barb in earthen ponds after 120 days culture ranged between 36.24 and 65.85 g, which was less than the present study. Mollah et al (2011) also reported that average weight of Thai sharpunti or silver barb in earthen ponds ranged between 41.09 and 55.88 g after 120 days culture, which was much lower than the present study. In this constancy, cage aquaculture of Thai silver barb might be more potential than earthen pond culture, possibly due to use floating feed and greater chance for feeding. In the present study, we tried to make relationship between WG and stocking density by regression line analysis. The linear regression line analysis revealed that there was a clear inverse relationship between WG with four different stocking densities (Figure 2) which strongly endorsed our findings. The figure showed highest WG at T_{30}; afterwards, WG of fish decreases as the stocking density increases which culminated in lowest WG at T_{90}. Similar trend was also reported by Hengsawat et al (1997) in African catfish (*Clarias gariepinus*)

Table 3

Growth performance and yield of Thai silver barb in different stocking densities in cage culture system in Kaptai Lake for 120 days

Parameters	*Stocking densities (fish m^{-3})*			
	T_{30}	T_{50}	T_{70}	T_{90}
Mean initial weight (g)	14.68 ± 0.65^a	14.83 ± 0.36^a	15.06 ± 0.47^a	14.96 ± 0.53^a
Mean final weight (g)	91.33 ± 1.40^a	83.67 ± 1.53^b	74.67 ± 1.41^c	66.33 ± 1.72^d
Weight gain (g)	76.65 ± 1.86^a	68.84 ± 1.73^b	59.61 ± 1.68^c	51.37 ± 1.92^d
Weight gain (%)	522.1 ± 6.32^a	464.2 ± 7.16^b	395.8 ± 7.55^c	343.4 ± 9.23^d
Average daily weight gain (g)	0.64	0.57	0.51	0.43
Specific growth rate (%)	1.52	1.44	1.34	1.24
Feed conversion ratio	2.77	2.85	3.06	3.28
Survival rate (%)	77.5^a	72.8^b	71.8^b	70.2^c
Gross fish production (kg/cage/120 days)	38.22^a	54.82^b	67.55^c	75.43^d
Net fish production (kg/m^3/120 days)	2.13^a	3.05^b	3.76^c	4.20^d

Values are means from triplicate groups of fish where the values in each row with different superscripts are significantly different ($p < 0.05$).

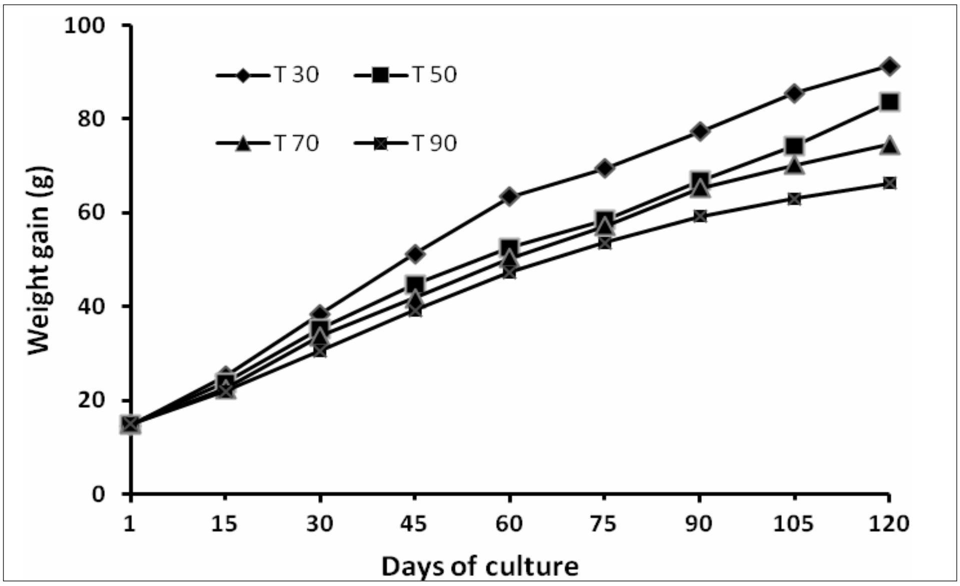

Figure 1. Mean weight gain at different stocking densities at each sampling day.

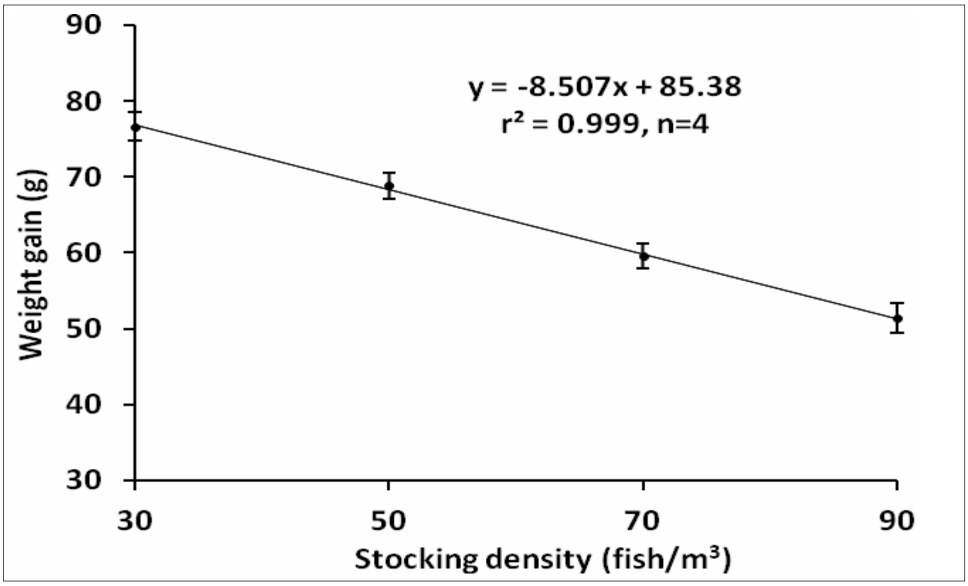

Figure 2. Relationship between weight gain and stocking density of Thai silver barb after 120 days of cage culture.

In the present study, the maximum and minimum average daily weight gain (ADWG) were found in lowest (T_{30}) and highest (T_{90}) stocking densities, respectively (Table 3). The ADWG decreased with increasing stocking densities among the treatment groups.

Likewise, SGR has negative correlation with stocking densities (Table 3). In this study, SGR ranged between 1.24 to 1.52%, the highest value 1.52% was observed in T_{30} and the lowest 1.24% was observed in T_{90}. Kohinoor et al (1999) observed the SGR value of Thai silver barb to be between 1.33 to 1.35% in polyculture with carps using low-cost feed, which were lower than T_{30} and T_{50} in the present study. Mollah et al (2011) also reported that SGR value of Thai silver barb in earthen ponds ranged between 1.47 to 1.73%, which were similar to T_{30} and T_{50} and higher than T_{70} and T_{90} in the present study.

Feed conversion ratio (FCR) was significantly affected by fish stocking densities in this experiment (Table 3). In the present study, FCR ranged between 2.77 and 3.28, the lowest value 2.77 was observed in treatment T_{30} and the highest value 3.28 was observed in treatment T_{90}. This finding was similar with that obtained by Mondal et al (2010) in caged Thai climbing perch and Gibtan et al (2008) at 50 and 100 fish m^{-3} in tilapia. However, Mondal et al (2010) observed FCR 0.79 in combined cage culture of Thai climbing perch and tilapia after 120 days culture, which was much lower than our studies. Our result showed, probably high density stocked fishes might have lower ability to convert given feed to flesh than fish stocked with low density in terms of growth (Liti et al 2005).

In this experiment, the survival rate of Thai silver barb ranged between 70.2 and 77.5% with T_{30} having the highest survival rate of 77.50% and T_{90} was lowest as 70.2%. Our results is in agreement with Liti et al (2005) and Abou et al (2007) where they found 70 and 75% survival rate in tilapia, respectively. In contrast, some researchers found high survival rate at high stocking density of caged tilapia (Gibtan et al 2008; Osofero 2009 ; Mondal 2010). Mollah et al (2011) reported that high survival rate (87 to 93%) during culture of Thai silver barb in earthen ponds. Kohinoor et al (1993) also reported similar survival rate (86 to 94%) during monoculture of Thai silver barb in ponds. The results of this study indicated an inverse relationship between survival rate and stocking density in cage culture of Thai silver barb. However, Refstie (1977) reported high mortality in low density culture of rainbow trout (*Onchorynchus mykiss*).

In the present study, there was an increasing trend of gross fish production with increasing stocking density (Table 3). The net average production in each treatment was 2.13 kg m^{-3}, 3.05 kg m^{-3}, 3.76 kg m^{-3} and 4.20 kg m^{-3} in T_{30}, T_{50}, T_{70} and T_{90}, respectively. The average production of T_{90} was significantly higher than those of other treatments (Table 3). In case of gross fish production, like WG and stocking density, we interpreted the data by best fitted logarithmic regression line analysis to show the relationship between productions at different stocking densities (Figure 3). We found that when stocking densities increases fish production also significantly increases at each treatment group ($p > 0.05$). Therefore, there was a positive correlation between productions and stocking density which is documented in this experiment. Similar trend was observed in some other important fish species (Gibtan et al 2008; Hengsawat et al 1997; Huang & Chiu 1997; Khatune-Jannat et al 2012; Rowland et al 2006).

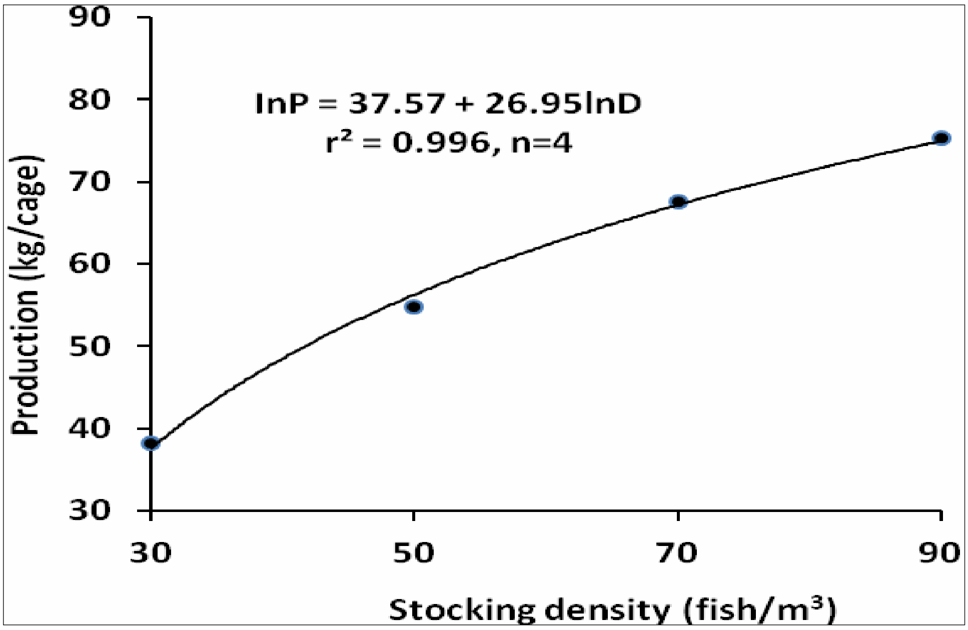

Figure 3. Relationship between production and stocking density of Thai silver barb after 120 days of cage culture.

Conclusions. The results demonstrated that on the basis of growth performance the stocking density of 30 fish m^{-3} could be recommended for the cage culture of Thai silver barb in Kaptai Lake. However, by considering production performance, 90 fish m^{-3} may also be stocked according to market demand. Further research could be conducted on different fish size to increase the survival rate and economic return from the cage culture of this important exotic fish species in Bangladesh.

Acknowledgements. This research work was funded by Fish production, Conservation and Strengthening Management at Kaptai Lake (Component - C, BFRI Part) Project (Code no. 05-4405-5470) under the Ministry of Fisheries & Livestock (MOFL) of the government of Bangladesh. The authors would like to extend their cordial appreciation to Director General (DG), Bangladesh Fisheries Research Institute (BFRI) for overall co-ordination of the project.

References

Abou Y., Fiogbe E. D., Micha J. C., 2007 Effect of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed *Azolla* diet, in earthen ponds. Aquaculture Research 38:595-604.

Ahmed K. K. U., 2001 Development of pen and cage culture technology and studies of the effect of artificial stocking in the Kaptai lake. Final Report, BFRI Riverine Sub-Station-BFDC Kaptai Lake Unit, Rangamati Hill Tracts, November 2001, 42 pp.

Ahmed K. K., Shah M. S., Mazid M. A., Haldar G. C., Haque M. K. I., 1990 Effect of supplemental feeds on the growth of carps reared in cages in Kaptai lake. Bangladesh Journal of Fisheries Research 13:23-32.

Alamgir M., Ahmed S. U., 2008 Sustainable management techniques of Kaptai lake fisheries. Bangladesh Fisheries Research Institute (BFRI), Mymensingh, 71 pp.
APHA (American Public Health Association), 1992 Standards Methods for the Examination of the Water and Wastewater. APHA, Washington DC, USA, 874 pp.
ARG (Aquatic Research Group-University of Chittagong, Bangladesh), 1986 Hydrobiology of the Kaptai reservoir. FAO, Rome, Italy. FAO/UNDP Final Report. DP/BGD/79/015-4/FI, 192 pp.
Balcazar J. L., Aguirre A., Gomez G., Paredes W., 2006 Culture of hybrid red tilapia (*Oreochromis mossambicus* × *Oreochromis niloticus*) in marine cages: effects of stocking density on survival and growth. Proceeding of the 6th International Symposium on Tilapia in Aquaculture, September 12-13, Manila, Philippine, pp. 479-483.
Beveridge M., 1983 Current status and potential of aquaculture in Bolivia. ODA Report, Institute of Aquaculture, University of Stirling, Stirling, UK, 65 pp.
Beveridge M. C. M., 1996 Cage aquaculture. Second edition. Fishing News Book, Oxford, 346 pp.
Boyd C.E., 1982 Water quality management for pond fish culture. Elsevier, Amsterdam, Netherlands, 318 pp.
Chowdhury S. H., Mazumder A., 1981 Limnology of Lake Kaptai I: physico-chemical features. Bangladesh Journal of Zoology 9:59-72.
Costa C., Menesatti P., Rambaldi E., Argenti L., Bianchini M. L., 2013 Preliminary evidence of colour differences in European sea bass reared under organic protocols. Aquaculture Engineering 57:82-88.
Cruz E. M., Ridha M., 1991 Production of tilapia *Oreochromis spirulus* Gunther stocked at different densities in sea cages. Aquaculture 99:95-103.
DoF (Department of Fisheries), 2013 [National Fish week compendium, 2013]. Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, 144 pp. [in Bengali]
Eng C. T., Tech E., 2002 Introduction and history of cage culture. In: Diseases and disorders of finfish in cage culture. Woo P. T. K., Bruno D. W., Lim L. H. S. (eds), CAB International, pp. 1-39.
Fernando C. H., 1980 The fishery potential of man-made lakes in southeast Asia and some strategies for its optimization. In: BIOTROP anniversary publication, Bogor, Indonesia, pp. 25-38.
Gibtan A., Getahun A., Mengistu S., 2008 Effect of stocking density on the growth performance and yield of Nile tilapia (*Oreochromis niloticus*) in a cage culture system in Lake Kuriftu, Ethiopia. Aquaculture Research 39:1450-1460.
Gupta M. V., Rab M. A., 1994 Adoption and economics of silver barb (*Puntius gonionotus*) culture in seasonal waters in Bangladesh. ICLARM technical paper no. 41. International Centre for Living Aquatic Resources Management (ICLARM), Manila, Philippines, 39 pp.
Halder G. C., Mazid M. A., Haque K. I., Huda S., Ahmed K. K., 1991 A review of the fishing fauna of Kaptai reservoir. Bangladesh Journal of Fisheries 14:127-135.
Hengsawat K., Ward F. J., Jaruratjamorn P., 1997 The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages. Aquaculture 152:67-76.
Huang W. B., Chiu T. S., 1997 Effects of stocking density on survival, growth, size variation, and production of Tilapia fry. Aquaculture Research 28:165-173.
Hussain M. G., Islam M. S., Hossain M. A., Wahid M. I., Kohinoor A. H. M., Dey M. M., Mazid M. A., 2002 Stock improvement of silver barb (*Barbodes gonionotus* Bleeker) through several generations of genetic selection. Aquaculture 204:469-480.
Khatune-Jannat M., Rahman M. M., Bashar M. A., Hasan M. N., Ahamed F., Hossain M. Y., 2012 Effects of stocking density on survival, growth and production of Thai climbing perch (*Anabas testudineus*) under fed ponds. Sains Malaysiana 41:1205–1210.
Kohinoor A. H. M., Akhteruzzaman M., Shah M. S., 1993 Production of *Puntius gonionotus* (Bleeker) in ponds. Bangladesh Journal of Zoology 21:77-83.

Kohinoor A. H. M., Islam M. S., Begum N., Hossain M. G., 1999 Production of Thai Sharpunti (*Puntius gonionotus* Bleeker) in polyculture with carps using low-cost feed. Bangladesh Journal of Fisheries Research 3:157-164.
Liti D. M., Fulanda B., Munguti J. M., Straif M., Waidbacher H., Winkler G., 2005 Effect of open-pond density and caged biomass of Nile Tilapia (*Oreochromis niloticus*, L.) on growth, feed utilization, economic returns and water quality in fertilized ponds. Aquaculture Research 36:1535-1543.
McGinty A. S., 1991 Tilapia production in cages: effects of cage size and number of non-caged fish. Progressive Fish Culturist 53:246-249.
Mills B. J., McCloud P. I., 1983 Effects of stocking and feeding rates on experimental pond production of the crayfish *Cherax destructor* Clark (Decapoda: Parastacidae). Aquaculture 34:51-72.
Mollah M. F. A., Moniruzzaman M., Rahman M. M., 2011 Effects of stocking density on growth and survival of Thai Sharpunti (*Barbonymus gonionotus*) in earthen ponds. Journal of the Bangladesh Agricultural University 9:327-338.
Mondal M. N., Shahin J., Wahab M. A., Asaduzzaman M., Yang Y., 2010 Comparison between cage and pond production of Thai climbing perch (*Anabas testudineus*) and tilapia (*Oreochromis niloticus*) under three management systems. Journal of the Bangladesh Agricultural University 8:313-322.
Moniruzzaman M., Mollah M. F. A., 2010 Effects of rice bran on growth and survival of Thai sharpunti (*Barbonymus gonionotus*) in earthen ponds. Journal of the Bangladesh Agricultural University 8:161-171.
Moniruzzaman M., Uddin K. B., Basak S., Mahmud Y., Zaher M., Bai S. C., 2015 Effects of stocking density on growth, body composition, yield and economic returns of monosex tilapia (*Oreochromis niloticus* L.) under cage culture system in Kaptai Lake of Bangladesh. Journal of Aquaculture Research and Development 6:357-363.
Osofero S. A., Otubusin S. O., Daramola J. A., 2009 Effect of stocking density on tilapia (*Oreochromis niloticus* Linnaeus 1757) growth and survival in bamboo-net cages trial. African Journal of Biotechnology 8:1322-1325.
Rahman M. M., Verdegem M. C. J., 2010 Effects of intra- and interspecific competition on diet, growth and behaviour of *Labeo calbasu* (Hamilton) and *Cirrhinus cirrhosus* (Bloch). Applied Animal Behaviour Science 128:103-108.
Rahman M. A., Hossain M. K., Azad M. A. K., Kamruzaman M., Rashid H. A., Rahman M. M., Hasan K. M. M., 2006 Culture potential of Thai sharpunti, *Barbonymus gonionotus* (Bleeker) with major carps in seasonal ponds. Pakistan Journal of Biological Science 9(10):1891-1897.
Rahman M. M., Bashar M. A, Farhana Z., Hossain M. Y., 2014 Temporal variation of physicochemical parameters in Kaptai lake, Bangladesh. World Journal of Fish and Marine Sciences 6:475-478.
Refstie T., 1977 Effects of density on growth and survival of rainbow trout. Aquaculture 11:329-334.
Robert C. S., Grindley, William E. E., 1940 Chemical methods for the study of river pollution. London, H.M.S.O. Fish Invest Serv1.4 (2).
Rowland S. J., Mifsud C., Nixon M., Boyd P., 2006 Effects of stocking density on the performance of the Australian freshwater silver perch (*Bidyanus bidyanus*). Aquaculture 253:301-308.
Tantong H., Thawornnan W., Khatong J., 1980 Induced spawning and culture of *Puntius gonionotus*, Bleeker. The Third Inland Aquaculture Training Course, National Inland Fisheries Inst, Bangkok, Thailand, 4 pp.

Received: 25 October 2015. Accepted: 08 December 2015. Published online: 19 December 2015.
Authors:
Mohammad Moniruzzaman, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh. Present address: Department of Marine Bio-Materials and Aquaculture, Feeds & Foods Nutrition Research Center (FFNRC), Pukyong National University, Busan, 608-737, Republic of Korea, e-mail: mzaman_bfri@yahoo.com
Kazi Belal Uddin, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh, e-mail: belal_bau@yahoo.com
Sanjib Basak, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh, e-mail: sanjibbasak25@yahoo.com
Abul Bashar, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh, e-mail: mabashar.bfri@gmail.com
Yahia Mahmud, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh, e-mail: yahiamahmud@yahoo.com
Muhammad Zaher, Riverine Sub-Station (Lake Fisheries), Bangladesh Fisheries Research Institute (BFRI), Rangamati-4500, Rangamati Hill District, Bangladesh, e-mail: zaherbfri@yahoo.com
Seunghan Lee, Department of Marine Bio-Materials and Aquaculture, Feeds & Foods Nutrition Research Center (FFNRC), Pukyong National University, Busan, 608-737, Republic of Korea, e-mail: shlee5863@naver.com
Sungchul C. Bai, Department of Marine Bio-Materials and Aquaculture, Feeds & Foods Nutrition Research Center (FFNRC), Pukyong National University, Busan, 608-737, Republic of Korea, e-mail: scbai@pknu.ac.kr

How to cite this article:
Moniruzzaman M., Uddin K. B., Basak S., Bashar A., Mahmud Y., Zaher M., Lee S., Bai S. C., 2015 Effects of stocking density on growth performance and yield of Thai silver barb *Barbonymus gonionotus* reared in floating net cages in Kaptai Lake, Bangladesh. AACL Bioflux 8(6):999-1008.