Nursing of Thai climbing perch, *Anabas testudineus* in Kaptai Lake cages

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Abstract. A 90-day experiment was conducted in Kaptai Lake, Bangladesh, to investigate the growth performance of Thai koi (*Anabas testudineus*) during nursing in cages. In this study, four treatments used four different stocking densities of *A. testudineus* like 80 fish m^{-3}, 120 fish m^{-3}, 160 fish m^{-3}, 200 fish m^{-3} designated as T1, T2, T3, T4, respectively, with three replicates in each treatment. The initial average total length and weight of *A. testudineus* fry were 3.52±0.44 cm and 1.28±0.41 g, respectively. Thai koi fry was randomly stocked in 12 net cages. In this study, growth in terms of final length, final weight, length gain, weight gain, specific growth rate, and survival of fishes were higher in T1 compared with those of T2, T3 and T4. The feed conversion ratio (FCR) of *A. testudineus* during nursing in cages was very high, but they show a higher survival rate than other species in cages and hapas. Based on growth performance, the results demonstrated that a stocking density of 80 fish m^{-3} was the best stocking density for *A. testudineus* nursing in Kaptai lake cages.
Key Words: growth performance, Kaptai Lake, nursing, stocking density, Thai climbing perch.

Introduction. Bangladesh is a riverine country enriched with vast fisheries resources. The total inland water body is estimated at 46.99 million hectares. Inland open waters, including rivers and estuaries, Sundarbans, beels, Kaptai Lake and floodplains, comprise about 39.06 lakh hectares, and closed waters, including ponds, seasonal water bodies, baors and shrimp farms comprise about 7.94 lakh hectares (DOF 2016). Among the inland open water bodies, Kaptai Lake, with an area of 68,800 hectares, plays a significant role in our country's annual fish production. The current yearly production of Kaptai Lake is 8,645 MT, which is 0.23% of Bangladesh's total annual fish production (DoF 2016). The production of commercially important fish species rui (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus cirrhosus*), and kalibaush (*Labeo calbasu*) has declined drastically year after year (Alamgir & Ahammed 2008). The current annual fish production in Bangladesh is lower than that of the human population needs (DoF 2016). So, it is essential to take the necessary steps to increase fish production from all available inland water bodies to fulfill the people's protein requirement.

Cage culture is the most appropriate technology to increase fish production by utilizing the vast open water bodies of Kaptai Lake. Widespread and profitable fish culture in cages has developed successfully in Asia, Europe, and America (Bardach et al 1972; Beveridge 1987). But in Bangladesh, unutilized vast inland open water body of Kaptai Lake could offer tremendous scope for increasing fish production through cage aquaculture, which will increase fish production, animal protein intake and income generation of the poor people beside Lake. Adaptation of cage culture in Kaptai Lake by introducing different fish species may be an appropriate option for increasing fish production in this area. It's an excellent opportunity to increase aquaculture production by using Kaptai Lake's available unutilized water resources.

Thai koi or the climbing perch (*Anabas testudineus*) is a freshwater fish species that can play a significant role to meet the protein requirement of large numbers of populations in our country. In 2002, it was introduced into Bangladesh from Thailand (Hasan et al 2010). Due to the high growth rate and bigger size of Thai koi, the farmers

are highly interested in its artificial breeding and culture in Bangladesh. It is also becoming a highly demanded fish in our country due to its high nutritional value, taste, and faster growth (Alam 2006). Thai koi showed that its culture could be highly profitable (Rahman & Kohinoor 2007). Hasan et al (2010) investigated Thai koi production in nylon hapas in Bangladesh. Mondal et al (2010) compared the aquaculture of Thai koi between cage and pond under three management systems in Bangladesh. Phuong et al (2006) studied integrated cage-cum-pond culture systems with climbing perch in cages suspended in Nile tilapia (*Oreochromis niloticus*) ponds in Vietnam. However, no study has been done to investigate the growth performance and survival rate of Thai koi during nursing in cages of Kaptai Lake. Such information is necessary for maximum resource utilization and practical and economically viable production technology for Thai koi in Kaptai Lake cages. Considering the above facts, the present study was undertaken to know the effects of different stocking densities on growth performance and survival rate of Thai climbing perch during nursing in Kaptai Lake cages.

Material and Method. To investigate the performance of Thai Koi during nursing in cages of Kaptai Lake (22°29'45''N, 92°13'45''E), the experiment was conducted from 5 March, 2016 to 3 May, 2016 at Baitush-sharp, Rangamati Sadar, near the Riverine Sub-Station of Bangladesh Fisheries Research Institute. Twelve net cages were installed in the experimental site (Figure 1), and all of the cages were the same size and same design. Sizes of the net cages were 3m × 3m × 2m, each made of a knot-less plastic net (mesh size 1.1 cm). Frames of the cages were made by straight and rigid bamboo poles and were floated using 250 liters size plastic drums. Each net cage was covered at the top with another piece of large mesh size (4.5 cm) net to prevent the escape of fish by jumping and predation of birds. The whole structure was fixed with a bamboo raft and tied with anchors at both sides by nylon rope to facilitate the easy floating of cages depending on the water level.

Figure 1. Experimental cages with *Anabas testudineus* in Kaptai Lake.

In this study, there were four treatments using four different stocking densities of *A. testudineus* like 80 fish m^{-3}, 120 fish m^{-3}, 160 fish m^{-3}, 200 fish m^{-3} designated as T1, T2, T3, and T4, respectively, with three replicates in each treatment. Hatchery-produced *A. testudineus* fry was collected from a local hatchery and kept in net hapas for 24 hours to conditioning the lake environment. Before stocking, the initial total length and weight of the fish were recorded individually in 'cm' and 'g' respectively by using measuring scale and sensitive balance (TANITA digital scale, model KD-160, Japan; ± 0.1 g). The initial average total length and weight of *A. testudineus* fry were 3.52±0.44 cm and 1.28±0.41 g, respectively.

Fish were fed twice daily with ACI-godrej commercial nursery powder feed. The feeding rate was 15% of the estimated body weight of fry for the first 15 days, 13% for the second 15 days, 11% for the third 15 days and 10% for the last 15 days. The proximate composition of the nursery feed used in the experiment was analyzed following the Association of Official Analytical Chemists (AOAC 1980) in the Nutrition Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The proximate composition of the feed is shown in Table 1.

Table 1

Proximate composition of the ACI-godrej nursery feed

Feed name	*Moisture (%)*	*Protein (%)*	*Lipid (%)*	*Crude fiber (%)*	*Ash (%)*	*Carbohydrate (%)*
ACI-godrej nursery feed	13.83	32.55	5.32	4.20	16.08	28.02

The water quality measurements were made between 7.00 am and 8.00 am on each sampling day. Water quality parameters like air and water temperature (Celsius thermometer), dissolved oxygen (DO) (Lutron digital DO, model 5509, China), and pH (HANNA pocket pH, model HI98107, Italy) were monitored weekly. The free carbon dioxide, total hardness, total alkalinity and ammonia were measured fortnightly following APHA (1992) and using a HACH water analysis kit (Model FF-1A, USA).

Fish sampling was carried out in the morning between 7:00 am and 9:00 am using a scoop net. Around 10% of fish in each treatment were sampled fortnightly (twice in a month) to determine the weight (TANITA digital scale, model KD-160, Japan; ± 0.1 g) and total lengths (measuring scale; ±1.0 mm). After 60 days, at the final harvest, all fish were weighed, measured and the survival rate and mean weight were determined. To determine the growth response of the fish, the following parameters were calculated as described by Olvera-Novoa et al (1990):

Weight gain: this was determined at the end of each 15 days as final weight – initial weight

Specific growth rate (SGR) = [(ln final weight (g) – ln initial weight (g) / time between weighing (days)] x 100

Feed conversion ratio (FCR) = feed fed [dry weight] g / weight gain [fresh weight] g

Survival rate (%) = (number of fish that survived / total number of fish stocked) x 100

After the completion of the experiment, collected data on different parameters were analyzed, and growth (length and weight) trends of fishes at 15 days intervals were presented in line graph forms using Microsoft Excel 2010 software program. The standard deviation of each parameter and treatment was determined and expressed as mean ± SD. The mean values for growth, survival and FCR of different treatments were subjected to one-way ANOVA followed by Fisher's least significant difference (LSD) post-hoc test. All statistical analyses were performed using IBM SPSS software (SPSS Inc., version 23.0, Chicago, IL, USA). Treatment effects were considered with the significant level at $p > 0.05$.

Results and Discussion. Mean values (mean±SD) and ranges of water quality parameters measured in the cages over the 60 days of the nursing of *A. testudineus* are presented in Table 2.

Table 2
Mean values and ranges (parentheses) of water quality parameters of experimental cages during the nursing period

Serial No.	*Parameters*	*Values (mean±SD)*
1.	Air temperature (°C)	28.20±2.49 (26-32)
2.	Water temperature (°C)	27.20±2.68 (23-30)
3.	Dissolved oxygen (mg L^{-1})	5.86±1.12 (5.1-7.8)
4.	Free CO_2 (mg L^{-1})	2.67±0.58 (1.95-3.38)
5.	pH	7.40±0.65 (6.5-8)
6.	Total hardness (mg L^{-1})	44.46±9.37 (34.2-51.3)
7.	Total alkalinity (mg L^{-1})	41.04±9.37 (34.2-51.3)
8.	Ammonia (NH_3) (mg L^{-1})	Nil

In this experiment, during the study period, air and water temperature ranged from 26 to 32°C and from 23 to 30°C, respectively. The range of temperature in the experimental cages was within the acceptable ranges for fish culture, and these results agree with the findings of Uddin et al (2015), Uddin et al (2016), Bashar et al (2015a), Bashar et al (2015b), Moniruzzaman et al (2015a), and Moniruzzaman et al (2015b). Boyd (1982) has also reported that the range of water temperature from 26.06 to 31.97°C is suitable for fish culture.

Oxygen is the most important stress factor that directly impacts the health and survival of caged fishes (Masser 1997). For optimal fish growth, DO levels should be above 5 ppm for warm water fish species (Boyd 1982). The concentration of DO in the experimental site ranged from 5.1 to 7.8 mg L^{-1}, which is within the acceptable ranges for fish culture and coincide with the findings of Uddin et al (2015), Bashar et al (2015a), Bashar et al (2015b), and Alamgir (2004). However, fish might survive in 0.50 mg L^{-1} DO concentration, but the most suitable range of DO for fish culture was suggested from 5.0 to 8.0 mg L^{-1} (DoF 1996).

The value of free CO_2 ranged from 1.95 to 3.38 mg L^{-1}. pH plays a significant role in the productivity of a water body. In this present study, pH ranged from 6.5 to 8; the observed pH values were favorable for fish growth and agreed well with the findings of Alamgir (2004), Bashar et al (2015a), and Uddin et al (2015). The values of pH recorded in the present experiment are well and indicate the water body's productive nature.

The values of total hardness and total alkalinity were the same for both parameters, ranging from 34.2 to 51.3 mg L^{-1}. Natural water, which contains 40 mg L^{-1} total alkalinity, is considered hard water for biological purposes (Rahman & Marimuthu 2010). Total alkalinity levels in the present study indicate productivity of the lake was medium (Bhuiyan 1970; Alamgir 2004). In this present study, the concentration of total ammonia (NH_3) was nil.

Growth and yield parameters. The details of the growth and production performance of *A. testudineus* during nursing in cages under four different treatments are summarized in Table 3. This table shows the initial and final mean length (cm) ±SD and mean weight (g) ±SD of fish, length (cm) and weight (g) gain, specific growth rate (SGR), feed conversion ratio (FCR) and survival rate. The final results indicated that the growth rate of *A. testudineus* during nursing showed variation between the treatments based on body weight at harvest.

Table 3

Growth performance, feed utilization and survival rate of Thai koi (*A. testudineus*) in different treatments after 60 days nursing in cages

Parameters	*Treatments*			
	T1	*T2*	*T3*	*T4*
Initial length (cm)	3.52±0.44[a]	3.52±0.44[a]	3.52±0.44[a]	3.52±0.44[a]
Final length (cm)	6.24±0.24[a]	6.11±0.15[a]	5.83±0.17[b]	5.75±0.20[b]
Initial weight (g)	1.28±0.41[a]	1.28±0.41[a]	1.28±0.41[a]	1.28±0.41[a]
Final weight (g)	5.17±0.57[a]	5.00±0.41[a]	4.17±0.32[b]	4.12±0.42[b]
Weight gain (cm)	3.87±0.02[a]	3.72±0.02[b]	2.89±0.02[c]	2.82±0.02[d]
Length gain (cm)	2.72±0.02[a]	2.59±0.02[b]	2.31±0.02[c]	2.23±0.02[d]
Specific growth rate (% day^{-1})	2.30±0.02[a]	2.27±0.02[a]	1.87±0.15[b]	1.75±0.03[b]
Feed conversion ratio	2.81±0.02[a]	2.94±0.02[b]	3.08±0.03[c]	3.19±0.03[d]
Survival rate (%)	97.67±0.58[a]	95.67±1.53[ab]	93.33±1.53[b]	92.33±1.53[b]

Values in each row having the same superscripts are not significantly different ($p > 0.05$).

Growth (length and weight) trends of fish at 15 days intervals are shown in Figure 2 and Figure 3. The initial length and weight of fry released in all of the experimental cages were the same. Growth in terms of final length, final weight, length gain, weight gain, SGR and survival rate decreased while FCR increased with increasing fish density in cages. In this study, growth in terms of final length, final weight, length gain, weight gain, specific growth rate and survival of fish was higher in T1 compared with those of T2, T3 and T4 although the same food was applied at an equal ratio in all the treatments. The results of the present study coincide with the findings of Mollah & Hossain (1998), Hasan et al (2010), Rahman & Marimuthu (2010), Rahman & Monir (2013), and Uddin et al (2016) during fry/fingerlings rearing of climbing perch in experimental cages, nylon hapas and ponds.

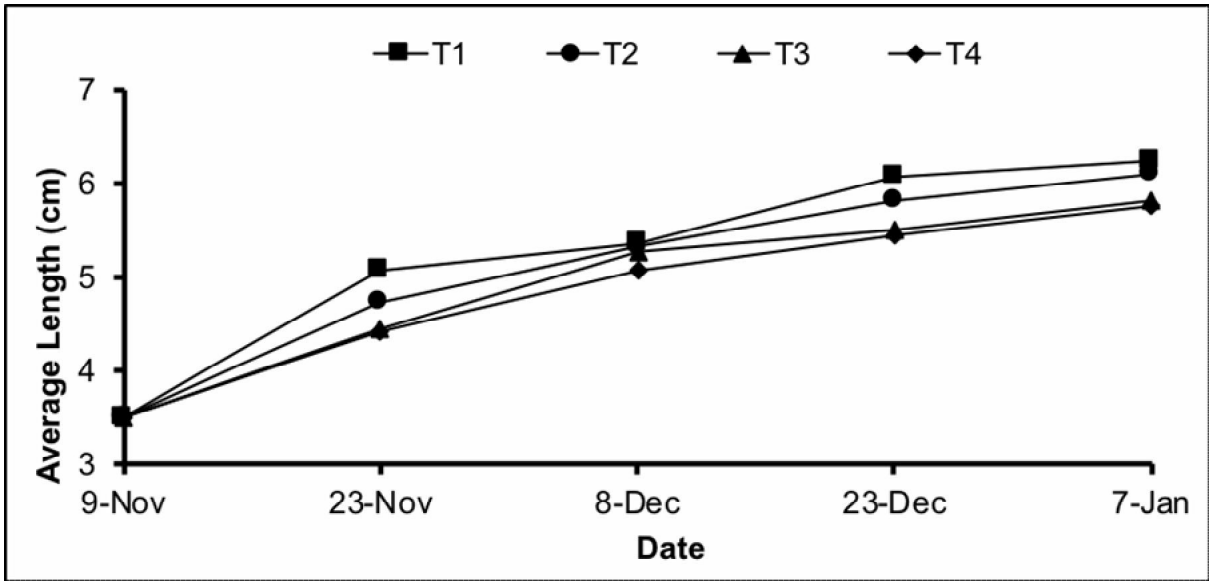

Figure 2. Changes in the average individual length of Thai koi (*A. testudineus*) fingerlings at different stocking densities over the nursing period of 60 days.

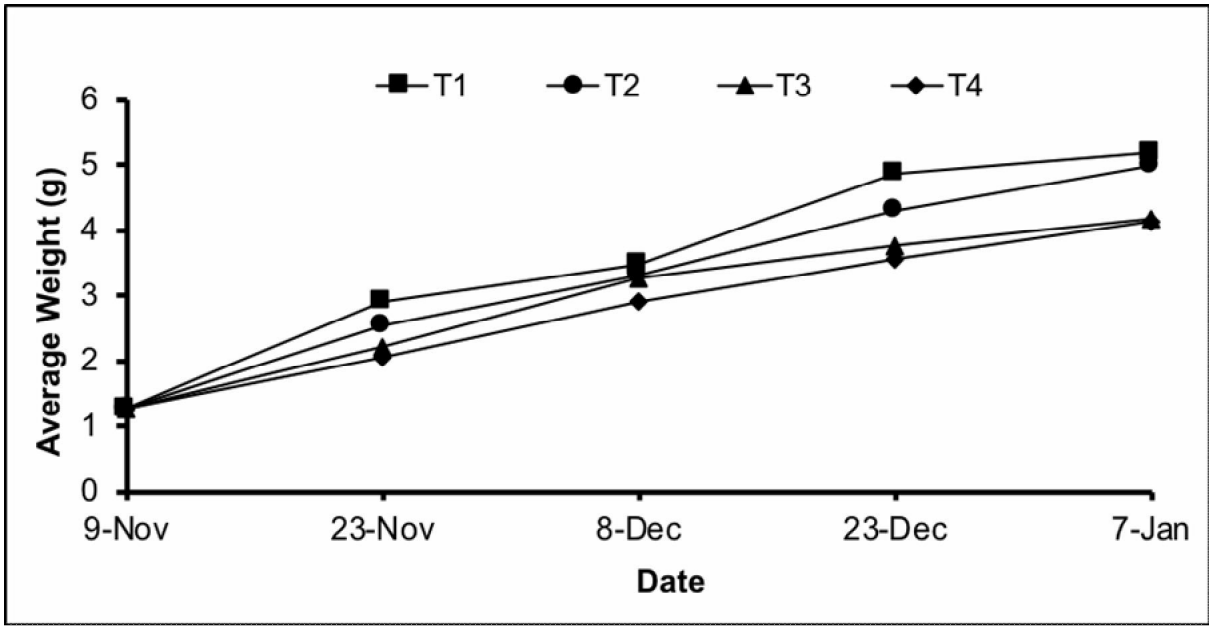

Figure 3. Changes in the average individual weight of Thai koi (*A. testudineus*) fingerlings at different stocking densities over the nursing period of 60 days.

In the present study, the highest individual final weight of fishes was 5.17±0.57 in T1 after 60 days of nursing in cages. Hasan et al (2010) reported that the weight gain of Thai climbing perch reared in nylon hapas in a pond has ranged from 32.60 to 37.20 g after 90 days. The result of the present study was lower than those of the above-mentioned experiment. Jiwyam (2012) has also reported that the final weight of Nile tilapia ranged from 2.8 to 5.2 g after 56 days of nursing in cages in a nutrient-enriched pond. This finding was lower than the present study. The present experiment's result was much lower than the result of Khatune-Jannat et al (2012), who observed that the average individual harvesting weight of Thai climbing perch was 84 to 90 g after three months of culture in ponds. Noor (2005), in her thesis, also reported that Thai koi obtained length 14.66 cm and weight 57.22 g for 50 days experimental period with supplemental feeding. Moniruzzaman et al (2015a) recorded the final mean weight of monosex Nile tilapia has ranged from 157.73 to 271.89 g during 120 days of cage culture in Kaptai Lake. Moniruzzaman et al (2015b) also reported that the final mean weight of Thai silver barb (*Barbonymus gonionotus*) has ranged from 66.33 to 91.33 g during 120 days of cage culture in Kaptai Lake. In this present experiment, the overall growth performance of Thai koi during nursing was lower than Moniruzzaman et al (2015a) and Moniruzzaman et al (2015b). Uddin et al (2016) found that the average individual weight of *A. testudineus* was 31 to 40 g after 90 days of culture in cages of Kaptai Lake. From the present experiment, it was observed that the growth of *A. testudineus* during nursing in cages was not satisfactory compared to the previous study. The reasons behind this less production might be feed and environmental differences and restricted movement of fish in net cages.

In the present study specific growth rate (SGR) ranged between 1.75 to 2.30% day^{-1}, the highest value of 2.30% day^{-1} was observed in T1, and the lowest 1.75% day^{-1} was observed in T4. Hasan et al (2010) mentioned that the SGR value of *A. testudineus* reared in nylon hapas ranged between 3.69 and 3.82% day^{-1}, which was higher than the present study. Uddin et al (2016) found that the SGR value of *A. testudineus* ranged between 2.24 and 2.52% day^{-1} when cultured in cages of Kaptai Lake, which is also higher than the present study. SGR values of 6.71 to 7.87% day^{-1} were obtained by Jiwyam (2012) during 56 days nursing of Nile tilapia in cages in a nutrient-enriched pond. It might be due to the differences in the source of feed. On the other hand, Moniruzzaman et al (2015b) found that the SGR of Thai silver barb ranged between 1.24 and 1.52% day^{-1} when cultured in net cages of Kaptai Lake, which is lower than the present experiment.

The FCR ranged from 2.81 to 3.19, the lowest value, 2.81, was observed in T1, and the highest value, 3.19, was observed in T4. Uddin et al (2016) reported the FCR of *A. testudineus* ranged from 2.65 to 2.93 when cultured in cages of Kaptai Lake. Christensen (1994) reported that the FCR of tin fold barb (*Puntius schwanenfeldii*) was 2.8 when fish were fed pellet feed in floating cages. The result of the present study has a similarity with Christensen's performed experiment. Hasan et al (2010) announced that the FCR value of *A. testudineus* reared in nylon hapas ranged from 3.31 to 3.99, higher than the present study. It might be due to the use of low-quality pellet feed by Hasan et al (2010). Osofero et al (2009) found the FCR of 1.56 to 2.21 for Nile tilapia (*O. niloticus*) during 91 days of culture in cages. Moniruzzaman et al (2015a) observed FCR in caged tilapia was 1.81 to 2.05 after 120 days culture in net cages of Kaptai Lake. The FCR of *A. testudineus* (2.81 to 3.19) during nursing in cages was very much higher than tilapia culture in cages.

The survival rate of *A. testudineus* during the nursing period has ranged from 92.33 to 97.67%. The lowest value, 92.33%, was observed in T4, and the highest value, 97.67%, was observed in T1 (Table 3). In this present study, the survival rate of *A. testudineus* during nursing was higher than Noor (2005), Hasan et al (2010), Moniruzzaman et al (2015b), and Uddin et al (2016). Moniruzzaman et al (2015a) observed survival rate in caged monosex Nile tilapia was 83.1 to 96.8% after 120 days of culture in net cages of Kaptai Lake. Jiwyam (2012) found that the survival rate of Nile tilapia ranged from 83 to 96% during 56 days nursing in cages in a nutrient-enriched pond. *A. testudineus* during nursing in cages shows a higher survival rate (92.33 to 97.67) compared to other species in cages and hapas.

Conclusions. The present study shows that the growth, survival and production of Thai koi (*Anabas testudineus*) were inversely related to the stocking densities of hatchlings. In all respects, a stocking density of 80 fish m^{-3} performed better than those obtained at higher stocking densities. The FCR of Thai koi during nursing in cages was very high, but *A. testudineus* shows a higher survival rate compare to other species in cages and hapas. This research has implications of sustainable and cost-effective cage culture approaches in lake environment. However, more research on the fish stocking density, size and FCR is needed.

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Conflict of interest. The authors declare that there is no conflict of interest.

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