Asian Australas. J. Biosci. Biotechnol. 2017, 2 (3), 226-237

Asian-Australasian Journal of Bioscience and Biotechnology
ISSN 2414-1283 (Print) 2414-6293 (Online)
www.ebupress.com/journal/aajbb

Article

Growth and production performance of Vietnamese koi (*Anabas testudineus*) with Magur (*Clarias batrachus*) at different stocking densities

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Received: 07 December 2017/Accepted: 20 December 2017/ Published: 31 December 2017

Abstract: A culture experiment was conducted to see the growth and production performance of Vietnamese koi (*Anabas testudineus*) with Magur (*Clarias batrachus*) at different stocking densities in a farmer's ponds under semi-intensive rearing system for a period of 120 days. The experiment was conducted in three ponds at Rahmatpur of Muktagachha Upazila of Mymensingh district from 5 August to 5 December, 2013. The size of ponds were 24 (T_1), 24 (T_2) and 24 (T_3) decimal with an average depth of 4 feet. Three different stocking densities were tested, namely treatments T_1 (400 fish /decimal, 350 Vietnamese koi and 50 magur); T_2 (450 fish /decimal, 400 Vietnamese koi and 50 Magur) and T_3 (550 fish /decimal, 500 Vietnamese koi and 50 Magur). Ruposhi Bangla feed was used in all treatments two times daily from the beginning of the fry stocking. The initial weight of Vietnamese koi and Magur were 5±0.00 g and 2±0.00 g respectively. The initial length of Vietnamese koi and Magur were 2.54 and 3.50 cm respectively. The average highest final weight gain of Vietnamese koi was (138.71±0.03 g) observed in T_1 and followed by T_2 (135.65±0.12 g) and T_3 (129.29±0.49 g). Similarly, the average highest final weight gain of Magur (76.00±0.58 g) was observed in T_1 and followed by T_2 (68.36±0.43 g) and T_3 (62.61±0.58 g) respectively. The average highest final length gain of Vietnamese koi (17.38±0.05 cm) was observed in T_1 and followed by T_2 (17.00±0.04 cm) and T_3 (16.33±0.03 cm). Similarly, the average highest final length gain of Magur (21.30±0.09 cm) was observed in T_1 and followed by T_2 (17.00±0.05 cm) and T_3 (15.87±0.02 cm) respectively. The survival rate of the stocking Vietnamese koi and Magur were recorded 95.14 and 72.00 % in T_1; 93.25 and 64.00% in T_2; 90.80 and 68.00 % in T_3 respectively. Fish production in T_1, T_2 and T_3 were 48.93; 52.79 and 60.83 kg/decimal/120 days, respectively. The total production of T_3 was increased with the increasing of stocking density compare to T_2 and T1. The benefit-cost ratio (BCR) was higher in T_3 where BCR was 1.67 and on the other two treatments BCR was 1.53 in T_2 and 1.52 in T_1 although the highest production was obtained in T_3 but individually growth performance of Vietnamese koi and Magur were higher in T_1. Based on the result of the present experiment, farmers could be suggested to rear Vietnamese koi with Magur at the stocking density of 550 fish/decimal (500 Vietnamese koi and 50 Magur) which was the highest density tried to get more production and financial benefit. Further experiment need to be conducted by taking higher density than the 550 fish/decimal for the optimization of stocking density to get more production and benefit.

Keywords: growth; production; performance; Vietnamese koi; Magur; stocking density

1. Introduction

Bangladesh is one of the world's leading inland fish producing countries, contributing about 4.39% to GDP (Gross Domestic Product), 22.76% to agricultural production and 2.46% to export earnings (DoF, 2011-2012). The sector provides full time employment opportunities to 1.2 million people and part time employment 2.0 million people. The aquaculture and fisheries sub-sector also plays an important role in alleviation of protein deficiency. Fish is the major protein source contributing about 60% of total animal protein intake. At present, fish consumption is only 18.94 kg per capita per year, whereas the requirement is about 20.44 kg (DoF, 2011-12). Among the available exportable fish and fishery products 30.06 percent was exported to USA, 48.51 percent to European countries, 9.32 percent to Japan and the remainder to Thailand and Middle Eastern countries (Hossain, 2003). In 2011-12 Bangladesh earned Taka 47039.50 million by exporting 92,479 MT of fish and fisheries products of which shrimp alone contributed 66% of the total by quantity and 84% by value. There are about 4,699,345 hectares of inland water areas, of them 39,25,290 hectares are open water and 7,74,055 hectares closed water. In closed water, the total area of ponds and ditches are 3,71,309 hectares which is the main source of inland production (DoF, 2011- 2012). Polyculture has been practiced with the aim that different species stocked in the ponds occupy different niches with their complementary feeding habits, utilizing all the natural food available in the ponds and increasing fish production of the ponds (Wahab *et al.,* 2001). Polyculture of carps in pond is a widespread practice in Bangladesh (Matsha Pakka Sankalan, 2002), but, there is no information on polyculture practice of *Anabas testudineus* (Anabantidae) and *Clarias batrachus* (Clariidae) in Bangladesh. The local name of *A. testudineus* and *C. batrachus* is koi and Magur (IUCN, 2000). So, this polyculture technology is a completely new one in South East Asia (Chakraborty and Mirza, 2008). The perch fish is one of the important fresh water fish of Bangladesh which is locally known as koi in different places of Bangladesh. It contributes 1.4% in the total inland water fish production (DoF, 2011- 2012). The fish is very popular for its delicious taste. This species considered as a valuable item of diet for sick and convalescent. According to Saha (1971), koi fish contain high values of physiologically available iron and copper essentially needed for hemoglobin synthesis. The breeding technology of native koi had successfully been developed in freshwater Station of the Institute (Kohinoor, 1991). But the growth rate is very slow in comparison to Thai Koi. Its slow growth and small size does not favour sustainable production per unit area in a culture system (Kohinoor *et al.,* 2009). Seed production of this species through artificial propagation technique has been developed (Kohinoor *et al.,* 2006). To improve this situation another variety of koi known as Vietnamese koi had recently been introduced in our country from Vietnam by Sarnolata Agro-Fisheries Ltd., Mymensingh with the support from Innovation Consulting (pvt.) Limited and Swiss funded catalyst in 2011. Vietnamese koi have been imported from Vietnam for being higher production and growth than the other variety of koi. Initial study shown that this variety of koi looked like our native koi but with higher growth rate. It was observed that Vietnamese koi attained maximum size of 400 g within 120 days in monoculture period. Another report shown that Vietnamese koi grows as big as 250-300 g within 4 months culture period where FCR is also good, 1.7 and the body color is almost same as deshi koi (Torafdar, 2013). *Clarias batrachus* is an indigenous Walking Catfish of South-East-Asia, which is locally known as "Magur" in different parts of Bangladesh. It contributes 2.12% in the total inland water fish production (DoF, 2011- 2012). It is not only recognized for its excellent taste and market value but is also highly sought after for its nutritional and medicinal benefits. The species has high content of protein (15.0%), low fat (1.0%) and high iron content (710 mg/100 g tissue) (Saha and Guha, 1939). Due to its high nutritive value the fish is recommended in the diet of the sick and the convalescents (Singh Kohli and Goswami, 1989). Being a lean fish it is very suitable for people for whom animal fats are undesirable (Rahman *et al.*, 1982). Therefore, the objectives of present study was to evaluate the growth, survival rate and production performance of Vietnamese koi and Magur at different stocking densities in polyculture system and to evaluate the combination of Vietnamese koi and Magur in the polyculture.

2. Materials and Methods

2.1. Study area and periods

The experiment was conducted to know the "Growth and production performance of Vietnamese koi with Magur at different stocking densities in a farmer's ponds" of Rahmatpur, Muktagachha Upazila of Mymensingh district. The study was conducted for a period of four months from 5 August to 5 December, 2013.

2.2. Description of the experimental units

Three earthen ponds were selected at Muktagachha Upazila under Mymensingh district for the experimental purpose. The size of the ponds were 24 (T_1), 24 (T_2), 16 (T_3) decimal. The ponds were equal in depth, basin, configuration and pattern including water supply facilities. The water depth was maintained at a maximum of 4

feet. There were well organized inlet and outlet system to maintain water level. Water quality was maintained properly through routine exchange of water. The ponds were free from aquatic vegetation and flood. They were exposed to sunlight. Water source of the ponds were from the shallow tube-well.

2.3. Experimental design

The experiment was undertaken with 3 treatments (T_1, T_2 and T_3). T_1, T_2 and T_3 were designated with Vietnamese koi polyculture along with Magur. The combination of Vietnamese koi and Magur were 350 and 50 per decimal in T_1; 400 and 50 per decimal in T_2 and 500 and 50 per decimal in T_3.The average size of fry Vietnamese koi and Magur were stocked 5.00 g and 2.00 g respectively for the research purpose. The experimental layout is shown in Table 1.

Table 1. Experimental layout of Vietnamese koi with Magurculture system.

Treatment	Pond size (decimal)	Name of fish	Stocking size(g)	Stocking density/ decimal	Total fish stocked	Total stocking density/decimal
T_1	24	Vietnamese koi	5	350	8400	400
		Magur	2	50	1200	
T_2	24	Vietnamese koi	5	400	9600	450
		Magur	2	50	1200	
T_3	24	Vietnamese koi	5	500	8000	550
		Magur	2	50	800	

2.4. Pond preparation

Pond preparation is a pre-requisite for successful fish culture. To achieve the goal of Vietnamese koi with Magur culture in ponds, the experimental ponds were prepared precisely. The ponds were dried before stocking fry. Pond water pumped out and then the ponds were exposed to sunlight for about 2 weeks. Ponds dykes and bottom were repaired where necessary. The excessive bottom mud was removed from the pond. Liming was done at the rate of 0.5 kg/decimal. After 7 days of liming experimental ponds were filled up with water up to 4 feet with shallow water pump machine that has propelled by electricity. Here after, the research ponds were fenced by nylon net with bamboo sticks.

2.5. Collection of fry

The fry of Vietnamese koi and Magur were collected from“Sharnalata Agro-Fisheries Ltd.” at Radakanai in Fulbaria of Mymensingh district.

2.6. Selection of feed

Commercial pellet feed named “Ruposhi Bangla” was selected for the present experiment. The Proximate composition of “Ruposhi Bangla” of the feed is given in Table 2.

Table 2. Proximate composition of different types of “Ruposhi Bangla Fish Feed’’.

Constituents	Amounts (%)	
	Starter	Grower
Moisture	12.27	11.16
Protein	33.12	33.08
Lipid	11.41	12.52
Ash	15.97	15.05
Fabre	6.37	5.88
Carbohydrate	20.86	22.31

2.7. Stocking of fry

Before stocking the fry in the experimental ponds Vietnamese koi fries were reared about 45 days in a nursery pond when the fry become about average 2.54 cm in length and weight about 5 g. Magur fries were reared about 28 days when the fry become about average 3.50 cm in length and weight about 2 g. Then both were stocked in the research ponds. The initial data of fry (length and weight) were recorded before releasing into the ponds.

2.8. Feeding Strategy

At the beginning of the experiment feed was supplied at the rate of 20% of the body weight of reared Vietnam koi and gradually it was readjusted to 15% (46-59 days), 12% (60-69 days), 10% (70-79 days), 7% (80-89 days), 5% (90-99 days), 4% (100-109 days) and 3% (110-119 days). No additional feed was supplied for Magur in Vietnamese koi with Magur culture system. Fish were fed two times daily at every 8 hours intervals.

2.9. Monitoring and data collection

Growth monitoring was done at 15 days. Both fish were caught with the help of seine net (berjal). The length and weight recorded by random sampling of 10 Vietnamese koi and 4 Magur fishes from each pond. Length was recorded by using a centimeter scale and weight by using a balance.

2.10. Analysis of experimental data on growth performances

The following parameters were used to evaluate the growth, survival and production of the fishes

a) Mean weight gain was calculated as –

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

b) Mean length gain (g) = Mean final length (cm) – Mean initial length (cm)

c) Percent weight gain (g) = $\frac{\text{Mean final weight (g)} - \text{Mean initial weight (g)}}{\text{Mean initial weight (g)}} \text{ X } 100$

d) Specific growth rate (SGR %)

SGR (% day) of the fishes of each species in each treatment was calculated as –

$$\text{SGR (\% day)} = \frac{\log W_2 - \log W_1 \times 100}{T_2 - T_1}$$

Here, W_2 = The final live body weight (g) at time T_2 day

W_1 = The initial live body weight (g) at time T_1 day

T_2 = Time duration at the end of the experiment

$T_2 - T_1$ = Duration of the experiment (day).

e) Survival rate (%)

Survival (%) = $\frac{\text{Number of fish harvested}}{\text{Number of fish stocked}} X\ 100$

f) Production of fishes

Net production= No. of fish caught × average final weight (g).

2.11. Data analysis

Data obtained from the present study were analyzed statistically to observe growth performance of different fish species. Data was entered into the Excel and then simple statistics such as mean and standard Deviation (SD) of growth parameters of the fishes was find-out statistically.

3. Results

3.1. Growth rate of Vietnamese koi and Magur

The growth performances of Vietnamese koi and Magur under different stocking densities were recorded 15 days interval. Both the species growth rate is shown separately in Table 7 and Table 8. The initial weight (g) of Vietnamese koi at the stocking time was 5 g. At the end of the study average weight gain of Vietnamese koi was recorded as 133.71±0.03, 130.65±0.12 and 124.29±0.49 g in T_1, T_2 and T_3. The initial of Vietnamese koi was about 2.54 cm. The final average length gain was recorded as 14.84±0.05, 14.46±0.04 and 13.79±0.04 cm (Table 3). The initial weight of Magur at the stocking time was 2 g. At the end of the study average weight gain of Magur was recorded as 74.00±0.58, 66.36±0.43 and 60.61±0.58 g in T_1, T_2 and T_3. The initial length of Magur was about 3.50 cm. The final average length gain was recorded as 17.80±0.09, 13.50±0.05 and 12.37±0.02 cm (Table 4).

Table 3. Fortnightly growth rate of Vietnamese koi (*Anabas testudineus*) by average weight (g) and length gain (cm) under pond culture system.

Parameters	Treatment	Fortnightly average value of *Anabas testudineus*									Average Weight gain (g)
		5 Aug	20 Aug	5 Sept	20 Sept	5 Oct	20 Oct	5 Nov	20 Nov	5 Dec	
Length gain (cm)	T_1	2.54±0	10.19±0.08	13.21±0.04	13.27±0.05	13.94±0.07	15.86±0.07	16.00±0.06	16.30±0.05	17.38±0.05	14.84±0.05
	T_2	2.54±0	9.38±0.08	12.55±0.05	12.57±0.07	13.41±0.04	15.53±0.05	15.71±0.05	15.93±0.04	17.00±0.04	14.46±0.04
	T_3	2.54±0	8.03±0.08	11.53±0.01	12.20±0.04	13.09±0.03	14.73±0.04	15.08±0.04	15.36±0,03	16.33±0.03	13.79±0.04
Weight gain (g)	T_1	5.00±0	20.37±0.86	38.13±0.57	53.23±0.98	70.91±0.05	91.75±0.13	104.03±0.50	121.37±0.18	138.71±0.03	133.71±0.03
	T_2	5.00±0	18.75±0.72	36.06±0.56	50.57±0.90	68.22±0.04	87.08±0.68	100.73±0.20	118.69±0.15	135.65±0.12	130.65±0.12
	T_3	5.00±0	16.06±0.82	33.07±0.13	49.16±0.37	66.62±0.78	82.62±0.76	98.03±0.42	113.39±0.94	129.29±0.49	124.29±0.49

Table 4. Fortnightly growth rate of Magur (*C. batrachus*) by average weight (g) and length gain (cm) under pond culture system.

Parameters	Treatment	Fortnightly average value (*C. batrachus*)									Average Weight gain (g)
		5 Aug	20 Aug	5 Sept	20 Sept	5 Oct	20 Oct	5 Nov	20 Nov	5 Dec	
Length gain (cm)	T_1	3.50±0.0	6.53±0.1	8.69±0.06	12.94±0.09	13.72±0.03	14.66±0.04	17.62±0.09	19.37±0.04	21.30±0.09	17.80±0.09
	T_2	3.50±0.0	5.62±0.04	7.48±0.09	11.13±0.02	11.81±0.05	12.61±0.07	14.29±0.09	15.59±0.02	17.00±0.05	13.50±0.05
	T_3	3.50±0.0	5.24±0.02	6.77±0.06	10.39±0.09	11.02±0.02	11.77±0.04	13.33±0.06	14.65±0.09	15.87±0.02	12.37±0.02
Weight gain (g)	T_1	2.00±0.0	10.37±0.91	19.73±0. 86	32.13±0.93	41.50±0.96	53.87±0.55	62.25±0.36	69.65±0.67	76.00±0.58	74.0±0.58
	T_2	2.00±0.0	8.92±0. 89	17.85±0. 94	25.78±0.37	37.71±0.02	46.64±0.02	53.57±0.32	60.50±0. 36	68.36±0.43	66.36±0.43
	T_3	2.00±0.0	8.33±0.47	15.16±0.58	23.99±0.42	36.33±0.47	41.63±0.65	49.93±0.93	55.55±0.74	62.61±0.58	60.61±0.58

3.2. Specific growth rate (SGR) (%/day)

The Specific growth rate of Vietnamese Koi was not significantly varied between the three treatments. However, weight gain of Magur was significantly ($p<0.05$) varied between the three treatments. The SGR**%** value of Magur was high and Vietnamese koi was low in all treatments (Table 5).

Table 5. Specific growth rate of Vietnamese koi and Magur under different treatments.

Treatments	Fish species	Specific growth rate (%)
T_1	Vietnamese koi	2.77
	Magur	3.03
T_2	Vietnamese koi	2.75
	Magur	2.94
T_3	Vietnamese koi	2.71
	Magur	2.87

3.3. Survival rate (%) of fish

The average survival rate of Vietnamese koi and Magur were found at the end of the experiment which were 95.14 and 72.00 in T_1; 93.25 and 64.00 in T_2; 90.80 and 68.00 in T_3 respectively (Table 6).

Table 6. Survival rate of Vietnamese koi and Magur under different treatments.

Treatments	Fish species	Survival rate (%)
T_1	Vietnamese koi	95.14
	Magur	72.00
T_2	Vietnamese koi	93.25
	Magur	64.00
T_3	Vietnamese koi	90.80
	Magur	68.00

3.4. Water quality parameters

3.4.1. Water temperature (ºC)

The water temperature of the treatments varied from 26.0 ºC to 31.5 ºC during the study period (Table 3). The maximum temperature 31.5 ºC was recorded in T_1 in 27 August, 2013. The minimum temperature 26.0 ºC was noted in T_2 in 27 November, 2013. The mean values of water temperature were recorded 29.85±1.60, 29.58±1.66 and 29.73±1.64 in T_1, T_2 and T_3, respectively (Table 8).

3.4.2. Dissolved oxygen (mg/l)

The dissolved oxygen content of the selected ponds was ranged from 4.9 to 7.0 mg/l during the study period (Table 7). The lowest dissolved oxygen content was found 4.9 mg/l in treatment T_3 in 12 November, 2013 and the highest dissolved oxygen content was found 7.0mg/l in T_1 in T_2 August, 2013.The mean values of dissolved oxygen were recorded 5.93±0.66, 5.48±0.34 and 5.29±0.27 in T_1, T_2 and T_3 respectively (Table 8).

3.4.3. Hydrogen ion concentration (pH)

The values of pH were ranged from 7.87 to 8.45 during the study period (Table 7). The maximum value of pH 8.45 was recorded in T_1 in T_2 September, 2013 and the minimum value 7.87 was recorded in T_3 in 27 September, 2013. The mean (±SD) values of pH were recorded 8.19±0.20, 8.12±0.16 and 8.03±0.12 in T_1, T_2 and T_3 respectively (Table 8).

Table 7. Fortnightly variation of water Temperature, Dissolved oxygen and pH during the period of experiment under different treatments.

Parameters	Treatment	Sampling date							
		12 Aug	27 Aug	12 Sep	27 Sep	12 Oct	27 Oct	12 Nov	27 Nov
Temperature(ºC)	T_1	31.2	31.5	30.9	30.4	29.8	29.5	29.0	26.5
	T_2	30.5	30.8	31.1	30.7	29.5	29.2	28.8	26.0
	T_3	31.0	31.4	30.9	30.5	30.0	29.0	28.5	26.5
Dissolved oxygen(mg/l)	T_1	7.0	6.5	6.0	5.5	6.0	6.2	5.0	5.2
	T_2	5.9	6.0	5.3	5.5	5.6	5.3	5.1	5.1
	T_3	5.5	5.5	5.7	5.3	5.3	5.1	4.9	5.0
p^H	T_1	8.35	8.40	8.45	8.31	8.00	8.06	8.00	7.95
	T_2	8.20	8.00	8.22	8.32	8.19	8.22	7.89	7.91
	T_3	8.22	8.20	8.03	7.87	7.95	8.00	8.07	7.92

Table 8. Average (Mean ± SD) values of water quality parameters under different treatments throughout the study period.

Parameters	T_1	T_2	T_3
Temperature(ºC)	29.85±1.60	29.58±1.66	29.73±1.64
Dissolved oxygen(mg/l)	5.93±0.66	5.48±0.34	5.29±0.27
p^H	8.19±0.20	8.12±0.16	8.03±0.12

3.5. Production of Vietnamese koi and Magur

In the present study the (Vietnamese koi+Magur) stocking densities in the treatments T_1, T_2 and T_3 were 400, 450 and 550 fish /decimal respectively. At the end of the experiment, the productions were 12,085.71; 13,039.13; 15,025.01 kg/hectare in T_1, T_2 and T_3 respectively. The highest production was found in T_3 followed by T_1 and T_2.The production shown in Table 9.

Table 9. Growth, Survival and Production of Vietnamese koi (*Anabas testudineus*) and Magur (*Clarias batrachus*) under different treatments.

Growth Parameters	Fish Species	T_1	T_2	T_3
Initial weight(g)	Vietnamese koi	5.00	5.00	5.00
	Magur	2.00	2.00	2.00
Final weight(g)	Vietnamese koi	138.71	135.65	129.29
	Magur	76.00	68.36	62.61
Net weight(g)	Vietnamese koi	133.71	130.65	124.29
	Magur	74.00	66.36	60.61
Stocking density/decimal	Vietnamese koi	350	400	500
	Magur	50	50	50
FCR		2.12	2.08	1.86
SGR(%day)	Vietnamese koi	2.77	2.75	2.71
	Magur	3.03	2.94	2.87
Survival rate (%)	Vietnamese koi	95.14	93.25	90.80
	Magur	72.00	64.00	68.00
Species wise fish	Vietnamese koi	46.19	50.60	58.70
production(kg/decimal/120 days)	Magur	2.74	2.19	2.13
Production(kg/decimal/120 days)		48.93	52.79	60.83
Species wise fish production(kg/	Vietnamese koi	11408.93	12498.2	14498.9
Hectare /120 days)	Magur	676.78	540.93	526.11
Production(kg/Hectare/120 days)		12085.71	13039.13	15025.01

3.6. Cost benefit analysis

3.6.1. Gross cost

Total (Vietnamese koi+ Magur) fry cost was BDT 545 in T_1, 605 in T_2 and 725 in T_3. The Ruposi Bangla fish feed was selected for the present experiment which was BDT 40/kg and total feed cost BDT 4149, 4392 and 4525 in T_1, T_2 and T_3 respectively. Pond preparation, liming and geolite, man power and others management

cost, the Gross costs were BDT 5544, 5847 and 6100 in the treatment T_1, T_2 and T_3 respectively. The Gross cost of different treatments is shown in Table 10.

3.6.2. Gross income

Total (Vietnamese koi+ Magur) gross income was calculated by multiplying total (Vietnamese koi+ Magur) production and market price of fishes. The gross income from the three treatments (T_1, T_2 and T_3) was BDT 8431.6, 8928.2 and 10201.4 per decimal respectively (Table 10).

3.6.3. Net income

The Net income was estimated by deduction gross cost from the gross income. The net profit was BDT 2887.6, 3081.2 and 4101.4 per decimal in T_1, T_2 and T_3 respectively (Table 10).

Table 10. Total production of Vietnamese koi (*Anabas testudineus*) and Magur (*Clarias batrachus*) in T_1, T_2 and T_3.

Treatments	Production per decimal (kg)	Production per hectare (kg)	Fish price Per (kg)	Gross income per decimal (BDT)	Gross cost per decimal (BDT)	Net income per decimal (BDT)	Gross income per hectare (BDT)	Net income per hectare (BDT)
T_1	Vietnamese koi -46.19	11408.93	160	7390.4			1825428.8	
	Magur -2.74	676.78	380	1041.2			257176.4	
Total T_1	48.93	12085.71		8431.6	5544	2887.6	2082605.2	713237.2
T2	Vietnamese koi- 50.60	12498.2	160	8096.0			1999712	
	Magur -2.19	540.93	380	832.2			205553.4	
Total T2	52.79	13039.13		8928.2	5847	3081.2	2205265.4	761056.4
T3	Vietnamese koi -58.70	14498.9	160	9392.0			2319824	
	Magur -2.13	526.11	380	809.4			199921.8	
Total T3	60.83	15025.01		10201.4	6100	4101.4	2519745.8	1013045.8

3.6.4. Benefit–cost-ratio (BCR)

BCR was calculated as the ratio of gross income to gross cost .The BCR was found in the three treatments T_1, T_2 and T_3 1.52, 1.53 and 1.67 respectively. The highest BCR was found in T3 followed by T2 and T_1 treatments (Table 11).

Table 11. Cost-benefit analysis of T_1, T_2 andT_3 culture system in the ponds at the end of the study period.

Items		T_1	T2	T3
Expenditure (BDT)				
Pond preparation		250	250	250
Price of fry	Vietnamese koi	420	480	600
	Magur	125	125	125
	Total	545	605	725
Liming and Geolite		40	40	40
Feed cost		4149	4392	4525
Man power		320	320	320
Others		240	240	240
Gross cost/decimal		5544	5847	6100
Income (BDT)				
Gross	Vietnamese koi	7390.4	8096.0	9392.0
income/decima	Magur	1041.2	832.2	809.4
l	Total	8431.6	8928.2	10201.4
Net profit (BDT)		2887.6	3081.2	4101.4
FCR		1.52	1.53	1.67

4. Discussion

The average weight gain of Vietnamese koi and Magur at the harvesting time were 133.71±0.03 and 74.00±0.58; 130.65±0.12 and 66.36±0.43; 124.29±0.49 and 60.61±0.58 g in T_1, T_2 and T_3 respectively. At the same way, the average length gain of Vietnamese koi and Magur at the harvesting time were 14.84±0.05 and 17.80±0.09; 14.46±0.04 and 13.50±0.05; 13.79±0.04 and 12.37±0.02 cm in T_1, T_2 and T_3 respectively .The highest weight and length gained both types of fishes in T_1 in which total stocking density was 400 fry/decimal. At the same way, the lowest weight and length gained both types of fishes in T_3 in which total stocking density was 550 fry/decimal. Weight gain was slightly varied among the three treatments. Similar results were observed by Ali *et al.* (2016); Anka*et al.* (2016); Habib *et al.* (2014); Haq *et al.* (2017); Islam *et al.* (2016); Islam *et al.* (2017); Rahman *et al.* (2015); Rahman *et al.* (2016); Rahman *et al.* (2017a); Samad *et al.* (2016); Shabuj *et al.* (2016); Zaman *et al.* (2017); Sharif *et al.* (2015); Hossain *et al.* (2016) and Rahman *et al.* (2017b). Stocking density is an important parameter which directly affects the growth of fish and its production (Backiel and Lecren, 1978). The Specific growth rate of Vietnamese koi and Magur were found 2.77 and 3.03; 2.75 and 2.94; 2.71 and 2.87 in T_1, T_2 and T_3, respectively. At higher stocking densities, presence of abundant feed substance could produce a competitive interaction among the larvae causing a stressful situation (Houde, 1975). Similar results were observed by Rahman *et al.* (2017b) and Haq *et al.* (2017). In the present experiment the average survival rate of Vietnamese koi and Magur were found at the end of the experiment which were 95.14% and 72% in T_1; 93.25% and 64% in T_2; 90.80% and 68.00% in T_3 respectively. The survival rate of Vietnamese koi and Magur were higher in T_1 at lower stocking density. Khan (2008) found that the survival rate of *Anabas testudineus* varied from 90.72% to 95.05%. Mollah (1985) reported that the lower density gave larger size and higher survival rate in *Clarias batrachus.* Similar results were observed by Anka *et al.* (2016); Habib *et al.* (2014); Haq *et al.* (2017); Islam *et al.* (2016); Islam *et al.* (2017); Rahman *et al.* (2016); Rahman *et al.* (2017a); Samad *et al.* (2016); Shabuj *et al.* (2016); Hossain *et al.* (2016) and Rahman *et al.* (2017b). Temperature also plays role in respect of fish production. In the present study the average water temperature was recorded 29.85±1.60 °C, 29.58 ±1.66 °C and 29.73±1.64 °C in T_1, T_2 and T_3, respectively. Actually there was no significant difference of temperature among the three treatments but those values were within the acceptable ranges for fish culture. From an experiment, Aminul (1996) reported that water temperature 25 °C to 35 °C is suitable for fish culture and Akhteruzzaman (1988) found water temperature 25.5 °C to 30.0 °C is favourable for fish culture. Similar results were also observed by Rahman *et al.* (1982); Takurand Das (1986); Patra (1993); Kohinoor *et al.* (1998); Flura *et al.* (2015); Islam *et al.* (2016); Shabuj *et al.* (2016); Zaman *et al.* (2017); Yeasmin *et al.* (2015); Hossain *et al.* (2016); Chowdhury *et al.* (2015); Asif *et al.* (2014) and Wahab *et al.* (2003). So in this present experiment, temperature ranges were acceptable for productive fish culture.

Successful fish culture depends on the careful management of dissolved oxygen at optimum level. During the experimental period the average values of dissolved oxygen level were recorded 5.93±0.66 mg/l, 5.48±0.34 mg/l and 5.29±0.27 mg/l in T_1, T_2 and T_3, respectively. DoF (1996) reported that the range of dissolved oxygen content for fish culture should be 5.0-8.0 mg/l. In the treatment T_1, dissolved oxygen level was fine and was not varied significantly due to continuous water flow. According to Rahman (1992) dissolved oxygen content should be 5 mg/l or more for a productive pond. It can be concluded that dissolved oxygen level in T_1 was impressive and very much productive for fish culture. Similar results were observed by Flura *et al.* (2015); Islam *et al.* (2016); Shabuj *et al.* (2016); Zaman *et al.* (2017); Yeasmin *et al.* (2015); Hossain *et al.* (2016) and Chowdhury *et al.* (2015). p^H is considered as an important factor in aquaculture and treated as the productivity index of a water body. The pH of the water is a measure of the hydrogen ion concentration on a scale 0 (very acidic) to 14 (very basic), with pH 7 being the alarmingly. In the present study the average values of pH level were recorded 8.19±0.20, 8.12±0.16 and 8.03±0.12 in T_1, T_2 and T_3, respectively. Similar results were observed by Flura *et al.* (2015); Islam *et al.* (2016); Shabuj *et al.* (2016); Zaman *et al.* (2017); Yeasmin *et al.* (2015); Hossain *et al.* (2016) and Chowdhury *et al.* (2015). For pond fish culture, the suitable ranges of pH are 6.5 to 8.5 (Byod, 1992). From a research, Uddin (2002) recorded that the pH value ranged from 6.24 to 8.88. From this context, it can be said that the research ponds were suitable for fish culture on the basis of pH value. Higher production was obtained from T_3 which might be due to higher number of fishes. In the present study, the production was 12085.71, 13039.13 and 15025.01 kg/ha in 120 days in T_1, T_2 and T_3 respectively. Although the mean weight gain both (Vietnamese koi and Magur) in T_1 was highest but total production was highest in T_3 which might be due to higher number of fishes. The present result supports the findings of Begum (2009); Islam *et al.* (2017b); Rahim (2010) and Alim (2013) who achieved the best production from higher stocking densities compared to that achieved with the lower ones. The present study showed that the highest growth rate was found in T_1, in which production was less. Although the total stocking density was also less than the T_2 and T_3. But experiment emphasized that using same area to maximize output. For doing this job successfully farmers

have to concentration on the management issues. From the present experiment it can be concluded that higher stocking density is better economically than the lower density.

5. Conclusions

The highest production was found from T_3 in which stocking density was high and lowest production was found in T_1. The production was not significantly varied between the treatments but more varied between treatments T_3 to rest two treatments (T_1 and T_2). The highest net income also obtained from T_3 followed by T_1 and T_2. The benefit-cost ratio (BCR) was done after the experiment. The best benefit was gained from T_3 in which BCR was 1.67 and the other two treatments BCR were 1.53 in T_2 and 1.52 in T_1. From the above discussion it can be concluded that Vietnamese koi and Magur culture with high stocking density may be done to get high production and maximum benefit. Here concerned is that the culture should be intensive and adopting appropriate management tactics.

Conflict of interest

None to declare.

References

Akhteruzzaman M, 1988. A study on the production of koi fish (*Anabas testudineus*) under semi-intensive culture system. Bangladesh J. Zool., 3: 39-43.

Ali MM, AA Asif, MAI Shabuj, S Vaumik, MA Zafar and BMN Sharif, 2016. Status of polyculturepangasiushypophthalmus with carps in Jhikargachaupazila of Jessore district, Bangladesh. Int. J. Fish. Aquat. Stud., 4: 423-430.

Alim A, 2013. Effects of stocking density on growth and production performance of mono-sex Tilapia (*Oreochromis niloticus*) in ponds, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Aminul IM, 1996. Qualities of water and soil in Aquaculture. *Fish week Compendium*. Department of Fisheries Publication, Ramona, Dhaka -1000.

Anka IZ, JS Jothi, J Sarker, ATalukder and MS Islam, 2016. Growth performance and survival of guppy (*Poecilia reticulata*): different formulated diets effect. Asian J. Med. Biol. Res., 2: 451-457.

Asif, AA, MA Samad, BMS Rahman, MA Rahman, MH Rahman, SM Yeasmin and A Nima, 2014. Study on management of fish fry and fingerling marketing of jessore in Bangladesh. International Journalof Business, Social and Scientific Research, 2: 127-135.

Backiel T and ED Lecren, 1978. Some density relationship for the population parameters. In: SD Jerking (Editor), Ecology of freshwater fish production. Blackwell Scientific Publications, Oxford. pp. 279-302.

Begum M, 2009. Effects of stocking density on growth and production performance of mono-sex Tilapia (*O. niloticus*) in ponds, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Chakraborty BK and MJA Mirza, 2008. Growth and yield performance of threatened Shingi (*Heteropneustesfossilis*, Bloch) under semi intensive aquaculture. J. Fish. Soci. Taiwan, 35: 117-125.

Chowdhury AA, MS Uddin, S Vaumik and AA Asif, 2015. Aqua drugs and chemicals used in aquaculture of Zakigonjupazilla, Sylhet, Asian J. Med. Biol. Res., 1: 336-349.

DoF, 2011-2012. Fisheries Statistical Yearbook of Bangladesh (July 2011-June 2012), Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh.

Flura, MA Alam, MA Rahman, T Ahmed and KC Roy, 2015. Ecology and water quality parameters of Ballabeel in Moulovibazar district of Bangladesh. Asian J. Med. Biol. Res., 1: 198-208.

Fry FE, 1971. The effect of environmental factors on the physiology of fish. In: Hoar WS, Randall DR, Brett JR (Editors), Environmental reaction and behavior, Academic Press, New York. pp. 1-98.

Habib MA, MR Sharker, MM Rahman, ME Ahsan and SN Pattadar, 2014. Effects of feeding frequency on growth and survival in fry of gold fish, *Carassius auratus* (Hamilton) in outdoor rearing system. Int. J. Fish. Aquat. Stud., 1: 97-102.

Haq ME, M Rahman, AHossain, AA Asif, H Rahman, P Chwakravorty, A Satter and MS Islam, 2017. Comparative growth performance between monosex and natural XY male tilapia in Noakhali region, Bangladesh. Asian J. Med. Biol. Res., 3: 391-397.

Hossain HZ, 2003. Effects of inorganic fertilizers on growth, production, protein and lipid contents of carps in polyculture system, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Hossain MT, MS Alam, MH Rahman, AA Asif and SM Rahmatullah, 2016. Present status of Indian major carp broodstock management at the hatcheries in Jessore region of Bangladesh. Asian Australas. J. Biosci. Biotechnol., 1: 362-370.

Houde ED, 1975. Effect of stocking density and food on survival, growth and yield of laboratory reared of sea Bream, *Archosargus rhomboidales* (L.). Journal of Zoology, 7: 115-127.

Islam MM, R Hassan, BMN Sharif, MM Rahaman, MA Islam and MR Amin, 2016. Water quality, feeding management and cost-benefit analysis of a fish hatchery in Jessore district of Bangladesh. Asian J. Med. Biol. Res., 2: 414-421.

Islam MS, AA Asif, B Sarker, AbSatter, M Ahmed, M Rahman, MA Zafar and SM Rahmatullah, 2017b. Fry production and its marketing system of North-West fisheries extension project at Parbatipur, Dinajpur, Bangladesh. Asian J. Med. Biol. Res., 3: 368-378.

Islam MS, MM Rashid, MS Arefin, P Naha and M Rokanuddula, 2017a.Performance of some growth promoters on hybrid walking catfish *(Clarias batrachus* × *Clarias gariepinus).* Asian J. Med. Biol. Res., 3: 103-108.

IUCN, 2000. Red book of threatened fish of Bangladesh .The World conservation Union.pp.61.

Khan MZ, 2008. Culture practice of *Anabas testudineus* (Thai koi) at different stocking densities at Tarakanda, Mymensingh, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Kohinoor AHM, AKMS Islam, DA Jahan, M Zaher and MG Hossain, 2006. Monoculture of climbing perch, Thai koi (*Anabas testudineus*, Bloch) under different stocking densities at on-farm management. Bangladesh J. Fish. Res., 11: 173-180.

Kohinoor AHM, M Akhteruzzaman and MS Shah, 1991. Observations on the induced breeding of Koi fish (*Anabas testudineus*, Bloch) in Bangladesh. Bangladesh J. Fish. Res., 14: 73-77.

Kohinoor AHM, MM Khan, SU Ahmed and MG Hussain, 2009. Culture potentials of climbing perch (*Anabas testudineus*, Bloch) under different stocking densities at semiintensive management. Bangladesh J. Fish. Res., 2: 115-120.

Kohinoor AHM, PC Modak and MG Hussain, 1998. Growth and production performance of Red tilapia and Nile tilapia (*O. niloticus)* under low input culture system. Bangladesh J. Fish. Res., 3: 11-17.

Matsha Pakka Sankalan, 2002. Department of Fisheries, Ministry of Fisheries and Livestock, People's Republic of Bangladesh, Dhaka, Bangladesh. pp. 44-45.

Mollah MFA, 1985. Effects of stocking density and water depth on the growth and survival of freshwater catfish (*Clarias macrocephalus*, Guther) larvae. Indian J. Fish., 32: 1-17.

Patra BC, 1993. Satiation time, appetite and daily pattern of feed intake and faces release by an air breathing fish, *Anabas testudineus* (Bloch*).* Journal of Aquaculture, 8: 41-46.

Rahim A, 2010. Effects of stocking density on growth and production performance of mono-sex Tilapia (*O. niloticus*) in ponds, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Rahman H, JA Mirza, AHossain, AA Asif, E Haq, P Chwakravorty and M Rahman, 2017b. Economics of fish production in paddy fields in Bangladesh.Asian J. Med. Biol. Res., 3: 379-390.

Rahman MA, H Gheyasuddin, MH Rasid and MFZ Choudhury, 1982.Proximate composition and native quality of freshwater Zeol fishes of Bangladesh. Bangladesh J. Fish. Res., 25: 37-38.

Rahman MH, MA Rahman, MMM Hossain, SM Yeasmin and AA Asif, 2015. Effect of feeding management of broodstock on breeding performance of bata *(Labeo bata)*. Asian J. Med. Biol. Res., 1: 553-568.

Rahman MM, DK Mondal, MR Amin and MG Muktadir, 2016. Impact of stocking density on growth and production performance of monosex tilapia (*Oreochromis niloticus*) in ponds. Asian J. Med. Biol. Res., 2: 471-476.

Rahman MS, 1992. Water Quality Management in Aquaculture. Published by Bangladesh Rural Advancement Committee. pp.75.

Rahman SH, MA Hossain, MR Hossain and S Sultana, 2017a.Growth evaluation of all male prawn and tilapia in ponds of northern Bangladesh. Asian J. Med. Biol. Res., 3: 198-204.

Saha KC and BC Guha, 1939. Nutritional investigation on Bengal fish. Indian J. Fish., 26: 921-927.

Saha KC, 1971. Fisheries of West Bengal, Government Press, Alipore, West Bengal, India. pp. 26.

Samad MA, A Khatun, MS Reza, M Asrafuzzaman and MH Ferdaushy, 2016.Effects of stocking density on growth, survival and production of mirror carp (*Cyprinuscarpio var. specularis*) spawn in nursery pond. Asian J. Med. Biol. Res., 2: 429-435.

Shabuj MAI, AA Asif, O Faruq, MR Bari and MA Rahman, 2016. Brood stock Management and Induced Breeding of Thai Pangus (*Pangasius hypophthalmus*) Practiced in the hatcheries of Jessore Region, Bangladesh. International Journalof Business, Social and Scientific Research, 4: 235-246.

Sharif BMN and AA Asif, 2015. A Present status of fish hatchlings and fry production management in greater Jessore, Bangladesh. International Journal of Fisheries and Aquatic Studies, 2:123-127.

Singh Kohli MP and UC Goswami, 1989. Studies on age and growth of an air-breathing catfish (*Heteropneustesfossilis* , Bloch). J. Inla. Fish. Soc. India, 21: 17-24.

Takur NK and P Das, 1986. Synopsis of biological data on catfish (*Heteropneustes fossilis*) and koi *(Anabas testudineus*). Bulletin number39 and 40, April 1986, Central Inland Fisheries Research Institute, Barrack pore, India. pp. 32 and 45.

Torafdar MAK, 2013. Drutobardhonshil Vietnamese koi, Bangladeshanatunjaterbideshimach, BdFISH Bangla. pp.1.

Uddin MM, 2002. Effects of addition of small fish on pond ecology and production in polyculture, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh.

Wahab MA, MF Azim, AHM Kohinoor and MM Haque, 2001.Optimization of stocking density of Thai silver barb (*Barbodes gonionotus*) in the duckweed-feed four species polycultue system. Bangladesh J. Fish. Res.5: 13.

Wahab MA, SH Thilsted and EN Haq, 2003.Small indigenous species of fish in Bangladesh.Proceedings of BAU-ENRECA/DANIDA workshop, 30-31 October 2003, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp.150.

Yeasmin SM, MA Rahman, MMM Hossain, MH Rahman and AA Asif, 2015. Identification of causative agent for fungal infection and effect of disinfectants on hatching and survival rate of common carp (*C. carpio*) larvae. Asian J. Med. Biol. Res., 1: 578-588.

Zaman MFU, MA Samad, MA Islam, MHU Jaman, S Khondoker and AA Asif, 2017. Assessment of sustainability of Pangasius (*Pangasius hypophthalmus*) farming at Jhikargachhaupazila in Jessore district, Bangladesh. Int. J. Fauna and Bio. Stud., 4: 109-119.