Journal of Fisheries & Livestock Production

Chakraborty and Haque, J Fisheries Livest Prod 2014, 2:1
DOI: 10.4172/2332-2608.1000113

Research article Open Access

Growth, Yield and Returns to Koi, *Anabas testudinous* (Bloch, 1792) under Semi-intensive Aquaculture System using Different Seed Types in Bangladesh

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Rec date: Feb 24, 2014, **Acc date:** May 20, 2014, **Pub date:** May 30, 2014

Abstract

The experiment was conducted for a rearing period of 100 days in nine earthen ponds having an area of 0.35 ha each. The fry stocked at 0.247 million.ha^{-1} was designated as treatment T_1, T_2 and T_3 at different private farms of Mymensingh district, Bangladesh. The ponds were stocked having an initial length of 0.75 ± 0.0.01 cm and 0.50 ± 0.02 g in T_1 (normal koi), 0.70 ± 0.01 cm and weight of 0.25 ± 0.01 g, in T_2 (hormone treated koi) and T_3 (Vietnam koi), respectively. Physicochemical parameters and plankton populations were at the optimum level for culture period. Maximum weight gain was observed in treatment T_3 and lowest in treatment T_1. Final length, final weight and survival of *Anabas testudineus* also followed the same trends as weight gain. Individuals in treatment T_3 produced significantly higher specific growth rate than treatment T_2 and T_1. Feed conversion ratio was significantly higher in treatment T_3 followed by treatment T_2 and T_1 in that order. Fish production in treatment T_1, T_2 and T_3 were 16381.2 ± 106.12, 19851.6 ± 104.07 and 22063.0 ± 104.57 kg.ha^{-1}.day^{-100} respectively. Significantly higher production was produced in treatment T_3 than in treatment T_2 and T_1, respectively. In despite of this, consistently higher net benefit was found also from treatment T_3 than from treatment T_2 and T_1. Significantly higher economically benefit was also recorded in treatment T_3 than in treatment T_2 and T_1, respectively. Overall, highest growth, survival and net benefits of *A. testudineus* were obtained from hormone treated Vietnami koi population at a density of 0.247 million.individual.ha^{-1}. Among three treatments, Vietnami koi population (treatment T_3) appears to be most suitable for good aquaculture practice of koi, *A. testudineus* in 100 days rearing system. Therefore, monoculture practice of *A. testudineus* is an ideal method of choice for an eco-socio-economically sustainable koi culture to meet up the protein deficiency of the general people of Bangladesh.

Keywords: *Anabas testudineus*; Stocking density; Growth; Survival; Net benefit; Total production

Introduction

The Perch fish *Anabas testudineus* (Bloch, 1792) is one of the important fresh water fishes of Bangladesh which is locally known as Koi in different places of Bangladesh. It is commonly found in open water (streams, lakes, floodplain and beels), paddy fields and swamps of Bangladesh and its preferred habitats are heavily-vegetated, stagnant waters. Total length is recorded 176 mm [1]. This species is very much popular for its excellent taste and high market value. Now-a-days, this species koi plays an important role in meeting the nutritional requirements of people of Bangladesh. This fish was abundantly available in our open water system but due to over exploitation and various ecological changes in its natural habitat; this native species is declining. Indiscriminate destructive practices have caused havoc to aquatic biodiversity [2]. Recent studies suggest that worldwide 20% of all fresh water species are extinct, endangered or vulnerable [3]. International Union of Conservation of Nature (IUCN) [4] enlisted *A. testudineus* as not threatened perch fish in Bangladesh. But due to rough and unplanned water management policy for irrigation, over exploitation, illegal practice of capture fisheries and various ecological changes in its natural habitat; this native species is threatened now [5]. Considering the importance of this species in nutritional, economics and biodiversity point of view, it is required to develop an appropriate culture technique of *A. testudineus*. This good aquaculture technology will be helpful to meet up the dietary demand and this tasty fish will be available for the rural people of Bangladesh [6]. For large scale production of fish, comprehensive information on culture technology is required. Therefore, the present study aims to find out the maximum growth, yield and economic performance of monoculture system. In order to do so, a huge quantity of genetically improved fingerling would be required which could be met through successful rearing of koi, *A. testudineus*. The present experiment has been undertaken to develop a practical and economically viable methodology for mass production of *A. testudineus* under controlled grow out monoculture technology. This technology is a good technology in aquaculture to meet up the protein deficiency and socio-economic status of the general people of Bangladesh.

Materials and Methods

Study area and experimental design

The research was carried out at the private rearing ponds of three Fish Farms, Shabajpur, Sadar and Gaffargaon Upazilla, Mymensingh, Bangladesh. The experiment was conducted for a period of 100 days from April to July, 2012 in nine earthen rearing ponds with a surface area of 0.35 ha with an average depth of 1.0 meter. The ponds were having similar rectangular size, depth, basin conformation, contour and bottom type. Three treatments of same stocking density of fry of normal koi, hormone treated koi and Vietnami koi were employed with three replicates each. Normal thai climbing perch and hormone treated fries were collected from Bramhaputra hatchery and and Vietnami koi was collected from Sharnalata Agro Fisheries Ltd, Radhakani, Fulbaria, Mymensingh, Bangladesh. Nazim Uddin Farm, Shabajpur, Sadar, Mymensingh (treatment T_1) was designed with normal koi. Babul Fish Farm, Basutia, Gaffargaon, Mymensingh (treatment T_2) was stocked with hormone treated koi and Rubel Fish farm, Doulatpur, Gaffargaon, Mymensingh (treatment T_3) was stocked with Vietnami koi.

Pond preparation and fertilization

The ponds were dewatered, freed from aquatic vegetation, exposed to full sunlight and had a well-designed system of inlet and outlet. After drying, quicklime ($CaCO_3$, 250 kg.ha^{-1}) was spread over the pond bottom. All the ponds were filled with ground water. Five days subsequent to liming, the ponds were fertilized with organic manure (cowdung @ 2470 kg.ha^{-1}). Quicklime (50 kg.ha^{-1}) was maintained fortnightly to control water quality of different treatments.

Stocking

An initial length of 0.75 ± 0.0.01 cm and 0.50 ± 0.02 g was stocked in treatment T_1 and same length 0.70 ± 0.01 cm and weight of 0.25 ± 0.01 g was stocked in treatments T_2 and T_3, respectively. Stocking densities of the treatments T_1, T_2 and T_3 were same at the rate of 0.247 million.ha^{-1}.

Supplementary feeding

In order to meet the increasing dietary demand, supplementary readymade floating Mega feed and sinking Soudi Bangla feed was supplied at the rate of 6-100% of their total biomass twice and daily commencing from the first day of stocking. Proximate composition of the feeds was analyzed according to AOAC [7] method, nitrogen free extract (NFE) by subtraction [8]. Floating Mega feed was supplied in early stage and sinking Soudi Bangla feed was supplied after 35 days of rearing for daily ration. Proximate composition (% dry matter) of the supplementary floating Mega feed (crude protein, crude lipid, Crude fiber, ash, moisture and Nitrogen-free extract) of experimental feeds was 30.0%, 3.0%, 10.0%, 17.0%, 12.0% and 28.0%; and sinking Soudi Bangla feed (crude protein, crude lipid, Crude fiber, ash, moisture and Nitrogen-free extract) was 30.0%, 6.0%, 07.0%, 18.0%, 12.0% and 27.0% respectively.

Water quality parameters

Physicochemical parameters of pond water were monitored every ten days interval between 9.00 and 10.00 h. Water temperature was recorded using a Celsius thermometer and transparency (cm) was measured by using a Secchi disc of 20 cm diameter. Dissolved oxygen and pH were measured directly using a digital electronic oxygen meter (YSI, Model 58, USA) and an electronic pH meter (Jenway, Model 3020, UK). Total alkalinity was determined by titrimetric method [9]. Total ammonia of water samples was determined with the help of a Hach Kit (Model DR 2010, USA). The chemical reagent Rochelle salt and Nesslar reagents were used for this purpose. Total hardness of the pond water was measured titrimetrically in the office of Fisheries Department, Bhaluka, Mymensingh. Phosphate-phosphorous of collected pond water was determined using a Hach Kit (DR-2010, USA) and necessary reagent pillow Phos Ver-5. Nitrate-nitrogen of water samples was determined by using a Hach Kit (DR-2010, USA) and necessary reagent pillow NitroVer-5. Nitrite-nitrogen of pond water samples was determined by using a Hach kit (DR- 2010, USA) and necessary reagent pillow NitroVer-3.

Plankton monitoring

Quantitative and qualitative estimates of plankton in the nursery ponds were taken every ten days interval. Water from different locations and depths of each pond were collected and filtered through fine-meshed plankton net (0.04 mm) to obtain a 50 ml sample. The samples were preserved immediately with 5% buffered formalin in plastic bottles. Plankton density was estimated by using a sub-sampling technique. A Sedgwick-Rafter (S-R) cell was used under a calibrated compound microscope for plankton counting. Plankton count (number of cells per liter of water sample) was made using the formula proposed by Rahman [10] and Stirling [11].

Water recycling

Water recycling method is developed regularly for controlling pollution of excretory product of individual and plankton bloom. Inlet and out let system of water body was to be processed and sometime water was recycled by a pump machine to maintain ecosystem of the ponds.

Estimation of growth, survival, production and feed utilization

Twenty individuals from in each pond were sampled every ten days interval until they attained the marketing size. The growth performance of the individual were assessed in terms of length and weight, Average Daily Growth (ADG), Specific growth rate (SGR), Conditioning Factor (K), Food Conversion Ratio (FCR), % Survival and Mean values (± SD) for each parameter were computed. The term of Conditioning Factor (K) was calculated according to Ricker [12]. Average Daily Growth (ADG) and % Survival were followed according to De Silva [13]. SGR and FCR were calculated according to Brown [14], Ricker [12], Castell and Tiews [8], Hepher [15] and Gangadhara et al. [16] respectively. After 100 days, the fishes were harvested by repeated netting, followed by drying the ponds. The individuals were counted and weighed. Survival (%) and production (number.ha^{-1}) of fishes were then calculated and compared among the treatments.

Analysis of Experimental Data

The data were analyzed through one way Analysis of Variance (ANOVA) using MSTAT followed by Duncan's New Multiple Range test to find out whether any significant difference existed among treatment means [17,18]. Standard deviation in each parameter and treatment was calculated and expressed as mean ± S.D. The level for significance was set at 0.05%.

Results

Water quality parameters

Mean levels of Physico-chemical parameters over the 100 days rearing of fishes are presented in Table 1. The mean water temperatures in treatment T_1, T_2 and T_3 were not statistically significant ($p>0.05$). Mean secchi disk transparency did not differed significantly ($p>0.05$) in different treatments. The Mean Dissolved Oxygen (DO) was decreased from T_3 to T_2 and T_2 to T_1 but did not differ significantly ($p>0.05$). The pH, Nitrate-nitrogen, Nitrite-nitrogen, Ammonia-nitrogen and Phosphate- phosphorus was increased from T_2 to T_1 and T_2 to T_3 but was not significantly different ($p>0.05$). Total alkalinity was decreased from T_3 to T_2 and T_2 to T_1 but differ significantly ($p<0.05$). Hardness was also decreased from T_3 to T_2 and T_2 to T_1 but differ significantly ($p<0.05$). Despite these variations, water quality parameters in all the experimental ponds were within the normal range for fish culture (Table 1) for water recycling method.

Parameter	Treatment		
	T_1	T_2	T_3
Temperature (0˚C)	29.88 ± 2.61 (26.88 - 31.00)	29.86 ± 2.66 (26.82 - 31.15)	29.90 ± 2.60 (26.77 - 31.05)
Transparency (cm)	28.22 ± 4.66^a (24.33 - 31.60)	27.28 ± 5.44^b (23.88 - 31.72)	26.26 ± 6.44^c (23.08 - 29.66)
pH	7.88 ± 0.14 (7.40 - 8.20)	7.80 ± 0.16 (7.30 - 8.60)	7.92 ± 0.12 (7.44 - 8.55)
Dissolved oxygen (mg/L)	5.20 ± 0.66 (4.10 - 5.50)	4.88 ± 0.48 (3.80 - 5.20)	5.01 ± 0.88 (4.74 - 5.44)
Total alkalinity (mg.L^{-1})	132.16 ± 8.84^b (115.33 - 140.58)	127.48 ± 7.14^c (120.44 - 132.67)	136.08 ± 8.44^a (121.10 - 142.44)
Hardness (mg.L^{-1})	122.72 ± 1.89^b (120.73 - 124.24)	117.14 ± 2.33^c (114.33 - 120.14)	127.11 ± 1.82^a (125.60 - 131.44)
Nitrate-nitrogen (mg.L^{-1})	1.34 ± 0.11^b (1.32 - 1.36)	1.26 ± 0.20^c (1.24 - 1.28)	1.38 ± 0.22^a (1.36 - 1.39)
Nitrite-nitrogen (mg.L^{-1})	0.03 ± 0.01 (0.02 - 0.03)	0.03 ± 0.02 (0.01 - 0.05)	0.04 ± 0.01 (0.02 - 0.05)
Ammonia-nitrogen (mg.L^{-1})	0.41 ± 0.01 (0.40 - 0.44)	0.45 ± 0.02 (0.43 - 0.48)	0.40 ± 0.01 (0.39 - 0.42)
Phosphate-phosphorus(mg.L^{-1})	0.10 ± 0.01 (0.09 - 0.12)	0.10 ± 0.01 (0.09 - 0.12)	0.12 ± 0.01 (0.10 - 0.14)

Table 1: Physico-chemical characters of water in the earthen ponds of *Anabas testudinous* during the experimental period (Figure in the same row having the same superscript are not significantly different ($p>0.05$). Figure in the parenthesis indicates the range)

Plankton enumeration

From the Table 2, it was found that the quantity of phytoplankton and zooplankton found in treatment T_1 (313.70 ± 53.94 and 107.12 ± 25.06)/ml stocked with normal koi fish, T_2 (276.22 ± 49.17 and 87.31 ± 21.94) ml^{-1} stocked with hormone treated F_1 generation and T_3 (234.35 ± 44.55 and 74.09 ± 18.68) ml^{-1} stocked with hormone treated F_2 generation koi fish, respectively (Table 2). Thirty genera of phytoplankton recorded in four group's viz. Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. The mean abundance of total phytoplankton of T_1 was significantly higher ($p<0.05$) than those of T_2 and T_3. The zooplankton population consisted of 12 genera including nauplii in two group's viz. Crustacean and Rotifera. Rotiferans were dominant over the entire experimental periods in all treatments. The abundance of zooplankton differed significantly ($p<0.05$), decreasing from T_3 to T_1.

Growth, feed utilization and production of fish

Growths (length and weight) of *A. testudinous* are shown in Figures 1 and 2. The increase in length and weight was the highest in T_3 followed by T_1 and T_2. Growth and production parameters of individuals are shown in Table 3. The initial length and weight of fish, stocked in the treatment T_1 was 0.75 ± 0.01 cm and 0.50 ± 0.02 g and treatment T_2 and T_3 were same (0.70 ± 0.01 cm and 0.25 ± 0.01 g). The fish in T_3 treatment showed the highest gain in both length and weight over T_1 and T_2 treatment, where stocking density of fry was same (247000 ha^{-1}). However, the mean final length and weight of fish between treatment T_3 and treatment T_1 and T_2 were significantly different ($p<0.05$). The highest weight gain was in T_3 and lowest in T_1. SGR in T_3 was significantly higher than T_2 and T_1, and was significantly different ($p<0.05$). FCR was comparatively lower in treatment T_3 than T_2 and T_1. Therefore, SGR and FCR were best for fish in T_3 where hormone treated Koi was reared. The lowest condition factor (K) was recorded in T_3, and the highest in T_1. Condition factor was significantly higher in T_1 than T_2 and T_3. The highest survival rate was also observed in T_3, and the lowest in T_1. There was a significant variation ($p<0.05$) in the survival rate in *A. testudinous* among different treatments.

Plankton group	Treatment		
	T1	T2	T3
Plankton (cell.ml^{-1}×10^3)			
Chlorophyceae	161.54 ± 8.55^b (158.31 - 164.22)	168.22 ± 7.32^a (164.40 - 172.28)	149.55 ± 4.61^c (146.28 - 154.32)
Bacillariophyceae	122.28 ± 3.24^b (119.44 - 124.20)	128.74 ± 4.74^a (126.08 - 132.60)	118.25 ± 4.61^c (116.30 - 121.22)
Cyanophyceae	68.54 ± 3.12^a (64.38 - 72.35)	56.45 ± 3.22^b (52.25 - 60.66)	49.77 ± 2.28^c (47.22 - 51.42)
Euglenophyceae	13.33 ± 1.08^b (10.52 - 16.25)	15.78 ± 0.78^a (13.28 - 17.62)	12.26 ± 0.55^c (10.57 - 16.72)
Total Phytoplankton	365.69 ± 64.53^b	369.19 ± 68.88^a	329.83 ± 62.66^c
Zooplankton (organism.ml^{-1}×10^3)			
Rotifera	66.62 ± 2.58^b (64.44 - 68.28)	68.27 ± 2.66^a (66.62 - 70.22)	62.43 ± 2.74^c (60.28 - 64.52)
Crustaceae	42.22 ± 1.24^c (40.22 - 44.95)	44.92 ± 1.1^b (40.84 - 48.45)	52.24 ± 2.029^a (50.12 - 55.18)
Others	9.28 ± 1.08^b (7.60 - 10.55)	8.12 ± 1.21^c (7.15 - 9.28)	9.42 ± 0.72^a (7.70 - 10.18)
Total Zooplankton	118.12 ± 28.77^c	121.31 ± 30.32^b	124.09 ± 28.13^a

Table 2: Average variation of phytoplankton and zooplankton population under different treatments (Figure in the same row having

Citation: Chakraborty BK, Haque SM (2014) Growth, Yield and Returns to Koi, *Anabas testudinous* (Bloch, 1792) under Semi-intensive Aquaculture System using Different Seed Types in Bangladesh. J Fisheries Livest Prod 2: 113. doi:10.4172/2332-2608.1000113

the same superscript are not significantly different (p>0.05). Figure in the parenthesis indicates the range)

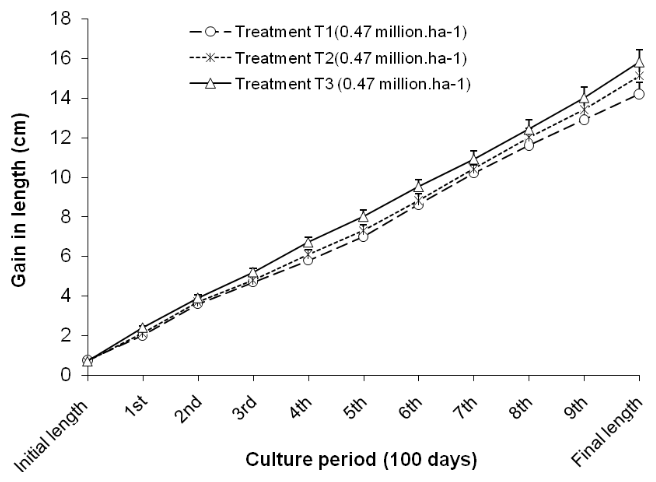

Figure 1: Mean length (cm) gain of *Anabas testudinous* after 100 days of rearing

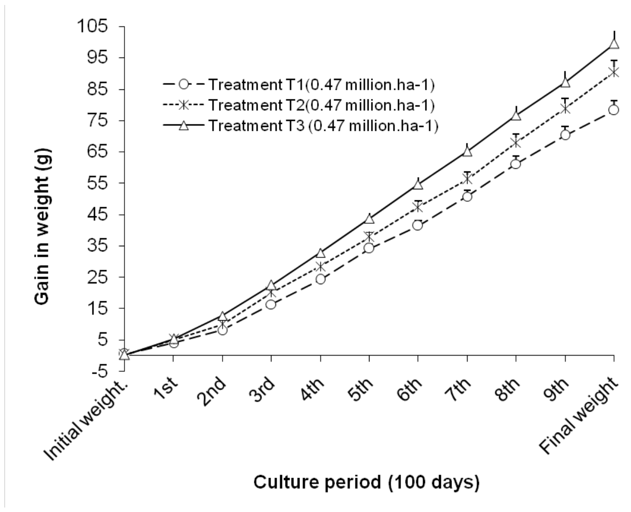

Figure 2: Mean weight (g) gain of *Anabas testudinous* after 100 days of rearing

The initial length and weight of fish, stocked in the treatment T_1 was 0.75 ± 0.01 cm and 0.50 ± 0.02 g, and treatment T_2 and T_3 were 0.70 ± 0.01 cm and 0.25 ± 0.01 g. It is evident from the data that the individual attained an average size of 15.80 ± 1.46 cm in length and 99.5 ± 4.81 g in weight in treatment T_3, stocking with Vietnami koi, while the fish attained an average size of 15.10 ± 1.66 cm in length and 90.05 ± 5.88 g in weight in T_2 stocking with hormone treated koi and 14.20 ± 1.61 cm in length, 78.25 ± 6.11 g in weight in T_1 with stocking normal koi. The growth in treatment T_2 stocking with hormone treated koi was higher than that of T_1 stocking with normal koi. This is clearly indicated that maximum growth in length and weight was attained in Vietnam koi than that of hormone treated koi (T_2) and normal koi (T_1). But lowest growth was recorded stocking with normal koi in treatment T_1.

The mean productions (kg.ha^{-1}) of koi fish were 22063.0, 19851.6 and 16381.2 kg in treatment T_3, $T_2$and T_1, respectively. Production was higher in treatment T_3 and lowest in treatment T_1. However, total production of Koi, *A. testudinous* differ significantly (p<0.05) among the three treatments (Table 3). On the other hand, cost of production in treatment T_3 was consistently higher than those treatments T_1 and T_2 (Table 4). Highest net benefit (Tk.ha^{-1}) was also recorded in treatment T_3 (1,43, 5501) followed by T_1 (1,24,9643) and T_2 (57,5449) in that order.

Parameters	Treatments		
	T_1	T_2	T_3
Initial length (cm)	0.75 ± 0.01 (0.68 - 0.79)	0.70 ± 0.01 (0.68 - 0.72)	0.70 ± 0.01 (0.68 - 0.72)
Final length (cm)	14.20 ± 1.68^a (13.88 - 15.10)	15.10 ± 1.66^c (14.0 - 16.1)	15. 80 ± 1.46^c (14.5 - 16.4)
Initial weight (g)	0.50 ± 0.08 (0.42 - 0.55)	0.25 ± 0.04 (0.21 - 0.28)	0.25 ± 0.04 (0.21 - 0.28)
Final weight (g)	78.25 ± 6.11^a (74.5 - 88.0)	90.5 ± 5.88^c (75.0 - 87.50)	99.5 ± 4.81^c (94.0 - 106.0)
Net weight gain (g)	77.75 ± 5.33^a (75.0 - 80.2)	89.80 ± 3.66^b (84.0 - 96.0)	99.25 ± 3.56^b (95.0 - 104.0)
Average daily growth (g)	0.78 ± 0.05^a (0.76 - 0.84)	0.81 ± 0.04^c (0.79 - 0.82)	0.99 ± 0.04^c (0.97 - 1.08)
Specific growth rate (SGR)	5.05 ± 0.22^a (4.80 - 5.02)	5.89 ± 0.16^c (5.95 - 6.21)	5.99 ± 0.16^c (5.95 - 6.21)
Condition Factor (K)	2.75 ± 0.16^b (2.65 - 2.80)	2.62 ± 0.18^c (2.59 - 2.64)	2.52 ± 0.12^a (2.88 - 2.92)
Survival rate (%)	85.30 ± 1.53^b (87.0 - 90.0)	89.50 ± 0.76^c (80.0 - 88.0)	90.00 ± 0.76^a (88.0 - 92.0)
FCR	2.02 ± 0.08^a (1.88 - 2.14)	2.02 ± 0.06^c (1.90 - 2.12)	2.04 ± 0.06^c (1.90 - 2.12)
Production (kg)#	16381.2 ± 106.12 (15308.0 - 17601.0)	19851.6 ± 104.07 (18801.0 - 20011.0)	22063.0 ± 104.57 (21888.0 - 22491.0)

Table 3: Growth performance, survival and production of *Anabas testudinous* after 100 days of rearing; mean ± S.D. with ranges in parentheses (Figure in the same row having the same superscript are not significantly different (p>0.05). Figure in the parenthesis indicates the range. # Total number of fishes harvested after 100 days)

Item	Amount TK.ha^{-1}. Day^{-100}			Remarks
	Treatment T_1 (Tk)	Treatment T_2 (Tk)	Treatment T_3 (Tk)	
Total return (TR)[b]	2293340	2977650	3530080	Price is related with size and weight
a. Variable cost: 1. Price of hatchlings	247000	247000	247000	
2. Feed (Tk. 28.00 kg^{-1})	1193808	1203924	1510496	
3. Lime & Fertilizer (Cowdung)	10992	10992	10992	
4. Human labour cost (Tk. 200 day^{-1})	50000	50000	60000	
5. Chemicals	40000	40000	40000	
6. Miscellaneous	50000	50000	100000	
Total Variable cost (TVC)	1591800	1601916	1968488	
b. Fixed cost : 1.Pond rental value (100 days)	6091	6091	6091	Tk. 150 dec^{-1}.yr.$^{-1}$ according to local area, Mymensingh rent.
2.Interest of operating capital	120000	120000	120000	10% interest of TK. 1200000 according to BKB, Bangladesh
Total fixed cost (TFC)	126091	126091	126091	
Total cost (TC= TVC+ TFC)	1717891	1728007	2094579	
Gross margin (GM= TR- TVC)	701540	1375734	1561592	
Net return (TR- TC)	575449	1249643	1435501	

Table 4: Cost and benefits from the culture practice of Koi, *Anabas testudinous* in 1-ha earthen ponds for a raring period of 100 days ([a]1 US$ =Tk. 70.00; BKB= Bangladesh Krishi Bank; Figures with different superscripts in the same row varied significantly ($p<0.05$). Figures in the parenthesis indicate range. [b]Sale price of fishes Tk. 140 kg^{-1} (T_1), Tk. 150 kg^{-1} & T_2) and Tk. 160 kg^{-1} (T_3))

Discussion

The environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organisms. Growth, feed efficacy and feed consumption of fish are normally governed by a few environmental factors [19]. The Physicochemical parameters, which included temperature, transparency, pH, oxygen, alkalinity, nitrate-nitrogen, nitrite-nitrogen, phosphate-phosphorus, ammonia-nitrogen and hardness of water, were found to be in suitable range for warm water fish culture [20]. The temperature of the experimental ponds was within the acceptable range for different treatments that agrees well with the findings of Haque et al. [21,22] and Kohinoor et al. [23]. Transparency was comparatively higher in treatment T_3, possibly due to the reduction of the plankton population by developing out let system of water and use of lime [20-22]. A suitable value of pH range was recorded during the period of investigation which is agreed by Dewan et al. [24], Hossain et al. [25], APHA [26], Kohinoor et al. [27] and Chakraborty et al. [28]. The dissolve oxygen in the morning was low down in the ponds of different treatment. Fluctuation of dissolve oxygen concentration in the ponds might be attributed to stop of photosynthetic activity in the night, and fish and other aquatic organisms used buffer stock of oxygen in the whole night. This phenomenon was observed by Boyd [29], Saha et al. [30], and Rahman and Rahman [31]. However the level of dissolve oxygen (DO) is within the acceptable range in all the experimental treatments due to develop water recycling method. pH values agree well with the findings of Kohinoor et al. [23], Rahman and Rahman [31] and Chakraborty [5]. Alkalinity levels indicate productivity of the ponds was medium to high [32]. Higher total alkalinity values might be due to higher amount of lime used during pond preparation and frequent liming during the experimental period [26,29,32]. The total hardness of the experimental ponds was suitable range which was similar to Kohinoor et al. [27]. The suitable range of nitrate-nitrogen and nitrite-nitrogen was recorded in the experimental ponds was more or less similar to these reported by Rahman [10] and Haque et al. [34]. The observed phosphate-phosphorus contents in water of the experimental ponds appeared to be within the acceptable range similar to those reported by Mollah and Haque [35], Rahman et al. [36] and Kohinoor et al. [27]. The tolerable range of ammonia-nitrogen was more or less similar than that reported by Dewan et al. [24], Ahmed [37], Haque et al. [34] and Kohinoor et al. [27].

The quantity of phytoplankton was higher in T_1 treatment where stocking with hormone treated F_1 generation and zooplankton was higher in treatment T_3, where stocking with F_2 generation. The phytoplankton abundances were consistently higher than that of zooplankton. Similar results were also recorded in various food fish rearing ponds [34,38-40]. Higher phytoplankton concentrations in pond water normally indicate higher productivity. But the higher abundance of phytoplankton compared to zooplankton might be due to excess uneaten feed. Because, climbing perch is not plankton feeder.

In this experiment, supplementary feeds are more or less similar to the supplementary feeds supplied for the growth of climbing parches. The crude protein levels (30.0% dry weight) in supplementary feeds were very near the dietary protein of 31% for the optimal growth of Labeo rohita [41]. Growth in terms of length, weight and weight gain of individuals was more or less similar in the different treatments where the stocking density was the same. De Silva and Davy [42] stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. Digestibility, in turn, depends on daily feeding rate, frequency of feeding, and type of food used [43,44]. However the FCR value in the present study indicates better food utilization efficiency, despite the values increased with applied stocking densities.

Growth in terms of length, weight, weight gain and SGR of Koi, *A. testudinous* was significantly higher in T_3 where the stocking density was same compared to those of T_1 and T_2 and same food was supplied in all the treatments at an equal ratio, which was agreed by Dan and Little, [45] and Mondal et al. [6]. There was a general decrease in FCR for normal koi than that of the hormone treated and Vietnam koi. Such observation may be related to the fact that FCR decrease with feeding rate and survivality of fish [46]. Vietnam koi increased the SGR and daily weight gain of the fish. Similar values of the individual for Vietnam koi as in the study were also observed by Diana et al. [47]. The FCR values of treatment T_3 was higher than that of T_2 and T_1. Chiu et al. [44] and De Silva and Davy [42] stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. Digestibility, in turn, depends on daily feeding rate, frequency of feeding, and type of food used. However the FCR values of different treatments indicate better food utilization efficiency, which is agreed by Das and Ray [44], Islam [48] and Islam et al. [49] During the experimental period, ecological factors, pond preparation, feed quality, quality healthy fry and fingerlings and stocking rate was influenced the high percentage of survival rate of fish [50]. It is found that higher survival was recorded in T_3 (Vietnam koi). The higher survival percentage of the Vietnam koi indicates that koi fishes have no adverse effect on the general health of the fish. Under the same feeding regime and stocking density, the variance in growth of *A. testudinous* between other culture methods may be due to dietary and exploitation differences, and stocked with normal population (T_1) and hormone treated (T_2) koi. Similar results were obtained by Tripathi et al. [51], Haque et al. [22], Kohinoor et al. [23], Rahman and Rahman [30] and Chakraborty et al. [52] for various carp and barb species.

In the present study, a significant higher production (22063.0 ± 104.57 kg.ha.day^{-100}) was recorded in treatment T_3 than those of treatment T_2 and T_1, respectively. Despite this, consistently higher net benefits (Tk. 1435501 ha.day^{-1}) were also obtained from treatment T_3 than those of treatment T_2 and T_1. The higher market price of the large size of fish produced in treatment T_3, where stocking with Vietnam Koi, substantially increased the net benefit compared to lower production that produced in other treatments T_2 and T_1. Overall, highest growth, survival, production and benefits were obtained with stocking density of Vietnam Koi where stocking density was 0.247 million.ha^{-1}. Growth of fish to a greater extent depended on the quality and quantity of food available. In the present investigation, the amount of supplementary feeds was given in different treatments based on the weight of fish stocked and amount of feed provided per fish was kept at the same level. Hence, the observed low growth at same stocking densities could be due to normal koi and hormone treated koi, variations in environmental parameters and developing water recycling method. The results in the present experiment are very similar to those of Saha et al. [30], Kohinoor et al. [23], Hossain [53], Rahman and Rahman [31] and Chakraborty et al. [40,52].

Finally, it can be concluded that the survival, growth and production of *A. testudinous* were related to the variety of different population of climbing parch stocking in different treatments. Production of adequate quality of Vietnami koi fish through application of present findings might be extremely helpful to meet up the demand of protein as daily ration and monoculture technology of Vietnam koi can be postulated as the ideal method of choice for an eco-socio-economically sustainable koi, *A. testudinous* culture in Bangladesh. But this monoculture technology is to be run if it is ensured supplying of high variety of Vietnam koi.

Acknowledgement

I wish to thank private hatchery and nursery owners who helped us for successfully conducting the experiments.

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