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Article

Culture and management techniques of Vietnamese Koi

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Abstract: The first time study approach about culture and management in Bangladesh was conducted to observe the induce breeding, nursing and rearing technique of Vietnam koi (*Anabas testudineus*) fish culture in fresh water farm in Mymensingh region, Bangladesh for a period of 120 days from May, 2013 to August, 2013. In this study, inducing agent PG was used to achieve fertilization and hatching success of climbing perch, *Anabas testudineus*. During induce breeding, male and female in a ratio of 1:1 were used. The females were given single injection of 6-8 mg PG/kg body weight and the males were given 2-3 mg PG/kg body weight and nursing and rearing of vietnam koi (*Anabas testudineus*) fish were carried out as monoculture in earthen ponds. In this study, two earthen ponds of 20 decimal with an average depth of 2.5 to 3 feet and two earthen ponds of 50 decimal with an average depth of 3 to 5 feet were used for nursing and rearing of Vietnam koi respectively. Nursing and rearing of Vietnam koi (*Anabas testudinus*) were carried out as monoculture in earthen ponds. The water temperature in the culture pond was ranged from 31.29±0.85 to 35.5±0.58 ^{0}C during nursing and rearing. The value of Dissolve Oxygen (DO) and pH was ranged from 6.20±0.41 to 5.0±0.71 mg/l and 7.8±0.62 to 7.1±0.47 respectively. The average weight of the fingerlings during stocking was 0.8g in nursery stage and 20g in rearing stage. Fingerlings were stocked at 1750 fish /decimal in the rearing pond. Fry in the nursing ponds were fed with Hatchery feed (powder) at the rate of 40-50% of their total body weight. Fingerlings in the rearing ponds were fed with Koi Starter and Koi Grower feed at the rate of 15-20% of their total body weight. The final average weight (g) of Vietnam koi was (0.8±0.08)g in nursery stage & (200.0±0.82)g in rearing stage. The Feed Conversion Ratio (FCR) of total artificial feed was 1.63. The survival rate of Vietnam koi fish was 70% and the net production was 167kg/decimal. The total benefit was 5,48,455.00 BDT. Benefit-cost ratio of this study was 1.43. Therefore, it could be concluded that nursing and rearing of Vietnam koi (*Anabas testudineus*) by using artificial feed under a monoculture system in the earthen ponds is potentially and economically feasible.

Keywords: culture techniques; management; Vietnamese Koi

1. Introduction

Bangladesh is one of the world's leading inland fisheries manufacturers with a production of 4134434 m. tones during 2015–2016, with total production from aquaculture of 2333352 m. tones during 2015-2016 (DoF, 2017). This sector contributing 3.00% of the total export earnings and 3.61% to the GDP. The contribution in GNP is 19567.90 crore taka, and contribution to agriculture sector is 24.41%. (DoF, 2017). Bangladesh is furnished with diversified natural fisheries resources. Different types of water bodies both inland and marine are present in

this country of these 200 species, 59 belong to 20 families that are commercially important, the majority of which are carps and catfish. There are also more than 40–50 small indigenous fish species which grow to a maximum length of 25 cm (Felts *et al*., 1996). In Bangladesh, aquaculture production systems are mainly extensive and extended extensive, with some semi-intensive and in very few cases intensive systems. Although the culture fishery contributes over 55 percent of inland fish production, it covers only about 11 percent of the total inland water resources (DoF, 2017). Polyculture of native and exotic carps is a popular technology used by many farmers throughout the country, in such systems pond preparation, species selection, stocking density, the application of feed, fertilizers, water exchange and proper husbandry are generally maintained. Induced breeding is a technique whereby ripe brood fishes are stimulated by treating them with inducing agents to breed in captivity. The stimulation promotes a timely release of eggs and milts from ripe broods. The technique of induced or artificial propagation of fish using pituitary hormone first came into light in 1934 in Brazil by Von Thering *et al.* although it was started experimentally in 1931. In Indian subcontinent, however, the technique of induced breeding was first attempted by Hamid Khan in 1937 with *Cirrhinus cirrhosus.* Koi fish (*Anabas testudineus*) is popular to the people as it is a very tasty and nutritious fish from the ancient time. Once upon a time koi fish found in a plenty in the canal, small rivers, swamp, inundation land of Bangladesh. This fish is also very precious nowadays. Koi fish is also known as *climbing perch, koi mach, anabas testudineus* etc. It is a local fish breed of Bangladesh. Koi fish is generally a freshwater fish. This fish can be found in small rivers, canal and swamp. Nowadays commercial koi fish farming in pond is very popular. In 2010, Vietnam koi was introduced in Bangladesh for culture purpose. The high growth rate and bigger size of Vietnam koi pursue the fish farmer enthusiastic for its artificial breeding and culture in Bangladesh (Hasan *et al.*, 2010). Therefore, culture of Vietnam koi is started to meet the consumers demand. The expansion of Vietnam koi culture results the demand of seed which gears the hatchery production. But, the consumers are not completely satisfied with the Vietnam koi as it lacks natural odor and taste. On the other hand, the growth rate of our native koi is slow taking more time to attain marketable size. Suitable water conditions for Vietnam koi are temperature 15-30°C, pH: 5.5–8.0, hardness: 36–447 ppm. Temperature may even play a part since many fish species are known to become more aggressive under warm conditions. Sexually active females are slightly larger and noticeably thicker-bodied than males, while males are darker in coloration and apparently develop tubercules on the pectoral fins when breeding. When in spawning condition males develop a reddish hue to the body, particularly on the pectoral and ventral fins and a blackish, diamond-shaped marking appears on the caudal peduncle, Females display only a faint reddish color while the caudal peduncle spot is oblong in shape and somewhat diffuse. Females also become rounded as they fill with eggs and exhibit a prominent bulge at the vent which is absent in males. Present study was conducted to achieve objectives, to increase production of Vietnam koi through scientifically improved nursing and rearing technique; to gain practical skills on induced breeding technique; to study the seed production technique of Vietnam koi through induced breeding; to gain practical experience of culture technique of Vietnam koi; to gain practical experience on nursing of Vietnam koi.

2. Materials and Methods

2.1. Study area

The experimental work was accomplished in the farm named Talukdar Fish Farm, Shambhuganj, Mymensingh as shown in Figure 1. Mostly they are prominent for culturing koi. The experiment was carried out during period of 21st April to 27th April, 2012.

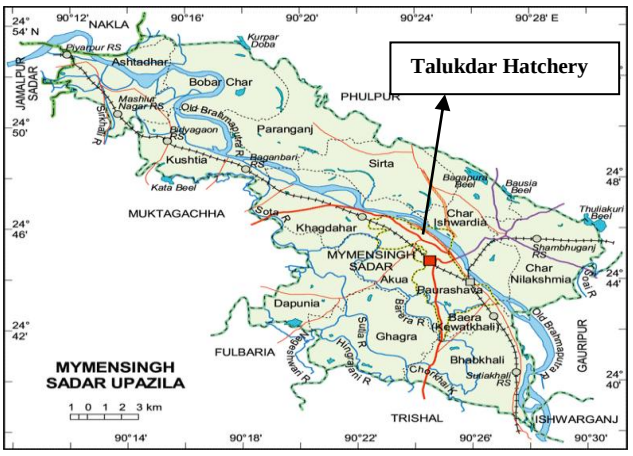

Figure 1. Map showing the geographical location of the study area.

2.2. Design of methodology

The present research work was a work on induce breeding, nursing and rearing of Vietnam koi fish culture started on May, 2013 and it was conducted in the ponds located in the Taukder Fish Farm from May, 2013 to September, 2013. The materials used and methodologies followed are described below:

2.2.1. Brood selection and conditioning

There are 100 brood fish were selected for breeding. Weights of female fishes are 3kg/ 25 pcs, 4kg/ 25pcs. Weights of male fishes are 1.5kg/ 25 pcs, 1.5kg/ 25 pcs. Broods are collected from the brood rearing ponds with a cast net at 5:00 pm on the day of breeding trails. Mature male and females from each source were selected and immediately transferred into the tank of hatchery. Male and female fish were kept separate tank and continuous water flow was maintained to ensure sufficient aeration.

2.2.2. Hormone Injecting of Vietnam koi

Mid February to July is suitable time for inducing Vietnam koi. Firstly, previously formulated PG extract was administered into the muscular basal part of the pectoral fin (Figure 2). After injection, both the males and females (about 100 fish) were shifted to breeding tank (1oft / 8ft) at 1:1 ratio which was provided with artificial aeration. The spawners were removed from the breeding tank after 7-8 hours when breeding activity was over.

Figure 2. Induce hormone Injection of Vietnam koi.

2.2.3. Period of spawning

Fishes were released eggs within 3 hours of injecting. All eggs were not released at a time. The spawners were removed from the spawning tank after 7-8 hours when breeding activity was over. The eggs of koi float on the surface of water (Figure 3). Fertilization periods were about 10 hours. The fertilization and hatching rate depends on parent's fitness. Fecundity rate about 20-30 thousand. The eggs of Vietnam koi float on the surface of water. After 18 hours enormous numbers of eggs were fertilized.

Figure 3. Fertilized eggs are floating (fertilized are darker).

Then 28 hours larvae release. Fertilization and hatching rate depends on fitness of parents. After 48 hours larvae goes down and unfertilized eggs remain. Then unfertilized eggs were collected by small meshed plastic basket.

2.2.4. Feeding

Finally 72 hours yolk sac was absorbed. Then 2 boiled egg yolk of duck was served for first feeding (Figure 4). Boiled egg yolk was blended, then mix with cyclop- EEZE and spreader out the breeding tank. First feeding was given at morning (10:30am) and afternoon (4:30pm). Feed was administered about four times before transferred to the nursery pond for nursing. Feed was administered about four times before transferred to the nursery pond for nursing by glass nylon.

Figure 4. Feeding administration onto the tank.

2.2.5. Stocking of fish fry in nursery pond and its management

Nursing can be done into two different ponds. After drying, liming and fencing watering needs to done up to 3 ft depth and 100 g flour/decimal is mixed with pond water. This flour results in growth of plenty of zooplankton which is very essential for fry. Water height of nursing pond is 2- 2.5 ft. After 7 days of hatching in tank, egg feeding should be stopped and flour mixed up need to provide and then use nursery feed (floating powder). Smallest koi fry were released into the nursery pond from the breeding tank 3-4 days later from spawning. Fry were stocked at 10000/decimal. In the present study 50 pair of brood gave 1.2 million and whole spawn were stocked in nursery pond. Feed was applied 3times/ day (morning, noon, evening). Flour and egg yolk are given first 5 days. After 2-3 days flour and nursery feed (3kg feed/ 1kg seed) were given. Nursing duration is 20- 22 days when fry become 5000 fry/ kg (each fry 0.2 gm).

2.2.6. Stocking of fingerlings in rearing pond and its management

After 20- 22 days of nursing fingerling were released into rearing pond. Stoking density is 800 (safe) - 2000(well managed)/ decimal. Two ponds were selected for rearing of Vietnam koi fingerlings. The perfect size of the rearing pond is 50-60 decimal. Ideal depth of the rearing pond is 3-6 feet. The areas of the selected two ponds were 50 decimal with 3-5 feet depth and 60 decimal with 3-6 feet depth respectively. In rearing pond first sampling was done after 7-10 days from release day of fingerlings into rearing pond. At that time fish became 1.5-2.0 g. Second sampling was done 13 days later and next 10 days later third sampling was done.

2.2.7. Feeding in culture pond

The stocked fish were fed with the prepared feed twice a day at the rate of 5% body weight and approximately two thirds of the total feed was provided at morning (9.00 am to 10.00 am.) and the rest of the ration at the afternoon (16.00 to 17.00 pm). And finally pellet feed are applied before marketing. Growth increase 10 gm/ month (1^{st} observation). And then 33gm/ month (2^{nd} observation). Duration of rearing depends upon farmers demand and market price.

2.2.8. Stocking of fish fry in culture pond

Rearing stage was done in 31-60 days. After that fish fry were released into the culture pond. Size of the culture pond is 50-60 decimal. In this stage artificial feed were supplied at the rate of 5-7% of the total body weight daily.

2.2.9. Disease problem
Only EUS (Epizootic Ulcerative Syndrome) is found that occurs in koi fish. EUS can also occur as a result of frequent netting. To prevent EUS salt is applied to pond water at the rate of 1 kg salt/decimal. Normally EUS occurs in winter season.

2.3. Methods for physical and chemical factors estimation
2.3.1. Transparency (cm)
The transparency of water was measured by a secchi disc of 20 cm in diameter. First the secchi disc was dipped into the water with the help of a measuring tape to the view of naked eye and then the length that was under the water was measured through the tape in cm.

2.3.2. Temperature (^oC)
Water temperature was recorded in the field with the help of a Celsius thermometer (1 div = 0.1^oC).

2.3.3. pH (Hydrogen ion concentration)
pH of pond water was determined by color comparative disc through HACH Test Kit (Model FF-2).

2.3.4. Dissolved oxygen (mg/l)
To determine the dissolved oxygen, water samples were collected in dark bottles and measured the amount of DO by using DO meter.

2.3.5. Nitrate and Ammonia (mg/l)
Nitrate and dissolved ammonia were measured by the Ammonia test kit of BIOVAC (Thailand) (Marketed by ACI Animal Health).

2.4. Other management
Liming, fertilizing, pulling horra and agitation of water were furnished when it was needed according to the existing situations of the experimental ponds. In case of excessive planktonic growth or bloom that might cause water quality deterioration, water exchange was done to maintain the quality parameters within suitable level. To discharge the toxic gases from the pond bottom, if any, horra was pulled in the bottom. If there were excessive gas and the water become foul-smelling due to using excessive food and fertilizer (especially rough food) then a medicine named zeolite or lime mixing with water was used after every 15 days.

2.5. Fish sampling
Fish sampling was done at an interval of 30 days (every 10th day of each month) to adjust the feeding rate by measuring the weight of fish, to observe the health condition and to keep the record of length and weight of fish. Length of fishes is measured, to the nearest cm, with a centimetre scale fitted to a wooden measuring board. Weight, to the nearest gram, is recorded by weight machine. After recording the length and weight of fishes they again were released to the respective ponds.

2.6. Growth study
2.6.1. Survival rate
Total number of fishes is counted species-wise and calculated the survivability of fishes as follows:

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

2.6.2. Specific growth rate (%SGR)
Specific growth rate (%SGR) is the instantaneous change of body of fish as the percent increase in body weight per month over a certain interval, which is measured as outlined by Brown (1957) as the following formula:

$$\%\ \text{SGR month} = \frac{\text{Log e}W_2 - \text{Log e}W_1}{T_2 - T_1} \times 100$$

Where,

W_1 = Initial body weight (g) at time T_1 (month)
W_2 =Final body weight (g) at time T_2 (month)

2.6.3. Average length and weight gain

Monthly record of length and weight of individual fish was kept at each sampling date from April 2012 to September 2012. Average growth in terms of length and weight increment of fish is calculated as follows:
Average length gain (cm) = Average final length (cm) - Average initial length (cm)
Average wt. gain (g) = Average final weight (g) - Average initial weight (g)
Average weight gain (g)/day at different months

$$= \frac{\text{Weight (g) in present month - Weight (g) in previous month}}{\text{Days of month}}$$

2.6.4. Feed conversion ratio (FCR)

Feed conversion ratio can be calculated by using the following formula:

$$\text{FCR} = \frac{\text{Total feed used}}{\text{Final body weight (g)} - \text{Initial body weight (g)}}$$

2.6.5. Cost and profitability analysis

For 1 year tenure there is no discount factor, hence benefit cost ratio should be,

$$\text{Benefit-cost ratio} = \frac{\text{Present value of benefit}}{\text{Present value of cost}}$$

2.7. Harvesting

Koi fish were cultivated in the above mentioned methods then they were suitable for collection and sale within 3-4 months. While collecting for sale each fish weights were about 40-80 grams. For selling purpose fishes were collected at dawn. Complete harvesting can be done by seine net. For koi, harvesting can be done in late night.

2.8. Marketing

Within 100-120 days marketing can be done. Feeding should be stopped at least 1 day before marketing. In July, koi is available. After 15 days, price fall continuously. Marketing channel of Talukdar fish farm are Shamvuganj bazaar, Mymensingh; Kawran bazar, Dhaka.

2.9. Data analysis

The gathered data were summarized and scrutinized consciously before actual tabulation. Some of the data were collected into local units and those data were converted into international units. After data entry, the data were analyzed by Microsoft Excel software.

3. Results

3.1. Induce breeding and seed production

Both male and female received single dose of PG. The best result was obtained by using 6-8 mg/kg female and 2-3 mg/kg male in respect of fertilization and hatching. Ovulation occurs after 7-8 hours of injection and after 18-20 hours of fertilization hatching occurs. Highest fertilization rate, hatching rate and survival rate were found around 85%, 80% and 70% respectively (Figure 5).

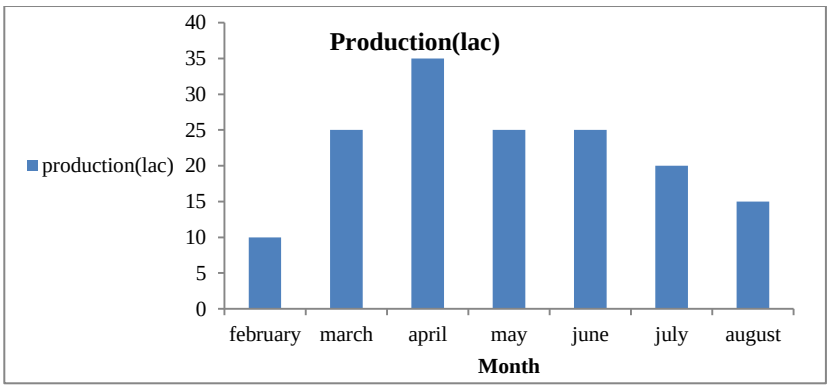

Figure 5. Month wise production of Vietnam koi fry.

3.2. Water quality parameters

The lowest water temperature (31.29±0.85^{0}C) was recorded in the month of August 2013 and the highest (35.5±0.58^{0}C) was recorded in June 2013. pH ranged from (8.01±0.62) to (7.17±0.71). The lowest value of pH (7.1±0.71) was found during July 2013 and the highest value of pH (8.01±0.62) was found during June 2013. The highest value of dissolved oxygen (6.20±0.41 mg/l) was found during June 2013 and the lowest value (5.0±0.71 mg/l) was found during August 2013. The water transparency was between (29.33±2.05 cm) to (4.67±0.62 cm) (Table 1).

Table 1. Monthly water quality parameters observed during culture period.

	May (Avg±SD)	June (Avg ±SD)	July (Avg ±SD)	August (Avg ±SD)
Temperature (^{0}C)	32.0±0.40	35.5±0.58	32.57±0.49	31.29±0.85
Dissolved Oxygen (mg/l)	6.07±0.82	6.20±0.41	5.17±0.63	5.0±0.71
Transparency (cm)	29.33±2.05	15.0±0.41	4.67±0.62	4.80±0.57
pH	7.8±0.12	8.01±0.62	7.1±0.71	7.5±0.47
NH_3	0.0	0.0	0.43±0.19	4.53±0.36

3.3. Feed application rate

In nursing stage, 270 kg Hatchery feed (powder) was supplied in about 9 kg per day for 30 days. Feed was applied according to body weight of fry. During nursing, feed was given at the rate of 40-50% of their total body weight. During rearing, feed was applied at the rate of 15-20% of their total body weight in initial stage. But at final stage, feed was applied at the rate of 2-3% of their total body weight. Feed Conversion Ratio (FCR) for artificial feed was 0.8 during nursing stage. But highest FCR value was 1.9 in the middle stage of rearing. At final stage, FCR value was 1.5. Total supplementary feed used for nursing and rearing was 23671 kg (Table 2). FCR for total supplementary feed was 1.63. Two stage nursing is more profitable because by this method uniform size of fry can be obtained. During culture proper growth was obtained by applying the following feeding schedule as 1st 10 days 50% of body weight (crumble); 2nd 10 days 30% of body weight (crumble); 3rd 10 days 20% of body weight (starter); 4th 10 days 15% of body weight (starter); 5th 10 days 10% of body weight (starter); 6th 10 days 5% of body weight (grower) and 7th 10 days 3% of body weight (grower) until marketing.

Table 2. Types of feed and feed application rate in different stages of Vietnam koi culture.

Culture stage	Nursing	Rearing			
Month	May	June	July	August	September
Types of feed	Hatchery Powder	Koi Nursery	Koi Starter	Koi Grower	
Artificial feed (kg)	480	1601	7300	11000	3500
Feeding rate (% of body wt)	40-50	15-20	8-10	4-5	2-3
FCR for artificial feed	0.8	1.8	1.9	1.7	1.5

3.4. Growth, production and survival rate of cultured Vietnam koi (*A. testudineus*)

The survival rate of Vietnam koi fish was 80%. Total production of Vietnam koi fish of this culture was 14000kg or 14 tons. Different growth parameters of Vietnam koi fish are given below in Table 3.

Table 3. Different growth parameters of Vietnam koi during culture period.

Culture stage	Nursing	Rearing			
Months	May	June	July	August	September
Average length (cm)	0.7mm	0.9	2.9	6.87	7.95
Average weight (g)	0.8±0.16	20.0±0.40	70.71±1.39	186.33±1.63	200.0±0.82
Average daily weight gain (g)/day	0.04±0.016	0.46±0.4	1.01±0.2	1.76±0.25	1.89±0.19
SGR (%)	7.89±0.16	6.35±1.17	2.5±0.38	1.29±0.49	0.8±.015
Mortality (pieces)	20000	2500	700	300	30
Survival rate (%)	92.21	97.87	99.3	99.73	99.97
Net production (kg/decimal)	2.23	167			

The average growth of fishes in weight (g), average weight gain (g/day) and specific growth rate (SGR %) at different months is shown in Figure 6, 7 and 8. Total 1, 75,000 pcs Vietnam koi fry were released in two culture

pond (87,000pcs fry in each pond) and total weight of fish fry (w/w) was 70.0kg. The initial average weight (g) of Vietnam koi fish was .005g in nursery stage and 0.4g in rearing stage while the final average weight (g) was (0.4±0.08)g in nursery stage & (100.0±0.82)g in rearing stage.

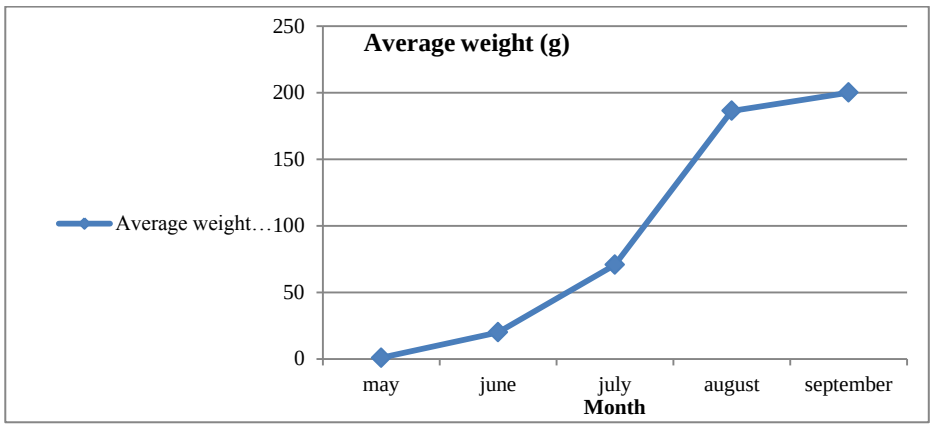

Figure 6. Observed average weight (g) during study period.

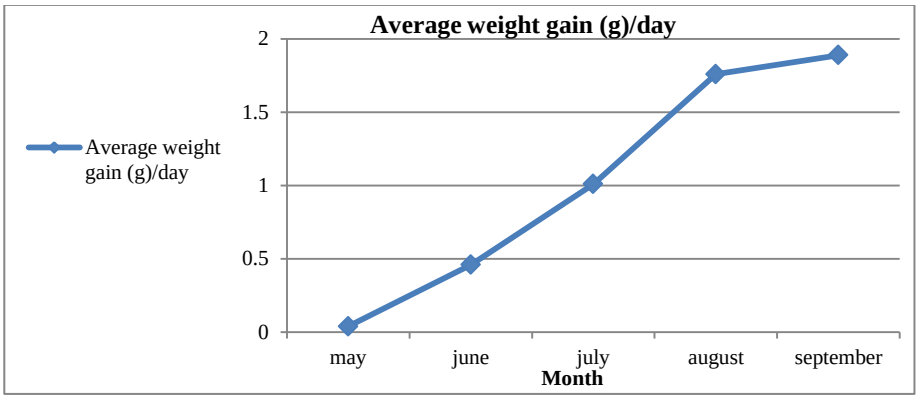

Figure 7. Observed average weight gain (g/day) during study period.

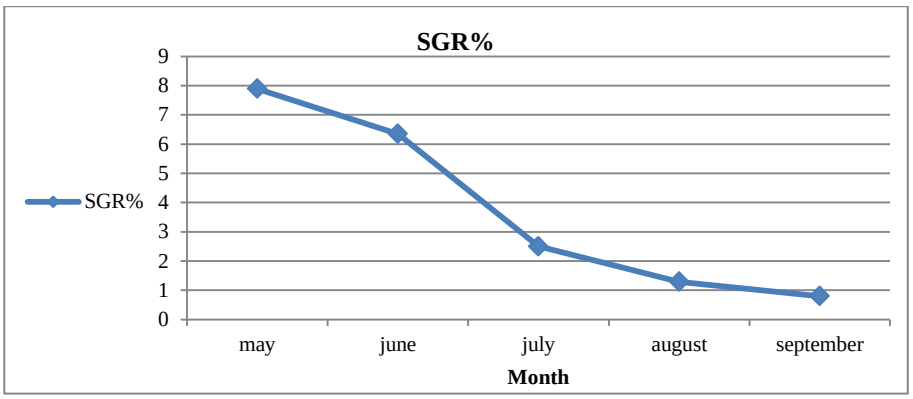

Figure 8. Observed specific growth rate (SGR%) during study period.

3.5. Cost and profitability analysis

There were different site of cost in the culture period of Vietnam koi. The total production cost of Vietnam koi was 12, 88,545.00 BDT, total income was 18, 37,000.00 BDT and benefit was 5, 48,455.00 BDT. Benefit-cost ratio was 1.43. Total cost of production & profitability are given in the Table 4.

Table 4. Cost and profitability analysis of Vietnam koi culture.

Expanses in production area	Amount	Cost(BDT)/unit	Total cost(BDT)
a. Management expanse			
1. Pond lease cost	(40+100) or 140 decimal	500.00/decimal	70,000.00
2. Labor cost (provides protection, feed supply, weed cleaning etc.)	1 person	5,000.00/month	20,000.00
3. Net dragging or doing horra (in every month)	3 times	150.00/time	450.00
4. Harvesting cost	1 time		5,500.00
5. Transportation and marketing			15,000.00
6. Water supply			7,000.00
7. Electricity			5,000.00
8. Others			700.00
Partial total			1,23,650.00
b. Cost of pond preparation			
1. Pond repair	10 labor	200.00/labor	2,000.00
2. Pond drying and removal of other fishes			1,500.00
3. Lime application	84 kg	12/kg	1,000.00
4. Fertilizer cost	200 kg	25/kg	5,000.00
5. Medicine			1,500.00
Partial total			10,200.00
c. Seed of Vietnam koi fish	1,75,000 piece	0.5/pc	87,500.00
d. Supplementary feed	23,671 kg	45.00/kg	10,65,195.00
e. Feed transportation and others			2,000.00
Total expanse (a+b+c+d+e)			12,88,545.00
Production & income			
i. Production of Vietnam koi fish (20% mortality rate and average wt of each fish)	16,700 kg	110.00/kg	18,37,000.00
Total income			18,37,000.00
Actual income (total income-total expanse)			5,48,455.00
Benefit-cost ratio			1.43

Total management cost of the farm was 1, 23,650 BDT. Cost of pond preparation was 10,200 BDT. A seed of Vietnam koi was collected from hatchery of this farm and the price of was 87,500 BDT at 0.50 BDT per piece. Supplementary feed cost was 10, 65,195 BDT at 45 BDT per kg feed in average. Here it is mentioned that the price of supplementary feed is different at different level of nursing and changes at different season.

4. Discussion

The higher and lower percentage of fertilized and hatching eggs is due to fluctuation temperature contributed by raining seasons during the study period of breeding. Highest fertilization rate, hatching rate and survival rate were found around 85%, 80% and 70% respectively which is more or less similar with the study of Ali *et al.*, 2016a; Ali *et al.*, 2016b; Islam *et al.* (2016); Islam *et al.* (2017a); Shabuj *et al.* (2016); Sharif and Asif, (2015); Yeasmin *et al.* (2016) and Rahman *et al.* (2017. Zhang *et al.* (1987) stated that physico-chemical parameters are largely determined by the pond size, depth, species density etc. Temperature is one of the most important water quality parameter that influences the growth, food intake, metabolism, reproduction and other biological activities of aquatic organisms. Water temperature varies with solar radiation, season, time of day, geographical position, water depth, meteorological condition etc. (Rahman, 1992). In the present study, the water temperature ranged from 31.0 to 35.0 ^{0}C in the culture pond. The result is more or less similar to Rahman (2005) and Kunda *et al.* (2008) who recorded temperature ranges from 26.0 to 35.0 ^{0}C and 22.0 to 34.0 ^{0}C, respectively. However, Ali *et al*. (2004) and Alim (2005) recorded temperature ranged from 22 to 29.5 ^{0}C and 17 to 33.5 ^{0}C, respectively which are slightly lower than the present study. This may be due to the variation in culture periods. The study of water temperature was conducted by Asif *et al.* (2014); Islam *et al.* (2017b); Vaumik *et al.* (2017); Asif *et al.* (2017); Akter *et al.* (2016) and Zaman *et al.* (2017). Their result is also 20^{0}C to 34^{0}C which is similar with the result of present study. Dissolved Oxygen (DO) in the present study was found to vary from 5.0±0.71

to 6.20±0.41 mg/l in the culture pond. The concentration of dissolved oxygen in the present study was also similar to the findings of Alam *et al.* (1997), Ahmed (2003), Ali *et al.* (2004) and Asaduzzaman (2005) who recorded dissolved oxygen ranged from 4.0 to 7.0, 2.0 to 7.04, 3.4 to 8.1, 4.3 to 6.9 and 1.2 to 7.2 mg/l, respectively. Zafar *et al.* (2017) and Shajib *et al.* (2017) found the similar results. Most water bodies have pH within the range of 6.5 to 8.5. The circum-neutral pH or slightly alkaline pH is most suitable for fish culture. An acidic pH reduces the growth rate, metabolic rate and other physiological activities of fish (Swingle, 1967). pH 6.5 to 9.0 is suitable for pond fish culture and pH more than 9.5 is unsuitable because free CO_2 is not available in this situation. Fish becomes easily attacked parasites and diseases when pH is less than 6.5 and at pH 11 fish dies. In the present study, pH was found to fluctuate from 7.1±0.71 to 8.01±0.62 and considered as suitable range for fish culture. The pH value recorded from the experiment agreed with the findings of Ahmed (2004), Ali *et al.* (2004), Asaduzzaman (2005) and Asaduzzaman *et al.* (2006) who found the ranges of pH from 6.3 to 8.9, 7.55 to 7.84, 7.05 to 7.72 and 7.51 to 7.91, respectively. In the study of Zafar *et al.* (2017) and Shajib *et al.*, (2017) also revealed that 7.8 and 7.6 as their culture pH respectively. Transparency of a water body may be affected by several factors such as suspended organic matter, microscopic organisms, silting, latitude, season, the angle and intensity of entering light (Reid, 1964; Jhingran, 1976). In the present study, transparency was recorded from 4.67±0.62 to 29.33±2.05 cm which assumed to be the suitable level. Boyd (1982) indicated that 15 to 40 cm transparency range is good for fish culture. Wahab *et al.* (1995) suggested that the transparency of productive water should be 40 cm or less. Asif *et al.* (2014) revealed that, transparency should retain 25-35 cm.
Recent studies suggest that both ammonia and ammonium (NH_4^+) ion may be toxic, but ammonia is much more toxic than ammonium (NH_4^+) ion. The total Ammonia (NH_3) concentration was found to vary from 0.0 to 4.53±0.36 mg/l during the study period which is higher than Rahman (2005) and Asaduzzaman *et al.* (2006) who recorded ammonia-nitrogen value ranged from 0.01 to 0.82 and 0.203 to 0.569 mg/l, respectively because good amount of artificial feed were used in the culture pond and also higher than Asaduzzaman (2005) who recorded ammonia- nitrogen value ranged from 0.268 to 0.327 and 0.160 to 0.230 mg/l, respectively in BAU campus. Chen (1988) found that lower than 1 mg/l of NH_3 gas content in pond was good for fish culture. However, he concluded that the permissible level was higher than the value of 0.012 mg/l commonly accepted by fish culturists. Growth in terms of length, weight and survival of Vietnam koi (*Anabus testudinus*) was significantly higher in this nursing and rearing period. In the present study, the stocking density was 1750 fingerlings/decimal during rearing of Vietnam koi. This might be due to competition for food and space in higher density. The result of the present study is similar with the findings of Ali *et al.* (2016c); Hossain *et al.* (2016); Haq *et al.* (2017); Rahman *et al.* (2015); Zafar *et al.* (2017); Shajib *et al.* (2017) and Zaman *et al.* (2017); Haque *et al.* (1994), Mollah *et al.* (1998), Islam (2002), and Rahman *et al.* (2005). Availability of quality feed is the vital factors that affect commercial fish culture. In the present study, Koi Starter and Koi Grower feed were used which contain 33% and 28% of protein respectively. Growth and production in fish culture are generally dependent on the daily feed consumption, qualities of feed and feeding frequency (Mookerjee and Mazumdar, 1946). In the present study, maximum average weight was 200.0±0.82 g obtained from the fingerlings fed with Koi Grower feed containing 28% protein. The observed result is in agreement with the report of Sangrattanakhul (1989) in which he estimated required dietary protein level for climbing perch ranged from 35-45%. Mookerjee *et al*. (1946) tested the performance of different diets containing 30, 34.7, 39.5, 44.1 and 48.9% protein in dry weight basis and reported that 39.5% protein is optimum in diet for commercial rearing of Vietnam koi. Doolgindachabaporn (1994) also recommended that the feed containing 38.6% protein as the best feed formula in term of growth and survival for Vietnam koi fry. In this study, the average daily weight gain were ranged from 0.04±0.016 to 1.89±0.19 g/day which is more or less similar to Ray *et al*. (1989) who found that climbing perch can achieve a rate of growth from 0.5 to 0.9 g/day when culture in earthen pond. The studied result is in agreement with the report of Haq *et al.* (2017); Rahman *et al.* (2015); Zafar *et al.* (2017); Shajib *et al.* (2017) and Sangrattanakhul (1989) reported that the average daily weight gain of *A. testudincus* fish ranging from 0.10 to 0.12g/day. The SGR values of Vietnam koi ranged from 0.8±.015 to 7.89±0.16% in this study. It is evident from the results of SGR values that, with the increase of age the values of SGR decrease. In this study, the FCR value was 1.63 which is more or less similar to Ali *et al.* (2016c); Hossain *et al.* (2016); Haq *et al.* (2017); Zaman *et al.* (2017) and Doolgindachabaporn, (1994) who found that the FCR value of *A. testudineus* ranges from 1.8-3.0. Potongkam (1972) reported that FCR of climbing perch fed on trash fish and pellet were 2.07 and 1.89, respectively. Yakupitiyage (1998) recommended that FCR of climbing perch fed on pellet feed ranging from 1.2-2.5 which is more or less similar to the result of the present study. Present study shows survival rate of *A.testudinus* was 85% which is similar with Noor (2005) who found that survival rate of Vietnam koi (*A. testudinus)* was 81.67% in her 50 days experiment with handmade feed. Productions (gross and net) of Vietnam koi *(A. testudinus)* found in this study were 14000 kg and 140 kg/decimal. Akhteruzzaman *et*

al. (1996) observed that under the monoculture condition, the production of *Puntius sarana* was 1200 kg ha^{-1} for 6 months. In the present study, an economic analysis was performed to estimate the net profit from nursing and rearing of Vietnam koi *(A. testudinus)*. The findings came up from the study that the production of Vietnam koi *(A. testudinus)* was 167 kg/decimal and per decimal total return was 18,370 BDT for the culture period. Cost of production was 12885.45 BDT per decimal and the Benefit Cost Ratio (BCR) was 1.35. So, nursing and rearing of Vietnam koi was profitable. Cost of fingerling, labor cost, feed cost, fertilizers and chemicals cost and culture period included in the profit frontier had a significant influence on profit of Vietnam koi culture in this study. Hasan *et al* (2010) found BCR for Vietnam koi culture was 1.08 in his study which is more or less similar to the present study. Rahman *et al.* (2017) found BCR 2.87 which is more or less similar with the present study. Rahman (2005) observed the BCR of Tilapia culture was 1.25 in his study of Profit efficiency of Tilapia monoculture in Trishal upozila of Mymensingh district. The production as well as economic return obtained was very encouraging and the Vietnam Koi (*A. testudineus*) culture would add an extra in such way that farmer especially in northern Bangladesh may get a chance to consume them readily than them to the market. Only EUS (Epizootic Ulcerative Syndrome) is found that occurs in koi fish. EUS can also occur as a result of frequent netting. To prevent EUS salt is applied to pond water at the rate of 1 kg salt/decimal. Normally EUS occurs in winter season. Some disease study mentioned different disease outbreak in koi culture, Chowdhury *et al.* (2015); Neowajh *et al.* (2017); Rahman *et al.* (2017); Shabuj *et al.* (2016); Yeasmin *et al.* (2016) stated disease, diagnosis procedure and treatment of disease.

5. Conclusions

This study was undertaken with a view to understand culture potentialities of vietnam koi culture in Bangladesh. Considering the different observations during the present study in mymensing was found to be potential area for Vietnam koi culture, The result of present study clearly indicate that farmers can make profit from fish culture and pond fish production can be increased by improving the production technology in existing ponds. The meteorological and hydrological conditions are suitable for the culture of this fish species. Vietnam koi fish culture is socially and economically feasible. Biologically productive natural waters with controlled weed growth and rich phytoplankton, zooplankton and macro invertebrate fauna would be ideally suited for the growth of Vietnam koi fish. The results of the current experiment suggest that Vietnam koi fish (*Anabas testudineus)* is *a* suitable and potential species for small scale fish farmers and commercial culture. It may be suggested that more emphasis should be given to develop the culture technique of fish and popularize it all over the country, because of the fact that the first and foremost prerequisite for successful intensive fish cultivation and development of Inland Fisheries is proper management. The culture is socially and economically feasible.

Conflict of interest

None to declare.

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