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Evaluation of production performances of Koi (*A. testudineus*), with Shing (*H. fossilis*) and GIFT Tilapia (*O. niloticus*) in semi-intensive culture management

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Abstract
Production potential of Koi (*Anabas testudineus*) with Shing (*Heteropneustes fossilis*) and GIFT Tilapia (*Oreochromis niloticus*), an experiment was carried out for a period of four months from March to June 2013 at Dohakhola village in Gouripur upazila under Mymensingh districts in six farmers' ponds having an area of 600-800 m^2 each. The stocking density of Koi was same in all treatments, but Shing and GIF tilapia density were varied in different treatments. Fingerlings of Koi were stocked at the rate of 125,000/ha in all three treatments. Shing were stocked 37500, 32500 and 27500/ha in treatments-I, II and III, respectively. In addition, monosex GIF Tilapia was also stocked 5000, 10000 and 15000 in treatments-I, II and III, respectively. In all the treatments, the fish were fed with pelleted feed (30% crude protein) at the rate of 5-20% of estimated body weight. All ponds were completely harvested after four months of rearing, first by seine netting followed by draining out of the ponds. Koi reached at an average final weight of 140.10 ±5.60, 132.66±5.11 and 129.73± 4.07g in treatments-I, II and III, respectively. The final weights of Shing were 32.47 ± 7.11g in treatment-I, 35.40±6.59 and 37.51± 6.95g in treatment-II and III. Relatively, identical growth of monosex GIFT tilapia in terms of weight was attained in all the treatments. It grew to an average weight of 210±9.75, 208±7.51 and 206±6.21g in treatments-I, II, and III, respectively. The survival rates of various species in three treatments were fairly high. The survival rate of Koi, Shing and monosex GIF tilapia were ranged from 82-88, 72-79 and 87-94%, respectively. The gross production of fish in three treatments was calculated from the growth and survival of each fish species. The highest gross production of 17995 kg/ha were obtained in treatment-I and the lowest of 16805 kg/ha in treatment-II.

Keywords: Koi, shing, GIFT tilapia, growth, production

1. Introduction
The climbing perch (*Anabas testudineus*), locally known as koi, is an important favourite small indigenous fish of Bangladesh. It inhabits in paddy fields, haors, ponds, swamps, marshes and canals. It can withstand harsh environmental conditions such as low oxygen, wide range of temperature and other poor water conditions [1]. The fish contain high values of physiologically available iron and copper essentially needed for hemoglobin synthesis [2]. In late 1980s, the catches of the fish have drastically declined from open waters due to various ecological changes in inland water bodies. The fish is now sold at an exorbitant price in the market. Keeping these in view, seed production technology through artificial propagation was developed in captive condition by the Bangladesh Fisheries Research Institute. But in culture aspects, the growth rate of native strain is very slow in ponds ecosystem [3]. Its slow growth and small size does not favor sustainable production per unit area in a culture system. To overcome this situation, another fast growing climbing perch known as Thai Koi and Vietnamese Koi (*Anabas testudineus*) strain has been introduced from Thailand and Vietnam in 2002 and 2010, respectively. These two strains have some special characteristics such as faster growth rate, shorter culture period, higher survival rate etc. Seed production through artificial propagation technique has been developed. Last couple of years, farmers is growing Vietnamese Koi and obtained good production as well as handsome profit within 3-4 months. But in recent years, farmers are not getting so much profit from Vietnamese Koi in grow-out system due to costly feed and low market price. Under these circumstances, farmers are looking for alternative species to culture in their farms to maximize the production as well as profit. Among the available farmed species, Shing & GIFT tilapia are the suitable species for

polyculture with Koi due to their desirable characteristics and high market price. So, the proposed research trial was under taken to optimize the suitable stocking density of Vietnamese Koi with Shing and GIFT tilapia at on-farm management.

2. Materials and Methods

2.1 Description of the study area and pond

The experiment was carried out for a period of four months from March to June 2013 in six farmer's pond having an area of 400 m^2 at Dohakhola village in Gouripur upazila under Mymensingh district. Ponds were primarily rain fed, well exposed to sunlight and without inlet or outlet but had facilities to provide water as and when needed from a deep tube-well using a flexible plastic pipe.

2.2 Pond preparation

Before starting the experiment, ponds were drained to eradicate all fishes, embankments were repaired. Later, the dried ponds were left exposed to sunlight for several days, then pond bottom were treated with bleaching powder at the rate of 5.0 kg/ha and left for five days. After five days, underground water was supplied from deep tube well to the ponds and filled up to the depth of 1 meter.

2.3 Experimental design

The experiment consisted of three treatments with three replications. Three stocking densities of Shing and tilapia were tested keeping the Koi stocking density similar. Each stocking density of Shing and tilapia were considered as treatment and replicated thrice. Fingerlings of Shing were stocked at the rate of 37500, 32500 and 27500/ha in treatments-1, 2 and 3, respectively while tilapia stocked at the rate of 5000, 10000 and 15000/ha in treatments-I, II and III, respectively. In all the treatments, Koi was stocked at the rate of 125000/ha. Design of experiment is shown in Table 1.

Table 1: Stocking density and species combination of fish under different treatments

Treatment	Fish species/ha			Total
	Koi	Shing	Mono sex GIFT Tilapia	
T-1	1,25,000	37,500	5000	1,67,500
T-2	1,25,000	32,500	10,000	1,67,500
T-3	1,25,000	27,500	15,000	1,67,500

2.4 Source of Fingerlings

The fingerlings of Koi (*A. testudineus*) and mono sex GIFT Tilapia (*O. niloticus*) were used in this experiment were produced in Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh. The size ranges of fingerlings of Koi and GIFT were 1.06-1.14g and 4.70-4.95g, respectively. Another species, Shing (*H. fossilis*) was collected from the Authentic Fish Hatchery, Shikarikanda, Mymensingh sadar, Mymensingh.

2.5 Fish stocking and Management

The fingerlings were stocked in the ponds according to experimental design on 01 April 2015. After stocking, in order to meet up the increasing dietary demand, commercial fish feed named Mega Fish feed (starter-1 and 2) containing 30% crude protein were applied as supplementary feed at the rate of 5-20% of standing biomass of fish twice daily at 9:00 am and 4:00 pm. Proximate composition of the feed was determined following the standard methods [4] in the Feed and Nutrition Laboratory of Freshwater Station, Bangladesh Fisheries Research institute, Mymensingh. The amount of feed was adjusted weekly on the basis of sampling of experimental fish. The proximate composition of the feed is shown in Table 2. Besides this, lime and table salt was applied in all the ponds at the rate of 25 and 100 kg/ha, respectively at fortnightly interval.

Table 2: Proximate analyses of the feed used (% dry mater basis)

Dry mater	Protein	Lipid	Ash	Crude fiber
81.10	30.00	3.11	18.20	10.10

2.6 Fish sampling

From each pond, random samples of 50 individuals of each species were sampled fortnightly by using a seine net. Individual weight of each species was measured by using a portable balance (Tanita, Japan; accuracy 1g). After recording weight, the fish were released again in the respective pond.

2.7 Water sampling and analysis

Physico-chemical parameters of pond water were monitored weekly between 09.00 and 10.00 h. Water Temperature (°C) and dissolved oxygen (mg/l) were determined directly by a portable digital water quality analyzer (HQ 40d)), pH by a digital pH meter (MI 150, Martini Instrument) and transparency (cm) by a Secchi disc. Total alkalinity was measured following the standard methods [5, 6]. While ammonia-nitrogen (mg/l) was measured using a high precision HACH Kit (DR 1900).

2.8 Harvesting of fish

At the end of the experiment, the fishes were harvested, first by seine netting and then by draining out of the ponds. The harvested fishes were counted and weight was recorded to find out the survival rate and production, respectively. Specific growth rate was estimated as:

SGR (% bw d^{-1}) = [in (final weight) – In (initial weight)]/culture period (days) ×100

2.9 Data analysis

For statistical analysis, ANOVA and DMRT were mostly applied [7]. Data were analysed using the statistical package, STATGRAPHICS version 7. ANOVA was performed on all the dependent variables to see whether the treatment had any significant effect or not.

3. Results and Discussion

During the trial period, results of the study on the growth performance, survival rate, fish biomass, water quality parameter and all other aspects as recorded are presented.

3.1 Water Quality Parameters

Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of natural food organisms. Growth, feed efficiency and feed consumption of fish are normally governed by a few environmental factors [8, 9]. Mean values of physico-chemical parameters over the 4 months rearing of Koi with Shing and

tilapia are presented in Table 3.

Physico-chemical and biological environment of a water body mostly influenced by water temperature which one of the most important physical factors. Temperature varied from 23.60 to 33.40°C with means of 28.70±2.72°C, 28.81 ±2.71°C and 28.76 ±2.68°C in T-1 and T-2, respectively. Temperature difference among the treatments was not significant (P>0.05) and were within the suitable range of growth of fish in tropical ponds [10-14] reported that the range of water temperature from 26.06 to 31.97 °C is suitable for fish culture [15].

Table 3: Water quality parameters (mean ±SE) of the ponds under different treatments

Parameter	Treatment-1	Treatment-2	Treatment-3
Temperature (°C)	28.70±2.72[a]	28.81 ±2.71 [a]	28.76 ±2.68 [a]
Transparency (cm)	26.87±2.90 [a]	30.31±3.44 [b]	35.31±3.53 [c]
pH range	7.84±0.52 [a]	7.78±0.40 [a]	7.89±0.43 [a]
Dissolved oxygen (mg/L)	5.60±0.61 [a]	5.31±0.81 [a]	5.06±0.56 [a]
Total Alkalinity (mg/L)	148.75±12.35[a]	143.31±15.05[a]	136.94±16.43[a]
Ammonia-nitrogen (mg/L)	0.10±0.034 [a]	0.08-0.02 [a]	0.09-0.03 [a]

* Dissimilar superscript indicates significant difference at 5% level of probability

Transparency readings varied between 23 and 40 cm when all ponds and sampling times were considered. It varied among the treatments with an average of 26.87±2.90, 30.31±3.44 and 35.31±3.53 cm in treatments-1, 2 and 3, respectively. These readings were significant (P<0.05), when compared using ANOVA. The values of transparency sometimes varied with sampling dates which could be due to differences in abundances in abundance of plankton. Transparency between 15-40 cm as appropriate for fish culture [15]. Transparency values were lower in all the treatments. This might be due to stocking of monosex GIFT strain because tilapia is an omnivorous in nature and consumed plankton from the ponds. So, that the values were varied among the treatments.

The concentration of pH plays a crucial role on the productivity of the water body. pH values of pond water under three treatments were found to be alkaline. It varied from 7.10 to 8.40 with treatment means of 7.84±0.52, 7.78±0.40 and 7.89±0.43, respectively, and these results were not statistically significant (P<0.05). During the study period, the pH values of pond water under different treatments were found to be alkaline. A pH range 7.12-8.90 in fish ponds located in Gouripur, Mymensingh [14]. The observed pH values of water ranging from 7.1-8.9 indicated that the experimental ponds were suitable for fish culture [15].

The dissolved oxygen concentration in treatments-1, 2 and 3 were 5.60±0.61, 5.31±0.81 and 5.06±0.56 mg/L, respectively but there was no significant (P>0.05) difference among the treatments. Kohinoor *et al.* (2007) observed dissolved oxygen values of 4.12 to 6.80 mg/L [16], whereas, Chakraborty and Nur (2012) recorded dissolved oxygen values ranging from 3.80 to 6.12 mg/L [12]. In another study, also recorded dissolved oxygen ranging from 5.91 to 6.03 mg/L during their experiment in farmers pond [14]. Although fish might have survive in 0.50 mg/l dissolved oxygen concentration but most suitable range of DO in a water body for fish culture was suggested from 5.0-8.0 mg/L [17].

The values of total alkalinity were found 130 to 174, 109-165 and 113 to 160 mg L^{-1} with mean values of 148.75±12.35, 143.31±15.05 and 136.94±16.43 mg L^{-1} in treatments-1, 2 and 3, respectively. When the results of all ponds collected over the entire experimental periods were compared, there was no significant difference. Higher total alkalinity level in the ponds of three treatments might be due to regular application of lime at fortnightly interval. The variations in total alkalinity in all the treatments were found in productive range for aquaculture ponds [15, 18, 12, 14].

Ammonia-nitrogen is toxic to fish and above a certain level it can cause fish mortality. The mean values of ammonia-nitrogen were 0.106±0.03, 0.085±0.02 and 0.091±0.03mg/L in treatments-1, 2 and 2, respectively. The highest ammonia-nitrogen value was 0.15 in the month of June in T-2 and the lowest value 0.03 in the month of March in T-3. The differences among treatments were not significant (P>0.05) when compared using ANOVA. Kohinoor *et al*. (2016) recorded ammonia-nitrogen values ranged from 0.05-0.85 mg/l in a study of climbing perch culture in farmers pond [14]. The suitable range of ammonia-nitrogen in fish culture less than 0.1 mg/l [15]. In the present experiment, ammonia-nitrogen content were higher that might be due to higher stocking density in all the treatments.

3.2 Growth and Production

For reporting the growth performance, only weight was considered along with other yield parameters. Yield parameters of different fish species, FCR, SGR and survival are presented in Table 4.

It was observed that among the species under three treatments, Koi reached an average weight of 140.10 ±5.60g in treatment-1, 132.66±5.11g in treatment-2 and 129.73± 4.07g in treatment-3, respectively. Koi was found to distinct variation in weight gain. When compared, the harvesting weight of Koi was significantly higher (P<0.05) in treatment-1 than those of treatments-2 and 3 (Table 4). Though the stocking density of Koi in all the treatments was same but the harvesting weight was not identical because, in all the treatments monosex GIFT tilapia was stocked in various densities. The average harvesting weight of Koi was high in treatment-1 where the stocking density of Mono sex GIFT tilapia was low. The lowest average harvesting weight of Koi was observed in treatment-3 where monosex GIFT tilapia stocked at higher stocking densities. The harvesting weight of Koi in all the treatments were found to be inversely correlated with stocking density of Mono sex GIFT tilapia (Table 4). The relationship were very highly significant (P<0.001).

Growth of Shing narrowly varied in different treatments. The harvesting weights of Shing in treatments-1, 2 and 3 were 32.47±7.11, 35.40±6.59 and 37.51± 6.95g, respectively. The mean harvesting weights of shing in different treatments were not significantly different (P<0.05). The highest weight gain in treatment-3 and lowest in treatment-1.

Relatively, identical growth of monosex GIFT tilapia in terms of weight was attained in all the treatments. It grew to an average harvesting weight of 210±9.75g, 208±7.51 and 206± 6.21g in treatments-1, 2, and 3, respectively. The values of mean harvesting weight were compared using ANOVA and no significant difference was found. Figure 1 shows the

performance of the three treatments and the relative contribution of each species in each treatment to the total production of fish. It is clear from Fig. 1 that in treatment-1, the contribution of GIFT tilapia and Shing in total production was 11.25%, while in treatment-2 and treatment-3 were 15.65% and 18.98%, respectively.

The SGR (% per day) of Vietnamese Koi was found 3.93, 3.92 and 3.94 in Treatments-1, 2 and 3, respectively. There was no significant difference (P>0.05) of SGR (%/day) observed among the treatments. When the SGR of Shing and GIFT tilapia were compared, these values did not vary significantly. In treatment-3, Shing showed higher SGR than treatments-1 and 2. Similarly, GIFT tilapia showed a higher SGR in treatment-1 than in treatments-2 and 3 are presented in Table-4.

Based on the number of fish harvested at the end of the experiment, survival ranged from 76 to 94%. The survival rate of Koi, Shing and monosex GIFT tilapia were ranged from 82-88, 72-79 and 87-94%, respectively. There was an inter-specific variability, Shing showed lower performance of survival among the species. There was no noticeable variation in survival of different species among the treatments.

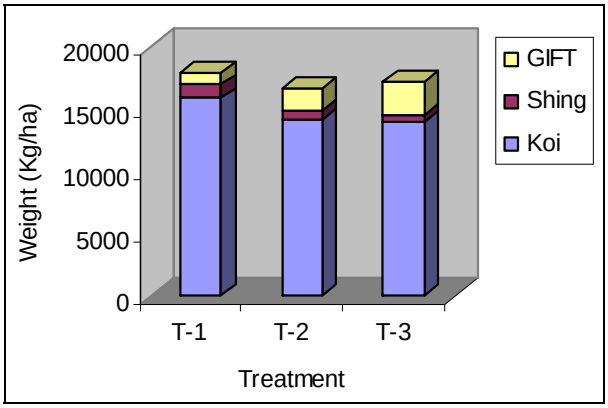

Fig 1: Production of fish and relative contribution of different species n three treatments

Table 4: Harvesting Weight, SGR, Survival and Production of Fish under different treatments

Treat.	Fish sp.	Stocking /dec.	Harvesting Wt. (g)	Survival (%)	SGR (%/day)	Sp. Wise Prod./dec.	Total Prod.
T-1	Koi	500	140.10 ±5.60 [a]	85	3.93	63.8	17995[a]
	Shing	150	32.47 ± 7.11 [a]	72	2.26	4.28	
	GIFT	20	210±9.75 [a]	94	3.15	3.90	
T-2	Koi	500	132.66±5.11 [b]	82	3.92	56.70	16805[a]
	Shing	130	35.40±6.59 [a]	76	2.28	3.28	
	GIFT	40	208±7.51 [a]	90	3.12	7.24	
T-3	Koi	500	129.73± 4.07 [b]	88	3.94	56.10	17310[a]
	Shing	110	37.51 ± 6.95 [a]	79	2.31	2.35	
	GIFT	60	206± 6.21 [a]	87	3.15	10.79	

At the end of the experiment, the mean gross production of fish were 17995, 16805 and 17310 kg/ha in treatments-1, 2 and 3, respectively. Production was highest in treatment-1 and lowest in treatment-2. The mean production in each treatment were further analysed by using ANOVA. It was observed that production of fish did not show any significant difference among the treatments. The highest production was found in treatment-1 which followed by treatment-3 and treatment-2. The total production scenario in different treatments is shown in Fig. 2.

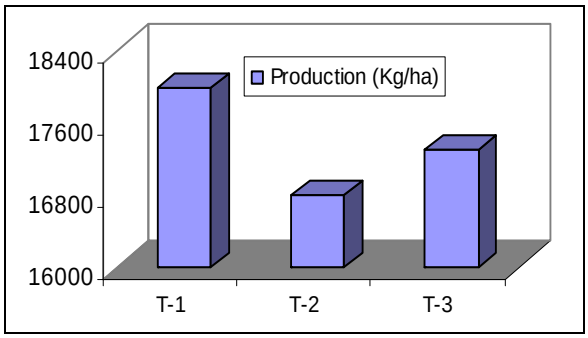

Fig 2: Total production of fish in kg/ha under three treatments

Koi (*Anabas testudineus*) production was 1,800 kg ha^{-1} in India by applying supplementary feed (rice bran, mustard oil cake and fish meal) with the stocking density of 60,000 ha^{-1} in 170 days [19]. They also stated that by applying the above feed, achieved 702 kg/ha over a period of 11 months, where the stocking density was 1,25,000 ha^{-1}. Earlier study evaluated the production potentials of native koi in monoculture management at the density of 16,000 ha^{-1} and obtained a production of 450 kg ha^{-1} in five months rearing with supplementary feed consisted of rice bran (50%), mustard oil cake (30%) and fish meal (20%) [20].

In a trial conducted by Kohinoor *et al*. (2007) investigated on the effects of stocking density on the growth and production of Thai Koi (*Anabas testudineus*) in Freshwater Station, Bangladesh Fisheries Research Institute at three stocking densities (50,000 to 1,25,000/ha) by applying supplementary feed (35% crude protein) [16]. They observed growth was increased in the treatment with lower stocking density and obtained production 6480 to 6617 kg/ha in 150 days culture period. In a recent study conducted by Kohinoor *et al.* (2016) assessed the production potentials of Thai Koi and Vietnamese Koi (*A. testudineus*) at on farm management [14]. They found the gross fish production of Vietnamese and Thai Koi were 15352 and 9456 Kg/ha respectively over a period of 04 months culture period by applying supplementary feed containing 30% crude protein. The production obtained in all the treatments in this experiment was higher than these mentioned results of different authors.

A simple cost-benefit analysis was performed to estimate the amount of profit that has been generated from such type of culture operation. The results of the analysis are shown in Table 4. The gross benefit were Tk. 2173000, Tk.1986250 and Tk.1988950/ha and net benefit were Tk.708000, Tk.521250 and Tk. 523950 in treatments-1, 2 and 3, respectively. Cost and benefit analysis showed that treatment-1 generated the highest net return over a period of four months. Tk. Tk.708000 and lowest net return was found Tk. 521250. In a study, reported that monoculture of endangered fish, gulsha (*Mystus cavasius*) gave a net benefit of Tk.

42,291/ha over a period of six months [21]. While, Roy *et al.* (2013) got the net benefit of Tk. 381750-564000 where the stocking density were 87500-137500/ha in monoculture of Thai Koi (*A. testudineus)* using the pelleted supplementary feed [22]. In a recent study of comparative production performances of Vietnamese and Thai Koi at on farm management, Kohinoor *et al*. (2016) also found Tk. 726780 and 264160/ha/4 months by applying supplementary feed containing 30% crude protein, respectably [14]. In the present study, the net return was higher than the above findings. Therefore, the stocking density of 167500/ha for culture of Vietnamese Koi along with Shing and GIFT tilapia is advisable for farmers in commercial basis.

Table 5: Cost and return analyses of fish production in different treatments (in one-hectare area)

Inputs	Treatment-I		Treatment-II		Treatment-III	
	Quantity (Kg)	Cost (Tk.)	Quantity (Kg)	Cost (Tk.)	Quantity (Kg)	Cost (Tk.)
Pond Lease value	-	50000	-	50000	-	50000
Pond preparation	-	10000	-	10000	-	10000
Fingerling	167500	105000	167500	105000	167500	105000
Feed (@ Tk. 50/kg)	25000	1250000	25000	1250000	25000	1250000
Miscellaneous cost (Harvesting, labour, Lime, chemicals etc.)	-	50000	-	50000	-	50000
Total cost	-	1,465,000	-	1,465,000	-	1465000
Gross benefit						
Sell price of Koi Tk.110/kg Shing: Tk. 300/ kg GIF Tilapia: Tk. 100/kg	17995	2173000	17311	1986250	16805	1988950
Net Benefit	-	708000	-	521250	-	523950

4. Conclusion

From the results, it was observed that, high valued indigenous fish, Shing and high yielding monosex GIFT Tilapia can be cultured with Koi in semi-intensive culture management for getting high production as well as net profit.

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