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GROWTH AND YIELD PERFORMANCE OF SHINGI, *Heteropneustes fossilis* AND KOI, *Anabas testudineus* IN BANGLADESH UNDER SEMI-INTENSIVE CULTURE SYSTEMS

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Abstract

Production potential of shingi, *Heteropneustes fossilis* and koi, *Anabas testudineus* in polyculture were assessed at a stocking density of 2, 47,000 and 3, 70,500 ha^{-1}, respectively in treatment T_1 and T_2. Monoculture of *H. fossilis* and *A. testudineus* was designed at a stocking density of 2, 47,000 ha^{-1} in treatment T_3 and T_4, respectively. Culture period of shingi was 120 days and koi was 100 days in all treatments. All fingerlings were of the same age at stocking, with a mean weight of 2.54±0.08 g for shingi and 0.50±0.01 g for koi, respectively. Commercial fish feeds (30.0% crude protein) supplied at the rate of 100 to 5% of total biomass twice daily. Fish production in treatment T_1, T_2, T_3 and T_4 were 18,803±111, 12,388±115, 10,042±5 kg ha^{-1} day^{-120} and 22,176±7 kg ha^{-1} day^{-100}, respectively. The feed conversion ratio (FCR) was significantly (P<0.05) lower in T_4 than that of the other three treatments. The net financial benefits incurred from treatment T_1, T_2, T_3 and T_4 were Bangladeshi Taka 17,65,769; 6,691; 15,83,990 and 16,29,409 BDT ha^{-1}, respectively. The mean differences of gross yields and net benefits among different treatments were significant (P<0.05). The polyculture technology of shingi and koi, and monoculture technology of koi may help to meet the dietary needs and improve the socio-economic status of the people of Bangladesh.

Keywords: Growth, Yield Performance, Shingi, Koi

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Introduction

Polyculture or composite fish culture is the system in which fast growing compatible species with different feeding habits are grown in the same pond (Jhingran, 1975). Polyculture management technique is based on the relationship between fishes at different levels of the food chain and environment. The outcome of fish production from polyculture systems depends on the species combinations and their stocking densities. Polyculture is one of the major culture techniques that have been used traditionally in Bangladesh, where carp polyculture is practised in the farmer's ponds for rapid growth and maximum production. However, there is no information on polyculture practice of *H. fossilis* (Heteropneustadae) and *A. testudineus* (Anabantidae) in Bangladesh. The local name of *H. fossilis* and *A. testudineus* is shingi and koi (IUCN, 2000). So, this polyculture culture technology is a completely new one in South East Asia (Chakraborty and Mirza, 2008).

Heteropneustes fossilis (Bloch) is an indigenous stinging catfish of South-East-Asia, which is locally known as Shingi or Shing in different parts of Bangladesh. It is not only recognised 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 iron (226 mg 100 g^{-1}) and fairly high content of calcium compared to many other freshwater fishes (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). The perch fish *Anabas testudineus* (Bloch) is one of the important fresh water fish of Bangladesh which is locally known as koi in different places of Bangladesh. Shingi and koi are commonly found in open waters (streams, lakes, floodplains and beels), paddy fields and swamps of Bangladesh and its preferred habitats are heavily-vegetated, stagnant waters. They are very hardy fish and can survive for a few hours out of the water due to the presence of accessory respiratory organs. Indiscriminate destructive practices have caused havoc to aquatic bio-diversity (Hussain and Mazid, 2001) in Bangladesh. International Union of Conservation of Nature (IUCN, 2000) enlisted *H. fossilis* and *A. testudineus* in the “not threatened” category in Bangladesh. The native species are threatened now due to poorly planned water management policy for irrigation, over exploitation, illegal fishing and various ecological changes in its natural habitat (Chakraborty, 2010). Considering the importance of these species form the nutritional, economic and biodiversity point of view, appropriate culture technologies for *H. fossilis* and *A. testudineus* are needed to meet the dietary demand and ultimately more of these tasty fishes will be available for the rural people of Bangladesh. For large scale production of these fishes, comprehensive information on culture technologies is required.

Therefore, the present study was conducted to find the maximum growth, yield and economic performance of shingi and genetically improved koi in various culture systems. The present experiment was also done to expand a practical and economically viable methodologies for mass production of these two species under controlled grow out culture practices. The polyculture technology of shingi and koi, and monoculture technology of koi can help to meet the dietary needs and improve the socio-economic status of the 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 in Sadar, Gouripur and Gaffargaon Upazilla of Mymensingh district, Bangladesh. Foyaz Uddin Farm, Gouripur and Nazrul Islam Shabajpur, Sadar, Mymensingh was designated as treatment T_1 and T_2 for polyculture, and Babul Fish Farm, Basutia and Rubel Fish farm, Doulatpur, Gaffargaon was designated as treatment T_3 and T_4 for monoculture with three replicates each.

The experiment was conducted for a period of 100 days for koi and 120 days for shingi from May to August, 2010 in 12 ponds. The ponds were rectangular with an area of 0.30±0.11 ha and an average depth of 1.10±0.12 m. The growth performance of *H. fossilis* and *A. testudineus* was evaluated under four treatments and was replicated thrice and the pond dyke was covered with netting.

Pond preparation and fertilization

The ponds, with well-designed inlet and outlet system, were drained, cleared of aquatic vegetation and exposed to sunlight. After drying, lime ($CaCO_3$, 250 kg ha^{-1}) was spread over the pond bottom. All the ponds were filled with ground water. Six days subsequent to liming, the ponds were fertilized with organic manure (cow dung @ 6,175 kg ha^{-1}). Lime application (50 kg ha^{-1}) was maintained fortnightly to control water quality in all the treatments.

Stocking of fingerlings

Treatment T_1 and T_2 were stocked with shingi and F_2 population of (hormone 17 α methyltestosterone treated) koi. Treatment T_3 was stocked with only shingi and treatment T_4 was stocked with only F_2 population of koi (Table 1). Stocking density was planned as shown in Table 1. The fingerlings of shingi were stocked 15 days before stocking koi. The experimental ponds were stocked with shingi and koi with an initial length of 3.05±0.01 cm and weight of 2.54±0.11 g, and 0.75±0.01 cm and 0.50±0.02 g, respectively. The same stocking density of 0.247 million ha^{-1} was maintained in treatments T_1 T_3 and T_4 while stocking density of 0.3705 million ha^{-1} was maintained in treatments T_2. Culture period of shingi was recorded 120 days in treatment T_1, T_2 and T_3 and Culture period of Koi was recorded 100 days in treatment T_1, T_2 and T_4.

Table 1. Details of species combination and stocking density (individual ha^{-1}) of four treatments

Sl. No.	Name of the species	Stocking densities treatment wise ha^{-1}			
		T_1	T_2	T_3	T_4
1.	*Heteropneustes fossilis*	74,100	1,23,500	2,47,000	-
2.	*Anabas testudineus*	1,72,900	2,47,000	-	2,47,000
	Total	2,47,000	3,70,500	2,47,000	2,47,000

Supplementary feeding

Saudi Bangla and Mega feed were used in all treatments. Proximate composition of these commercial feeds was analysed according to AOAC (1995) method and nitrogen free extract (NFE) by subtraction (Castell and Tiews, 1980). Proximate composition (% dry matter) of the supplementary floating Mega feed (crude protein, crude lipid, crude fibre, ash, moisture and nitrogen-free extract) of experimental feeds was 30.0%, 03.0%, 10.0%, 17.0%, 12.0% and 28.0% and sinking Saudi Bangla feed (crude protein, crude lipid, crude fiber, ash, moisture and nitrogen-free extract) of experimental feeds was 30.0%, 06.0%, 07.0%, 18.0%, 12.0% and 27.0%, respectively. Feeds were supplied at the rate of (100-60)% for the 1st 15 days, (50-30)% from 16-30 days, (30-20)% from 31-45 days, (20-10)%

from 46-60 days, (10-8)% from 61-75 days , 6% from 76-90 days and 5% from 91-120 days twice daily in the morning and afternoon commencing from the first day of stocking. Daily ration was adjusted by estimating the standing crop once every fortnight by random sampling of the stock. Fifteen species of shingi and fifteen species of koi were sampled by using a seine and cast net.

Water quality parameters

Physico-chemical parameters of pond water were monitored fortnightly between 0900 and 1000 hr. 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 (Clesceri *et al.*, 1989).

Water recycling

Low-lift-pump was used to recycle surface water and shallow tube-well was used for adding under ground water in the pond (8000 L day^{-1}). This method mitigated pollution from excretory product of individuals and maintained water quality suitable for the experimental fish and primary productivity.

Estimation of growth, survival, production and feed utilisation

Fishes were sampled by using seine and cast net. The length (cm) and weight (g) of individual fish was recorded separately with the help of a measuring scale and a portable sensitive balance. Weight of each species was measured separately to assess the health condition of fish and their growth. Twenty individuals of both *H. fossilis* and *A. testudineus* species from each pond were sampled fortnightly until they attained marketable size. Growth in terms of weight, average daily growth (ADG), specific growth rate (SGR), food conversion ratio (FCR), and percentage survival and mean values (±SD) for each parameter were computed. ADG and percentage survival were followed according to De Silva (1989). SGR was calculated according to Brown (1957) and Ricker (1979), and FCR was calculated according to Brown (1957) and Gangadhara *et al.* (1997). The marketable size koi and shingi were harvested after 100 and 120 days, respectively by repeated netting, followed by draining or drying the ponds. The number of individuals were counted and weighed. Survival percentage and production (individuals ha^{-1}) of fingerlings were then calculated and compared among the treatments.

Analysis of experimental data

The data were analysed through one way analysis of variance (ANOVA) using MSTAT followed by Duncan's New Multiple Range test to find out whether there was any significant difference among treatment means (Duncan, 1955; Zar, 1984). The results were calculated and expressed as mean ±SD. A simple cost-benefit analysis was done to estimate the net benefits from different treatments.

Results

Water quality parameters

Mean levels of physico-chemical parameters over the 120 days culture of *H. fossilis* and *A. testudineus* are presented in Table 2. The mean water temperature, pH and dissolved oxygen in treatments T_1, T_2 ,T_3 and T_4 were not significantly (P>0.05) different during the study period. Mean Secchi disk transparency and total alkalinity differed significantly (P<0.05) among different treatments. Despite these variations, water quality parameters in all the experimental treatments were within the normal range for fish culture.

Table 2. Physico-chemical parameters of experimental ponds under four treatments

Parameters	Treatment T_1	Treatment T_2	Treatment T_3	Treatment T_4
Temperature (^{o}C)	25.98±4.21 (14.18-32.40)	25.94±7.06 (14.15-32.40)	25.81±7.24 (14.20-32.40)	25.92±5.20 (14.85-32.30)
Transparency (cm)	28.48±2.19^{c} (23.80-39.50)	30.30±3.64^{b} (24.40-41.40)	36.24±4.16^{a} (24.10-45.20)	25.54±3.06^{d} (22.10-33.40)
pH	8.12±0.30 (7.70-8.50)	8.08±0.33 (7.80-8.60)	8.17±0.31 (7.70-8.55)	8.20±0.30 (7.60-8.60)
Dissolved oxygen (mg L^{-1})	4.72±0.66 (3.80-6.12)	4.34±0.70 (3.50-6.10)	4.05±0.88 (3.20-5.43)	4.40±0.68 (3.20-5.83)
Total alkalinity (mg L^{-1})	160.60±6.24^{a} (148.40-174.20)	153.23±16.69^{d} (150.60-188.20)	155.81±8.85^{c} (146.50-181.40)	156.43±7.80^{b} (146.20-171.40)

Figures with different superscripts in the same row varied significantly (P<0.05).
Figures in the parenthesis indicate range.

Growth and production of fish

The results of growth and production of fishes in terms of gain in weight in the four treatments are presented in Table 3. The results showed that there was significant difference in growth variation in each treatment and continued until the final harvest.

Table 3. Survival and production of *H. fossilis* and *A. testudineus* species as obtained under four treatments during 120 and 100 days study

Parameters	Fish species	Treatments			
		T_1	T_2	T_3	T_4
Initial length (cm)	*H. fossilis*	3.05±0.01	3.05±0.01	3.05±0.01	-
	A. testudineus	0.75±0.01	0.75±0.01	-	0.75±0.01
Final length (cm)	*H. fossilis*	18.02±3.42^{a}	12.88±3.86^{b}	18.17±3.88^{a}	-
	A. testudineus	15.71±2.40^{a}	10.02±3.11^{b}	-	15.88±2.61^{a}
Net length (cm)	*H. fossilis*	14.97±3.02^{a}	9.83±3.66^{b}	15.12±3.38^{a}	-
	A. testudineus	14.96±2.36^{a}	9.27±3.01^{b}	-	15.13±2.41^{a}
Initial weight (g)	*H. fossilis*	2.54±0.08	2.54±0.08	2.54±0.08	-
	A. testudineus	0.50±0.01	0.50±0.01	-	0.50±0.01
Final weight (g)	*H. fossilis*	50.14±3.22^{a}	30.24±3.91^{c}	46.44±3.11^{b}	-
	A. testudineus	98.84±3.02^{a}	56.62±3.66^{b}	-	98.92±3.82^{a}
Net weight gain(g)	*H. fossilis*	47.60±3.11^{a}	27.70±3.44^{c}	43.90±3.05^{b}	-
	A. testudineus	98.34±3.01^{a}	56.12±3.32^{b}	-	98.42±3.08^{a}
Average daily gain	*H. fossilis*	0.40±0.01^{a}	0.23±0.01^{c}	0.37±0.03^{b}	-
(g)	*A. testudineus*	0.98±0.04^{a}	0.56±0.02^{b}	-	0.98±0.02^{a}
SGR	*H. fossilis*	3.14±0.04^{a}	2.63±0.03^{c}	3.06±0.02^{b}	-
(% bw·day^{-1})	*A. testudineus*	5.29±0.02^{a}	4.73±0.04^{b}	-	5.29±0.02^{a}
FCR	*H. fossilis* *A. testudineus*	2.0±0.04^{c}	2.8±0.06^{a}	2.6±0.04^{b}	1.9 ±0.04^{d}
Species wise	*H. fossilis*	87.08±2.51^{b}	64.70±4.88^{c}	87.55±2.02^{a}	-
survival rate (%)	*A. testudineus*	90.55±2.24^{a}	70.77±3.41^{b}	-	90.76±2.07^{a}
Average survival rate (%)	*H. fossilis* *A. testudineus*	88.82±2.45^{b}	67.74±4.29^{d}	87.55±2.02^{c}	90.76±2.07^{a}
Species wise production	*H. fossilis* (kg ha^{-1} day^{-120})	3328.50±5.66^{b}	2416.30±6.42^{c}	10337.36±5.44^{a}	-
	A. testudineus (kg ha^{-1} day^{-100})	15474.08±6.14^{b}	9897.23±6.88^{c}	-	22175.60±7.35^{a}
Total production (kg ha^{-1})		18802.58±111.06^{b}	12388.25±115.22^{c}	10042.56±5.44^{d}	22175.60±7.35^{a}

Values in the same row having the same superscript are not significantly different (P>0.05).
Shingi and Koi fish were harvested after day^{-120} and day^{-100}

H. fossilis (Shingi)

During the investigation, mean final length and weight of *H. fossilis* was recorded as 14.97±3.02 cm, 9.83±3.66 cm and 15.12±3.38 cm; and 50.14±3.22 g, 30.24±3.91 g and 46.44±3.11 g in treatments T_1, T_2 and T_3, respectively (Fig. 1 and 2). The increase in weight of *H. fossilis* was the highest in T_1 followed by T_3 and T_2, respectively. The initial weight of fingerlings, stocked in all the ponds did not vary significantly (P<0.05). The fish in T_1 treatment showed the highest gain in weight as compared to the polyculture treatment T_2 and monoculture treatment T_3. However, the mean final weight of individuals in different treatments were significantly different (P<0.05). SGR in treatment T_1 was significantly higher (P<0.05) than in T_3 and T_2. The highest survival rate was also observed in T_3 and the lowest in T_2. There was a significant variation (P<0.05) in the survival rate of *H. fossilis* among different treatments. The mean productions of *H. fossilis* were 3,328.5±5.66, 2,416.30±6.42 and 10,337.36±5.44 kg ha^{-1} day^{-120} in treatments T_1, T_2 and T_3, respectively. The total production of *H. fossilis* differed significantly (P<0.05) among the treatments (Table 3). Production was higher in monoculture treatment T_3 and lower in polyculture treatments T_1 and T_2.

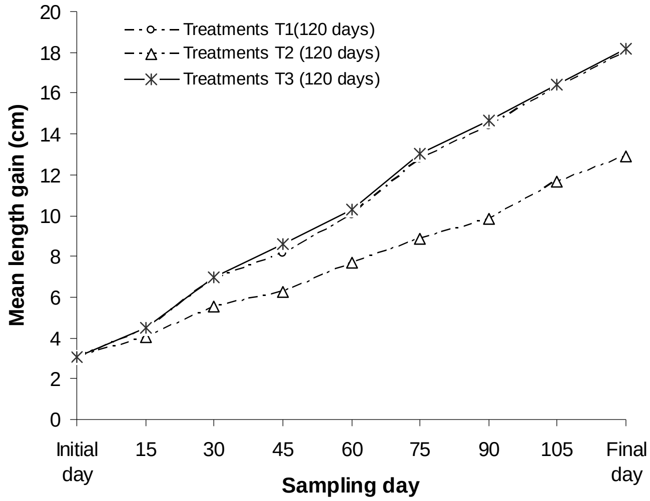

Fig.1. Fortnightly mean length (cm) gain of shingi under different treatments over a period of 120 days

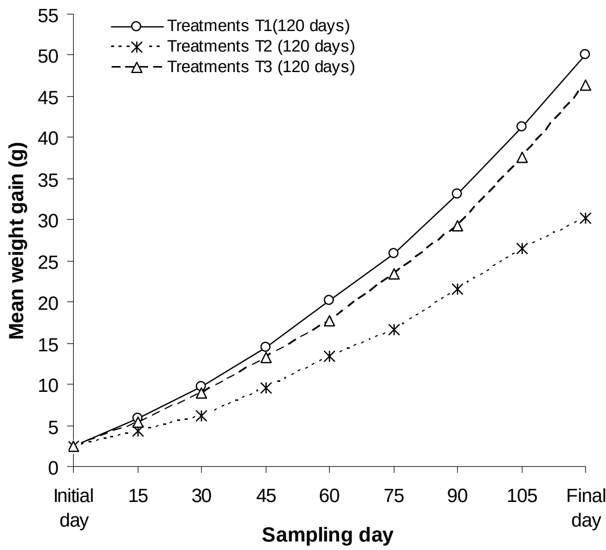

Fig.2. Fortnightly mean weight (g) gain of shingi under different treatments over a period of 120 days

A. testudineus (Koi)

During the experimental period, the final mean length and weight of *A. testudineus* was found to be 14.96±2.36 cm, 9.27±3.01 cm and 15.13±2.41 cm, and 98.34±3.02 g, 56.62±3.66 g and 98.92±3.82 g in treatments T_1, T_2, and T_4, respectively (Fig. 3 and 4). Growth and production parameters of *A. testudineus* are shown in Table 3. The initial weight of fingerling, stocked in all treatments did not differ significantly. The fish in monoculture treatment T_4 showed the highest gain in weight as compared to the polyculture treatments T_1 and T_2. However, the mean final weight of *A. testudineus* in treatment T_1 and T_4 were not significantly different (P>0.05). SGR in polyculture treatment T_1 and monoculture treatment T_4 was the same but significantly higher than in another polyculture treatment T_2 (P<0.05). The highest survival rate was also observed in monoculture treatment T_4 and the lowest in polyculture treatment T_2. There was a significant variation (P<0.05) in the survival rate of *A. testudineus* individuals among different treatments. The mean productions of *A. testudineus* were 15,474.08±6.14, 9,897.23±6.88 and 22,175.6±7.35 kg ha^{-1} day^{-100} in treatments T_1, T_2 and T_4, respectively. Production was higher in monoculture treatment T_4 and lowest in polyculture treatment T_2. The growth rate was the same in treatment T_1 and T_4 but lower in treatment T_3. The production of *A. testudineus* also differed significantly (P<0.05) among the three treatments.

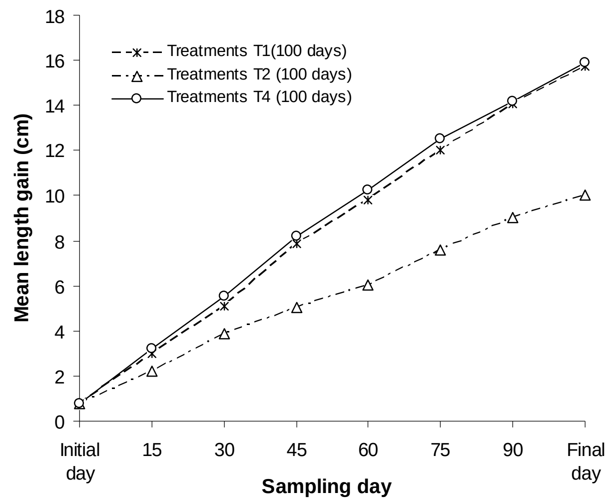

Fig. 3. Fortnightly mean length (cm) gain of koi under different treatments over a period of 100 days

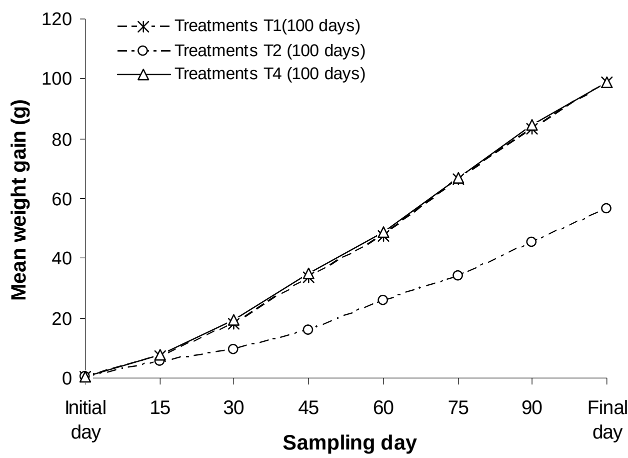

Fig. 4. Fortnightly mean weight (g) gain of koi under different treatments over a period of 100 days

Total production

In the study, FCR was significantly lower in monoculture treatment T_4 than in polyculture treatment T_1 followed by the monoculture treatment T_3 and polyculture treatment T_2. Best FCR was recorded in monoculture treatment T_4. Total net production of fish as recorded in treatments T_1, T_2, T_3 and T_4 were 18,802.58±111.06, 12,388.25±115.22, 10,042.56±5.44 and 22,175.6±7.35 kg ha^{-1}, respectively. The production of fish was higher in monoculture treatment T_4, where only F_2 population of *A. testudineus* was stocked at 2, 47,000 ha^{-1} and lowest production was recoded in monoculture treatment T_3, where only *H. fossilis* was stocked at 2, 47,000 ha^{-1}. Second highest production was recorded in polyculture treatment T_1, where *H. fossilis* and *A. testudineus* were stocked respectively at 74,100 and 1,72,900 no. ha^{-1} and an intermediate production was obtained in polyculture treatment T_2, where *H. fossilis* and *A. testudineus* were stocked respectively at 1,23,500 and 2,47,00 ha^{-1}. The production levels in all treatment differed significantly (P<0.05).

Economic analysis

A simple cost-benefit analysis was performed to estimate the amount of profit that had been generated from these four types of culture operations. The results of the analysis are shown in Table 4. The cost of production in treatment T_2 was consistently significantly higher than those of treatments T_4, T_1 and T_3. Highest net benefit was obtained in treatment T_1 (BDT. 17,65,769) followed by T_4 (BDT. 16,29,406), T_3 (BDT. 15,83,990) and T_2 (BDT. 6,691). Second and third net return benefit was found to be in the monoculture treatments T_4 and T_3. Treatment T_2 appeared to give poor net return levels and differed significantly (P<0.05) from T_1, T_3 and T_4. Although the higher production was recorded in monoculture of *A. testudineus* (treatment T_4), the higher net benefit was found in polyculture treatment T_1 due to reason of high market price of *H. fossilis.*

Table 4. Cost and return of fish production under a polyculture management of *H. fossilis* and *A. testudineus* over a period of 120 and 100 days

Item	Amount BDT ha^{-1} day^{-120}				Remarks
	Treatment T_1 (Tk)	Treatment T_2 (Tk)	Treatment T_3 (Tk)	Treatment T_4 (Tk)	
Total return (TR)	3453527[a]	1813585[d]	3213619[c]	3326340[b]	Price related with size and weight
a. Variable cost:					
1. Price of fingerlings	321100	494000	494000	247000	
2. Feed	1024912	961208	806286	1100710	(BDT 25.00 kg^{-1})
3. Fertilizer	10369	10369	10369	10369	(BDT 9.00 kg^{-1})
4. Human labour cost	48000	48000	48000	48000	(BDT 200.00 day^{-1})
5. Chemicals	12470	11580	12870	13750	
6. Miscellaneous	100250	100250	100250	100250	
Total Variable cost (TVC)	1517101	1625407	1471775	1520079	
b. Fixed cost :					BDT 200.00 $dec.^{-1}$
1. Pond rental value (day^{-120})	18947	18947	18947	18947	according to local rate, Mymensingh
Interest of operating capital	151710	162540	138907	157907	10% interest according to BKB, Bangladesh
Total fixed cost (TFC)	170657	181487	157854	176854	
Total cost (TC= TVC+TFC)	1687758[b]	1806894[c]	1629629[d]	1696933[a]	
Gross margin (GM= TR-TVC)	1936426[a]	188178[b]	1741844[d]	1747261[c]	
Net return (TR-TC)	1765769[a]	6691[d]	1583990[c]	1629409[b]	

Values with different superscripts in the same row varied significantly ($P<0.05$).
1.00US$ = 75.00 BDT (Bangladeshi Taka).
BKB= Bangladesh Krishi (Agricultural) Bank.
Sale price of shingi and koi in treatment T_1 was BDT 350.00 kg^{-1} and 150.00 kg^{-1}, and in T_2 BDT 300.00 kg^{-1} and 100.00 kg^{-1}, respectively, in T_3 (only shingi) BDT 320.00 kg^{-1} and in T_4 (only koi) BDT 150.00 kg^{-1}.

Discussion

Growth, feed efficacy and feed consumption of fish are normally governed by a few environmental factors (Brett, 1979). The temperature, water transparency, pH, dissolved oxygen and total alkalinity of the experimental ponds were within the acceptable range for fish culture that agrees well with the findings of Boyd (1979), Wahab *et al.* (1994) and Chakraborty *et al.* (2005). Higher total alkalinity level in the water of the experimental ponds might be due to higher amount of lime applied during pond preparation and frequent liming every 15 days interval during the study period (Boyd, 1982; Jhingran, 1991).

In this experiment, similar supplementary feeds are supplied for the growth of *H. fossilis* and *A. testudineus,* as explained by Haque and Barua (1989). 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* (De Silva and Gunasekera, 1991). Growth in terms of weight, weight gain and SGR of individuals of *H. fossilis* and *A. testudineus* was significantly higher in T_1 (polyculture), where the combined stocking density of the two species was the same with the stocking density of *H. fossilis* monoculture in T_3 as well as the stocking density of *A. testudineus* monoculture in T_4, although the same food was supplied in all the treatments at an equal ratio. The low growth rate of *H. fossilis* and *A. testudineus* in treatment T_2 appeared to be related with higher densities and increased competition for natural food and space. The inverse relationship between the stocking density and the growth rate is a space limiting effect on the population (Johnson, 1965).

During the experimental period, ecological factors, pond preparation and good management practices, feed quality, healthy fingerlings, and stocking rate influenced the high performance in the survival rate of *H. fossilis* and *A. testudineus* (Choudhury *et al.,* 1978). Chiu *et al.* (1989) and De Silva and Davy (1992) stated that digestibility plays an important role in lowering the FCR value by efficient utilization of food. The FCR value in monoculture treatment T_4 was significantly lower than those of polyculture treatments T_1 and T_2, and monoculture treatment T_3. Digestibility, in turn, depends on daily feeding rate, frequency of feeding, and type of food used. There was a general decrease in FCR for the population of treatment T_4 than that of the treatment T_1, T_3 and T_2 which is supported by Pechsiri and Yakupitiyage (2005). The FCR values of different treatments were acceptable and indicated better food utilization, which is agreed by Das and Ray (1989), Reddy and Katro (1979) and Islam (2002). Significantly, higher survival was recorded in monoculture treatment T_4 and polyculture treatment T_1, where, the stocking density was lower than treatment T_2. The reason for reduced survival rate in treatment T_2 might be due to higher stocking density of individuals as well as competition for natural food and space in the water area of pond which is supported by Tripathi *et al.* (1979), Haque *et al.* (1994) and Chakraborty *et al.* (2005).

In the present investigation, the amount of supplementary feeds given in different treatments was based on the number of fingerlings stocked and amount of feed provided per individual was kept at the same level. In this experiment, at higher stocking densities, presence of abundant food substances could produce a comparative interaction among the population causing a stressful situation (Houde, 1975). Hence, the observed poor growth at higher stocking densities could be due to space limiting effect, stressful situation caused by supplementary feed, some variations in environmental parameters and less availability of natural food. The results in the present experiment are very similar to the study of Ameen *et al.* (1984); Vijayakumar *et al.* (1998); Usmani *et al.* (2003) and Chakraborty *et al.* (2005).

In the present study, a significant higher production (22,175.6±7.35 kg ha^{-1} day^{-100}) was recorded in treatment T_4 than those of treatment T_1, T_2 and T_3, respectively. Despite this, consistently higher net benefits (BDT. 17,65,769 ha^{-1}) were obtained from treatment T_1 than those of treatment T_4, T_3 and T_2. The higher net benefit in treatment T_1 was obtained due to stocking of *H. fossilis* (high market value fish), although the second higher production was recorded in this treatment. The observation of higher net benefit is in agreement with those of Thakur and Das (1986), Munshi (1996), Vijayakumar *et al.* (1998), Noor Khan *et al.* (2003), Usmani *et al.* (2003) and Chakraborty *et al.* (2005). Overall, highest growth, survival, production and benefits were obtained from the monoculture treatment T_4 and second higher growth, survival, production and highest benefit were recorded in polyculture treatment T_1 which is influenced by a well developed water recirculation method (Chakraborty and Mirza. 2008).

In the present investigation, the amount of supplementary feeds given in different treatments was based on the weight of fish stocked and amount of feed provided per individual was kept at the same level. Hence, the observed low growth, production and lowest benefit in treatment T_2 could be due to higher stocking density, variations in environmental parameters. The results in the present experiment are very similar to those of Saha *et al.* (1988); Kohinoor *et al.* (1998); Hossain (2001) and Chakraborty and Azad (2008).

Conclusion

The survival, growth and production in polyculture and monoculture systems were inversely related to the stocking densities of fingerlings. Monoculture of *A. testudineus* as in treatment T_4 and polyculture of *H. fossilis* and *A. testudineus* as in treatment T_1 can be recommended to fish farmers to produce more protein food for the Bangladesh population. . This may also be helpful towards the protection of shingi from extinction as well as for the conservation of koi.

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