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Production Potential of Nutrient Rich Small Indigenous Species Dhela (*Osteobrama cotio*) In Carp Polyculture System

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Abstract: The compatibility of Dhela (*Osteobrama cotio*) (Hamilton) with major carps was studied in grow-out carp polyculture system for a period of 138 days in a set of six earthen ponds varied from 4 to 14 decimal days from 16 July 2013 to 30 November 2013 at Rayghar village of Golabgonj upazilla under Sylhet district, Bangladesh. Two different species combinations evaluated were T_1: catla (*Catla catla* Hamilton.), rohu (*Labeo rohita* Hamilton), mrigal (*Cirrhinus mrigala* Hamilton) and dhela at 1:0.67:0.67:2; and T_2: catla, rohu and mrigal at 1:0.67:0.67 at combined density of 16055 and 8645 fingerlings/ha respectively. While survival levels of the carps did not differ significantly in treatments (P>0.05), silver carp recorded highest survival levels (94-96%) followed by olive barb (87-90%), mrigal (72-74%), rohu (72-73%) and catla (67-69%). All the treatments were subjected to same regime of feed and fertilizers. Yield of dhela was found 37.45 kg ha^{-1} in treatment T_1. Production of dhela was very low because it did not able to take part breeding due to late stocking. Survival of dhela observed 83.56%. Total production of fish obtained in this experiment was 768.09 kg ha^{-1} and 806.64 kg ha^{-1} in treatment T_1 and T_2, respectively. There were no significant differences in total production between the treatments. Water parameter analysis showed that mean values of water temperature, transparency and dissolved oxygen were not significantly different among the treatments except pH. The total revenues per ha pond during study period were Tk. 94520 and Tk. 96720 in treatments T_1 and T_2, respectively. The net benefits from treatment T_1 and T_2 were Tk.44605 and Tk. 57515, respectively. However, from the result of the experiment it can be concluded that dhela may be one of the good candidate species for carp plolyculture system considering its high nutritional value and having no negative impacts on the growth of carp species.

Key words: Dhela · Small Indigenous Species · Production · Polyculture and Carp

INTRODUCTION

Fish and fisheries play an important role, in agro-based economy of Bangladesh, contributing 60 percent of total animal protein intake. Total fish production in Bangladesh during 2011-2012 was 3.26 million MT and the target for 2020-2021 is 45.5 million MT [1]. So it needs to increase fish production through aquaculture as well as open water fish production to meet up the growing demand of fish in Bangladesh. Small indigenous fish play an important role in the Bangladeshi diet, not only as a source of animal protein but also as a source of a range of other essential nutrients, such as calcium, iron and vitamin A. Deficiency of vitamin A is widespread in Bangladesh, particularly among women and children. Calcium is an important nutrient for growth in young children, fetal growth and milk production. Analyses of a number of species have shown great variation in vitamin A and calcium content [2]. Since small fish are normally consumed with bones, they are an important source of calcium. Small fish are defined as those species which attain a maximum length of 25 cm or less. Many small indigenous fish species (SIS) of Bangladesh attain a length of less than 10 cm [3]. In the past, these small

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fishes in the pond were regarded as weed fish and used to eradicate by using of pesticides. Recently these small indigenous fish species have been considered as an important source of essential macro and micro nutrients, vitamins and minerals which can play an important role in the elimination of malnutrition from this country [2]. Since these species are normally cooked and eaten whole, their effect on the diet is further enhanced since the bones also provide a source of calcium. Some of the small indigenous fish species such as mola, dhela, punti and chela contain more available vitamin than any other edible freshwater fish [4].

Many of the important fish species are gradually disappearing from the nature, especially small indigenous fish species. Dhela (*Osteobrama cotio*) is one of the most important nutrient rich small fish which contained about 22 mg retinol and 31 mg dehydroretinol per 100 mg fresh edible tissue per 2.7 to 3.0 g dhela [5]. Once distributed widely in the natural waters in the South East Asian countries, the poor seed survival [6] and over-exploitation over the years have reduced its natural population to the extent of placing it under vulnerable group [7].

Though the small indigenous SIS is important from nutritional point of view and easily accessible to the peasants, very little attention has been given on their culture, conservation and management. Since sixties, UNICEF has been trying to attract the attention of people to culture these fishes in small water bodies like mini ponds [8]. But farmers are intended to culture major carps as cash crop and do not pay attention to their family nutrition. However, the high consumer preference, culture potential, makes the species a suitable candidate not only for diversifying the carp culture [7] but also can serve for its conservation status. Successful farming of dhela in grow-out polyculture system necessitates study on its compatibility with other carps in the conventional culture system. Therefore, if a viable fish polyculture technology could be developed which would allow simultaneous production of this species for peasants' consumption and large carps as cash crop that would serve the dual purpose.

Considering the availability of limited literature on grow-out farming of the species and its compatibility with other species in particular, the present study was attempted to generate first hand information on its compatibility with the important major carp species viz., catla, rohu and mrigal to evaluate its relative performance in grow-out carp polyculture systems as well as the cost benefit analysis of this production on the farmers' families. The generated information is envisaged to help in popularizing the species among carp farmers, besides satisfying to its conservation needs.

MATERIALS AND METHODS

Study Area and Period: A number of experimental trials have been undertaken for the culture of dhela in combination with carp polyculture in experimental ponds at Rayghar village of Golapganj Upazilla, Sylhet, Bangladesh from 16 July 2013 to 30 November 2013. The farmer's experimental ponds are situated between 24º41´ and 24º55´ north latitudes and between 91º55´ and 92º06´ east longitudes (Figure 1).

Experimental Design: The experiment was carried out in 6 ponds selected from Rayghar Village with a varied range of pond size from 4 to 14 decimals with 2 to 3 m water depth. All ponds were rain-fed and moderately exposed to prevailing Sunlight. The experiment was carried out with two treatments viz., treatment-1 (T_1) and treatment-2 (T_2). The treatments were randomly assigned with three replications viz., R_1, R_2 and R_3. Dhela (*O. cotio)* was stocked with Catla (*Catla catla),* Rohu *(Labeo rohita)* and Mrigal *(Cirrhinus cirrhosus)* in (T_1) and (T_2).

Field Experiment: Standard procedures of pre-stocking pond preparation including removal of predatory and weed fishes by bleaching powder (10 mg l^{-1} chlorine) and repeated netting. Ponds were prepared properly with lime at the rate of 1 kg per decimal. After 7 days of liming initial fertilization was done with urea, TSP and cowdung at the rate of 500g, 500g and 5kg per decimal, respectively [9]. Before stocking of fish abundance of natural feed was tested by using Sacchi disc.

The stocking densities for T_1 were 3705, 2470 and 2470 fingerlings/ha for catla, rohu and mrigal respectively. For T_2 were 3705, 2470 and 2470 fingerlings/ha for catla, rohu and mrigal respectively. For each trial 7410 dhela fingerlings/ha were used with carps. Fingerlings of carps were collected from a local hatchery of Golabgonj, Sylhet, Bangladesh. Dhela fries were collected from one of the natural canal named Bulbuli Khal close to the study area. The canal is connected to Hakaluki haor, Bangladesh. Initial length and weight of dhela were measured before releasing into the pond. Fish fingerlings were stocked early in the morning. The stocking size of fingerlings of catla, rohu, mrigal and dhela were 4.24±0.04 g, 3.3±0.6 g, 5.16±0.8 g and 2.07±0.5 g, respectively.

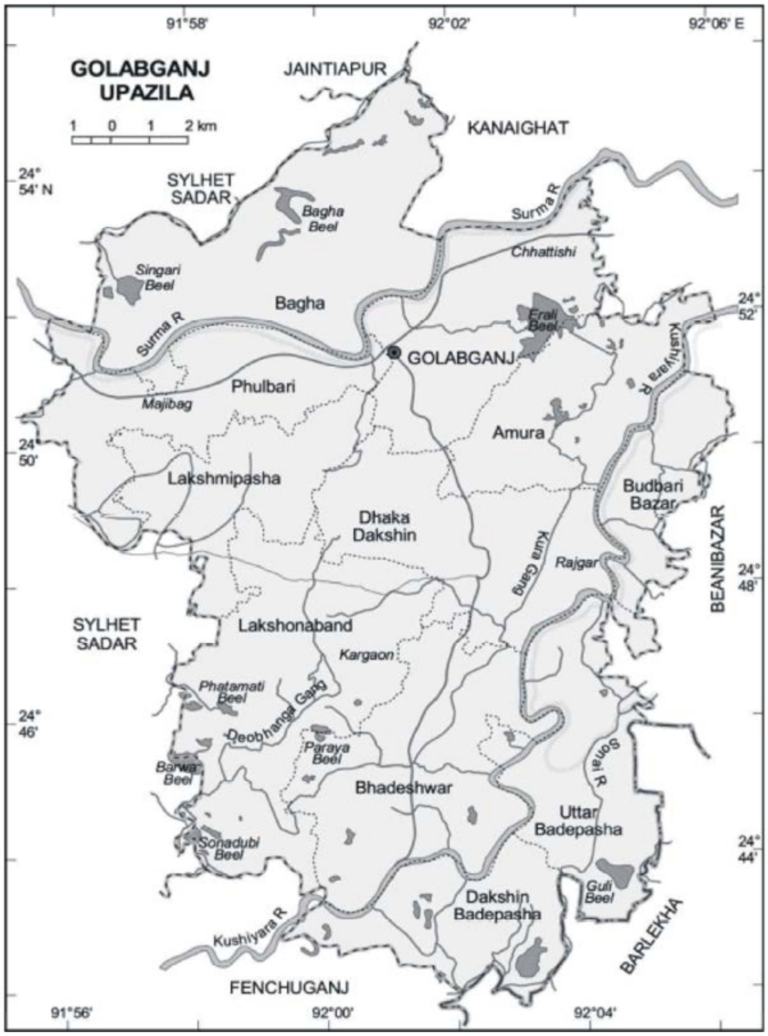

Fig. 1: Map showing the experimental site

Mustard oil cake and rice bran were used as supplementary feed in a 1:1 ration (w/w) at 6% of biomass per day during first month, 5% during second month, 4% during third and fourth month and 3% in rest of the culture period. After stocking of fish fingerling urea, TSP and cowdung were used at 15 days interval at the rate of' 100g, 100g and 4 kg per decimal, respectively. Fishes were fed with mixture of rice bran and groundnut oil cake in a 1:1 ratio (w/w) at 5% of biomass per day during first month, 3% during second and third months, 2% in fourth to sixth month and 1.5% in rest of the culture period. The quantity of daily feed was calculated based on average fish growth recorded through monthly sampling and at an assumed 80% survival [10]. Daily ration was provided twice daily at 07:00-08.00 h and 16-17h. Intermittent fertilization was carried out with fortnightly application of 500 kg cow dung, 10 kg urea and 15 kg single super phosphate (TSP) per hectare to maintain pond fertility in the subsequent period [11].

Water samples were collected from the ponds monthly between 07:00 and 08:00 h and analyzed for important parameters. All the water quality parameters were measured directly from the experimental ponds. A Celsius thermometer was used for measuring the water temperature. Transparency was measured with a Secchi disc of 20cm diameter. Dissolved oxygen of water samples was measured by portable digital DO meter (YSI model 85-10 FT) and pH of the water measured by a direct reading digital pH meter (HANNA HI- 98107).

Fish were harvested at the end of the experiment by repeated netting and the species-wise number and total weight of fish were recorded for each pond for calculation of various yield parameters. The following parameters were used to evaluate the growth.

- Average weight gain = Mean final fish weight- Mean initial fish weight;
- Food conversion ratio = dry weight of feed consumed/ wet weight of gain
- Specific Growth Rate (% day) = ($Log_e W_2$ - $Log_e W_1$ ×100)/T_2-T_1 Where, W_1=the initial live body weight (g) at time T_1 (day) and W_2= the final live body weight (g) at time T_2 (day);
- Survival (%) = No. of fishes harvested×100/No. of fishes stocked and
- Production of fishes: Yield= No. of fish caught × Average final weight

A simple cost-return analysis was calculated to determine economic returns of different treatments. The analysis was based on market prices of local market for fish. All other items expressed in Bangladesh taka, BDT (US $1= BDT 80).

The data on fish growth, survival and biomass production were subjected to statistical analysis using SPSS (Version 18.0) statistical software (SPSS Inc., Chicago, USA). Differences were considered significant at an alpha of 0.05. Means were given with ± standard deviation (SD).

RESULTS

Water Quality Parameters: During the culture period, the water quality parameters (temperature, dissolved oxygen, pH and transparency) were measured between 10.00 to 12.00 AM. The recorded water temperature varied from 27 to 32°C. The mean value of water temperature was 29.20±1.63°C and 29.27±1.50°C in treatment T_1 and T_2 respectively (Figure 2). The ranges of water transparency varied from 17 to 39 cm without significant differences between treatments (P>0.05). The mean value of water transparency was 22.90±4.87 cm and 23.57±4.57 cm in treatment T_1 and T_2, respectively (Figure 2). Dissolved oxygen also did not show marked variation between treatments (P>0.05) and remained between from 4.8 to 6.4 mgl^{-1}. Overall mean values of DO were found 5.49±0.27 mgl^{-1} and 5.62±0.34 mgl^{-1} in T1 and T_2, respectively (Figure 2). The pH of water was found to be approximately neutral or slightly alkaline. The highest and lowest values of pH of the pond water under T_1 were between 7.1 and 7.8 with an average value of 7.49±0.2 and in T_2 were 7.2 and 7.8 with an average of 7.50±0.15 (Figure 2).

Growth and Production Performance: The average body weight gain of catla as well as mrigal was almost similar in the two treatments (P>0.05) (Table 1). Rohu showed a lower average body weight gain in presence of dhela in T_1 compared to T_2 where dhela was absent (P>0.05). Survival of the fish species was at least 75%. Mrigal recorded the highest survival of 81.31±5.37 % in T_2, while the same in catla was the lowest (78.33±9.95%). Survival of dhela at 83.56±8.75% in the T_1 was higher than those of other species in two treatments (Table 1). However, the level did not differ significantly in any of the species among its respective treatments (P>0.05).

The species-wise biomass production of catla, rohu and mrigal were not significantly different in their respective treatments (P>0.05) (Table 1). The gross biomass production in T_2 (806.64±89.62 kg ha^{-1}) in absence of dhela was slightly higher than those of T_1 (768.09±116.15 kg ha^{-1}). The feed conversion ratio (FCR) in T_1 (1.2±0.0) and T_2 (1.1±0.14) were also similar and there is no significant variation among treatments. Contribution of catla in the total biomass production was highest (46.66-48%) in all treatments, followed by rohu (25.72-30.28%), mrigal (22-23%) and dhela (4.9%). The relative contributions of different fish species to total production under two treatments are shown in Figure 3.

Table 1: Growth and production performance of fish obtained from the treatments

Treatment	Species	Initial weight (g)	Final weight (g)	% Survival	FCR	SGR	Gross yield (kg/ha)	Net yield (kg/ha)
T_1	*O. cotio*	2.07±0.50	6.0±1.40	83.56±8.75	1.2±0.19	0.75±0.17	37.45±11.23	22.17±11.23
	C. catla	4.24±0.40	125.96±34.25	78.37±2.39	1.2±0.19	2.43±0.22	363.84±90.71	348.14±90.71
	L. rohita	3.30±0.60	107.69±19.82	75.00±13.23	1.2±0.19	2.52±.14	197.61±41.46	189.46±41.46
	C. cirrhosus	5.16±0.80	88.07±11.64	77.44±5.74	1.2±0.19	2.05±.10	169.19±31.58	156.44±31.58
	Total	14.77±1.15	327.72±45.84	78.59±3.12	1.2±0.0	1.94±0.71	768.09±116.15	716.21±116.00
T_2	*C. catla*	4.24±0.0	129.07±39.05	78.33±9.95	0.90±0.19	2.44±0.25	376.34±129.64	360.63±129.64
	L. rohita	3.30±0.0	125.36±23.96	79.09±10.47	1.2±0.19	2.62±.14	244.28±53.30	236.13±53.30
	C. cirrhosus	5.16±0.0	92.61±6.33	81.31±5.37	1.2±0.19	2.09±.05	186.02±18.03	173.28±18.03
	Total	12.70±0.76	347.04±16.38	79.58±1.26	1.1±0.14	2.38±0.22	806.64±89.62	770.04±77.85

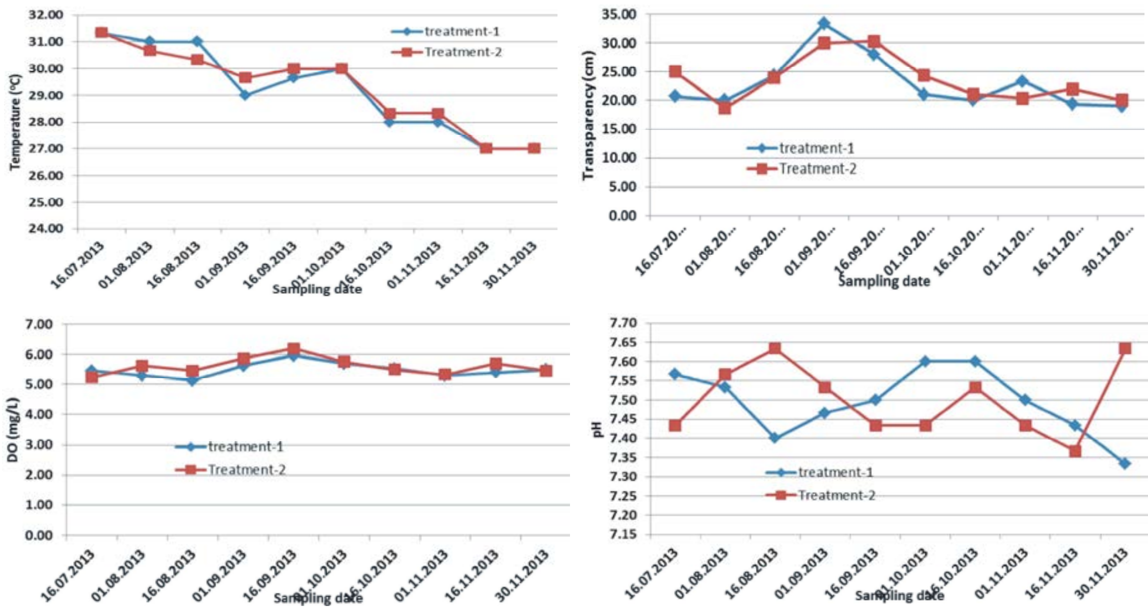

Fig. 2: Changes in temperature, transparency, dissolved oxygen (DO) and pH of water during grow-out carp polyculture under different treatments

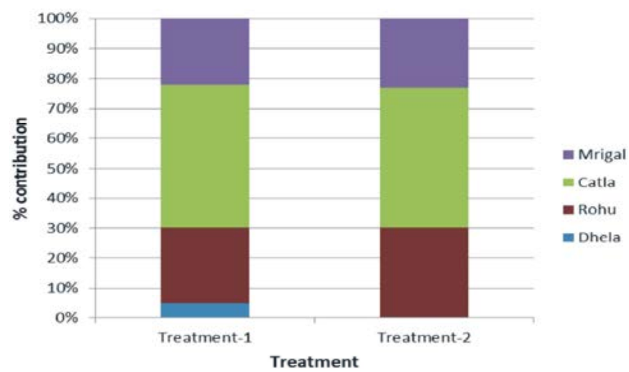

Fig. 3: The relative contribution of different species to total fish production under two treatments

Table 2: Cost and revenue analysis (per hectare) of treatment 1 (T_1) and treatment 2 (T_2)

		Item required		Unit price (Tk.)		Total price (Tk.)	
	Item	T_1	T_2	T_1	T_2	T_1	T_2
	Lime (kg)	250	250	12	12	3000	3000
Fertilizer	Urea (kg)	100	100	15	15	1500	1500
	TSP (kg)	100	100	25	25	2500	2500
Feed	Rice bran (kg)	561	460	15	15	8415	6900
	Mustard oil cake (kg)	280	229	35	35	9800	8015
Seed (no.)	Dhela	7410	0	1	0	7410	0
	Catla	3705	3705	2	2	7410	7410
	Rohu	2470	2470	2	2	4940	4940
	Mrigal	2470	2470	2	2	4940	4940
	Total cost					49915	
Revenue	Dhela (kg)	37	0	200	0	7400	0
	Catla (kg)	363	376	120	120	43560	45120
	Rohu (kg)	194	244	120	120	23280	29280
	Mrigal (kg)	169	186	120	120	20280	22320
	Total revenue					94520	96720
	Net benefit					44605	57515
	Benefit-cost ratio					1.893:1	2.47:1

Cost-Return Analysis: Operational costs involved the cost of the pond preparation, the purchase of fingerlings, feed and fertilizers. The cost of physical labor involved was not considered because farmers themselves were involved in pond management works. The total operational costs during study period calculated were BDT 49915 and BDT 39205 in treatment T_1 and T_2 respectively. Fingerlings and feed were the main investment and the profit was calculated by subtracting the expenditures on pond management from the value of the harvested fish. The total revenues per ha pond during study period were BDT 94520 and BDT 96720 in treatment T_1 and T_2 respectively. The net benefits for treatment T_1 and T_2 were BDT 44605 and BDT 57515, respectively. However, carp polyculture system provided higher benefit than carp-dhela polyculture. Benefit-cost ratio (BCR) was obtained 1.89 and 2.47 in treatment T_1 and T_2, respectively (Table 2).

DISCUSSION

Extensive resource base, huge water bodies and favorable climate offer a great opportunity to enhancement of fish production with optimization of nutritional and economic benefit for rural people in the haor region of Bangladesh. Wise and sustainable use of natural resources to enhance the production of low input aquaculture systems can help to increase the income and food security of the people in rural areas.

Growth and Production Performance: Yield of dhela obtained 37.45 kg ha^{-1}. Dhela did not able to take part in breeding due to late stocking; this is why dhela production was low. Dhela production was not affected by the plolyculture composition and carp production also was not affected by the presence of dhela, because there were no significant differences of total fish production between two treatments with dhela (768.09 kg ha^{-1}) and without dhela (806.64 kg ha^{-1}). The highest weight gain (124.83 g) and SGR (2.44%) value of catla was observed in T_2. Survival of catla did not show any significant differences. Yield of catla in T_1 and T_2 was 348.14±90.71 kg ha^{-1} and 360.63±129.64 kg ha^{-1}, respectively and there were no significant differences. Kunda *et al.* [12] observed net yield of catla 471-503 kg ha^{-1} within 4 months of culture period in carp small fish mola and prawn plolyculture system which is close to the results of the present study. Roy *et al.* [13] obtained production of catla 486-698 kg ha^{-1} from carp plolyculture system by 7 months trial which is more or less similar to the result of the present study. Production of rohu was found 197.61±41.46 and 244.28±53.30, respectively in T_1 and T_2. Rohu production observed significantly higher in treatment T_2, it might be so happen due to presence of dhela and there might have some competition with food among dhela and rohu. SGR (% bw/day) value of rohu was 2.52 and 2.62 in T_1 and T_2 respectively. Net production of rohu was observed 171-187 kg ha^{-1} within 4 months of culture period in carp-mola and prawn plolyculture system [12] which is similar to the results of the present study. Observation by Roy *et al.* [13] in case of rohu was 589-754 kg ha^{-1} by 7 months trial of carp plolyculture system which is higher than the present study.

The highest mrigal production obtained 186.02±18.03 kg ha^{-1} in treatment T_2, where no dhela was stocked and production in treatment T_1 found 169.19±31.58 kg/ha. Roy *et al.* [13] obtained production of mrigal was 557-761 kg ha^{-1} from carp plolyculture system by 7 months trial which is much higher than the result of the present study. SGR (%bw/day) value of mrigal was 2.05 and 2.09 in T_1 and T_2, respectively which is very similar for both the treatments.

Water Quality Parameters: Environmental parameters exert an important role on the growth and production of fish and other aquatic organisms. The suitable water quality parameters are prerequisite for a healthy aquatic environment and for the production of sufficient fish food organisms. The primary productivity of water body is dependent on physical and chemical factors of water in relation to the other environmental factors [14]. The water quality parameters measured in all the ponds throughout the experimental period were found within the acceptable range of fish culture and all of them were more or less similar with a few exceptions. Without few exceptions, there was no significant difference among the treatments.

Water temperature regulates the growth, reproduction and metabolism as well as feeding intensity of fishes. The range of water temperature (27 to 32°C) as observed to prevail in the experimental ponds appeared to be suitable for fish culture. Kohinoor [15] also recorded water temperature to vary from 18.5 to 32.9°C in the experimental ponds which is similar to the present study. Water transparency is generally expressed as the level of productivity of water body and also indicates the presence or absence of fish food particles. The values of transparency range (17.0-39.0 cm) as recorded in the present study indicate that the ponds were productive.

The turbidity that appeared might be due to the presence of common carp which is reported to be the most common natural reason for turbidity apart from plankton population. Wahab *et al*. [16] reported that common carp damages pond embankments by searching for food or burrowing to build nests which results reduced transparency. Boyd [17] recommended a transparency ranged from 15 to 40 cm as appropriate for fish culture.

pH is an important factor in a fish pond and also called the productivity index of a water body. An acidic pH of water reduces the growth, metabolism and other physiological activities of fishes. Kohinoor *et al.* [18] observed the pH range 7.18 to 7.24 in carp-mola polyculture ponds at the Fisheries Field Laboratory, Complex, Bangladesh Agricultural University, Mymensingh. The observed pH values of water ranged from 7.1 to 7.8 indicated that the experimental ponds were suitable for fish culture which within the range recommended by Boyd[17]. The significant difference in pH that was observed among the treatments might be due to interacting effects of different species composition and stocking densities to the water column.

The concentration of dissolved oxygen (DO) in the experimental ponds had generally fluctuated and ranged from 4.8 to 6.4 mg/L. Banerjea [19] reported that dissolved oxygen ranging from 5 to 7 mg/L is good for fish Culture. DoF [20] also reported the ranges of dissolved oxygen suitable for fish Culture would be 5.0 to 8.0 mg/L. Wahab *et al.* [21] recorded similar dissolved oxygen values that ranged from 2.2-7.1 mg/L.

Economic Analysis: The economic analysis of the proposed system was carried out to assess the economic return of carp dhela polyculture under low input management. The trialed carp-dhela polyculture systems were semi-intensive in nature and expected to be sustainable, because no extra input was given. The fish production can be improved by integrating dhela or other SIS in a polyculture, because SIS use unutilized food resources in the pond [22] and can increase their number rapidly through their multiple breeding habits. Dhela is a self-recruiting species but in this study, it did not take part in breeding due to late stocking. The net benefits for T_1 and T_2 were Tk.44605 and 57515, respectively. Roy *et al.* [13] reported Tk. 94,925, 88,330 and 68,270 as net benefits per hectare per 7 months for only carps, carps plus mola and carps plus chela polyculture systems were, respectively. However, only carp polyculture system provided higher benefit, followed by carp-mola polyculture without silver carp. Roos [22] reported that the net profit was Tk. 34,100 ha^{-1} in carp-native SIS ponds and Tk. 28,100 ha^{-1} per season in carp mola ponds, while Mymensingh Aquaculture Extension Project recorded the profit Tk. 32,000 ha^{-1} for 8 months production season in perennial ponds. Benefit-cost ratio obtained 1.893 and 2.47 in T_1 and T_2, respectively in the present study.

CONCLUSION

The conclusion, based on the field experience and preliminary data analysis of this field trial is that *O. cotio* can be cultured successfully in farmer's small seasonal ponds in polyculture with carps. The farmers are interested in culturing *O. cotio* because of its tasted and nutritional value. In the present study, it was observed that there were no significant differences of total carp production in combination with dhela and without dhela. So, it revealed that dhela have no negative impact on growth and production of carp species and dhela can be culture in pond. As *O. cotio* is a very high nutrient rich small indigenous species of fish and it is gradually disappearing from the nature which is now recognized as vulnerable species, so initiatives will have to be taken to conserve this species in nature as well as promote in pond aquaculture. Considering the above context it may be concluded that *O. cotio* can be a suitable species to be cultured with carps in pond polyculture system. For encouraging successful culture of *O. cotio* with carps in small seasonal ponds, certain conditions must be met. Good quality *O. cotio* broodfish must be available to the farmers. In this field trial, broodfish from local wild stocks were used successfully but in order to expand this production technology, it is necessary to ensure availability of local broodstock. There is great potential for integrating *O. cotio* and other small indigenous fish species in the further development of aquaculture in Bangladesh. This new approach in aquaculture can play an important role in ensuring greater diet diversity and increased intake of essential nutrients among rural populations. However, further research is needed to find out suitable and sustainable carp-dhela polyculture technology.

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