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INCLUSION OF BIVALVE IN CARP POLYCULTURE PONDS MANAGED BY SMALL INDIGENOUS PEOPLE UNDER BARIND TRACT

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Abstract

The present experiment was carried out in the household ponds (0.04 to 0.08 ha in area with 1.3 to 2.4 m in depth) of small indigenous people at Barind Tract region, northwest Bangladesh during September, 2017 to June, 2018 to know the growth performance of bivalve with carp. Two different treatments with 3 replicates were used, in treatment one (T_1) only the carp polyculture was performed and in treatment two (T_2) carp and bivalve polyculture was performed. Good quality of carp fingerlings (*Labeo rohita, Gibelion catla, Cirrhinus cirrhousus, Hypophthalmichthys molitrix and Ctenopharyngodon idella*) and freshwater bivalve (*Lamellidens marginalis*) seeds were stocked in the ponds. Stocking density and size of the seeds were similar for all of the study ponds. During the experiment there were no significant differences was observed in growth performance of the fishes between the two different treatments ($p<0.05$). The weight gain was recorded for *L. rohita* 420.31 g in T_1 and 436.25 g in T_2, for *G. catla* 237.01 g in T_1 and 329.66 g in T_2, for *C. cirrhosus* 263.53 g in T_1 and 301.74 g in T_2, for *H. molitrix* 559.6 g in T_1 and 593.57 g in T_2, for *C. idella* 510.11 g in T_1 and 619.57g in T_2. The weight gain of *L. marginalis* was 12.3 g in T_2. During this experiment the production of carp was recorded 2524.5 kg/ha in T_1 and 2618.2 kg/ha in T_2 and the bivalve production was 1284.4 kg/ha in T_2. This study is the first report on growth performance of bivalve with carp in the Barind Tract region of northwest Bangladesh. The result of this study will be helpful for the development of bivalve aquaculture in this climatically vulnerable region.

Key words: Barind Tract, Bivalve, Carp, Indigenous people, Polyculture

Introduction

Aquaculture is the farming and husbandry of aquatic organisms under controlled or semi-controlled conditions. With the increase in human population and diminished natural fisheries resources, aquaculture is rapidly gaining importance. Pond aquaculture is growing fast in many resource-constrained Asian countries (Hossain et al. 2020). In order to maintain the present per capita fish demand, further growth of aquaculture production is needed as the supply through capture fisheries cannot grow any more. Aquaculture has turned to a promising economic sector in Bangladesh. Aquaculture contributes over 50% of the total fish production of Bangladesh (DoF 2017). Advancement of technologies leads to aquaculture as a more profitable approach day by day.

Apart from the technology, recent climate change aspect makes some region more vulnerable than other parts of the country. Barind Tract is one of the climatically vulnerable zones in northwest Bangladesh, characterized by red or yellow clay soil, limited rainfall and lack of water sources in the dry season. Barind Tract is potential for aquaculture development in the homestead ponds by the poor indigenous people (Arook et al. 2016). In recent years, small indigenous people are facing critical challenges of poverty, nutrition and

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employment (Samad 2006). Bivalves are one of the most favorite food items to the small indigenous people, they usually collect the bivalves from different water bodies and consumed as food. In recent years the availability of the bivalves in the water resources rapidly declined due to over harvesting, habitat degradation, pollution etc. So, there is a great potential of inclusion of bivalve in the carp culture ponds of the small indigenous people in the Barind Tract region.

Worldwide, there are many research works have been reported on carp polyculture (Rahman et al. 2006). In southern India, fresh water bivalve's aquaculture is initiated for human consumption (Chakraborty et al. 2008). Still to date there is no research work on bivalve aquaculture, especially in the Barid Tract region of the northwest Bangladesh. Therefore, the present experiment investigated the growth performance of bivalve in carp polyculture ponds managed by small indigenous people at Barind Tract, northwest Bangladesh. The culture of bivalves with carps could offer the best possibility of nutritional enhancement of the small indigenous people in the climatically vulnerable Barind Tract region. The specific objectives of this experiment were i) to evaluate the water quality parameters of the study ponds; ii) to evaluate the growth performance of bivalve and carps; and iii) to recommend the suitability of carp-bivalve polyculture in the ponds at Barind Tract region.

Materials and Methods

Study area and pond selection

The present experiment was conducted in the homestead ponds at Jugisho village of Tanore upazila under Rajshahi district in northwest Bangladesh for a period of 10 months during September 2017 to June 2018 (Fig. 1). The geographical location of the study site was in between 24º34´and 24º36´north and in between 88º33´and 88º35´ east. Historically the Tanore upazila is one of the important areas in the northwest region, where small indigenous people (Swantal) are living and contributing to the socio-economic development of this region. The experimental ponds were selected from the indigenous people community having 0.04 to 0.08 ha in area with 1.3 to 2.4 m in depth. All the selected ponds were rain-fed, well exposed to prevailing sunlight and without inlet or outlet.

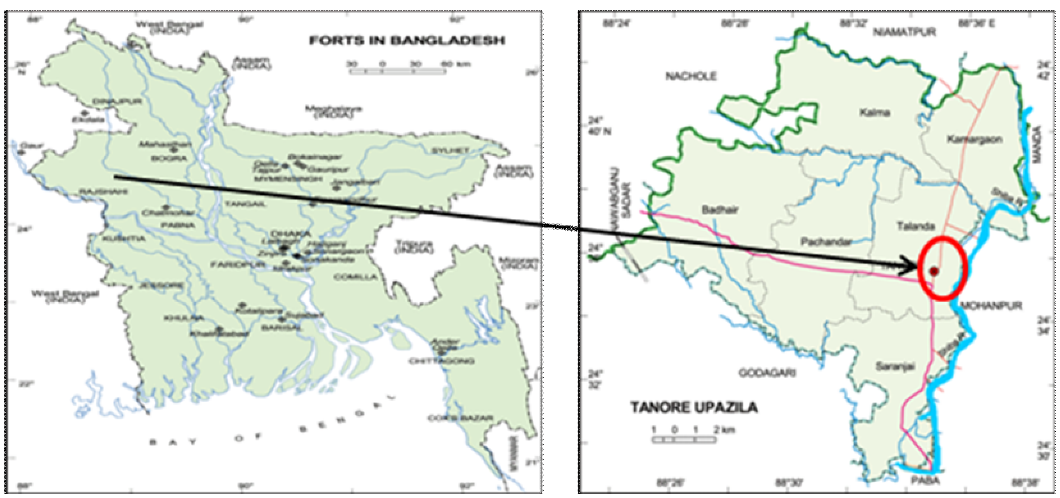

Fig. 1: Location of study area at Tanore upazila under Rajshahi district, Northwest Bangladesh.

Experimental ponds

The experiment included two treatments with three replicates each and the treatments were selected randomly. In this experiment, only the carps were stocked in the ponds of T_1 and carp with bivalve *Lamellidens marginalis* were stocked in the ponds of T_2. Stocking density was same for carp in both of the treatments.

Pond preparation

The pond banks and embankments were raised and repaired properly in broken places. Aquatic vegetation was removed completely from the ponds manually. All predatory and unwanted fishes were removed from the experimental ponds by repeated netting.

Liming

Ponds were prepared properly with lime (494 kg/ha). Before applying lime, it was mixed with water carefully and kept exposed for a while to avoid heat generation and finally spread over the surface of the mud in a soluble form. After 7 days of liming, ponds were filled with supplied ground water.

Fertilization

Fertilization was done in the ponds with Urea and TSP (triple super phosphate) at a proportion of 1:1 to stimulate the productivity of the ponds and applied 7 days before stocking with the preferred type of fishes as basal fertilization. The initial basal fertilization dose was urea (123 kg/ha) and TSP (123 kg/ha). TSP was applied into the ponds, after dissolving in plastic bucket 10 to 12 h before fertilization.

Stocking

Good quality carp seeds were collected from a reputed fish fry trader of Amnura, Chapainawabganj and transported in aluminum container with aeration to minimize the mortality. Bivalves (*L. marginalis)* seed were collected from the research pond of Fisheries Department of Rajshahi University. The initial length and weight of carp fingerlings and bivalves seed were measured and stocking was done early in the morning (at 7.0 AM) after 7 days of basal fertilization (Table 1).

Table 1. Species composition, initial length, weight and stocking density in each treatment.

Fish and bivalve species	Initial length (cm)	Initial weight (g)	Stocking density (piece/ha)	
			T_1	T_2
Labeo rohita	19.9±1.2	101.8±13.6	1250	1250
Gibelion catla	27.8±2.3	263.8±47.4	500	500
Cirrhinus cirrhosus	21.7±0.4	138.9±2.8	1250	1250
Hypophthalmichthys molitrix	16.0±1.0	40.1±8.6	1500	1500
Ctenopharyngodon idella	16.3±4.1	58.9±54.0	500	500
Lamellidens marginalis	4.3±0.5	14.1±1.7	-	50000

Post stocking management

Immediately after stocking, daily fertilization was followed as Urea 6.25 kg /ha, TSP 6.25 kg /ha. The TSP was dissolved in water and then mixed with urea and spread this water surface of the ponds. Commercial fish feed was used daily at the rate of 3-4% of fish body weight.

Fish growth monitoring

To determine the growth performance of the fish and bivalve, monthly length and weight were measured. The total length of fish species and bivalve was recorded separately to the nearest centimeter scale. The weight of both carp and bivalve was taken by a digital electric balance. Fishes were sampled monthly using a seine net and bivalves were sampled by hand picking to determine the growth and to adjust the feed ration. Growth and production of fishes was calculated after Brett and Groves (1979) as follows:

Final weight (g) = Weight of fish at harvest (g)

Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

Specific growth rate (SGR, % bwd^{-1}) = [L_n (final weight) - L_n (initial weight)]/ culture period (days) $\times$ 100

Fish yield (kg/ha/culture period) = Fish biomass at harvest – Fish biomass at stock.

Monitoring of water quality parameters

Some important water quality parameters of the experimental ponds such as water temperature, transparency, dissolved oxygen (DO), pH, alkalinity and free carbon dioxide (CO_2) were monitored monthly between 10:00 AM to 11:00 AM for the present study. Water temperature was recorded with the help of a Celsius thermometer at 20 to 30 cm depth of water. Transparency was measured by a Secchi disk. DO, pH, alkalinity and free CO_2 were determined using HACH kit (FF-2, USA).

Data analysis

Data on water quality parameters, fish growth and yield of polyculture under two different treatments was subjected to paired t-test using computer software SPSS (version-20.0) at $p<0.05$ level of significance.

Results

Growth performance of fish and bivalve

In the present experiment, there were no significant differences was observed in growth performance both length and weight of *L. rohita, G. catla, C. cirrhosus, H. molitrix* and *C. idella* between two different treatments ($p<0.05$). Weight increment of the fishes was slower during September to December 2017 and a rapid weight increment was observed during January and June 2018 (Fig. 2-6). However, growth of the fishes was higher in T_2 in compare with T_1 (Fig. 2-6).

Length gain

The length gain for *L. rohita* was recorded 9.95 cm in T_1 and 13.5 cm in T_2. In case of *G. catla* length gain was 4.69 cm in T_1 and 7.05 cm in T_2, for *C. cirrhosus* 7.04 cm in T_1 and 7.17 cm in T_2, for *H. molitrix* 15.71 cm in T_1 and 20.64 cm in T_2, for *C. idella* the length gain was 17.54 cm in T_1 and 18.37 cm in T_2. During the study, the higher length gain *H. molitrix* and lower length gain was recorded for *G. catla*. The length gain of *L. marginalis* was 1.73 cm in T_2 (Table 2).

Weight gain

The weight gain for *L. rohita* was recorded 420.31 g in T_1 and 436.25 g in T_2. In case of *G. catla* weight gain was 237.01 g in T_1 and 329.66 g in T_2, for *C. cirrhosus* 263.53 g in T_1 and 301.74 g in T_2, for *H. molitrix* 559.6 g in T_1 and 593.57 g in T_2, for *C. idella* the weight gain was 510.11 g in T_1 and 619.57 g in T_2. The weight gain of *L. marginalis* was 12.3 g in T_2 (Table 2).

Specific growth rate (SGR %)

The specific growth rate SGR (%) of *L. rohita* was obtained as 0.54%, 0.55%, in T_1, and T_2 respectively. In case of *G. catla* it was 0.21%, and 0.27%, in T_1 and T_2 respectively. In *C. cirrhosus* SGR (%) was observed as 0.35%, and 0.38%, in T_1 and T_2 respectively. For *H. molitrix* SGR (%) was 0.90% and 0.91% in T_1 and T_2 respectively. For *C. idella* SGR (%) was 0.75%, and 0.81% in T_1 and T_2 respectively. The specific growth rate of *L. marginalis* was 5.23% in T_2 (Table 2).

Fish and bivalve production

In the present experiment, the production of carp fish was recorded 2524.5 kg/ha in T_1 and 2618.2 kg/ha in T_2 (Table 2). The production of bivalve was obtained 1284.4 kg/ha in T_2 (Table 2).

Table 2. Final weight, length gain, weight gain, specific growth rate (SGR%) and production of fish and bivalve during the experiment.

Treatments	Species	Final weight (g)	Length gain (cm)	Weight gain (g)	SGR (%)	Production Kg/ha
T_1	*L. rohita*	518.2±53.24	9.95	420.31	0.54	2524.5
	G. catla	500.85±35.81	4.69	237.01	0.21	
	C. cirrhosus	402.5±42.41	7.04	263.53	0.35	
	H. molitrix	602.25±27.52	15.71	559.80	0.90	
	C. idella	569.1±25.85	17.54	510.11	0.75	
T_2	*L. rohita*	538.2±46.13	13.50	423.31	0.55	2618.2
	G. catla	588.29±48.59	7.05	324.45	0.27	
	C. cirrhosus	443.08±65.87	7.17	304.11	0.38	
	H. molitrix	633.25±52.01	20.64	602.15	0.91	
	C. idella	681.78±63.9	18.37	624.45	0.81	
	L. marginalis	26.5±9.2	1.73	12.30	5.23	1284.4

SGR = Specific growth rate, T = Treatment.

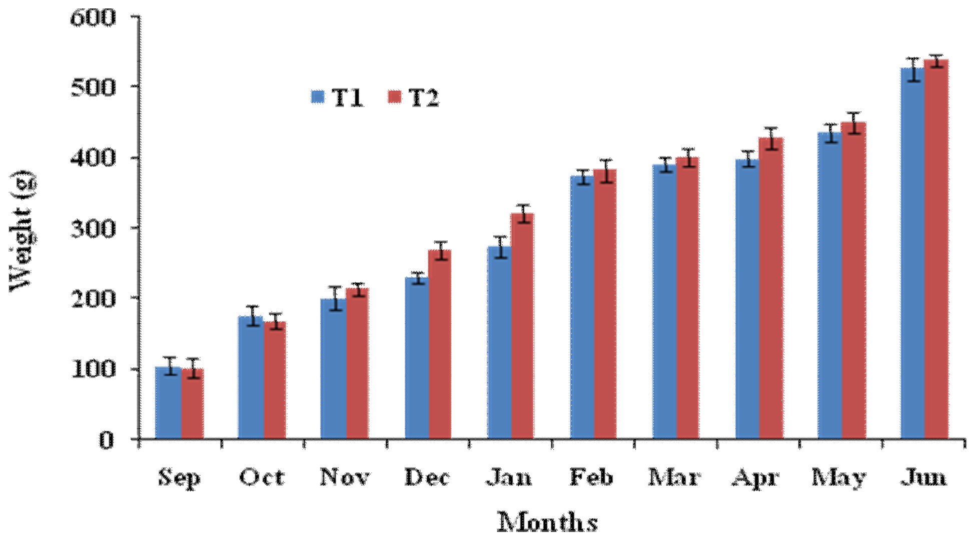

Fig. 2: Monthly weight increment (Mean ± SD) of *L. rohita* in T_1 and T_2.

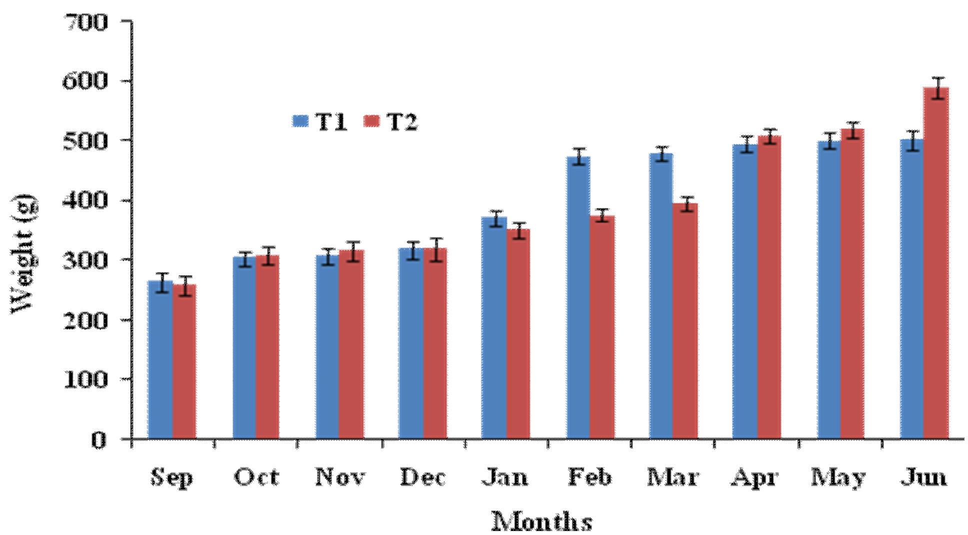

Fig. 3: Monthly weight increment (Mean ± SD) of *G. catla* in T_1 and T_2.

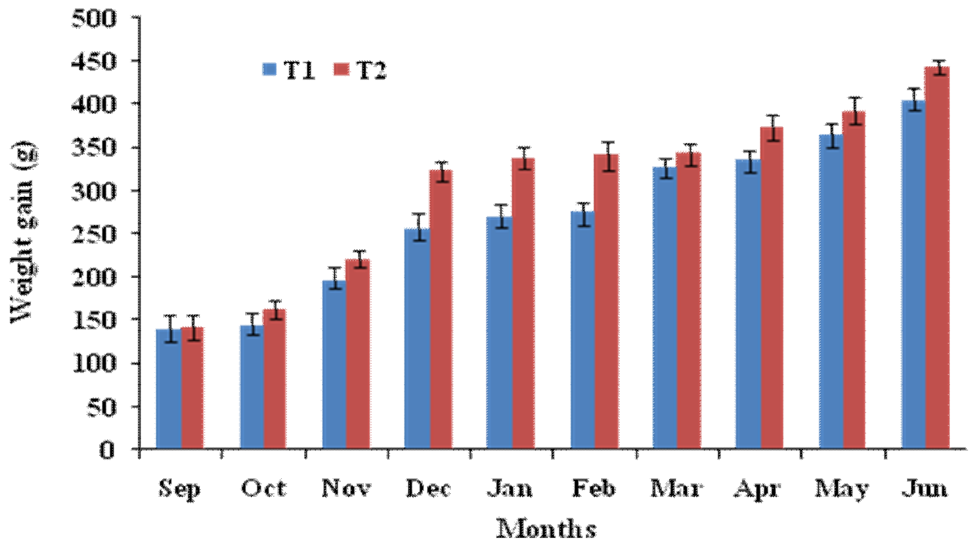

Fig. 4: Monthly weight increment (Mean ± SD) of *C. chirrhosus* in T_1 and T_2.

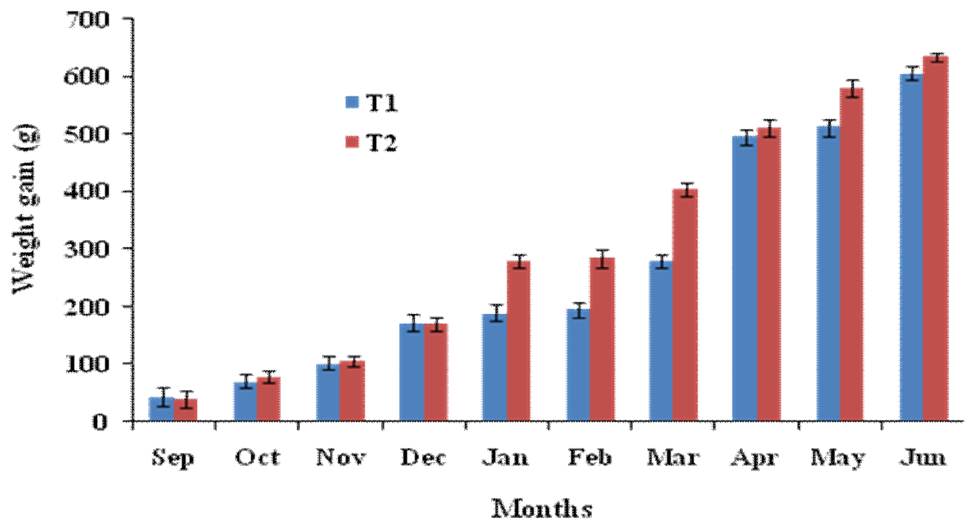

Fig. 5: Monthly weight increment (Mean ± SD) of *H. molitrix* in T_1 and T_2.

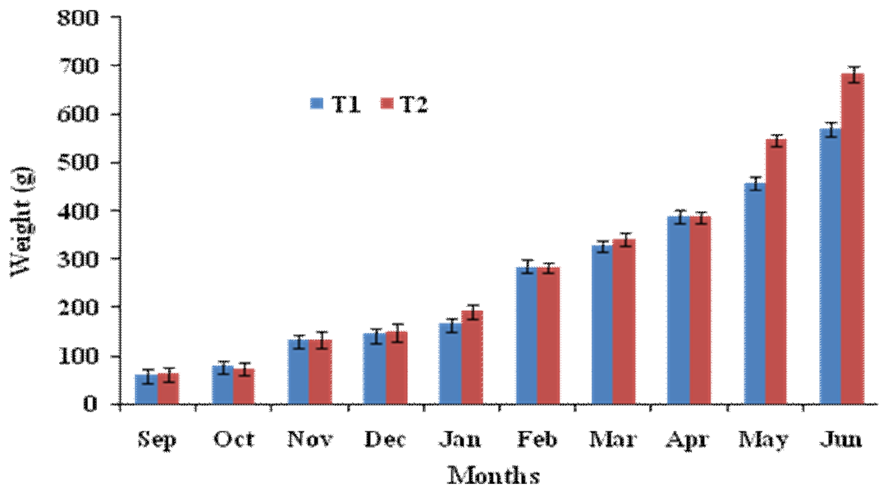

Fig. 6: Monthly weight increment (Mean ± SD) of *C. idella* in T_1 and T_2.

Water quality parameters

The result of water quality parameters temperature, transparency, dissolved oxygen, pH, CO_2 and alkalinity are shown in Table 3. During this experiment, the water temperature ranged between 19.2 - 30.4°C in T_1 and 18.3 - 31.0°C in T_2, transparency 23.0 - 31.0 cm in T_1 and 22.0 - 32.0 cm in T_2, DO 4.5 - 7.2 mg/l in T_1 and 5.4 - 7.2 mg/l in T_2, CO_2 5.4 - 8.5 mg/l in T_1 and 5.0 - 8.7 mg/l in T_2, alkalinity 48.0 - 85.0 mg/l in T_1 48.0 - 75.0 in T_2 and pH 6.8 - 7.6 in T_1 and 6.8 - 7.8 in T_2. The water quality parameters of this experiment were within the suitable range did not differ significantly between the treatments (p <0.05, Table 3).

Table 3. Monthly variations of water quality parameters in T_1 and T_2

Parameters	Treatments	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temperature (°C)	T_1	29.0	25.6	26.2	21	19.2	22.5	26	26.8	28.5	30.4
	T_2	28.0	25.9	26.5	21.8	18.3	22	25.8	26.5	28.8	31
Transparency (cm)	T_1	27.5	25	26.0	23	24.4	24.8	25	26.8	27	31
	T_2	28.0	25.5	23.0	22	24.5	23.2	24	27	29	32
DO (mg/l)	T_1	5.15	4.5	5.9	6.3	6.8	5.6	6.7	7.2	6.9	7.1
	T_2	6.2	5.8	6.4	6.9	7.2	6.5	5.4	6.8	6.4	6.9
CO_2 (mg/l)	T_1	8.5	6.4	5.4	5.8	7.6	7.5	6.8	5.8	6.6	6.8
	T_2	7.6	8.7	5.9	5	6.4	7.2	5.8	6.5	5.4	8.9
Alkalinity (mg/l)	T_1	52	64	48	58	69	55	52	60	85	75
	T_2	55	48	45	58	65	65	75	68	56	62
pH	T_1	7.2	7.6	6.8	7.1	7.3	7.5	6.9	7.8	7.2	7.6
	T_2	7.5	7.3	7.3	7.5	6.8	7.3	6.8	7.5	7.5	7.8

Discussion

In this experiment growth rate of the fishes was lower during September and December and a dramatic growth performance was observed from January to June. During this experiment, length gain was the highest for *C. idella* in T_1 and *H. molitrix* in T_2 and lowest length gain for *G. catla* in both of the treatments. On the other hand, the highest weight gain was recorded for *C. idella* in both of the treatments and lowest weight gained for *G. catla* in T_1 and *C. cirrhosus* in T_2. During this experiment, growth performance of the fishes was not significantly different between the treatments ($p > 0.05$), while a higher growth was recorded for all the fishes in T_2. The better growth performance of the fishes recorded in the T_2 could be linked with the inclusion of the bivalves in the ponds. Freshwater bivalves are an important component of many healthy river and pond ecosystem. In addition, freshwater bivalves often are used by various agencies to monitor environmental quality, including trends of chemical contamination (Rosenberg and Resh 1993).

Fish production

Final weight, weight gain and SGR (%) of the fishes in this experiment were more or less similar with the findings of Kabir et al. (2017) and Talukder et al. (2018) whereas they followed irregular stocking combination and smaller initial stocking size for fishes. In the present experiment the fish production was 2524.5 kg/ha in T_1 and 2618.2 kg/ha in T_2 and bivalve production was obtained 1284.4 kg/ha in T_2 (Table 2). Haque (2010) reported the production of Indian major carp ranging from 2618.85±57.5 to 2747.47±116.47 kg/ha/year, which is similar with the production of the present experiment. The finding of this study are more or less similar to the findings of Lakshman et al. (1971), they reported similar production for Indian major carp and exotic carp by feeding with supplementary feed containing rice bran and mustard oil cake in composite culture. A study conducted by Talukder et al. (2017) in carp polyculture ponds under drought prone Barind area had reported a fish yield ranging from 1411.29 ± 25.19 to 3693.23 ± 69.37 kg/ha/6 months which was also comparable with the findings of the present study. Hossain et al. (2020) from the same geographic area reported the production of carps 3451.50±32.62 to 4192.54±79.37 kg/ha/6 months. They used carp fattening technology and stocked larger size fish species in their culture ponds.

Water quality parameters

Water quality is one of the most important factors in ensuring a healthy fish production. Water quality in aquatic environment considerably affects the growth and reproduction of fishes. If the water quality is beyond tolerable limits, fish health is adversely affected. The primary productivity of water body is dependent on physical and chemical factors of water in relation to the other environmental factors (Rahman et al. 1982). Aquaculture depends almost completely on the water quality. The suitable water quality parameters are prerequisite for a healthy aquatic environment and for the production of sufficient fish food organisms. In the present experiment there was significant differences was observed in water quality parameters between the two different treatments ($p < 0.05$). The water temperature of the study ponds were found to vary from 18.3-31.0°C. The highest temperature was recorded in the month of June and the lowest temperature was recorded in the month of January. A more or less similar temperature was recorded by Mollah and Haque (1978) who recorded the water temperature ranges from 26.0 to 32.44°C in ponds at Bangladesh Agricultural University Campus, Mymensingh. Alam et al. (2002) recorded minimum surface water temperature (16°C) during winter and maximum (33°C) in summer. The fluctuation of water temperature might be due to solar radiation or rain. Bhatnagar and Devi (2013) suggested 20 to 30°C water temperature is suitable for carp polyculture ponds which is also more or less similar with the findings of the present study. During the study period the water transparency varied from 22.0 - 32.0 cm, which was more or less similar to Wahab et al. (1995) who suggested that the transparency of productive water should be 40 cm or less. Boyd (1998) recommended a transparency between 30- 45 cm as good for fish culture. Dissolved oxygen is another important water quality parameter, on which fish depend on to live. If dissolved oxygen shortage found in the pond water fish start gasping and in that cases aeration should be provided immediately, otherwise sever fish mortality may occur. During the study period the dissolved oxygen varied from 4.5 to 7.2 mg/l. More or less similar result was reported by Hossain et al. (1999), they recorded DO values of fish ponds ranged from 3.8 to 6.9 mg/l. Bhuiyan (1970) stated the DO concentration 5.0 to 7.0 mg/l within the good productive range. Banerjee (1967) and Bhuiyan (1970) reported 5 to 7 mg/l DO content of water is fair or good in respect of productivity and water having DO less than 5 mg/l to be unproductive. During the present study the values of free Carbon-dioxide were fluctuated between 5.0-8.7 mg/l. Alam et al. (2002) recorded free CO_2 (5-13 mg/l) from fish culture ponds in Mymensingh. Suitable range of free CO_2 is not more than 12 mg/l (DoF 2015). The suitable range of free CO_2 for fish culture is less than 10.0 ppm (Boyd, 1990). The concentration of free carbon dioxide was found directly related to the amount and nature of biological activities in the water. The carbon dioxide, pH and alkalinity are thus directly related with each other (Michael, 1969). During the study period the value of alkalinity ranged from 48.0 - 85.0 mg/l. Alikunhi (1957) reported that total alkalinity more than 100 mg/l should be presented in high productive water bodies. Rath (2000) stated that calcareous water with alkalinity more than 50 ppm was most productive. He also described the range of alkalinity 0-20 ppm as low productive, 20-40 ppm as medium productive and 40 - 90 ppm as high productive. On the basis of above author's findings it can be accomplished that the total alkalinity recorded from the present study was within productive range. During the study period, the range of pH values recorded in the ponds were found to vary between 6.8 to 7.8, which are more or less similar to Boyd (1990), who stated that the suitable range required for fish culture 6.5 to 9.0. According to Trivedi and Raj (1992) the optimum range of pH for aquatic life was recorded as 6.8 - 9.0. However, the pH value in alkaline condition in water was supposed to be helpful for proper growth and development of fishes and aquatic organisms (Nikolsky 1963, Jhingran 1991). An acidic pH reduces the growth rate, metabolic rate and other physiological activities of fish (Swingle 1969).

Conclusion

The findings of the present experiment showed that inclusion of bivalve in the carp aquaculture enhanced the production of carp and with additional production of bivalve. The results will provide invaluable information of carp-bivalve aquaculture and will provide an important baseline data for the future studies on freshwater bivalve aquaculture. Therefore, further studies need to optimize stocking density and species composition to explore ultimate potential of bivalve aquaculture in the Barind Tract region for boosting up overall aquaculture production in Bangladesh.

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