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Production Enhancement of Carps and Tilapia in Creeks of Chittagong Hill Tract Districts, Bangladesh

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ABSTRACT

An experiment was conducted to evaluate the production performance of carps and tilapia in creeks of Chittagong Hill District in 2018. A total of 09 creeks (average size 60 decimal) were selected in three upazillas (Langadu, Rangamati Sadar of Rangamati district and Mahalchari upazila under Khagrachori District) of Chittagong Hill District for evaluating growth, survival and production performance of carps and tilapia in a completely randomized design into three different treatments where each treatment had three replications for 300 days. Fishes were stocked with same stocking density with combination of Rui 14, Catla 14, Mrigal 12 and Monosex tilapia 20 individuals/decimal with weight 21.28±10.64, 53.45±30.33, 32.55±9.75 and 1.95±1.23 g; respectively. Artificial feed was used containing 25-28% protein. The highest final weight of Rui (825.12±35.18), Mrigal (775.15±102.42) and Monosex Tilapia (515.1±35.15) were recorded in T1 (Rangamati Sadar) whereas highest final weight of Catla (984.10±85.24) was recorded in T3 (Langadu). The highest SGR of Rui (Labeo rohita), Mrigal (Cirrhinus cirrhosus) and Monosex Tilapia (Oreochromis mossambicus) were recorded in T1 (Rangamati Sadar) whereas highest SGR of Catla (Catla catla) found in T3 (Langadu). The Lowest FCR 1.35 was found in T2 (Mahalchari). The highest BCR 1.59 was found in T2 (Mahalchari). Fish productions for 300 days were 8067.02 kg ha^{-1}, 8286.85 kg $ha^{-1}$and 7879.30 kg ha^{-1}in T1, T2 and T3; respectively. The net benefit was BDT 420798.00 ha^{-1}, 480551.00 ha^{-1} and 371587.00 ha^{-1} T1, and T2 & T3 respectively. The highest net return (BDT 480551.00 ha^{-1}) and lowest gross cost per ha were found in T2.

Keywords: Production, Enhancement, Creek Aquaculture, Livelihood and CHT

1 | Introduction

The area of the Chittagong Hill Tracts is about 13,180 km2, which is approximately one-tenth of the total area of Bangladesh. Topographically, the Chittagong Hill Tracts are the hilly areas in Bangladesh. The depression of hilly slope connected with the main Lake or its stream and become inundated with enormous hilly streams during monsoon is called the creek. Fish culture in creeks of the three hill districts has good prospects. Three sides of arms of the creek should be surrounded by hilly land while the rest remain directly linked with the main body of the Lake or not. There are of 4727 creeks (covering 4297

ha areas) in Chittagong Hill Tracts (CHT) among them 1200 creeks are adjacent to the Kaptai Lake (DoF, 2012). The production capacity of these creeks is 2100 kg/ha that is eight to nine times more than the Kaptai Lake (Alamgir and Ahmed, 2005).

According to an estimate of Bangladesh Fisheries Development corporation (BFDC) in the year 2002-03 total fish production of the Kaptai Lake

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was 4556 MT but it was 9364 MT in the year 2015-16. Over fifteen years, production of total fish from this Lake received limited management attention as a result production of major carps (Labeo rohita, Catla catla, Cirrhinus cirrhosus) species decreased remarkably whereas small fishes especially (Gudusia chapra and Corica soborna) increased briskly. In spite of, the stocking of huge number of carp fingerling in the Lake every year, alarming decreases of aforementioned species were observed. Production of Lake declined due to lack of optimum flow of water, siltation which reduces the rate of water flow and causes habitat degradation, the loss of spawning ground and decline of natural seed production of major carps. Since, the current fish production at this Lake is declining fast intervention through creek aquaculture can be adopted in order to fully utilize the Lake's fishery potential.

The annual fish production of Chittagong Hill Tracts is 14773.46 MT (culture, capture and Kaptai Lake) which is comparatively lower than the total annual inland capture (FRSS, 2014). Fish demand is increasing due to population growth and cultivable land is decreasing for population explosion. To overcome this problem we have to ensure the maximum utilization of the limited resources. For aquaculture practice polyculture is the best culture system for maximum utilization of pond food web and ecosystem (Halver, 1984). The Department of Fisheries is trying to modernize creeks aquaculture activities in hill districts and conducted several training programs for the improvement of existing creeks by repairing and some steps were taken to create new creeks for fish culture. Bangladesh Fisheries Research Institute is trying to adopt various fish culture techniques in the hilly creeks, as well as carrying out research for boosting fish production. Therefore, the study was conducted to evaluate the growth performance, survival, and of carps and tilapia in creek aquaculture systems.

1 | Materials and Methods

2.1 Site selection and experimental design

The experimental site was selected at 03 (Three) Upazila; Rangamati Sadar, Langadu upazila of Rangamati district and Mahalchari upazila under Khagrachori district of Chittagong Hill Tract. A total of 09 creeks (average size 60 decimal) were selected for 09 replications under three treatments by following a completely randomized design (Table 1). In this study, treatments represent different geographic locations with similar management practices.

Table 1 | Experimental design of creek aquaculture of carps and monosex tilapia

Treatment / Location	Replications	Species composition (no. decimal^{-1})	Total stocking density	Size (cm)
T1: Rangamati Sadar	R1, R2, R3	Rui (14); Catla (14); Mrigal (12); Monosex tilapia (20)	60 fish decimal^{-1} (14,820 ha^{-1})	7-10
T2: Mahalchari, Khagrachari	R1, R2, R3	Rui (14); Catla (14); Mrigal (12); Monosex tilapia (20)	60 fish decimal^{-1} (14,820 ha^{-1})	7-10
T3: Langadu, Rangamati	R1, R2, R3	Rui (14); Catla (14); Mrigal (12); Monosex tilapia (20)	60 fish decimal^{-1} (14,820 ha^{-1})	7-10

2.2 Creek selection and preparation

Creeks were selected based on site characteristics, water retention capacity and water depth (1-5 m). Preparation of the creeks was done by repairing mouth of the creeks and unwanted vegetation and bottom sludge were removed from the creek bottom. Lime was applied @ 250 kg/ha. The selected creeks were fertilized with compost (mixture of chopped and sun-dried green plants 88%, cow dung 10%, urea 1% and lime 1%) @ 1,250 kg/ha, urea @ 37.5 kg/ha and TSP @ 25 kg/ha). Then the creeks were left for 10 days to promote algal development.

Figure 1 | Stocking of fish fry in creek aquaculture system

2.3 Collection and stocking of quality fry/fingerlings

Good quality fingerlings were collected and required numbers of fingerlings were stocked in each creek after proper acclimatization (Fig. 1).

2.4 Feeding management and fertilization

Formulated feed contained rice bran, mustard oil cake, fish meal, and vitamin–mineral premix, with a crude protein level of 25–28% and was supplied twice daily @ 10 to 5% body weight of fish. The feed was adjusted periodically in accordance with the growth performance of fishes. Water in the creeks were fertilized on monthly basis using urea @ 37 kg ha^{-1}, TSP @ 25 kg $ha^{-1}$and cow dung @ 1235 kg ha^{-1} (Figure 2).

Figure 2 | Feeding management in experimental creeks

2.5 Monitoring of water quality parameters

Water quality parameters such as air and water temperature, DO, free CO2, total hardness, total alkalinity and pH were monitored fortnightly using a water test kit (HACH, Model FF-2).

Figure 3 | Water quality monitoring using HACH kit

Transparency and water depth were measured using a Secchi disc and a meter scale respectively (Fig. 3).

Figure 4 | Length data recorded for growth performance study

2.6 Monitoring of fish growth

At least 10% fish of each species were collected by seine net and growth parameters such as length, weight and specific growth rate (SGR) were monitored as well as recorded fortnightly (Fig. 4 and 5). At the end of the experiment, all the fish were harvested and final length, weight, survival rate, specific growth rate (SGR) and benefit cost ratio (BCR) were estimated by following formula:

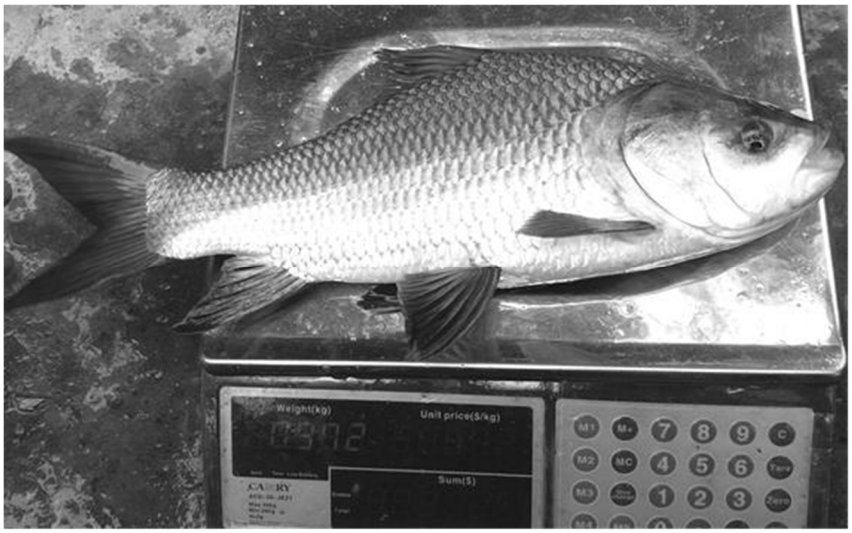

Figure 5 | Weight data recorded for growth performance study

2.7 Survival rate

At the end of the experiment most of the fishes were caught by net and the rest by drying the ponds. It was calculated as:

$$\text{Survival rate (\%)} = (\text{Number harvested} / \text{Number stocked}) \times 100$$

2.8 Specific growth rate (% per day)

The specific growth rate in the instantaneous change in weight of fish calculated as the percentage increase in body weight per day over given time interval. Growth in terms of weight was calculated by subtracting the initial weight of fish (at the time of stocking) from final weight of the same. The specific growth rate was calculated from the following formula:

$$SGR\ (\%\ day^{-1}) = [(\ln W_2 - \ln W_1) / (T_2 - T_1)] \times 100$$

Where W_1 = initial live body weight (g) at time T_1 (day), and W_2 = final live body weight (g) at time T_2 (day).

2.9 Food conversion ratio (FCR)

The food conversion ratio of fish expressed by the rate of food consumed to weight gain was determined for each of the three stocking rates.

$$FCR = \text{Food fed} / \text{Live weight gain}$$

2.10 Production

At the end of the experiment most of the fishes were caught by net and the rest by drying the ponds. The production was calculated as:

$$\text{Production} = \text{Number harvested} \times \text{Final average weight.}$$

2.11 Statistical analysis

Prior to analysis, data were tested for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test. As the assumptions of parametric analysis were satisfied, differences among treatments were evaluated using one-way ANOVA. Since no significant differences were observed ($p > 0.05$), post hoc multiple comparison tests were not performed.

1 | Results and Discussion

3.1 Water quality parameters

Mean values of water quality parameters over the study period are presented in Table

2. The results of the water quality analysis indicated that the parameters for fishes in creeks of Chittagong hill districts remained within suitable ranges. The water quality parameters of different sampling sites (Treatments) remained almost similar ($p > 0.05$). The growth of fish and other aquatic organisms depends on the water quality parameters. The air and water temperature of experimental sites of Chittagong hill districts were found to vary from 16 to 33oC and 17 to 31oC, respectively. These values are considered suitable for fish growth (Bashar et al., 2014). The concentration of dissolved oxygen (DO) and free CO2 in the experimental sites ranged from 4.95 to 8.7 mg L^{-1} and 2.2 to 10 mg L^{-1} respectively. DO concentrations were suitable for fish throughout the study period (Bashar et al., 2014). The range of pH of different areas varied from 6.5

to 7.5. The range of total alkalinity and total hardness of the different areas varied from

17.1 to 140 mg L^{-1} and 17.1 to 106.6 mg L^{-1} respectively. The water depth and transparency of the experimental sites varied from 3.7 to 8.5 ft and 0.6 to 1.6 ft respectively. The DO level was within the acceptable range in all creeks as described by Bashar et al., 2014. The observed pH values were in agreement with the findings of Islam et al. (2014), Chakraborty et al. (2003) and Alamgir et al. (2005) and are within the range of good water quality for pond fish culture. Total alkalinity ranged 56.00±17.37 mg L^{-1} to 60.01±20.84 mg L^{-1} indicating the productivity of the ponds as medium to high (Bhuiyan, 1970).

Table 2 | Water quality parameters of three different treatments during the study period (Mean ± SE)

Parameters	Rangamati Sadar (T1)	Mahalchari (T2)	Langadu (T3)
Air temperature (oC)	26.20±5.59 (16-31)	26.20±5.07 (16-30)	27.10±4.84 (17-33)
Water temperature (oC)	25.50±4.48 (17-30)	26.50±4.60 (17-31)	25.70±4.22 (18-31)
Dissolved Oxygen (mg/l)	6.03±1.01 (4.95-8)	6.76±1.17 (5-8.7)	6.18±0.94 (5-7.6)
CO2 (mg/l)	4.74±1.99 (3.3-10)	3.51±1.09 (2.2-5)	4.38±2.24 (2.3-10)
pH	7.10±0.39 (6.5-7.5)	7.20±0.42 (6.5-7.5)	7.20±0.26 (7-7.5)
Total alkalinity (mg/l)	59.35±34.46 (17.1-140)	56.00±17.37 (34.2-88)	60.01±20.84 (17.1-92)
Total Hardness (mg/l)	83.66±34.45 (43-163)	67.16±26.90 (17.1-106.6)	65.05±20.42 (34.2-91)
Water depth (ft.)	4.75±1.04 (3.7-6.4)	5.49±1.57 (3.8-8.5)	5.05±1.14 (4-7.2)
Transparency (ft.)	1.22±0.46 (0.8-2.4)	1.09±0.31 (0.6-1.6)	1.12±0.21 (0.7-1.4)

3.2 Growth performance study

The details of growth performance of Rui, Catla, Mrigal and Monosex Tilapia during culture in the creeks under three different treatments are summarized in Table 3. This table shows the initial and final mean length (cm) ±SD and mean weight (g) ±SD of fish. Rui (14), Catla (14), Mrigal (12) and Monosex Tilapia (20) were stocked in three treatments at the rate of 60 fingerlings per decimal. The highest final weight of Rui (825.12±35.18 g), Mrigal (775.15±102.42 g) and Monosex Tilapia (515.1±35.15 g) were recorded in T1 (Rangamati Sadar), whereas the highest final weight of Catla (984.10±85.24 g) was recorded in T3 (Langadu) (Table 3). Basak et al. (2017) found the highest weight of Catla 622.50±293.50 g, Rui 572.40±153.90 g and Mrigal 532.0±117.54 g for carp polyculture in creeks of CHT. The present study showed higher growth than Basak et al. (2017).

The survival rate of major carps was higher than those of Islam et al. (2014), who conducted a study on the feasibility of carp fry raising in Kaptai Lake creeks. The highest SGR was calculated for the experimental species under different treatments, such as Rui 1.22 in T1 (Rangamati Sadar) followed by 1.21 in T2 (Mahalchari); Catla 0.97 in T3 (Langadu); Monosex Tilapia 1.86 in T1 (Rangamati Sadar) and T2 (Mahalchari); and Mrigal 1.06 in T1 (Rangamati Sadar) (Table 3). The lowest FCR 1.35 was found in T2 (Mahalchari), and production was 8067.02 kg ha^{-1}, 8286.85 kg ha^{-1} and 7879.30 kg ha^{-1} in T1, T2 and T3, respectively (Table 3). Production was higher in T2 (Mahalchari) due to higher survival rate. Differences in production among locations may be attributed to variations in water depth, nutrient availability, and management practices. There was no significant difference among the three treatments in production ($p > 0.05$). Basak et al. (2017) found the highest production of 4643 kg ha^{-1} for carp polyculture in creeks of CHT. The present study showed higher growth than Basak et al. (2017).

Polyculture is an efficient means of increasing fish production. Polyculture can give higher production if fish with different feeding habits are stocked in proper ratios and combinations (Halver, 1984). The range of production from traditional polyculture of carps in Bangladesh was 3119 to 4067 kg ha^{-1} yr^{-1} (Mazid et al., 1997). Hossain and Islam (2006) reported that the key techniques of polyculture are based on efficient utilization of natural food, resulting in increased fish yield per unit area. Akter et al. (2010) obtained 5751 kg ha^{-1} in 142 days by applying formulated feed. Basak et al. (2017) revealed that 60 fingerlings per decimal stocking density gives the best survival rate and is most suitable for higher production of creek polyculture in CHT; this study also shows the same result.

Table 3 Growth performance of Rui, Catla, Mrigal and Monosex tilapia after 300 days of culture in three different areas of Chittagong Hill Districts

Treatment / location	Species	Initial length (cm)	Initial weight (g)	Final length (cm)	Final weight (g)	Survival (%)	Production (kg dec.$^{-1}$)	SGR	FCR	Total production (kg ha^{-1})
T1 Rangamati Sadar	Rui	12.88±2.82	21.28±10.64	37.80±1.45	825.12±35.18	74	8.55	1.22	1.47	8067.02
	Catla	15.1±2.8	53.45±30.33	38.80±3.11	966.32±152.12	68	9.20	0.96		
	Mrigal	15.1±1.71	32.55±9.75	38.00±1.15	775.15±102.42	65	6.05	1.06		
	Monos	3.91±0.8	1.95±1.23	29.7±1.0	515.1±35.2	85	8.86	1.86		

	ex tilapia	5		9	5					
T2 Mahalchari	Rui	12.88±2.82	21.28±10.64	36.25±2.10	810.14±58.12	79	8.96	1.21	1.35	8286.85
	Catla	15.1±2.83	53.45±30.33	37.54±2.85	945.20±125.08	72	9.53	0.96		
	Mrigal	15.1±1.71	32.55±9.75	36.28±1.36	729.14±92.22	70	6.12	1.04		
	Monosex tilapia	3.91±0.85	1.95±1.23	28.52±2.05	508.20±42.04	88	8.94	1.86		
T3 Langadu	Rui	12.88±2.82	21.28±10.64	35.40±2.14	778.24±68.84	76	8.28	1.19	1.53	7879.30
	Catla	15.1±2.83	53.45±30.33	39.74±2.47	984.10±85.24	70	9.29	0.97		
	Mrigal	15.1±1.71	32.55±9.75	34.45±2.20	705.15±134.02	75	6.35	1.03		
	Monosex tilapia	3.91±0.85	1.95±1.23	26.54±1.84	475.24±47.34	84	7.98	1.83		

Table 4 Cost-benefit analysis of Rui, Catla, Mrigal and Monosex tilapia after 300 days of culture in three different areas of Chittagong Hill Districts per hectare in BDT

Items	T1 (Rangamati Sadar)	T2 (Mahalchari, Khagrachari)	T3 (Langadu, Rangamati)
Cost			
Creeks lease (Tk. 55,000/ha/yr)	41200.00	41200.00	41200.00
Lime (Tk. 25/kg)	9262.00	9262.00	9262.00
Cow dung (Tk. 6/kg)	7410.00	7410.00	7410.00
Aquakleen (Tk.1200/1L)	9880.00	9880.00	9880.00
Rotenone (Tk. 300/Kg)	9600.00	9600.00	9600.00
Fingerling (Tk.5.85/Pcs)	86697.00	86697.00	86697.00
Feed (Commercial formulated)			
Mega (Tk.48/kg)	569088.00	536978.00	578655.00
Labor (Tk. 400/day) Harvesting	82333.00	82333.00	82333.00
Labor and others - Miscellaneous	14408.00	20583.00	24700.00
Total cost (A)	829845.00	803910.00	849704.00
Gross benefits			
Fish Selling (B)	1250643.00	1284461.00	1221291.00
Net benefit (B-A)	420798.00	480551.00	371587.00
BCR	1.51	1.59	1.44

3.3 Cost-benefit analysis

Price of fish was average Tk. 155.00/kg (T1, T2 and T3).

A simple Cost-Benefit Analysis was performed to estimate the net profit of three different treatments. The economic analysis was conducted based on prevailing market prices in 2018. A constant fish selling price (BDT 155 kg^{-1}) was assumed across all treatments. Labor and input costs were considered fixed during the study period.The cost of artificial feed was BDT 48.00 kg^{-1}. Economic analysis is presented in table 4.

During economic analysis of the present study, it was found that the net benefit/ha was BDT 420798.00, 480551.00 and 371587.00 T1, and T2 & T3 respectively. The highest net return per ha (BDT 480551.00) and lowest gross cost per ha were found in T2. Rahman et al. (2017) obtained net benefit BDT 193513.00. The present study indicates higher net benefit because of higher survival rate. The present study deals with uniform stocking density in each treatment and spatial variation were observed in specific growth, higher net benefit of carps & tilapia polyculture were reported from Mahalchari, Khagrachari creeks, suggesting its suitability for developing creeks aquaculture technology.

1 | Conclusion

The study demonstrates that creek aquaculture of carps and tilapia in the Chittagong Hill Tracts is biologically productive and economically viable. Among the study sites, Mahalchari (T2) showed superior economic returns due to better survival and feed efficiency. However, variations among locations highlight the influence of environmental and management factors on production performance. Therefore, site-specific management practices with improved culture techniques is essential for optimizing fish production and enhancing employment opportunities in the region.

Acronyms and Abbreviations

BCR : Benefit Cost Ratio
BFRI : Bangladesh Fisheries Research Institute
CHT : Chittagong Hill Tract
CO2 : Carbon Di-oxide
DO : Dissolve Oxygen
DoF : Department of Fisheries
Etc. : Et cetera (and others and so forth)
FCR : Feed Conversion Ratio
ft. : Feet
ha. : Hectare
i.e. : That is
kg : Kilogram
MT : Metric Ton
SD : Standard Deviation
SGR : Specific Growth Rate
Tk. : Taka
TSP : Triple Super Phosphate

Author Contributions

Azhar Ali: Conceptualization, data collection, data analysis, interpretation, manuscript writing, and editing. Kazi Belal Uddin: Conceptualization, data collection, data analysis, fund acquisition, manuscript writing and editing. Md. Abul Bashar: Conceptualization, data collection, data analysis, and supervision. B.M. Shahinur Rahman: Conceptualization, data collection, data analysis, and supervision. Rabina Akther Lima: Conceptualization, data collection, data analysis, and supervision. Rubana Ferdousi: Conceptualization, data collection, data analysis, writing and editing. All authors have read and approved the final published article

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated and analyzed during this study are included within the manuscript. No additional datasets are available.

Ethics Statement

Not applicable.

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