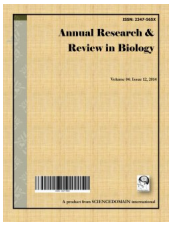

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Creek`s Aquaculture Techniques in Rangamati Hill Tracts of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author MMR designed the study, wrote the protocol, conducted the research study, the statistical analysis and wrote the first draft of the manuscript. Author KBU participated in data collection and author MAA managed the analyses of the study. Author AKMSI managed the literature and searches. Author YM coordinated the research team. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in nine suitable (average .10±2 ha) creeks of Rangamati hill tracts Bangladesh *viz*., of Langadu, Naniarchar and Sadar Upazila for evaluating growth, survival and production performance of Indian major carps (*Labeo rohita, Catla catla, Cirrhinus mrigala*) in a completely randomized design into three different treatments with three replications for a period of one year. Stocking density, growth, survival was checked periodically and total yield calculated from stocking and harvesting data. A significant spatial variation in specific growth rate (SGR) and yields was found despite uniform stocking densities, attributable to variation in environmental parameters. Among the results rohu was found to have comparatively higher SGR of 1.51±0.55 in Naniarchar where as langadu creek was reported with higher SGR of 1.46±0.94, 1.57±0.41 and 1.46 ±.64 for rohu catla, and mrigal. Rangamati sadar Upazilla creek was found to be conducive to Catla with a SGR of 1.55±.78. In general, higher gross and net productions were reported from

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Sadar Upazilla, Langadu and Naniarchar creeks, suggestive of its suitability for developing creeks aquaculture technology. However research findings will help the community of Chittagong hill tracts by giving appropriate technology for sustainable fish production in creeks.

Keywords: Creeks; carps; polyculture; cost-benefit analysis; Kaptai Lake; hill tracts.

1. INTRODUCTION

The depression of hill slope which inundated with enormous hilly streams during monsoon is called the creek. Three sides of arms of the creek may be surrounded by hilly land while the rest remain directly linked with the main body of the Kaptai Lake (situated north-east region of Bangladesh) or not. From a survey report, there are 1200 numbers of creeks surroundings this lake can be used for fish culture and its area is about 3887 hectares (ha) [1] and also 4727 number of creeks in Chittagong hill tracts might be used for fish culture and its area is about 4375.90 hectares (ha) [2]. The annual fish production of Chittagong hill tracts is 14773.46 metric tonnes MT (culture and capture) which is comparatively less amount (0.62%) of total annual inland catch and the aquaculture fish is decreasing in Chittagong hill tracts due to various reasons [2]. The production capacity of these creeks is 2100 kg/ha that is 8 to 9 times more than the Kaptai Lake [3]. The Present production of Kaptai Lake is 9000 MT and contribution of this lake fishery is largely limited with unwanted species [2].

The most valuable major carp's species (rui, katla, mrigal, calibaush and mohasoal) have devastatingly declined from the initial 81% as recorded in 1965 to 1966 to about 4% at present and low valued small forages fish species (kechki, chapila, mola etc.) have boomed from the initial 3% in 1965 to 1966 to about 90% now [1]. The production curve of this lake is going downwards due to natural calamities and man-made intervention [4]. Our demand is increasing and cultivable land is decreasing due to population explosion. To overcome these problems we have to take initiatives to produce more products by proper utilization of the limited resources [5].

As fish production in the country from the natural sources is gradually declining, intensive efforts are being directed towards polyculture of Indian major carps and some exotic carps [6]. The last three years fish production were 29 (2009-10), 31(2010-11), 33(2011-12) lakh metric tonnes (MT). Every year extra 2 lakh MT fish is needed for filling up the increasing population demand. [2]. Government has taken initiatives for these creeks development for filling up the criteria of Millennium Development Goal 2015 and Vision 2021. Polyculture is the best culture system for maximum utilization of pond food web, ecosystem [7]. Aziz and Hossain [8] reported that the hills of Bangladesh contain a number of rivers and streams, creeks and also a large reservoir called Kaptai Lake. Kaptai Lake fish stocks have been overexploited and require serious management effort through stocking and introduction of aquaculture in creeks, in order to fully utilize the lake fishery potential.

Further potential of increasing fish production is offered by streams, creeks and rivers where culture could be introduced. Department of fisheries implemented a project in the mid-1990s "Fish Culture Development and Extension in hills" created 11.5 ha of nursery ponds and 92 ha of other water bodies by modifications of creek flows and construction of small dams, and these were brought under fish culture. Training of farmers about aquaculture was given special attention under this project. Department of fisheries has implemented a project entitled "Improvement and extension of fish culture by developing creek in the Chittagong hill tracts from 2000 to 2010". By this project Department of fisheries developed 287 creeks and established 3 mini hatcheries in Chittagong hill tracts. The third phase of the project is on the process. Third phase will repair 903 creeks and establish 1 hatchery by five years [2]. Our major challenges are management of natural resources to ensure sustainable production and conservation, meet up present and future food needs and poverty alleviation, lack of appropriate production technologies for intensification [9]. Thus this project has been designed for overcoming these challenges and giving developed creeks aquaculture technology to the beneficiaries as part of Bangladesh Fisheries Research Institute responsibility towards every citizen of Bangladesh.

2. MATERIALS AND METHODS

2.1 Study Area and Experimental Design

Nine suitable creeks (average 1.acre) were considered for the whole study of creek

experiments. The study was conducted in Langadhu, Sadar, Nanarchar Upazila of Rangamati Hill Tracts throughout a production cycle from February 2013 to December 2013. For achieving objectives under this project, the trial was conducted in a completely randomized design into three different treatments (T_1-Langadhu, T_2-Sadar, T_3-Nanarchar) with two replications for each composition with one control which ranged in size (0.13±.01 ha, 0.10±03 ha, 0.08±0.02 ha) and all the creeks were similar in configuration, basin and contour type, well-exposed to sunlight and natural air flow.

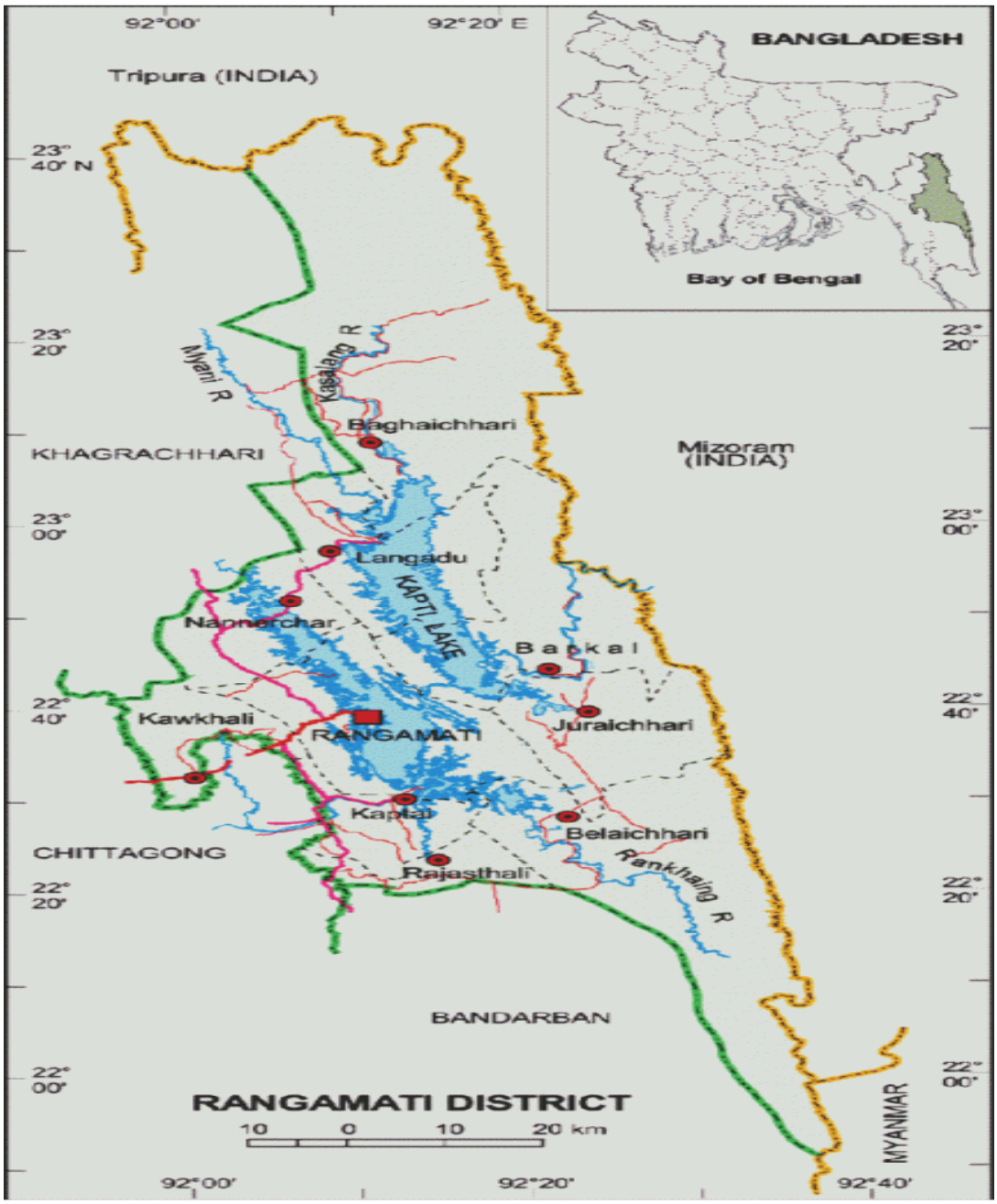

Fig. 1. Map showing the study sites of Sadar, Langadu, Naniarchar Upazilla of Rangamati hill tracts of Bangladesh

2.2 Selection and Preparation of the Creeks

Creeks were selected by examining creeks site, soil type, water retention capacity, pollution free and water depth (3 m to 9 m) Preparation of the creeks was conducted by repairing mouth of the creeks (making dam or construction of pen or both). After two weeks, dirty materials was removed from the creeks bottom and lime (CaCO3) was applied at the rate of 250 kg/ha. Then all concerned creeks were fertilized with compost (mixture of chopped and sun dried green plants at 88%, cow dung at 10%, urea at 1% and lime at 1%) at 1,250.0 kg/ha, urea 37.5 kg/ha and Tripple super posphate 25.0 kg/ha. Then the creeks were left 10 days to promote algal development.

2.3 Collection of Quality Fry/Fingerling and Stocking

Good quality fry/fingerling was collected from Raipur (Laxmipur) Government Carp hatchery and stocking density was 70/decimal according to the experimental design. The size of fry/ fingerlings was 8.21±2.02 cm, stocking was carried out in the afternoon, and care was taken to gradually acclimate the fish to the creek condition. For gaining good production healthy and disease free fingerling was stocked before March.

2.4 Food and Feeding Management

All creeks were fertilized fortnightly throughout the study period. Formulated feed (20-25% protein) was supplied twice daily (at dawn and before dusk) for fish with the help of feeding trays in treatments at the rate of (10 to 5%) body weight. The feed was adjusted periodically.

2.5 Sampling for Checking Growth and Survival of Fishes

In order to observe the growth performance of fish as well as to adjust the feed quantity, sampling was done twice in every month. Fishes were collected randomly at least 10% of each species from each pond using a cast net of 10 square meters effective area with 10 mm mesh size. The fish weights was taken in gram using a portable electronic balance (Ohaus, precision 0.1 g) and lengths were measured using a measuring board (precision 1 mm). Specific growth rate (SGR) was calculated after Brown (1957).

2.6 Final Harvest and Estimate the Growth and Survival Rate

All the fishes were harvested after completion of the experiment period in December/2013 and counted and measured the weight individually to assess the rate of survival and growth of fishes. Specific growth rate (% body weight day 1) was calculated using the formula of Day and Fleming [10], SGR= [lnWTf-lnWTi] x 100/T, where WTf is the average final fish fry weight (g), WTi is the average initial weight (g), T is the duration fo the experiment (days) ln is natural log.. Survival rate was calculated using the formula of, survival rate (%) = [number of fish fry at the end of the experiment/number of fish fry at the start of the experiment] x 100. Mean growth (length in cm, weight in g) was recorded by taking average of random samples from each creek.

2.7 Studies of Water Quality and Environmental Conditions

Water quality parameters such as pH, temperature, transparency, dissolved oxygen (DO) and ammonia were measured fortnightly throughout the study period in the late morning (9:00 to 10:00 A.M). Some water quality parameters were measured on the spot while for rest of parameters, samples were collected from the creeks in properly cleaned plastic bottles with stopper having a volume of 250 ml each and marked with pond number for subsequent chemical analysis using HACH kits (Model FF-3, Company HACH, Made in USA) The opening and closing of the sterile bottles was done with meticulous care to avoid any contamination. Temperature was measured by a Celsius scale, transparency was measured by a secchi disc of 20 cm diameter, ammonia-nitrogen (NH_3-N) was determined by HACH kit (DR/2010). A direct reading spectrophotometer. Primary production of surface water was measured and correlation-regression analysis was performed to find out the probable linkage with monthly growth performance and yield. Extent of availability of

natural food was checked in each month following plankton biomass analysis.

2.8 Economic and Statistical Analysis

An economical analysis was performed to estimate the net return and benefit–cost ratio in the different treatments. The following equation was used: R = I– (FC ± VC ± Ii) where, R=net return, I=income from rohu, catla, and mrigal sale, FC=fixed/common costs, VC=variable costs and Ii=interest on inputs. The benefit cost ratio was determined by the following equation: Benefit cost ratio (BCR) = Total net return / Total input cost. The whole sale prices of inputs and fishes correspond to the wholesale market prices was expressed in Bangladeshi taka (1 US$= 80.BDT). For statistical analysis of data, a one-way ANOVA (Analysis of Variance) and DMRT (Duncan's Multiple Range Test) was done by using the SPSS (Statistical Package for Social Science) version-20. Significance was assigned at 5% level. Duncan's tests were used to test the results of multiple ranges for comparisons of averages.

2.9 Participatory Approach at Different Stages of Technology Development

A participatory concept was followed from the commencement of the project activity. A group of entrepreneurs living within the immediate vicinity of the creek, which have property right (beneficiaries), was assigned for overall management of the project. At least ten to fifteen beneficiaries were considered for a group selection including a team leader. Entrepreneurs was responsible for guarding, cleaning shoreline of creeks, administering feed as per requirement, taking part of fish harvesting, etc. They also participated in each progress meeting. As such, attending the aforesaid activities they become acquaint themselves was in all stages of technology development that was turn them capable to undertake such type of aquaculture system individually at the end of project period.

3. RESULTS

3.1 Hydrographical Parameters

Hydrographical parameters of the creeks were within permissible limits as well as suitable for aquatic lives (Table 1). Temperature was found more or less similar and ranged from 24.94±3.73℃, 23.41±1.81℃ and 20.16±1.43℃ in T_1, T_2 and T_3 treatments respectively. However water temperature had an inverse relationship with DO indicating DO increased with decreasing temperature. The Dissolved oxygen was recorded higher in T_1 and lowest in T_3 treatments respectively and significantly different ($p<0.05$) in three treatments. The value of pH was found slightly alkaline and higher in T_1 than that of T_2 and T_3 treatments respectively. The level of ammonia & alkalinity content was recorded in trace and more or less similar amount in three treatments respectively. Ammonia had a significant inverse correlation with pH (r=- 0.275) suggesting that NH_3 reduced the pH level The Free CO (mg/l) ranged between 15±4.03 and 20±3.18, total hardness (mg/l) was between 38.3 and 77.6; transparency were found to be 0.5±0.5, 0.3±0.2 and 0.18±0.12 in T_1,T_2, T_3 treatments respectively.

Table 1. Stocking of fingerling in different treatment

Species	T_1-Langadu,	T_2-Sadar,	T_3-Nanarchar
Catla catla	25	25	25
Labeo rohita	25	25	25
Cirrhinus mrigala	20	20	20
Total	70	70	70

Table 2. Hydrographical parameters of three Upazilla of Rangamati hill tracts, Bangladesh

Parameters	T1 Langadu	T2 Sadar	T3 Naniarchar
Temperature(^{o}C)	24.94±3.79	23.41±1.81	20.16±2.43
pH	7.18±0.52	7.14±0.75	5.28±0.43
DO (mg/l)	5.46±0.59	5.01±0.78	4.41±0.74
CO_2 (ppm)	15±4.03	20±3.18	17±4.10
Alkalinity (mg/l)	80.37±10.70	133.16±17.02	52.58±22.41
Ammonia (mg/l)	0.05±0.02	0.03±0.01	0.02±0.02
Hardness (mg/l)	80.37±10.70	133.16±17.02	52.58±22.41
Transparency	0.5±0.5	0. 3±0.2	0.18±0.12

Table 3. Growth performances of carp's species under polyculture management in three different creeks of Rangamati hill tracts Bangladesh

Creeks	Size (ha) (mean±stdv)	Depth (m)	Replication	Species	Stocking length (cm)	Stocking weight (g)	Final length (cm)	Final weight (g)	Survival rate (%)	SGR (%) at 280 days
T1 /Sadar	0.13±.01	1.5±.6	3	Rohu	8.21±2.05	16.40^{b}±2.60	41.5±5.9	908^{b}±436	60	1.43^{b}± 0.56
				Catla	7.30±1.10	18.1^{a}±3.21	45.1±6.7	1390^{b}±410	62	1.55^{a}±0.78
				Mrigal	9.50±1.30	15.5±1.70	35.3±4.5	716±251	43	1.36±0.41
T2 /Langadu	0.10±.03	1.8±.3	3	Rohu	8.56±170.	16.7±2.31	38.4±7.3	1022±232	51	1.46±0.94
				Catla	7.61±1.90	18.2^{ab}±2.93	$45.7±4.9^{b}$	1489^{b}±532	56	1.57^{ab}±0.41
				Mrigal	8.21±2.02	15.3±1.69	36.3±8.6	917±180	40	1.46^{b}±0.64
T3/ Naniarchar	0.08±0.02	1.2±.2	3	Rohu	8.86±1.90	16.9±2.28	39.9±3.4	1190±350	47	1.51^{a}±0.55
				Catla	7.70±1.68	18.12^{a}±2.15	$37.6±7.8^{b}$	1520^{a}±470	50	1.58^{ab}±0.39
				Mrigal	9.60±1.89	15.9±3.30	35.4±6.1	740±230	60	1.37±0.77

Mean data within column with different superscripts are significantly different (P<0.05)

Table 4. Average survival, gross production, net production and production of carp's fingerlings under polyculture management

Parameters	T1 /Sadar	T2 / Langadu	T3/ Naniarchar
Stocking density (no/ha)	17290	17290	17290
Survival average (%)	55	49	52.33
Gross production (kg/ha)	1738.9	980.23	836.63
Net production (kg/ha)	1730.4	968.07	827.149
Production of fishes (No./ha)	1236	847	719

Table 5. Cost-benefits analysis

Items	T1 / Sadar	T2 / Langadu	T3/ Naniarchar
Cost			
Creeks lease (Tk. 60,000/ha/yr)	8,000/-	6,000/-	5,000/-
Lime (Tk. 20/kg)	3,000/-	2,500/-	2,000/-
Cow dung (Tk. 7/kg)	2,000/-	1,800/-	1,600/-
Aquakleen (Tk.1000/1L)	5,000/-	4,000/-	3,500/-
Rotenone (Tk. 300/Kg)	1,000/-	800/-	600/-
Fingerling (Tk.10./Pcs)	23,100/-	19019/-	17,500/-
Feed.(Commercial formulated)			
Mega (Tk.1000/25kg)	43,000/-	24,500/-	21,000/-
Labor (Tk. 260/day)			
Harvesting	10,000/-	8,000/-	7,000/-
Miscellaneous	5,000/-	4,000/-	3,500/-
Total cost	1,02,100/-	70,619/-	61,700/-
Gross benefits			
Fish Selling	2,95,613/-	1,66,600/-	1,42,227/-
Net benefit(B-A)	1,93,513/-	95,981/-	80,527/-

**Tk., Bangladesh Taka (1 US$ = Tk. 80.00). ** Price of Fishes was Tk. 1.70/kg (T_1, T_2 and T_3)*

3.2 Growth Performances

Growth, survival and specific growth rate of carps species under different treatments over the 10 month experiment are summarized in Table 3 among the three treatments Rangamati Sadar Upazilla creek's was reported with higher growth rates of catla, rohu and mrigal. A significant spatial variation in specific growth rate was evident despite uniform stocking densities, attributable to variation in environmental parameters. Among the results Rohu was found to have comparatively higher SGR of 1.51±0.55 in Naniarchar where as Langadu creek was reported with higher SGR of 1.46±0.94, 1.57±0.41 and 1.46 ±.64 for Rohu Catla, and mrigal. Rangamati Sadar Upazilla creek was found to be conducive to catla with a SGR of 1.55±.78. The gross and net production after 280 days of rearing were 1738.9 kg/ha, 980.23 kg/ha and 836.63 kg/ha in Sadar, Langadu and Naniarchar respectively. However gross and net production varied among three creeks (Table 4). The total cost of production of langadu, Sadar, and Naniarchar was Tk 1,02,100/-Tk 70,619/-,Tk-61,700/- and net benefits (1,93,513/-Tk/ha), (95,981/-Tk/ha), (80,527/-Tk/ha) was Sadar, Langadu and and Naniarchar Upazilla respectively (Table 5).

4. DISCUSSION

The findings (% survival of 49% to 55%, yield 836.63 kg/ha to 1738.9 kg/ha) from the experiments is similar to the Islam et al. [11] who conducted a research study on feasibility of carps fry raising in Kaptai Lake creeks. He found satisfactory result about survival, growth and economic viability of carps fry and fingerling raising in the creeks of Chittagong hill tracts. Alamgir and Ahmed [3] conducted a research study on extensive pen culture in hilly creeks of Kaptai Lake. A total of four creeks, each ranging from 0.96 to 2.28 ha with 0.1 to 9.32 m depth were established during 1997 to 1999 at different regions of the reservoir (Rangamati Sadar, Naniarchar and Langadu of Rangamati hill tracts). Five species of carp's viz. *L. rohita, C. catla, C. mrigala, C. carpio*. and *C. idella/ A. nobilis* of 8.0-64.0 gm at densities ranging

from 8000 to 10,000 fingerlings/ha during the high-water season (August) were stocked and were harvested at low water-level during April-July. The reared fish reached an average weight of 325.5 g that ranged from 109 to 1920 g during the 8-9 months period. The average yield from the reservoir creeks during 1997 to 99 was 882.34 kg/ha, which was slightly higher to our present findings because our experimental creeks area and depth was comparatively too low. The average yield ranged from 836.63 kg/ha to 1738.9 kg/ha which was about six to thirteen times higher than the natural catch from the reservoir of a similar unit area (average natural catch ± 130 kg/ha) and [3] noted that by proper management fish production in the creek of Kaptai Lake would be 2 ton/ha, that is 8-9 times higher than present production of Kaptai lake. Polyculture is an efficient means of increasing fish production. Polyculture can give higher production if the fish with different feeding habits are stocked in proper ratios and combinations [7]. Hossain and Islam [12] found that the key techniques of polyculture are based on the efficient utilization of natural food and thus it results in increase fish yield per unit area. The range of production from the traditional polyculture of carps in Bangladesh was 3,119 to 4067 kg/ha/yr [13,14]. Miah et al. [15] obtained 3,434.07 kg/ha fish in 10 month by applying cow dung, supplementary feed and 50 kg/ha inorganic fertilizer Akter et al. [16] obtained 5751 kg/ha fish in 142 days by applying formulated feed in an improved polyculture system. The above mentioned result is higher than from our present findings because of low survival rate of Indian major carps in hilly creeks due to turbid water, lower natural food organism and hilly surface run off. Physicochemical parameters play a significant role in the maintenance of a healthy aquatic environment and production of natural food organism. Growth, feed efficiency and feed consumption of fish are normally governed by environmental factors [17]. Water temperature (℃) was found in experimental creeks within the acceptable range of warm water fishes that agree well with the findings of [18,6]. Consistent higher turbidity in Naniarchar could be attributed to the Findings from the present study might have reduction of the plankton population by hindrances of light penetration [4,3,8,11]. Dissolved oxygen level was found to fluctuate from 4.41±0.74 to 5.46±0.59 mg/l in the experimental creeks. Saha et al. [19], Wahab et al [20] and Hossain et al. [14] also reported similar trends of dissolved oxygen in various carp ponds. Fluctuations in DO concentrations might be due to alteration in the rate of photosynthesis [21]. However, the DO level was within the acceptable range for in all creeks. The observed pH values agree well with the findings of Islam et al. [11], Chakraborty et al. [22] and Alamgir et al. [3] and are within the range of good water quality for rearing pond. The alkalinity or acid combining capacity of impounded waters generally caused by carbonates and Compendium, bicarbonates of calcium and magnesium combining with dissolved CO. These carbonates and bicarbonates form an equilibrium which plays an important role in the fish culture productivity of the system. Total alkalinity levels (52.58±22.41 mg/l to 80.37±10.70 mg/l) indicating the productivity of the ponds was medium to high [23]. The findings of the present study are in agreement with those of [5,12,24], catla was reported with significantly ($p<0.05$) higher SGR (1.57±0.41) from Langadu, Rangamati Sadar creek after a period the of 280 days. Stocking density and supplemental feeding had previously been observed to have a direct effect on the growth of fish [13,15,14,16]; anyway the present study deals with uniform stocking densities in each creeks and spatial variation were observed in specific growth rate (SGR), higher gross and net production of Indian major carps were reported from Rangamati Sadar, Langadu, Naniarchar creeks, suggestive of its suitability for developing creeks aquaculture technology.

5. CONCLUSION

Findings from the present study is an important implications for starting aquaculture under polyculture management in creeks of Rangamati hill tracts in Bangladesh.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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