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Demonstration of Indian featherback (*Chitalachitala*) farming under backyard pond condition of Tripura, North East India following different feeding strategies

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ABSTRACT

Chital(*Chitalachitala*) is a high-value fish (Rs. 500-1500/kg) endemic to North-East India. Once, the fish was available in plenty in Indian water bodies, but wanton killing, habitat modifications, and climate-induced perturbations have threatened their populations. To invigorate their populations, it requires captive farming. Being a highly predatory fish, they can be farmed using Tilapia as forage/prey fish; therefore, in the present study an attempt was made in the Dhalai district, Tripura employing nine backyard ponds of farmers (each 0.08 ha; 1.0 m depth). Chital was stocked @ 1200 numbers/ha and provided forage fish (Tilapia @ 3000 numbers/ha, T1), pellet feed @3% of fish biomass, T2) and forage fish + pellet feed (T3). The duration of the study was 10 months. Fish growth was assessed monthly. The highest growth and survival were observed in T2 (SGR: 1.0 %/day; Survival: 71.8%) and the lowest in T1 (0.92 %/day; 62.6%). The highest biomass was observed in T2 (819.15 kg). Profit was maximum in T2 (Rs. 315323/ha) and minimum in T1 (Rs. 204450/ha). From this study, it was concluded that Tilapia, which is a pest fish, can be used as a forage fish for backyard farming of Chital. For augmented overall production of Chital, pellet feed can be offered with forage fish.

1. Introduction

Chitalachitala(Hamilton-Buchanan, 1882) is a high-value fish endemic to freshwater ecosystems such as rivers, wetlands, reservoirs, lakes, mini-barrages, ponds, *etc.*in India, Pakistan, Myanmar, Bangladesh, Sri Lanka, Nepal, Thailand and Indonesia (Mirza, 2004). It belongs to the family *Notopteridae* and is commonly known as Clown Knife fish or Humped Featherback or Chital (popularly). The species is different from *Notopterusnotopterus,* another important fish of this group, by possessing a highly convex dorsal profile, 15 silvery bars on each side of the dorsal ridge and 5-9 small black spots near the end of the caudal fin. Chital is rheophilic; it prefers deep and clear water and likes hunting other fishes. The maximum reported size is 122 cm and 19 kg (Hossain et al., 2006). Like most other tropical fishes, it breeds during the monsoon (June and July). During the early life stages, they eat plankton, insects, molluscs, shrimps, minnows, tadpoles, tender roots of aquatic plants, *etc.* but when they become fingerlings, they become highly carnivorous and predaceous, thus, co-culture of the fish with carps is prohibited (Azadi et al. 1994).

Chital fetches competitive market prices (Rs. 500-1500/kg) in Tripura, Assam, West Bengal, *etc.* due to its high-quality taste, flavour and tender to firm meat texture. There is a very popular dish in the Bengali communities made out of (the dorsal part) of the fish called '*Chital machermuithai*' (fish kofta). Being low-fat (1.2%) and high-protein (16.7%) containing fish, it is advocated in the diets of health-conscious people. Besides food value, it has ornamental value (Sarkar et al., 2006); it is one of the angler's choice fish during game fishing. Chital is a self-recruiting fish, thus one-time stocking will multiply their population. In those ponds/ water bodies which are heavily infested with weed fishes such as Tilapia, minnows, barbs, insects, tadpoles, *etc.* and commercial carp culture is not possible, Chital could be used as a candidate fish for harnessing the benefit out of interactions exist between prey-predator in the food chains (Riaz and Ahmed, 2006).

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The fish was available in plenty in the wild water bodies of Eastern and North Eastern parts of India during 1970s and 1980s, but its production has significantly declined by more than 70% in the recent past due to indiscriminate fishing, habitat modifications, pollution and climate-induced perturbations (Sarkar et al., 2006; Banik and Roy, 2014). It has become an endangered species (CAMP, 1998) and is demanding conservation and rehabilitation (NBFGR, 2011). To conserve and rehabilitate the fish various strategies are under implementation such as declaring it as the 'State fish' of Uttar Pradesh (Ayyappan et al., 2019), promotion of captive farming for *ex situ* conservation, stock enhancement by ranching hatchery-produced seedlings, *etc.*

Aquaculture could a potential tool for conservation and rehabilitation of threatened fish or fish under the vogue of extinction (Ayyappan et al., 2001). By captive farming, on one hand, fishing pressure on their wild stocks can be lessened and on other hand, enough broodstocks (of choice) can be produced for mass-scale propagation of the fish. At present, information about the aquaculture aspects of Chital is less available (Ghosh, 1996). Also its nutritional aspects, which are vital for domestication of fish, are less covered in the available literatures. Being a predatory fish, its aquaculture potential using tilapia as a bait/forage fish has not been explored (Samad et al., 2017).Given the lack of knowledge, we set out to evaluate the production performance of the Chital using Tilapia as forage fish as compared to feeding pellet feed in backyard pond conditions where commercial carp culture is difficult to practice due to heavy infestation of aquatic plants and weed fishes, insufficient water depth, disease outbreak, and use of water for multiple works.

2. Material and Methods

The study was conducted at Dhalai, an administrative district in Tripura, North East India. Nine ponds (each of 0.08 ha; 1.0 m depth) were employed to test three feeding regimes such as feeding Tilapia as forage fish (@ 3000 numbers/ha) (T1), feeding pellet feed (@3% of biomass of chital) + Tilapia (@ 3000 numbers/ha (T2) and feeding only pellet feed (T3). Before the study, all ponds were properly cleaned and then lime was applied @ 250 kg/ha. After a week, cattle manure was applied @ 3000 kg/ha and single super phosphate (SSP) @ 30 kg/ha to improve the pond fertility. To sustain the pond fertility and plankton productivity, intermittent fertilization was done on monthly basis applying cattle manure (@ 500 kg/ha), urea (@ 10 kg/ha) and SSP (@15 kg/ha). Intermittent liming (@100 kg/ha) was done quarterly. Aeration was regularly provided by beating the water with a bamboo pole (Debnath and Sahoo, 2017).

The seedlings of Chital (average weight 46.66g) were collected from State Govt. farm and stocked @ 1200 numbers/ha after basal pond fertilization and they were fed according to the aforementioned schedule (T1, T2 and T3). Five fish were randomly collected from each pond on every month by a cast net and their length and weight were estimated. The water quality parameters (temperature, dissolved oxygen, pH, transparency, total alkalinity and inorganic nutrients) were monthly analysed following Standard Methods (APHA, 1998). The soil quality parameters (pH, available N, available P and organic C) were analysed before starting the study and after ending the study. Plankton were also analysed on monthly basis (Jhingran et al., 1969).

The study was concluded after 10 months. At the end of study, all fish were harvested by using a drag net. All fish were counted and survival rate was calculated. The weight of 10 fish was estimated to calculate the following growth parameters.

- Specific Growth Rate, SGR (%/day) = (Ln final weight-Ln initial weight) X 100/ duration of fish culture
- Average Daily Gain, ADG (g/day) = (Final weight-Initial weight) / duration of fish culture

Data analysis was performed in SPSS (version 21) following one-way ANOVA to assess the difference in the growth, survival and biomass of *C. chitala*under different feeding regimes. A simple cost-benefit analysis at the prevailing market rates was performed to estimate the economic viability of the intervention.

3. Results and Discussion

Water quality and plankton

The success of aquaculture is largely dependent upon the value of the water quality parameters prevailing in the culture system. Aquaculture is nothing but the culture in water; hence, better the water quality, higher the fish production and productivity and lower the water quality, poor the fish growth and survival, and product quality. Aquaculture as a commercial or livelihood enterprise will be assumed unprofitable if water quality remains in a dire strait (Shoko et al., 2014). Therefore, during fish farming, the water and soil quality parameters should be kept under regular monitoring and maintenance applying proper management strategies (Debnath et al., 2017). In this study, all water quality parameters (water temperature, dissolved oxygen, pH, total alkalinity, transparency, nitrate, nitrite and phosphate) remained within the normal range (Table 1) and there was no abrupt change (both daily and diurnally) in the value of any of the parameter throughout the study period of 10 months, from which it could be stated that the ponds were kept under proper management as per the requirement for fish (Debnath et al., 2013; Debnath et al., 2014). When compared to T1 where Tilapia was used as a forage fish, nitrate level was observed higher ($p \leq 0.05$) in T2 and T3. This can be attributed to the application of pellet feed and spillage of nutrients from uneaten or wasted feed, however, it didn't exceed thelimit recommended in fish culture (Debnath et al., 2015a). The water temperature had negative correlation with dissolved oxygen which was due to the fact that with the increase of temperature of water, its oxygen holding capacity gets reduced. The pH remained in the optimum range which was due to liming (Boyd,1979). The pH level had a positive correlation with the level of total alkalinity and this is comparable to the finding of Debnath and Sahoo (2017). From the pH value, it could be stated that it has no negative effect on the growth and survival of fish under study. The plankton density remained at the optimum level (>2 ml/50 litres) in all ponds; it was highest ($p \leq 0.05$) in T2 due to extra nutrient supply from the excreta of forage fish and leaching of nutrients from wasted feed and lowest in T1. Phytoplankton populations dominated over zooplankton in all ponds which was due to the application of raw cattle manure (Debnath et al., 2015b). This was also an indirect indicator towards the ponds under use were very productive and responded well to external fertilizer application (Debnath et al., 2015a).

Soil quality

The value of the soil quality parameters remained within the normal range (Table 2). After farming *C. chitala,* the nutrient status of the pond sediments improved. This could be attributed to the leaching of nutrients from fertilizer application and uneaten feed, accumulation of nutrients from fish excreta, dead fish, plankton die-off, *etc.*with the progress of fish culture. A similar observation was reported in the farming of Indian butter catfish *Ompokbimaculatus*by Debnath et al. (2019). Based on the current soil nutrient status, the ponds under study could be classified as low to medium productive following Ayyappan et al. (2019).

In this study, the change in the level of water parameters and soil parameters followed almost identical trends across the ponds. This could be attributed to almost identical shape, size, depth, contour and basin conformation of the ponds in use (Murty et al., 1978), uniform fertilization, liming and other management schedule (Debnath et al., 2015b, 2016) and same geographical location for all water bodies. Eutrophication and fish engulfing (piping) were unnoticeable in any of the pond, which indicated that the quantity of feed or fertilizers applied were either inadequate to affect the water quality (Debnath et al., 2016) or their side-effects were adjusted in the course of ten month long fish culture period (New, 1987).

Table 1. The mean values of water quality parameters under different feeding regimes. Mean values bearing different superscripts in same row are significantly different ($p \leq 0.05$)

Parameters	T1	T2	T3
Temperature (^{0}C)	28.42±0.32^a	28.38±0.28^a	28.40±0.34^a
Dissolved oxygen (ppm)	4.62±0.22^a	4.72±0.24^a	4.66±0.20^a
pH	7.22±0.12^a	7.12±0.15^a	7.20±0.10^a
Total alkalinity (ppm)	42.25±3.55^a	42.12±4.24^a	42.22±3.22^a
Transparency (cm)	35.55±2.35^a	36.55±2.24^a	36.65±2.62^a
Nitrate-N (ppm)	2.55±0.24^a	3.72±0.32^b	3.55±0.28^b
Nitrite-N (ppm)	0.52±0.12^a	0.72±0.14^a	0.64±0.16^a
Phosphate-P (ppm)	0.62±0.04^a	0.70±0.05^a	0.66±0.05^a
Plankton (ml/50-l)	2.42±0.13^a	3.54±0.16^b	2.92±0.14^c

Table 2. The mean values of soil quality parameters under different feeding regimes. Mean values bearing different superscripts in same row are significantly different ($p \leq 0.05$)

Parameters	T1	T2	T3
pH	6.20±0.11^a	6.22±0.12^a	6.23±0.11^a
Avail. N (mg/100g)	15.56±1.22^a	16.82±2.44^a	16.75±2.24^a
Avail. P (mg/100g)	2.82±1.18^a	3.22±1.22^a	3.05±1.25^a
Organic C (%)	0.42±0.22^a	0.52±0.18^a	0.50±0.21^a

Fish growth and survival

Supplementary feeding plays an important role in the nutritional management of fish during farming (Debnath et al., 2018b). In the aquaculture, feed is considered as one of the critical factors of fish production as it forms 40-60% of the total operational cost (Debnath et al., 2019). Hence, during fish farming, feed should be applied judiciously, preferably as per the biological demand of fish, so that there is more of assimilation of feed nutrients into flesh and less of wastage of feed (Chantal, 2004). The cost involved in the nutritional management of fish during husbandry could be reduced by understanding the biological nature of the fish to be cultivated (Lovell, 1998). In this study, the benefit out of the biological nature of Chital predating upon other fish as prey was harnessed using Tilapia as forage fish. This type of feeding strategy can minimize the cost involved in the supply of artificial feed significantly (Planquette, 1974).

Forage fish are also called prey fish or bait fish. They feed on plankton and rapidly multiply and occupy an important place in the trophic chains; they move in shoal/ school; larger predators like hunting them for food (Engelhard et al., 2014). In this study, the problem of Tilapia infestation in most of the backyard pond systems was attempted to manage by using them as bait for the predatory fish *C. chitala*. As Tilapia has a prolific breeding habit, it can produce enough number of baits for the fish to be used for table purpose. In many ponds located in Tripura and many other States in NE India, commercial carp culture is not possible despite having excellent soil fertility and health status due to the rapid multiplication of Tilapia. In that situation, use of those tilapia populations as forage fish for production of predatory fish like Chital, Murrel, *etc.*appears the only proposition for enhancing aquaculture production from those water bodies. By delivering prey Tilapia and predator Chital an ecosystem for interaction, on one hand, the overpopulations of tilapia could be checked and on another hand production of high-value fish under minimized nutritional management cost is possible (Samad et al., 2017). This type of prey-predator aquaculture could be assumed ecologically sustainable and economically viable as here the natural relationship exists between the predators and the preys in the food webs gets maintained. Similar strategy was successfully demonstrated for the production of Murrel and Sea bass (Cruz and Shehadeh, 1980; Yi et al., 2002). In the present study, we have provided Chital forage fish in T1 and T3, so that they can run behind them for hunt and remain vim and vigour the way they remained in their natural habitats.

The monthly growth performance of *C. chitala*(in terms of weight) under different feeding regimes is presented in Figure 1. The growth curve of the fish followed almost sigmoid pattern which was comparable to finding of Debnath et al. (2020a, b) in Indian Major Carps, small indigenous species *Esomusdanricus*, catfish *Ompokbimaculatus*, *etc.* The growth of Chital was better in T2 where forage fish and pellet feed were offered together to the fish. In T1, its specific growth rate and size at the time of harvesting were found lowest (Table 3) which indicated that forage fish alone was not enough for the nutrition for Chital. Another cause could be less proliferation of forage fish in absence of feed supplementation from the outside; as a result, there was not enough prey for the fish (Nkhoma and Musuka, 2014). As a result, the number of forage fish required for each Chital fish was unmaintained in T1 and hence the growth of chital was less. The growth of Chital in T3 was better than growth appeared in T1 which was due to application of pellet feed containing 21.8% CP and increased availability of plankton from nutrients leached from the wasted/uneaten feed. The growth and survival of Chital was best at T2 where the fish was offered forage fish and pellet feed together. It appeared that proliferation of forage fish was higher in T2 when compared to T1 due to applying pellet feed; as a result, the number of prey required for the growth of each Chital fish was more in T2. Plankton production was also higher in T2 when compared with T1 due to increased availability of fish excreta from increased proliferation of forage fish. Pellet feed besides serve as a direct food for Chital, provided nutrients for the proliferation of forage fish and increased proliferation of forage fish increased the production of plankton. Rodrarang and Plungdi (2000) also reported that chital grows well in cages when fed with trash fish and rice polish.

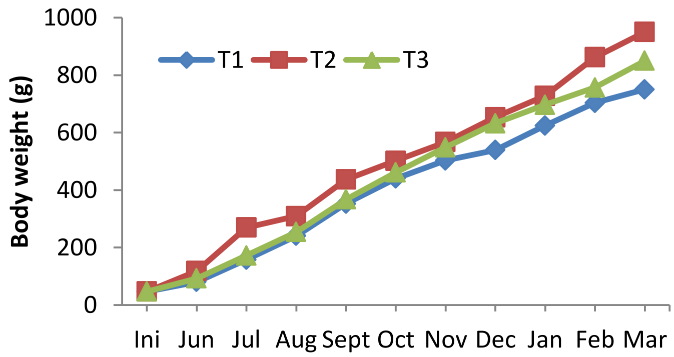

Fig.1. The monthly weight of chital under different feeding regimes

Table 3. The growth attributes of chital under different feeding regimes. Mean values bearing the same superscript in the same row indicate no significant difference (*p≤0.05*)

Parameters	T1	T2	T3
Size at stocking (g)	46.66±4.10[a]	46.66±4.10[a]	46.66±4.10[a]
Size at harvesting (g)	750±24.50[a]	950±16.32[b]	850±24.41[c]
SGR (%/day)	0.92±0.03[a]	1.00±0.39[a]	0.96±0.03[a]
ADG (g/day)	2.34±0.09[a]	3.01±0.07[b]	2.67±0.07[c]
Survival (%)	63.13±2.80[a]	71.80±3.64[b]	62.50±2.50[a]
Production (Kg)	568.90±47.35[a]	819.15±58.60[b]	637.75±38.90[a]

Economic benefit

The results of economic assessment under different feeding treatments is presented in Table 4 in which it can be observed that during the backyard pond farming of Chital, net benefit is Rs. 315325/ha when the fish is fed with forage fish and supplementary food, Rs. 204450/ha when the fish is fed with only forage fish and Rs. 210375/ha when the fish is fed with only supplementary food. Based on present estimates, it could also be concluded that Chital farming in the backyard pond condition is two times more profitable when compared with carp farming under low-input management (Debnath et al., 2018a).

4. Conclusion

Feed supplementation plays an important role in the farming of Indian featherback *C. chitala.* For optimum fish production and productivity, under the backyard pond condition, they should be fed with supplementary feed and forage fish together. Chital though a predator and messy eater, its farming has no negative effect on pond health in terms of deterioration of water and soil quality parameters of the ecosystem. In those ponds which are infested with Tilapia, and commercial carp culture has remote possibility, *C. chitala* can be considered as candidate fish. Pond farming will reduce fishing pressure on their wild stocks and help them invigorating their dying populations. Further research is recommended for optimization of prey-predator ratios for production of *C. chitala* sustainably.

Table 4. The estimated cost-benefit from chital farming in a pond of one hectare size

Items	Treatment		
	T1	T2	T3
A. Cost			
Pond lease	10000	10000	10000
Pond clearance	2500	2500	2500
Lime @ 250kg/ha	5000	5000	5000
Manure @ 10000 kg/ha	15000	15000	15000
Urea (@250 kg/ha) and SSP (@ 500 kg/ha)	10000	10000	10000
Chital seed @Rs. 5/piece	6000	6000	6000
Feed (@ Rs. 30/kg)	1500	16500	30000
Labour (100 mandays) @ Rs. 250/manday	25000	25000	25000
Miscellaneous (medicines, watch and ward, custom hiring service, etc)	5000	5000	5000
Total	80000	94250	108500
B. Gross benefit			
Table fish Chital @ Rs. 500/kg	284450	409575	318875
C. Net benefit (B-A)	204450	315325	210375

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