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Fish Productivity Enhancement through Aquaculture Diversification with Small Indigenous Species *Esomus danricus*

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ABSTRACT

To meet the ever-mounting demand of fresh fish in many NE States, an attempt was made on fish productivity enhancement through composite culture of self-recruiting small indigenous species *Esomus danricus* (Darkina) in earthen pond condition. The duration of study was eight months. Three treatments with replication of each treatment thrice were evaluated. Treatment-1 (T1) contained three Indian major carps (IMCs), *i.e.,* Catla, Rohu and Mrigal (4:3:3), Treatment-2 (T2) contained IMCs with *E. danricus* (10000 numbers/ha) and Treatment-3 (T3) contained IMCs with *E. danricus* (5000 numbers/ha) and *Amblypharyngodon mola* (5000 numbers/ha). The stocking density of IMCs was 10000 fingerlings/ha. Floating feed (20-22% CP) was used @ 2-4% to feed the fish. The populations of *E. danricus* and *A. mola* were thinned at three months interval. Water quality parameters were assessed monthly and there was normal variation. The fish growth was also assessed monthly and there was 5.5per cent higher fish production in T2 and 1.1 per cent higher in T3 when compared with T1. Fish productivity was reduced in T3 due to significant dietary overlap between the cohabiting species. The benefit-cost ratio was 4.5 per cent higher in T2. Thus, it was concluded there is potential of production and income enhancement through culture of *E. danricus* with IMCs at almost no extra cost.

Key Words: Benefit-cost ratio, Composite culture, Fish yield enhancement, Indian flying barb, Small indigenous species

INTRODUCTION

Esomus danricus is a high-value small indigenous species (SIS) of NE India. It belongs to the carp family *Cyprinidae* and popularly known as Darkina, Darki, Darkya or Dedhuwa. It mainly inhabits in freshwater ecosystems comprise ponds, weedy ditches, brooks, rivers, floodplains and inundated fields. Gupta and Gupta (2006) reported the availability of the fish in brackish water also. *E. danricus* is very rich in micronutrients and protein (Bijen *et al,* 1990; Debnath *et al*, 2014); 100g of the fish contains 18-24g protein, 500-1500 RAE vitamin A, 891 mg Calcium, 12 mg Iron, and 2.1 mg Zinc (Roos *et al,* 2003), which is almost tantamount to Mola carplet (*Amblypharyngodon mola*), another well regarded SIS from NE India. Besides food value, it has ornamental value (Froese and Pauly, 2015). *E. danricus* domesticates well in confined water bodies including aquarium, accepts plankton as well as artificial feeds, tolerates crowding stress, multiply profusely in phytoplankton-rich pond (Santhosh *et al,* 2011). It spawns in batches and fecundity is 400-500/fish. There is huge demand for the fish (Kohinoor *et al,* 2001; Mohanty *et al*, 2013; Rai *et al*, 2014), but no attempts were made till date to bring the fish into the fold of commercial culture.

Aquaculture of *E. danricus* can fulfil multiple purposes like it can help in fulfilling the vacant niches of the pond ecosystems and enhance the overall pond fish productivity. *E. danricus* can complement the pond fertilization and plankton production by egestion of high-value fish manures. Those food scraps and plankton, which remain unused by the big carps, can be better used by their stocking. Being a phytoplankton eater, it can help in controlling plankton bloom and the likelihood of

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occurrence of eutrophication in pond. Further the fish can be used as 'forage fish' for the farming of other high-value fishes like Pabda, Chital, Murrels etc which are predatory in habit.

Aquaculture further can supply high-quality raw materials for sustainable production of value-added fish products like smoke fish, dry fish, fermented fish etc out of the fish, which are very popular in NE States. There will be year-round fish availability with its culture. The poor fish farmers can use it for home consumption and sale big-carps for cash income. Being self-recruiting in habit, if any farmer miss stocking of big-carps' seeds in any year due to financial hardship, he/she can still earn some income by maintaining the fish in pond. The burden of hidden hunger (deficiency of micronutrients) which is prevalent among the people of NE India can be better grappled by the regular consumption of the fish (Thilsted *et al,* 1997**)**. Being marketable at small sizes, the seasonal water bodies can be better used for its production. Further it can help in supplying high-quality brood stocks for augmentation of ornamental fish farming enterprises laid upon it. Aquaculture itself would be a mean for its *ex situ* conservation being presently endangered in nature (Devi and Boguskaya, 2009). Considering the above benefits, the present study undertook to assess the potential of the fish in pond productivity augmentation in NE India with an aim to bring the fish into the fold of commercial culture.

MATERIALS AND METHODS

The experiment was conducted in the research ponds of ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra ($23^0$54'N Lat., $91^0$19'E Long., 16.2m above MSL). The ponds were rectangular in shape, each with 300m^2 in surface area and 1.5-2.0m in depth. The experiment was conducted in a completely randomized block design (CRBD) with three treatments and replication of three treatments three times. Treatment-1 (T1) contained three Indian major carps (IMCs), i.e., Catla, Rohu and Mrigal (4:3:3), Treatment-2 (T2) contained IMCs with *E. danricus* (10000 numbers/ha) and Treatment-3 (T3) contained IMCs with *E. danricus* (5000 numbers/ha) and *Amblypharyngodon mola* (5000 numbers/ha). The average weight of fish during stocking was 10 g in IMCs and 1.5g in *E. danricus* and *A. mola.* The duration of experiment was eight months (July-February).

The pond preparation and management was done following the practices recommended in Scientific Pisciculture. Briefly, the ponds were first cleaned and their inlet and outlet facility were properly designated. Then 1/3rd of total lime requirement (500 kg/ha) was applied by hydrating it overnight. After seven days, 1/3rd of total cattle manure requirement (10,000 kg/ha) was applied by broadcasting over the pond surface. Two days before stocking fish, 1/3rd dose of total inorganic fertilizers' requirement (1000 kg/ha; Urea, SSP and MOP- 4:5:1) was applied by broadcasting over the pond surface. Then *E. danricus* and *A. mola* were stocked. After seven days of their stocking, fingerlings of IMCs were stocked. Supplementary feeding was started with floating feed (20-22% CP) after 24 hr of their stocking. Regular feeding and its adjustment were done as per the biomass of IMCs. Feeding rate was 4per cent during the initial two months, 3 per cent during the next two months and 2 per cent during the last four months of culture. The remaining doses of lime, cattle manure and inorganic fertilizers were applied on monthly installments. The water loss in the ponds was periodically adjusted to maintain the desired water depth.

The water analysis and the plankton analysis were done monthly. Water temperature, and dissolved oxygen and pH were estimated using a portable water tester; total alkalinity was estimated by Method of APHA (1992) and total ammonia (NH_3-N) was estimated using the kit (API, USA). Plankton analysis was done following the direct census method (Jhingran *et al,* 1969). Fish growth was assessed (in terms of length and weight) monthly by cast net fishing. The sample size was six (n=6) for each species of IMCs and ten (n= 10) for *E. danricus* and *A. mola*. Thinning of *E. danricus* and

Table 1: The water quality parameters in different treatments of the culture system.

Parameter	T1	T2	T3
Temperature (^{0}C)	27.52(16.7-32.8)	27.45(16.5-32.8)	27.62(16.5-32.6)
pH	7.22(7.2-7.5)	7.25(7.2-7.6)	7.18(7.3-7.7)
Dissolved oxygen (ppm)	5.22(4.6-6.8)	5.15(4.5-6.5)	5.12(4.0-5.8)
Total alkalinity (ppm)	72.45(58.1-81.5)	72.54(65.2-82.5)	70.6(62.12-75.52)
NH_3-N (ppm)	0.66(0.52-0.74)	0.88(0.62-1.55)	0.74(0.65-0.88)
Total phytoplankton ($\times10^3$ cells/l)	6.90(6.60-7.24)	6.73(6.55-6.98)	6.56(6.37-6.77)
Total zooplankton (x10^3 individuals/ l)	2.17(2.04-2.26)	2.00(1.99-2.13)	1.95(1.92-2.07)

A. mola was started from third month of stocking. IMCs were harvested after eight months by drag net fishing and their numbers were counted and survival rates were calculated following the formula: (No. of fish recovered/ No. of fish stocked) x 100. The food conversion ratio (FCR) was calculated following the formula: Amount of feed supplemented/ fish biomass increment.

The data were analyzed using SPSS v.21 and the difference between the treatments was compared by one-way ANOVA setting the level of significance at 5%. A simple cost-benefit analysis was calculated at the prevailing market rates to estimate the benefit out of the culture system.

RESULTS AND DISCUSSION

Water quality and plankton

The water quality and the plankton density are presented in Table 1. There was slight variation in their levels when compared among the treatments, however, that variation was statistically insignificant ($p\geq0.05$). The water temperature was highest in the month of June and lowest in December. The phytoplankton density was dominated over the zooplankton in the all ponds. There were four groups of phytoplankton and two groups of zooplankton. The phytoplankton groups were Bacillariophyceae (*Cyclotella, Surirella, Melosira, Synura* and *Dinobryon*), Chlorophyceae (*Carteria, Platymonas, Chlamydomonas, Chlorogonium, Pyramimonas, Gonium, Pandorina, Eudorina, Volvox, Physocystium, Pleudorina, Phacotus* and *Dysmorphococcus*), Cyanophyceae (*Microcystis, Anabaena, Oscillatoria, Spirulina, Arthrospira* and *Raphidiopsis*) and Euglenophyceae (*Euglena* and *Trachelomonas*), Dinophyceae (*Peridinum* and *Ceratium*) and the zooplankton groups were Crustacea (Cyclops, Mesocyclops, *Diaptomus*, *Moina*, *Daphnia*, *Bosmina*, *Ceriodaphnia* and *Dipahanosoma*) and Rotifera (*Brachionus, Asplanchna, Polyarthra* and *Keratella*). Chlorophyceae was the dominant phytoplankton group and Rotifera was the dominant zooplankton group.

Fish growth and production

The fish growth and production are illustrated in Table 2. Catla dominated the size (in wet weight) across the treatments, followed by Rohu and Mrigal. And, their growth was highest in T2 and survival in T1. The biomass of *E. danricus* was increased by 744.6% in T2 and by 386% in T3. The average weight of *E. danricus* was reduced by 10.5% in T3 (from 1.23g in T2 to 1.1g in T3). The total fish production was enhanced by 5.5% in T2 and 1.1% in T3. The survival of IMCs was affected by *A. mola* in T3. *A. mola* demonstrated 532% increment in its biomass. The size of *E. danricus* and *A. mola* during harvest was lesser than their size at the time of stocking. The FCR in T2 was better than T1 and T3. The benefit-cost ratio was enhanced by 4.5% in T2 when compared with T1 and T3 (Table 3).

Table 2: The growth and production of fish in different treatments.

Treatments	Fish	Stocking density (no/ha)	Survival (%)	Final weight (g/fish)	Final biomass (kg/species)	Total Prod. (kg/ha)	FCR
T1	Catla	4000	75.67	560.00	1694.4	3516.5	2.8
	Rohu	3000	75.67	440.00	998.4		
	Mrigal	3000	82.33	333.33	823.7		
T2	Catla	4000	74.67	563.33	1682.3	3711.2	2.7
	Rohu	3000	74.33	446.60	996		
	Mrigal	3000	81.67	370.00	906.2		
	Darkina	10000	-	1.23	126.7		
T3	Catla	4000	74.0	560.00	1657.2	3555.8	2.8
	Rohu	3000	74.66	433.40	971.6		
	Mrigal	3000	80.33	350.00	843.1		
	Darkina	5000	-	1.10	36.5		
	Mola	5000	-	1.43	47.4		

The water temperature was normal for culturing fish and it is comparable to finding of Debnath *et al* (2015). The highest water temperature in June is due to the onset of summer season and relatively higher intensity of sunlight and lowest in December is due to winter season and lower intensity of light. The DO level indicates optimum condition for fish culture (Jena *et al,* 2002) and its average value greater than 5 ppm across the treatments is due to regular aeration in the pond. A slight decrease in its level in T2 and T3 is due to extra fish biomass with the incorporation of *E. danricus* and *A. mola.* The decrease of DO with the progression of fish culture is due to fish biomass increase in the pond (Jena *et al*, 2002). The pH and the total alkalinity level indicate optimum condition for fish growth and production (Debnath *et al*, 2013; 2014). The total alkalinity level indicates that the ponds were low to medium productive; despite it sustained high productivity due to regular feeding and fertilization in the pond. The similar trend change in pH and total alkalinity across the treatments indicates there is unvarying pond fertilization and feeding schedule across the treatments. The ammonia level is comparable to Debnath *et al* (2015). It was slightly higher in T2 and T3 due to additional fish biomass and its concentration elevation with the progress of culture is due to gradual deposition of metabolites, and spillage of a portion of nutrients from feed and fertilizers (Jena *et al* 2002). The increased ammonia level particularly during the winter period can be attributed to reduced water temperature and thereby reduced assimilation capacity by plankton (Boyd and Tucker 1998).

The plankton density indicates that the ponds were productive; regular fertilization and feeding helped them to sustain their productivity (Keshavanath *et al*, 2002). Its higher density in T1 is due to lower fish biomass and lower density in T2 and T3 was due to higher fish biomass. The dominance of phytoplankton over zooplankton is due to the application of organic manure. The appearance of diverse plankton groups indicates there was blending of nutrients with the application of organic as well as inorganic fertilizers (Das 1996). There was no incidence of eutrophication or sedimentation in any of the ponds throughout the study which indicates that the quantity of feed or fertilizers applied was either below their threshold level or their effects were adjusted in the course of fish culture. Overall, fish culture markedly improved the pond fertility.

Table 3: The economics (Rs./ha) of fish culture in different systems.

Item	Treatment		
	T1	T2	T3
A. Total cost			
Pond clearance	30000	30000	30000
Lime	12000	12000	12000
Manure	23000	23000	23000
Fertilizers	6825	6825	6825
Fish seeds	20000	23000	23000
Feed	150000	150000	150000
Labour	72000	72000	72000
Miscellaneous	5000	5000	5000
Total	318825	321825	321825
B. Total benefit			
Table fish	703300	742240	711160
C. Net benefit (B-A)	384475	420415	389335
D. Benefit-cost ratio (B/A)	2.21	2.31	2.21

The domination of Catla over Rohu and Mrigal across the treatments is due to its inherent genetic ability and metabolic capacity and this is very apparent in many culture systems using IMCs (Debnath *et al,* 2016; Jena *et al,* 2002). The increase in their growth and biomass in T2 is due to complementary effect of *E.* danricus; there might be better socialization among the cohabiting species and better utilization of plankton and food scraps available in the different niches of the culture system (Jhingran, 1991). In T3, there might be significant overlapping of diets among the fishes (Dewan *et al,* 1991) particularly between *E. danricus* and *A. mola* as both subsists on phytoplankton. As a result, none of them could bloom their populations and it affected overall pond fish productivity (Kohinoor *et al,* 2005). The size reduction in *E. danricus* and *A. mola* both in T2 and T3 is due to their multiple breeding in a season and increase of population size (Alam *et al,* 2004; Roy *et al*, 2002). Overall, fairly high survival and production was found in the study which can be attributed to the following of proper management and feeding schedule in the pond.

CONCLUSION

The study concludes by stating that *E. danricus* culture improves fish productivity of the pond (>5.5%). It complements in the growth of Indian major carps. Its farming markedly improves the pond fertility and its auto-recruitment habit can be harnessed for additional fish production with almost no extra cost. Poor farmers can use it for home consumption and sale big-carps for income generation. There are tremendous scope on addressing the issues 'hidden hunger' prevalent among the people in NE India using this fish; by consumption of 100g *Darkina*, a child's complete requirement of vitamin A, an adult's complete requirement of calcium, and a lady's 57.2 per cent daily requirement of dietary iron and 26.3 per cent daily requirement of dietary zinc requirement can be fulfilled. The trial further strictly discourages its culture with other small fishes like *A. mola*. Further study is recommended on culture of fish with other big carps for productivity enhancement.

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