

Polyculture of Monosex Nile Tilapia (*Oreochromis niloticus*) with Indigenous Major Carps of India

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Abstract

Little is known about the impact of androgen-treated, sex-reversed *Oreochromis niloticus* on the growth potentiality of Indian major carps in polyculture. In our study, equal numbers of mixed and monosex tilapia were cultured in earthen ponds along with *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*. At the end of the five month culture period, though the general trend of carp growth pattern was maintained, culture with monosex tilapia yielded significantly higher weight and length for all the species. Besides, monosex tilapia can be beneficial for maintaining natural fish diversity in natural water bodies. The species diversity index within ponds harbouring monosex tilapia population along with other indigenous fishes was more compared to ponds where mixed-sex tilapia population was present.

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Introduction

Composite culture of fish is accomplished by stocking different proportions of fast growing compatible species with different feeding habits and habitat preferences in the same water body (Azad et al. 2004). Stocking two or more complementary species with different feeding habits can increase the production through better utilization of all available food in the ponds. The aquaculture practices in India are carp oriented with three Indian major carps (rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*)) contributing about 87% of the total freshwater production in 1999 (World Fish Center 2005).

For many years, tilapias have drawn attention of the farmers for their better growth performance. They are currently ranked second only to carps in global production (Ridha 2006). The climatic and ecological conditions in the eastern region of India are suitable for culture of tilapia and aquaculturists have widely introduced this exotic fish in the shallow and seasonal ponds of the region. However, ecologists are concerned with the potential adverse effect of this exotic species on the indigenous fish population (Bartley and Martin 2004; De Silva et al. 2004). Moreover, its performance in open water reservoirs of India has been discouraging (Sugunan 2000). In spite of this, it is felt that tilapia can contribute to the animal protein intake of low-income rural and urban population. Hence, new techniques for maintenance of high growth rate of tilapia along with indigenous major carps in mixed culture are the need of the day. Considering this aspect, the present study aims to evaluate the growth performance of the major carps and sex-reversed monosex tilapia in mixed culture. Besides, we have also analyzed the ecological impact of sex-reversed, monosex tilapia culture in open water systems under Indian perspective.

Materials and Methods

Two groups (n=120; mean weight 0.021 ± 0.003 g; mean length 1.22 ± 0.04 cm) of 3 day old mixed sex juveniles of Nile tilapia (*Oreochromis niloticus*) were reared in glass aquaria for one month. During this period, one of the groups was given control diet at the rate of 20% body weight•day⁻¹ while the other group was fed with 17 α methyltestosterone (17 α MT) treated diet with a dose of 10 mg•kg⁻¹ at the same rate.

After one month, the control and treated tilapia were stocked in separate earthen ponds along with equal numbers of *L. rohita* (n=40; mean weight 10.48 ± 0.1 g; mean length 9.43 ± 0.07 cm), *C. catla* (n=20; mean weight 11.94 ± 0.06 g; mean length 8.91 ± 0.03 cm) and *C. mrigala* (n=20; mean weight 10.2 ± 0.08 g; mean length 8.51 ± 0.06 cm). The size of the ponds were 0.01 ha and the fishes were stocked at a density of 20,000 fingerlings $\cdot$ ha⁻¹ with a ratio of 60% *Oreochromis* sp, 20% *L. rohita*, 10% *C. catla* and 10% *C. mrigala*. The experiment was conducted in three replicating units and culture was continued for five months. During that time the fish were fed twice daily at the rate of 10% body weight $\cdot$ day⁻¹ for the first two months and 5% body weight $\cdot$ day⁻¹ for the remaining three months. Prior to fish introduction, the ponds were freed from predatory and undesirable species, limed and manured to stimulate productivity. To record the growth of the fishes, 10% of all fish species from each pond were sampled monthly to measure the length and weight of each species. All the fishes were harvested at the end of culture period and individual weight, length, daily weight gain (DWG) and specific growth rate (SGR) were calculated (Pechsiri and Yakupitiyage 2005). Finally, data were analyzed statistically to observe the performance of fishes under both situations. All the data are expressed in terms of mean $\pm$ standard error. Duncan's test (at 5%) (Duncan 1955) was followed to compare the means for significant variations and the statistically homogenous means were denoted by similar alphabets.

In order to determine the ecological impact of monosex tilapia culture on fish diversity of a natural water body, Shannon – Weaver indices (Shannon and Weaver 1949) were calculated using the following formula: $H = - \sum_{i=1}^S P_i \ln P_i$ where, n_i , The number of individuals in each species; S , The number of species; N , The total number of all individuals ($\sum_{i=1}^S n_i$); P_i , The proportion of the individual species to the total (n_i/N). Fish diversities (Shannon – Weaver index values) before introduction of tilapia were calculated for fifty natural ponds, naïve to tilapia, at different places of the state. Twenty five ponds under 'group 1' were stocked with 50 juvenile control Nile tilapia while the other 25 ponds under 'group 2' were stocked with same number of juvenile sex-reversed tilapia. Shannon – Weaver index was again calculated after a period of 2 years to interpret the ecological implication of monosex tilapia culture in natural water bodies.

Results

After one month of culture in the laboratory before introduction in the pond, the mono-sex, treated tilapia grew significantly more than the control (mean weight 5.7 ± 0.07 g in control and 12.5 ± 0.09 g in hormone treated; mean length 6.89 ± 0.03 cm in control and 9.18 ± 0.04 cm in hormone treated; P-value < 0.05). After five months of culture in ponds, the monosex tilapia showed a significantly better weight and length compared to the mixed sex tilapia (Table 1). Weight and length of the carps cultured with monosex tilapia were significantly higher compared to those that were reared with mixed sex tilapia. Among the carps, *C. mrigala* had the least mean weight while *C. catla* had the highest mean weight in culture with mixed sex as well as monosex tilapia. Mixed sex tilapia showed the lowest DWG value while monosex tilapia had the highest; DWG value of *C. mrigala* and *L. rohita* from the ponds with monosex tilapia had statistically non-significant difference. On the other hand, *C. catla* from the ponds with mixed sex tilapia had lowest SGR. The total production obtained at the end of the culture period from the ponds with monosex tilapia (4156.2 ± 24.14 kg•ha⁻¹) were significantly higher (P-value < 0.05) than the production obtained from the ponds with mixed sex tilapia (1752.5 ± 23.7 kg•ha⁻¹). Besides, production of the three major carps in the ponds with monosex tilapia was 1171.5 ± 12.14 kg•ha⁻¹ while their production in the ponds with mixed sex tilapia was 841.34 ± 17.9 kg•ha⁻¹.

Table 1. Comparative growth of species of fish after 5 months of culture in ponds with mixed-sex and monosex tilapia. Similar alphabets denote non-significant differences.

Culture type	Fish	Growth parameters			
		Weight (g)	Length (cm)	DWG	SGR (%)
Culture with mixed-sex tilapia	<i>Labeo rohita</i>	$104.5^f \pm 0.24$	$18.06^e \pm 0.1$	$0.62^e \pm 0.007$	$1.53^d \pm 0.007$
	<i>Catla catla</i>	$115.22^e \pm 0.3$	$20.2^d \pm 0.12$	$0.69^d \pm 0.003$	$1.51^e \pm 0.003$
	<i>Cirrhinus mrigala</i>	$100.29^g \pm 0.33$	$18.04^e \pm 0.11$	$0.53^f \pm 0.03$	$1.52^e \pm 0.005$
	<i>Oreochromis</i> sp	$75.70^h \pm 0.2$	$16.32^f \pm 0.12$	$0.49^f \pm 0.009$	$1.72^b \pm 0.008$
Culture with monosex tilapia	<i>Labeo rohita</i>	$140.72^c \pm 0.61$	$23.04^c \pm 0.2$	$0.88^c \pm 0.009$	$1.73^b \pm 0.008$
	<i>Catla catla</i>	$165.38^b \pm 0.8$	$24.31^a \pm 0.29$	$1.04^b \pm 0.009$	$1.75^a \pm 0.004$
	<i>Cirrhinus mrigala</i>	$135.43^d \pm 0.36$	$22.66^c \pm 0.24$	$0.87^c \pm 0.03$	$1.72^b \pm 0.006$
	<i>Oreochromis</i> sp	$250.34^a \pm 0.4$	$23.54^b \pm 0.1$	$1.6^a \pm 0.006$	$1.68^c \pm 0.005$

The fish diversity indices of two groups each comprising 25 natural ponds before and after introduction of tilapia are given in [figure 1](#). The number of mixed sex tilapia in all the group 1 ponds increased greatly during the study period but the number of other fishes decreased, as a result the Shannon – Weaver index value for these ponds decreased. But, in the other group the number of monosex tilapia introduced remained the same and the number of other fishes has either increased or stably maintained as a result of which the Shannon – Weaver index value increased ([Fig. 1a](#)). The individual differences in the numbers of different indigenous fish species in a single experimental set ([Fig. 1b](#)) provide a simple physical representation of this changed scenario.

Discussion

In recent years, polyculture has been gaining importance in aquaculture production systems. But, the problems associated with polyculture if species are not properly selected are overlap of food or habitat preferences in species, or even downright antagonism, and most importantly acceptance by producers and consumers. In many cases, the otherwise ideal candidate for a polyculture system may have low consumer acceptance thereby making such production less profitable. Culture of monosex all male tilapia with Indian carps not only ensured better production of tilapia alone, but also yielded significant increase in growth of the carps. Such increased production level might be attributed to the fact that the monosex male tilapia could not disrupt the stocking equilibrium by producing overlapping juvenile population. In traditional forms of polyculture, waste products of primary species and the natural productivity they foster provide the basis for production of supplemental species. Species combinations for polyculture are sometimes developed with the intent of improving water quality ([Azim and Wahab 2005](#)). Moreover, semi-intensive polyculture of carps and tilapia are likely to be more suitable for adoption by the poor farmers in Asia ([Dey et al. 2005](#)).

The phenomenon of sex reversal and monosex culture of tilapia has great ecological implications. The results from the species diversity indices clearly indicate that introduction of tilapia in a native ecosystem can be devastating with unintended consequences. But, tilapia has been transplanted to and stocked in waters of more than 90 countries worldwide,

Figure 1a.

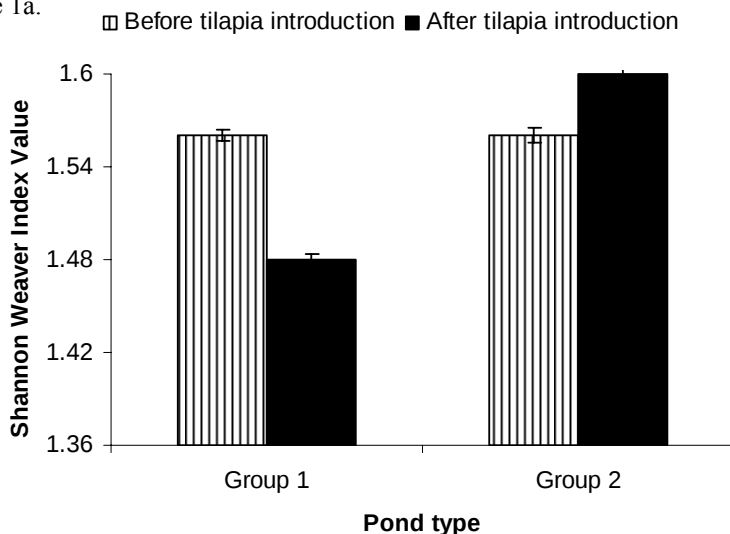


Figure 1b.

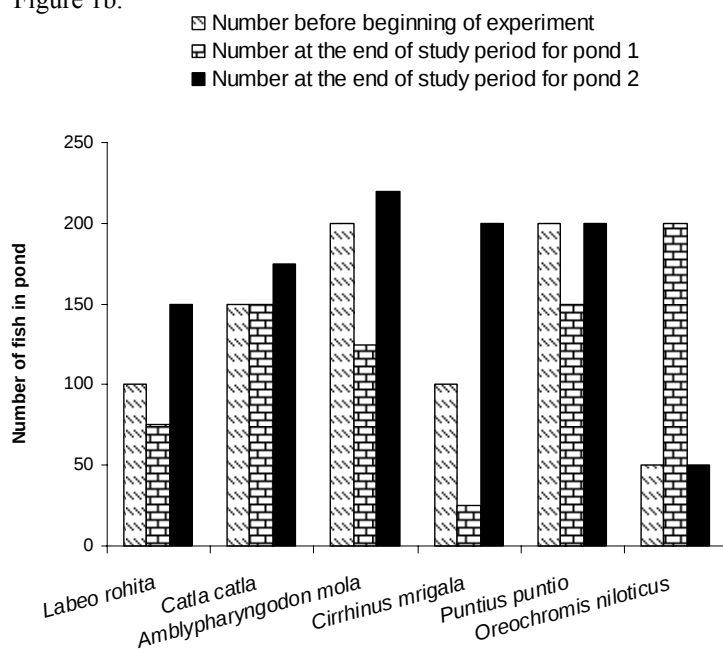


Figure 1. (a) Shannon Weaver index values for two groups of natural ponds before and after introduction of tilapia. Ponds of group 1 were stocked with control tilapia while ponds of group 2 with 17 α MT treated tilapia. (b) Comparative numbers of different fish species in two ponds at the start and end of the study period. Pond 1 was stocked with control tilapia while pond 2 with 17 α MT treated tilapia.

with a global distribution second only to common carp (De Silva et al. 2004). The persistence and coexistence of species in a habitat depends on the availability of a minimum food patch size (P^*) and resource concentration (R^*). The exclusive niche for one species depends on the P^* and R^* of all the species present in that ecosystem (Ritchie and Olff 1999). Being omnivore, tilapia shares a common food niche with almost every indigenous fish species of India, thus reducing their exclusive niche. Hence, the competitive success of indigenous fish population for coexistence with tilapia mainly depends on the ability to breed and propagate. But the huge auto-stocking propensities of tilapia generally overcome the indigenous fish populations that are prone to breeding failure. The monosex population of tilapia cannot breed to increase in number and alter the ecological balance of the water body. Hence, the natural diversity of the system can still be maintained even after the introduction of tilapia. Though hormone treatment does not ensure production of 100% monosex tilapia population, it can still reduce the problem of self-stocking of tilapia to a large extent. Thus, from the ecological view point also, culture of monosex tilapia might be suggested.

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