Indian J. Fish., 62(4) : 45-49, 2015

Evaluation of growth performance and compatibility of *Labeo fimbriatus* (Bloch, 1795) with major carps in polyculture system

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ABSTRACT

Growth performance and compatibility of *Labeo fimbriatus* were studied in a yearlong experimental trial of grow - out carp polyculture in earthen ponds. At a combined stocking density of 7500 fingerlings ha^{-1}, the three different species combinations evaluated were: T1 (Control): catla, silver carp, rohu and mrigal at 0.5:0.5:1:1; T2: catla, silver carp, rohu and *L. fimbriatus* at 0.5:0.5:1:1 and T3: catla, silver carp, mrigal and *L. fimbriatus* at 0.5:0.5:1:1. Incorporation of *L. fimbriatus* into the carp polyculture system did not affect survival of any other carp irrespective of species combination. However, except silver carp, growth of all other species were affected by the species combination. While silver carp and catla showed similar growth in T1 and T2, harvested size of *L. fimbriatus* in T2 was 30% less than mrigal in T1. The 11.4% lower growth ($p<0.09$) of *L. fimbriatus* in presence of mrigal in T3 compared to its counterpart in T2, in absence of the latter, suggested existence of inter-specific competition between the two species in T3. Such results suggested feasibility of incorporating *L. fimbriatus* as an alternative species to mrigal in the major carp based polyculture system without affecting the total biomass yield.

Keywords: Compatibility, Growth, *Labeo fimbriatus*, Polyculture

Introduction

Labeo fimbriatus (Bloch), commonly called the 'fringe lipped carp', was once abundant in the natural waters of central and peninsular India and neighboring countries including Bangladesh, Nepal, Pakistan and Myanmar. In India, it was a major fishery in the Narmada river system. However, in recent years the population of this species has significantly depleted in the natural water bodies, mainly due to habitat destruction and over exploitation (Kharat *et al*., 2003). Although there have been extensive studies on the biology of this species (Bhatnagar and Karamchandani, 1970; Bhatnagar, 1972; 1979), with success in controlled breeding and mass scale seed production (CIFA, 2007), research efforts on its grow out culture have been limited. Study carried out at the ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar, India on rearing *L. fimbriatus* with rohu from fry to fingerling in concrete tanks at combined density of 20 fry m^{-2} showed higher weight attainment in the former (CIFA, 2007). Evaluating growth performance of the species in polyculture with rohu (*Labeo rohita*), kuria labeo (*Labeo gonius*) and silver barb (*Puntius gonionotus*) during fingerling rearing, Jena *et al*. (2011) reported comparatively higher growth performance of *L. fimbriatus* at the initial phases than that of rohu. Mohanta *et al*. (2008) reported that the species attained >450 g in the first year, which indicated its potential as an important cultivable species. Possible incorporation of the species in the carp polyculture system would not only help in diversification of culture practices, but can also help for its conservation. Chopin (2006) opined that stocking rate and optimum inclusion levels of species are important in the multitrophic polyculture system that coalesce the feeding habits of different organisms and intra- or inter-specific competition for maintaining an ecological equilibrium within the system by allocating differentially. Therefore, evaluation of the compatibility of *L. fimbriatus* with other component carp species and its growth performance is a primary requirement to assess its potential in the multi-species carp polyculture system.

Materials and methods

The grow out carp polyculture experiment was carried out in nine earthen ponds of 0.08 ha each for a period of one year at the fish farm of ICAR-CIFA, Bhubaneswar, India. *L. fimbriatus* was incorporated with catla (*Catla catla*), silver carp (*Hypophthalmichthys molitrix*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) in different species combinations. The three triplicated treatments evaluated were: T1 (control): catla, silver carp, rohu and mrigal at 0.5:0.5:1:1; T2: catla, silver carp, rohu and *L. fimbriatus* at 0.5:0.5:1:1; and T3: catla, silver carp, mrigal and *L. fimbriatus* at 0.5:0.5:1:1. Ponds were stocked at a combined density of 7500 fingerlings ha^{-1}. The average initial size of silver carp, catla, rohu, mrigal and *L. fimbriatus* were 9.8, 2.9, 5.2, 6.5 and 5.1 g respectively. Standard procedures of pre-stocking pond preparation including removal of predatory and weed fishes using bleaching powder (10 mg l^{-1} chlorine) and basal fertilisation [cowdung at 3 t ha^{-1} and single super phosphate (SSP) at 30 kg ha^{-1}] were carried out (Jena *et al*., 2005). Intermittent fertilisation with fortnightly application of 500 kg cowdung, 10 kg urea and 15 kg SSP ha^{-1} was done to maintain pond productivity all through the culture duration (Jena *et al*., 2005). Fish were fed with a mixture of rice bran and groundnut oil cake (1:1 ratio, w w^{-1}) in dough form at 4% of biomass per day for the first two months, 3% during the next two months and 2% throughout the rest of the culture period, once daily between 08.00 and 10.00 hrs. Fish growth was assessed through monthly sampling and the quantity of daily feed was calculated based on the average fish growth with an assumed 80% survival (Jena *et al*., 2005). Water sampling in the ponds was carried out at fortnightly intervals between 07.00 and 08.00 hrs. Water quality parameters such as temperature, dissolved oxygen and pH were measured *in situ* with digital sensors (Orion 2 star pH Benchtop, Thermo Electronic Corporation, USA and Orion 3 star DO portable, Thermo Electronic Corporation, USA). Total alkalinity, hardness and inorganic nutrients (ammonia, nitrite, nitrate and phosphate) were measured in the laboratory following standard methods (APHA, 1998). At the end of the culture period, fishes were harvested by repeated netting, followed by complete draining of ponds, and species-wise survival and biomass production was recorded. Specific growth rate (SGR) and survival were estimated as:

$$\text{SGR } (\%\ \text{day}^{-1}) = \frac{(\ln \text{final weight} - \ln \text{initial weight}) \times 100}{\text{Number of experimental days}}$$

The data on fish growth, survival and biomass production were statistically analysed using PC-SAS program for Windows, release v 6.12 (SAS Institute, Cary, NC, USA), and Duncan's multiple range test was performed to compare the fish yield parameters among the treatments at 5% level of significance.

Results and discussion

Water temperature in the treatments during the culture period varied between 26.4-32.9^{o}C, which were within suitable range for carp farming. The other hydrobiological conditions prevailing in treatment ponds (Table 1) were also within the optimum ranges (Tripathi *et al*., 2000; Jena *et al*., 2002a, b, 2007; Das *et al*., 2004; Sahu *et al*., 2007), which could be attributed to the intermittent liming and fertilisation measures.

Treatments showed almost similar variation in water pH in a range of 6.35-8.22. Similarly, no marked variations in dissolved oxygen (3.1 - 5.62 mg l^{-1}), total alkalinity (44 - 120 mg l^{-1}) and total hardness (40 -108 mg l^{-1}) were observed among the treatments, which might be due to similar management practices adopted for the ponds. The inorganic nutrients *viz.*, total ammonia nitrogen (0.08-1.09 mg l^{-1}) and nitrate (0.08 - 1.34 mg l^{-1}), in general, showed an increasing trend with the progress of culture, attributed to the gradual accumulation of metabolites and dissolved organic matter from leftover feed (Jena and Das,

Table 1. Water quality parameters in different treatments in grow out polyculture of *Labeo fimbriatus* with different species combinations

Parameter	T1	T2	T3
Temperature (^{o}C)	27-32.7	26.6-32.5	26.4-32.9
pH	6.35-8.1	6.58-8.22	6.51-8.18
Dissolved oxygen (mg l^{-1})	3.2-5.62 (4.04±0.44)	3.11-5.44 (4.02±0.40)	3.1-5.28 (4.09±0.43)
Total alkalinity (mg $CaCO_3$ l^{-1})	44-120 (72.2±13.8)	48-120 (75.3±15.7)	52-108 (71.6±12.7)
Total hardness (mg $CaCO_3$ l^{-1})	52-100 (69.6±11.7)	40-108 (70.8±14.6)	48-108 (71.2±12.9)
Total ammonia nitrogen (mg l^{-1})	0.08-1.07 (0.58±0.27)	0.08-1.09 (0.65±0.31)	0.08-0.97 (0.57±0.26)
Nitrite-nitrogen (mg l^{-1})	0.002-0.09 (0.04±0.02)	0.001-0.083 (0.038±0.02)	0.002-0.074 (0.04±0.02)
Nitrate-nitrogen (mg l^{-1})	0.08-0.8 (0.39±0.16)	0.08-1.28 (0.41±0.21)	0.11-1.34 (0.41±0.22)
Phosphate-phosphorus (mg l^{-1})	0.06-0.42 (0.23±0.09)	0.07-0.39 (0.23±0.08)	0.064-0.41 (0.22±0.089)

Figures in parentheses (Mean±SD) represent average of the parameters in the treatments during the culture period

2011). However, no specific trend or marked variation was observed in the other two nutrients, *i.e.,* nitrite and phosphate, among the treatments.

Among the carp species, silver carp, catla and rohu showed almost similar survival which ranged between 86-92% (Table 2), while the same in mrigal and *L. fimbriatus* was 74.5-78%. Such observed survival ranges in carps, other than *L. fimbriatus,* are comparable with several earlier studies reported in polyculture (Jena *et al*., 2001; 2002 a, b). In case of *L. fimbriatus*, Keshavanath *et al*. (2002) and Jena *et al*. (2011) reported 85-95% survival after 60 and 90 days of fingerling rearing, respectively. None of the major carps showed any significant variation in survival in their respective treatments (p>0.05), despite incorporation of *L. fimbriatus*, indicating their compatibility.

Both silver carp and catla registered distinctly higher growth over the other carps in all the three treatments (Fig. 1; Table 2) which indicated the non-overlapping of feeding niches of these two surface feeders with the introduced species, *L. fimbriatus*.

The varied species combination did not affect the growth of silver carp in different treatments (p>0.05). But, catla showed significantly higher harvest size and specific growth rate in T3 (p<0.05) compared to the other two treatments. Silver carp, mrigal and catla were common species in T1 and T3, and the first two did not show any significant difference (p>0.05) in their harvest size or

Table 2. Stocking and harvesting attributes of carp species with incorporation of *L. fimbriatus* as candidate species

Treatment	Species	Size at harvest (g)	Survival (%)	Gross biomass (kg pond^{-1})	Net biomass (kg ha^{-1})	SGR (% day^{-1})
T1	Silver carp	880.0±32.8^{a}	88.3±3.21^{a}	77.8±5.3^{a}	960±66^{a}	1.23±0.01^{a}
	Catla	922.0±53.4^{e}	85.7±5.13^{d}	78.9±4.1^{e}	982±52^{e}	1.58±0.01^{e}
	Rohu	418.3±17.1^{m}	88.0±2.78^{m}	73.7±4.8^{m}	908±61^{m}	1.2±0.01^{m}
	Mrigal	404.0±17.6^{p}	76.0±5.07^{p}	61.4±5.5^{p}	752±69^{p}	1.13±0.01^{p}
	*Total/Average	656.1±258^{u}	84.5±6.34^{uv}	291.8±17.2^{u}	3601±215^{u}	1.28±0.18^{u}
T2	Silver carp	816.7±55.3^{a}	91.7±0.58^{a}	74.9±5.5^{a}	924±68^{a}	1.21±0.02^{a}
	Catla	949.3±8.14^{e}	89.3±2.08^{d}	84.8±2.7^{e}	1057±33^{d}	1.58±0.01^{e}
	Rohu	433.0±23.2^{m}	89.5±3.77^{m}	77.4±3.0^{m}	955±37^{m}	1.21±0.02^{m}
	L. fimbriatus	281.0±5.29^{x}	78.0±3.28^{x}	43.8±2.1^{x}	535±26^{x}	1.09±0.00^{x}
	*Total/Average	620±285.8^{v}	87.13±6.05^{u}	281.0±8.4^{u}	3469±105^{uv}	1.28±0.19^{u}
T3	Silver carp	803.3±36.8^{a}	89.3±4.16^{a}	71.7±3.4^{a}	884±42^{a}	1.21±0.01^{a}
	Catla	1024.0±32.6^{d}	90.3±4.72^{d}	92.4±3.6^{d}	1152±45^{d}	1.61±0.01^{d}
	Mrigal	419.3±15.2^{p}	74.5±3^{p}	62.4±2.1^{p}	764±26^{p}	1.14±0.01^{p}
	L. fimbriatus	249.0±6.56^{y}	76.3±5.35^{x}	38.0±3.1^{y}	463±38^{x}	1.07±0.01^{y}
	*Total/Average	623.9±320.4^{v}	82.63±8.45^{v}	264.6±8.2^{u}	3262±102^{v}	1.26±0.22^{v}

Values are expressed as mean ± SD. Species-wise mean with different superscript in a column differ significantly (p<0.05)
*The treatment average for harvested size, survival and SGR are calculated considering data of the four species from the three replications at a time

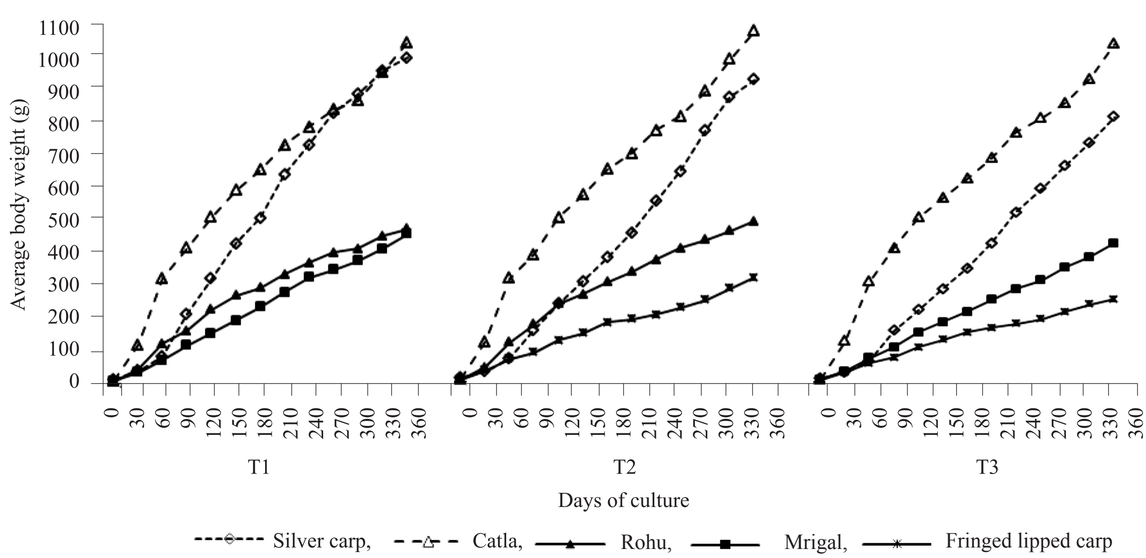

Fig. 1. Growth of different carp species during the grow out polyculture

SGR. But, catla showed inferior growth in T1 in presence of rohu compared to its counterpart in T3 which had *L. fimbriatus*. The lower growth in T1 may be attributed to competition from rohu as and reported earlier in grow out pond (Jena *et al*., 2007) and its higher growth in T3 indicated its compatibility with *L. fimbriatus*.

Inter-specific competition of mrigal with rohu has already been documented in culture ponds in several earlier studies (Talwar and Jhingran, 1991; Chondar, 1999) and such phenomenon also might have occurred between the two species in T1 limiting the growth of mrigal. But, mrigal showed similar growth between T1 and T-3 in the present study which suggested existence of an inter-specific competition in T3 as that of T1 probably from *L. fimbriatus*, owing to their common inclination as bottom dweller. In T1 and T2, silver carp, catla and rohu were common species and showed similar growth between the counterparts in treatments. But, growth of mrigal was 43.8% higher in T1 compared to *L. fimbriatus* in T2 (Table 2). Mrigal also showed 68.4% higher growth than *L. fimbriatus* when these two species were cultured together in T3, which indicated superiority of the former and possible inter-specific competition between the two. Further, 11.4% lower growth of *L. fimbriatus* in T3 compared to its counterpart in T2 corroborated its larger inter-specific competition with mrigal.

The survival, harvest size and net biomass are the functions of inter-specific compatibility of the carp species grown in a pond. The net biomass yield of rohu was 5.2% higher in the presence of *L. fimbriatus* in T2 over T1 where mrigal was present, whereas performances of other component species were similar in these treatments. Such higher biomass yield of rohu in T2 despite having similar survival and harvest size as that of T1 depicted its better compatibility with *L. fimbriatus* compared to mrigal.

The species-wise biomass production in silver carp, rohu and mrigal did not vary significantly ($p>0.05$) among the treatments irrespective of the species combinations. But in catla, while survival was similar in treatments, the significantly lower harvest weight in T1 directly resulted in a lower biomass yield. However, the total biomass production in this treatment, despite lower catla yield, was significantly higher among the treatments ($p<0.05$), which revealed superiority of the species combination of this treatment. Further, biomass in T2 (3469 kg ha^{-1}) was intermediate between those of T1 (3647 kg ha^{-1}) and T3 (3262 kg ha^{-1}). Because contribution of both catla and silver carp in these treatments were similar ($p>0.05$), the significantly higher net biomass in T2 over T3 is due to higher performance of the rohu-*L. fimbriatus* combination in T2 over the mrigal-*L. fimbriatus* of T3.

The grow out carp polyculture study revealed that *L. fimbriatus* did not overlap the feeding niches of the two surface feeders *viz.*, silver carp and catla. With its incorporation as a component species in carp polyculture, it showed inferior growth compared to mrigal as result of the inter-specific competition between the two. However, in presence of silver carp and catla as the other two component species, better compatibility of *L. fimbriatus* with rohu helped to yield a total biomass closer to that of mrigal and rohu combination. The results suggested feasibility of incorporating *L. fimbriatus* as an alternative species to mrigal in the major carp polyculture system without affecting the total biomass yield.

Acknowledgements

The authors thank the Director, ICAR-CIFA, Bhubaneswar for providing necessary facilities to conduct the experiment. The financial assistance from ICAR, New Delhi through the National Fellow scheme to the first author is thankfully acknowledged.

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Date of Receipt : 03.02.2014
Date of Acceptance : 13.05.2015