E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(6): 348-353

www.fisheriesjournal.com
Received: 11-09-2018
Accepted: 15-10-2018

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Studies on the growth performance of carps with silver barb (*Barbonymus gonionotus*) in polyculture system

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Abstract
The growth performance of carps with silver barb, *Barbonymus gonionotus* in the polyculture with two major Indian carps, viz., *Labeo rohita* and *Catla catla* and another species mirror carp *Cyprinus carpio* var. *specularis* has been studied in seasonal ponds over a period of 5 months from March 2018 to July 2018. In polyculture of silver barb with Indian major carps decreased the growth of Indian carps while increased that of mirror carp. Commercially available mega fish feed applied in all the experimental ponds at the same ratio and water quality parameters were suitable ranges for fish culture. Significantly higher fish productions were observed 5272.18±726.98 kg/ha/5 months in the four species polyculture system containing silver barb when the combined yield of all species was compared. It can be concluded that silver barb is the suitable candidate for polyculutre with carps in ponds.

Keywords: *Barbomymus gonionotus*, Indian major carps, growth, polyculture

1. Introduction

The principle of polyculture of fish is the culture of different fish species with different feeding habits in the same pond, is the best utilization of natural foods of different strata and zones without any harm to each other but selection of different fish species plays an important role for any culture practices [1, 2]. For the better utilization of different strata and zones of a pond three or more species with proper ration must be stocked. Earlier studies by Dewan *et al*. [3], Wahab *et al*. [4] and Wahab and Ahmed [5] clearly indicated that the competition for food among the exotic fishes of silver carps, bighead carps and the native species of catla was very high and ultimately their growth and production of the later were significantly reduced in polyculture. It is indicated that addition of any exotic fish within a native species especially in polyculture should not be encouraged without evidence of strong economic benefit. Ahmed [6] reported that in species selection for polyculture, primary importance was given to Indian major carps; rohu (*Labeo rohita*), catla (*Catla catla*), and mrigal (*Cirrhinus mrigala*). Sometimes calbasu (*Labeo calbasu*) has been included in the polyculture in the pond culture in Indian sub-continent including Bangladesh.

Barbonymus gonionotus is well known an indigenous food fish of Thailand where it is locally known as Thai silver barb. It was introduced into Bangladesh in 1977 to augment fish production through incorporation into our carp polyculture system. During last few years, the silver barb which local name in our country is Thai punti or Raj punti became an important fish species for aquaculture in Bangladesh. It is an herbivorous species [7] and grows well on low protein diets, whether feeding on certain aquatic plants or given supplementary feeds and can tolerant a wide range of environmental conditions [8]. It has become a popular culture species because of its rapid growth, good market demand, bright silvery appearance, good taste and easy of culture under a variety of different conditions. Introduction of silver barb in polyculture with native carps increased total fish production although it had a slight antagonistic effect on growth and production of native carps [9]. There is very few information available about the compatibility of silver barb in mixed carps (native carps and exotic carps) in pond polyculture system. However, those species proves environmentally compassionate and has no adverse effect on native and exotic species then it may be an excellent candidate for pond polyculture [10]. Considering the need for a systematic investigation with the most favoured and biologically compatible species for the pond polyculture, the present study has been undertaken to evaluate the compatibility of silver barb *B. gonionotus* in the carp polyculture and to compare the growth performance with or without addition of silver barb in ponds.

2. Materials and Methods

2.1 Study area and duration

The experiment was conducted in farmer's ponds of Baraigoan under Trishal Upazila, Mymensingh for a period of 5 months from March 2018 to July 2018. A total of six perennial ponds were divided under two treatments i.e. T1 and T2 each having three replicates.

2.2 Pond preparation, Fingerlings stocking and feeding

The ponds were rectangular in shape and the surface area of each pond was 0.041 ha (10 decimal). Each pond had inlet and outlet to enter and out of water when needed. Before starting the experiment the ponds were dried and freed from aquatic vegetation. After drying, liming (CaO) was done in all the ponds at the rate of 1 kg/decimal. Ponds were then filled with ground water at a depth of about 1.37 meter. Seven days after liming, all the ponds were manured with cow dung at the rate of 2470 kg/ha, Urea and TSP were used in all of those ponds at the rate of 37 kg/ha and 18.5 kg/ha, respectively. Soon after the appearance of light-plankton bloom, all the ponds were stocked with experimental fishes. Two treatments were tried in this experiment. In treatment-1 (T1), fingerlings of rohu (*Labeo rohita*), catla (*Catla catla*) and mirror carp (*Cyprinus carpio* var. *specularis*) were stocked. For treatment-2 (T2), equal number and ratio of rohu, catla and mirror carp fingerlings and as additional species of silver barb (*Barbonymus gonionotus*) fingerlings were stocked as per experimental design (Table-1).

Table 1: Layout of the experimental design with species composition and stocking density under two treatments

Treatments	Species composition	Stocking densities ((No of fish/pond)	Stocking densities ((No of fish/ha)	Average weight (g)
T1	Rohu (*Labeo rohita*)	250	6175	5.54±0.89
	Catla (*Catla catla*)	100	2470	6.24±0.93
	Mirror carp (*Cyprinus carpio* var. *specularis*)	100	3705	3.12±0.34
T2	Rohu (*Labeo rohita*)	250	6175	5.54±0.89
	Catla (*Catla catla*)	100	2470	6.24±0.93
	Mirror carp (*Cyprinus carpio* var. *specularis*)	100	3705	3.12±0.34
	Silver barb (*Barbonymus gonionotus*)	150	2470	2.88±0.12

For the proper growth of fishes, commercially available mega fish feed was applied throughout the experimental period @ of 7 to 3% of their body weight. The feeding was adjusted on the basis of monthly sampling of fishes. In each sampling ten fish of each species from each pond were caught by cast net. The weight was taken by ordinary balance.

2.3 Physico-chemical and Biological parameters

The water quality parameters of pond water such as water temperature, transparency, dissolved oxygen (DO) and pH were monitored fortnightly throughout the experimental period between 09.00 and 10.00 hr. Temperature (^{0}C) and dissolved oxygen (mg/l) were determined directly by a digital water quality analyzer Hanna DO meter (Model-HI 9146, Romania), pH by a digital pH-meter (Milwaukee pH meter, Model-PH55/PH56, USA), and transparency (cm) by a secchi disc. Plankton samples were collected fortnightly from experimental ponds to study the qualitative and quantitative estimates of plankton. In this purpose, 10 litre samples of pond water were collected from 1 meter depth of surface water of different areas and filtered through a fine mesh (25 mm) phytoplankton net. Filtered sample was taken into a measuring cylinder and carefully made up to standard volume with distilled water. Using a plastic tubing, water was siphoned off from the measuring cylinder and plankton were concentrated into 50 ml and preserved using 5% buffered formalin in small plastic vials for subsequent studies. From each 10 ml preserved sample, 1 ml subsample was examined using Sedgwick-Rafter cell (S-R cell) under binocular microscope. All the plankton present in 10 squares of the cell chosen randomly were counted and used for quantitative estimation by the following standard method of Rahman [11].

2.4 Harvesting of fish

At the end of the experiment the water of the ponds were pumped out and all the fishes were harvested. After harvesting all fish were counted and weighted individually for each pond to assess the growth in weight (g) by using a balance.

2.5 Estimation of survival rate, growth and production of fish

The survival rate was estimated by the following formula:

$$\text{Survival Rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

2.5.1 Fish Production

At the end of the experiment, all fish were harvested and the following parameters were used to determine the production of fishes at the experimental ponds.

Individual stocking weight (g)

Individual fish weight was taken using electric balance as gram (g) during stocking.

Individual final weight (g)

It was taken at the time of harvest and was expressed as gram (g).

Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

Statistical analysis

The collected data of the experiment was analyzed by individual sample t-test. Statistical significance was assessed using a probability level of P= 0.05

3. Results and Discussion

3.1 Physico-chemical and Biological parameters

The physic-chemical parameters of experimental pond water were recorded and summarized in Table 2. The mean values of water transparency, water temperature, dissolved oxygen (DO) and pH of the ponds in the experimental ponds were 34.12±2.59 and 37.29±3.12 cm, 29.54±0.82 and 29.68±0.75 °C, 5.12±0.24 and 4.21±0.58 mg/l and 7.83±0.11 and 7.91±0.14 in T1 and T2, respectively (Table 2). Azam [12], Nahar [13], Kawser [14], Haque *et al*. [10], Tasneem [15], Rashid [16], Israfil [17], Kabir [18], Khatun [19], Chowdhury [20], Uddin [21], Hossain *et al*. [22] and [23] and Ali *et al*. [24] recorded almost similar water temperature, transparency, DO and pH values of pond water in more or less similar experiments. Transparency indicates the presence and absence of food particles and productivity of a water body, which is influenced by the suspended materials, silt and micro-organisms. A fortnightly variation of water transparency ranged was 21.00 to 47.00 cm and 23.00 to 51.00 cm in T1 and T2, respectively. Rahman [11] stated that the transparency of productive water bodies should be 40 cm or less (turbidity resulting from plankton). Kohinoor [25] recorded transparency values ranging from 15 to 58 cm. According to Kamal *et al*. [26] transparency fluctuated between 19 cm and 49 cm in the seasonal ponds whereas Hossain *et al*. [23] recorded transparency between 27.00 to 38.00 cm in earthen nursery ponds at Natore, Bangladesh. In case of transparency and water temperature, there was no significant difference between two treatments. During the experimental period, the ranges of water temperature were 26.50 to 32.50 ^{0}C in T1 and 26.50-33.00 ^{0}C in T2, respectively. The water temperature was suitable ranges for fish culture and there was no significant difference (p > 0.05) among the treatments when individual t-test was performed. Moniruzzaman and Mollah [26] recorded water temperature range of 29.73-29.75 ^{0}C from an earthen ponds of shaprpunti culture. Ahmed *et al*. [28] recorded water temperature of 30.41 ^{0}C from a pond situated at Bangladesh Agricultural University Campus, Mymensingh. Haque *et al*. [10] recorded water temperature from 27.2 to 31.6 ^{0}C from a pond of Thai silver barb inclusion in the polyculture of carp's ponds. Dissolved oxygen content of the ponds were found 4.28 to 6.02 mg/l and 4.04 and 5.32 mg/l in T1 and T2, respectively. The mean values of dissolved oxygen were significantly higher ($p < 0.05$) in T1 than T2 due to lower stocking density. The dissolved oxygen was significantly higher in T1 than T2 due to lower stocking densities. Hossain [29] found the DO content ranged from 4.8-8.7 ppm. Kamal *et al*. [26] recorded DO content varied from 1.80 mg/l to 9.8 mg/l in the seasonal ponds of Natore, Bangladesh. Banerjea [30] stated that 5-7 ppm of dissolved oxygen of a water body is good for biological productivity. Throughout the study period, pH of water of the ponds were found to be approximately neutral or slightly alkaline and ranged from 7.00 to 8.40. According to Swingle [31] and Hossain *et al*. [32], pH 6.5 to 9.0 is suitable for pond fish culture and pH more than 9.5 is unsuitable because free CO2 is not available in this situation. Kamal *et al*. [26] found the pH values ranged from 6.88 to 9.22 at the seasonal ponds of Natore, Bangladesh. Hossain *et al*. [23] observed the fluctuations of pH values during the experimental period in winter and summer ranged from 7.0 to 9.0 and 8.0 to 9.0, respectively.

Table 2: Physico-chemical characters of pond water during the study period

Parameter	Treatment		Level of Significance
	T1	T2	
Transparency (cm)	34.12±2.59 (21.00-47.00)	37.29±3.12 (23.00-51.00)	NS
Water temperature (°C)	29.54±0.82 (26.50-32.50)	29.68±0.75 (26.50-33.00)	NS
Dissolved oxygen (mg/l)	5.12±0.24 (4.28-6.02)	4.21±0.58 (4.04-5.32)	S
pH	7.83±0.11 (7.00-8.20)	7.91±0.14 (7.00-8.40)	NS

NS= Not significant, S= Significant

The group-wise mean abundance of plankton observed in two treatments and summarized in Table 3. Phytoplanktonic population mainly comprised of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Among the four groups of phytoplankton, Chlorophyceae showed the quantitative dominance over other groups in both treatments. The highest mean value of phytoplankton was recorded 18466±1947 cells/l in T1 and the lowest value was observed 15082±1782 cells/l in T2. The zooplankton population was represented by only two groups *viz.*, Crustacea and Rotifera. Crustecea was the dominant group in terms of abundance between the treatments. The mean abundance of zooplankton was 9705±1254 cells/1 in T1 and 9712±1189 cells/l in T2 (Table 3). Plankton population was significantly higher (p < 0.05) in T1 than T2.

Table 3: Mean values (±SD) and ranges of plankton abundance (cells/l) of pond water of fortnightly samples during the study period

Plankton group	Treatment-1	Treatment-2
Phytoplankton		
Bacillariophyceae	5548±708 (4587-6205)	3894±987 (2200-4350)
Cyanophyceae	2554±896 (2214-3354)	2452±1024(1452-3250)
Chlorophyceae	8542±1008 (6848-8920)	7024±782 (6002-7980)
Euglenophyceae	1822±851 (1124-2740)	1712±639 (1124-1845)
Total	$18466±1947^a$	$15082±1782^b$
Zooplankton		
Crustacea	6471±845 (4680-6835)	6388±932 (4570-6727)
Rotifera	3234±1140 (2240-4008)	3324±1120 (2320-4225)
Total	$9705±1254^a$	$9712±1189^a$

Values in the same row having the different superscript are significantly different ($p < 0.05$).

Wahab and Ahmed [5] found that Cyanophytes dominated in the ponds containing Indian major carps. Wahab *et al*. [33]

observed the phytoplankton number ranging from $2\times10^5$to 8×10^5cells/1 and the Zooplankton of $2\times10^4$to 2×10^5 individual/1 in their study. Similar results were found by Rahman *et al*. [34] and Siddique *et al*. [35].

3.2 Growth performance and production of fish

The growth parameters of experimental fishes under two treatments using the same feeding regime were studied in fortnightly. The growth parameters like average initial weight (g), average weight gain (g), average final weight (g) and survival rate were recorded and shown in Table 4. There was no variation among the initial weight of various species between the two treatments. Among all species included in this study, the weight gain of mirror carp showed significantly (p <0.05) higher in T2 (36±2.62 g) than that of T1 (541.10±5.54 g). Catla showed the second highest ranked in average weight gain in T1 (362.47±4.77 g) than T2 (337.02±2.21 g). Rohu showed the gain per fish with a higher mean value of 330.91±3.13 g in T1 and lower mean weight of 310.98±2.40 g in T2. Gain per individual fish of silver barb was 207.68±2.59 g in T2. Rohu, catla and mirror carp showed the highest final weight in T1 than that of T2. The survival rates of four experimental fishes in two treatments were fairly high and ranged from 91.10±2.04% to 92.63±1.11%. All species had a similar trend of survival in both treatments. The lowest survival rate was observed in mirror carp (91.10±2.04%) in T1 and the highest in catla (92.63±1.11%) in T2, respectively. In the present study, the average survival rate for four fish species in different treatments varied between 91.10 to 92.63% which were higher than the survival rates reported by Wahab *et al*. [4] for Indian major carps in polyculture and Haque *et al*. [10] studied the impact of Thai silver barb inclusion in polyculture with carps. Laksmanan *et al*. [36] observed survival rate of 80% with seven species composite culture of Indian and Chinese carps where ponds were fertilized with both organic and inorganic manures. In the present experiment, the highest survival rate was observed in case of silver barb (92.63%). Kohinoor *et al*. [37] obtained survival rate of 86 to 94% in the monoculture of sharpunti. Wahab *et al*. [9] also found survival of all fish including sharpunti was higher than 80% in polyculture of native carps.

Table 4: Yield parameters of different species of fish over a culture period of 5 months

Parameters	Species	T1	T2
Average initial weight (g)	*L. rohita*	5.54±0.89	5.54±0.89
	C. catla	6.24±0.93	6.24±0.93
	Cyprinus carpio var. *specularis*	3.12±0.34	3.12±0.34
	B. gonionotus		2.88±0.12
Average final weight (g)	*L. rohita*	332.03±3.13	315.57±3.75
	C. catla	368.20±4.04	343.53±1.83
	Cyprinus carpio var. *specularis*	544.60±5.01^b	647.18±4.86^a
	B. gonionotus		210.77±2.33
Average weight gain(g)	*L. rohita*	330.91±3.13	310.98±2.40
	C. catla	362.47±4.77	337.02±2.21
	Cyprinus carpio var. *specularis*	541.10±5.54^b	649.36±2.62^a
	B. gonionotus		207.68±2.59
Survival rate (%)	*L. rohita*	91.81±0.47	92.56±0.96
	C. catla	92.63±1.11	91.53±1.71
	Cyprinus carpio var. *specularis*	91.10±2.04	92.21±1.76
	B. gonionotus		91.05±1.65
Species-wise production (Kg/ha/5 month)	*L. rohita*	1848.61±5.25	1811.72±6.04
	C. catla	831.36±6.39	776.10±4.90
	Cyprinus carpio var. *specularis*	1855.62±7.78^b	2211.98±6.26^a
	B. gonionotus		472.38±6.54
Total production (Kg/ha/5 month)		4535.59±604.15^b	5272.18±726.98^a

Values in the same row having the different superscript are significantly different (p < 0.05).

The production of mirror carp ranked in first position in both treatments when the species-wise production was observed with gross production of 1855.62±7.78 and 2211.98±6.26 Kg/ha in T1 and T2, respectively. The production of rohu ranked second position in both treatments but higher production was obtained from T1. Production of catla possessed third position was lower in T2 in comparison to that of T1. This might be due to antagonistic effect of sharpunti inclusion in the polyculture. The overall production of T2 (Including sharpunti) was significantly higher than the treatment T1 (without sharpunti) with total production of 4535.59±604.15 kg/ha/5 months and 5272.18±726.98 kg/ha/5 months, respectively. In all ponds, supplementary feed of mega commercially fish feed were used regularly to obtain higher production of fish. Murty *et al*. [38] demonstrated a high production of 4,096 kg/ha/yr from composite fish culture by using Indian and exotic carp species applying supplementary feed and nitrogenous fertilizers. Hussain *et al*. [39] obtained production of 1952 kg/ha/5 month of *P. gononotus* with only supplementary feed. Wahab *et al*. [9] also observed 5,294-5,670 kg/ha/yr production in the polyculture of carps with sharpunti. Haque *et al*. (1998) recorded the net production of 1436.30 kg/ha/115 days (including thai sharpunti) and 1793.65 kg/ha/115 days (without thai sharpunti) in polyculture of carps. By including sharpunti, synergistic interaction has resulted from faecal input of sharpunti. The excreta has enriched the bottom of the pond with essential food materials edible for mirror carp. This has helped to increase the growth and production of mirror carps [10]. Shahabuddin *et al*. [40] also found positive effect of sharpunti on the growth of comrnon carp. The overall increase in total fish production may have been due to the confounding effect of additional numbers of sharpunti which help to increase the growth of common carp and also have decreased the availability of food materials for other con-inhabiting major carp species. Thus, addition of sharpunti slightly affected the growth of rohu and catla. Similar negative effects of silver carp, bighead carp and Thai silver barb has been observed by Dewan *et al*. [3], Wahab *et al*. [4] and Haque *et al*. [10].

4. Conclusion
Finally it may be concluded that polyculture of carps with silver barb (*B. gonionotus*) has overall increased fish production although it has exerted an aggressive effect on growth and production of major Indian carps. From the present study it is clearly indicate that silver barb is the appropriate candidate for polyculture with carps for its synergistic effect on the growth and production of mirror carp. So, this study may be important for the future development of polyculture technology in Bangladesh or elsewhere in the region.

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