

Evaluation of Performance of Carp–SIS Polyculture Technology in the Rural Farmers' Pond

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Abstract

An experiment on the polyculture of large carps (both Indian and Chinese) with small indigenous fish species (SIS) mola (*Amblypharyngodon mola*) and chela (*Chela cachius*) was carried out to evaluate the production performance of carp-SIS culture in the farmers' pond of Boilor-Dhanikhola village under the Mymensingh district, Bangladesh. The main objective was to develop a sustainable carp and small fish polyculture technology for enhancing the nutritional and socio-economic status of the rural people. Three treatments were tried with 10 replicates each. Only carp species (grass carp, rohu, catla and mrigal) were stocked in treatment 1 (T₁), carps with mola were stocked in treatment 2 (T₂), and carps with chela were stocked in treatment 3 (T₃). Large carps and small fish were stocked at the rate of 10,000 and 25,000 fish·ha⁻¹, respectively. Productions of carps and small fish over a period of 210 days were 2,560, 2,412 and 2,176 kg·ha⁻¹, in three treatments, respectively. However, while there was no significant difference in fish production between T₁ and T₂, the production in T₃ was significantly (P<0.05) lower than T₁. Despite the yield values, it is argued that carp-SIS culture technology is a good proposition as a rural aquaculture technology in terms of nutrition and socio-economics aspects. Partial harvest of small fish is a prerequisite to maintain compatible existence among large carps and small fish.

Introduction

In the past, small fish were considered undesirable in fish ponds used in the aquaculture of Indian major and Chinese carps because they were believed to compete for food and space with large carps (Kohinoor et al. 1998). There-

fore, they were eradicated from fishponds before stocking. Nevertheless these small fish still provide the major portion of animal protein and micronutrients to the rural poor people (Roos et al. 1999). Efforts have recently been made to promote the culture of large carps and small fish together. The rural people are interested, but viable technology is lacking. It has been observed that small fish enter the ponds along with run-off during rainy days and through other means and constitute a substantial quantity during harvest, even after eradication using pesticides (Roos et al. 1999).

In this country, 16 SIS have been identified for aquaculture (Felts et al. 1996). Among these, mola (*A. mola*), chela (*C. cachius*), punti (*Puntius sophore*) and chapila (*Gadusia chapra*) are of special interest to the fish culturist because of their high nutritional value. Mola is particularly important due to its high vitamin A content (Ahmed 1981). Zafri and Ahmed (1981) reported that mola contain 200 IU of vitamin A per gram of edible protein. Thilsted et al. (1997) reported that 100 g raw mola contain approximately 1,960 µg, 1,071 mg and 7.0 mg of vitamin A, calcium and iron, respectively. It has also been found that small fish with bones are calcium-rich food (Larsen et al. 2000). Thus, these small indigenous fish, if cultured with large carps, could make an excellent contribution to the diet of the rural poor. The farmers could use these fish to feed their family and sell the large carp as cash crop.

Despite the considerable work devoted on the culture of Indian major and Chinese carps in this region, there has been hardly any systematic attempt to explore the culture potential of the small fish with carps, especially in farmers' ponds. As part of ongoing efforts in this direction at the BAU's Field Laboratory, Bangladesh, the present study was designed to assess the production performance of small fish with carps in the rural ponds under low input management.

Materials and Methods

Study area

The experiment was conducted from June 1999 to January 2000 in the farm ponds of Boilor-Dhanikhola village under Trishal Upazila in Mymensingh district, Bangladesh. Thirty ponds of different sizes varying from 400 to 1000 m² with depths of 1.5 to 2.5 m were used for this study. All the ponds were rain fed, well exposed to sunlight and without inlet or outlet.

Preparation of ponds

All predatory and small fish species were removed from the experimental ponds through repeated netting. Ponds were prepared by using lime at the rate of 250 kg·ha⁻¹. Seven days after liming, the ponds were fertilized with cow manure at the rate of 1,000 kg·ha⁻¹ and urea and TSP at the rate of 12.5 kg·ha⁻¹ and 25 kg·ha⁻¹, respectively.

Experimental design and stocking of fish

The experiment consisted of three treatments with ten replications. Ponds were chosen for different treatments following stratified random sampling based on size. The ponds were stocked seven days after fertilization. The stocking density of Indian major carps, rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) was 9,500 fish·ha⁻¹ with a ratio of 1:1:1, respectively. Grass carp (*Ctenopharyngodon idella*) was stocked at the rate of 500 fish·ha⁻¹. The SIS, mola and chela were stocked at the rate of 25,000 fish·ha⁻¹. Large carps, rohu (*L. rohita*), catla (*C. catla*), mrigal (*C. mrigala*) and grass carp (*C. idella*) were stocked in all treatments. The SIS, mola and chela were stocked only in ponds under T₂ and T₃, respectively. In T₁, only large carps were stocked with the same ratio and density (Table 1).

Post stocking management

All ponds were subject to the same regime of feed and fertilizer application. The commonly available agricultural by-product rice bran (100%) was used as supplementary feed at the rate preferred by farmers, which was about 3 to 5% of standing crop of fish. Soft grass and banana leaves were supplied for grass carp on a daily basis up to satiation. All ponds were fertilized with cow manure at the rate of 1,000 kg·ha⁻¹ at fortnightly intervals. All feeds and fertilizer inputs were supplied from the farmers' households. Fish were sampled at monthly intervals to assess their growth and health.

Water sampling and analysis

Water quality parameters such as temperature, transparency, pH, dissolved oxygen (DO) and total alkalinity were estimated at monthly intervals from 0900 to 1000 hrs. Water temperature was recorded using a Celsius thermometer, and transparency was measured using a Secchi disc of 20-cm diameter. Dissolved oxygen was measured directly using a digital DO meter (YSI Model-58) and pH was measured by a digital pH meter (CORNING pH meter 445). Alkalinity was determined following the EDTA titrimetric method (APHA 1992).

Table 1. Fish species composition and stocking densities per hectare pond in three treatments.

Fish species	Treatment-1	Treatment-2	Treatment-3
Grass carp (<i>C. idella</i>)	500	500	500
Rohu (<i>L. rohita</i>)	3,167	3,167	3,167
Catla (<i>C. catla</i>)	3,167	3,167	3,167
Mrigal (<i>C. mrigala</i>)	3,166	3,166	3,166
Mola (<i>A. mola</i>)	-	25,000	-
Chela (<i>C. cachius</i>)	-	-	25,000

Plankton enumeration

Plankton samples were collected at monthly intervals following Dewan et al. (1991). To enumerate plankton population, 10 l of water samples were collected from different areas and depths of the experimental ponds and passed through a plankton net (mesh size 25 μ m). Plankton samples were preserved in 5% buffered formalin in small plastic bottles.

The preserved plankton samples were studied using a Sedgewick-Rafter counting cell, under a binocular microscope (Olympus, SWIFT M-4000D). A 1 ml subsample from each sample was transferred to the counting cell and then all planktonic organisms present on 10 squares of the cells chosen randomly were counted and later on used for quantitative estimation using the following formula:

$$N = \frac{A \times 1000 \times C}{V \times F \times L} \text{ (Stirling 1985)}$$

where:

N = No. of plankton cells per liter of original water

A = Total no. of plankton counted

C = Volume of final concentrated sample in ml

V = Volume of a field = 1 cu mm

F = No. of field counted

L = Volume of original water in liter

Growth parameters

The following parameters were used to evaluate the growth of fishes:

a. Weight gain (cm) = Average final weight (g) – average initial weight (g)

b. Survival rate (%) = $\frac{\text{No. of fish harvested}}{\text{Initial no. of fishes}} \times 100$

Analysis of specific growth rate (SGR)

The growth performance of experimental fish in different treatments were measured using the following formula:

Specific growth rate (SGR):

$$\text{SGR (\% bw} \cdot \text{day}^{-1}) = \frac{\text{Loge}W_2 - \text{Loge}W_1}{T_2 - T_1} \times 100 \text{ (Brown 1957)}$$

where:

bw = Body weight

W_1 = Initial live body weight (g) at time T_1 (day)

W_2 = Initial live body weight (g) at time T_2 (day)

Harvesting of fish

Partial harvesting of small fish in T_2 and T_3 was done three months after stocking and continued onwards fortnightly until final harvest of all fish. All ponds were completely harvested by seine net after seven months of rearing. During harvest, all fishes were counted and weighed separately to assess survival rate and production.

Statistical analysis

Data were analyzed using the statistical package, Statgraphics, Version 7. ANOVA was performed on all dependent variables to study if treatments had any significant effect. Duncan's Multiple Range Test was also applied to identify which treatments were different.

Results and Discussion

Water quality

The overall mean values of each water quality parameter in different treatments are presented in table 2. Temperature varied from 20.8 to 30.1°C with mean values of 26.39 ± 0.25 , 26.37 ± 0.27 and 26.58 ± 0.26 °C in three treatments, respectively. Temperature differences between treatments were not significant ($F=0.207$). Mollah and Haque (1978) recorded temperatures ranging from 26 to 32.4°C in the pond water of Mymensingh. Wahab et al. (1996) also recorded water temperature to vary from 28.5 to 31.3°C in the ponds used for fertilization experiment.

The observed transparency ranged from 19 to 30, 18 to 55 and 20 to 31 cm with mean values of 23.31 ± 0.35 , 25.43 ± 0.63 and 24.50 ± 0.32 cm in three treatments, respectively. The values of transparency varied with sampling date, which could be due to differences in abundance of plankton. Boyd (1982) recommended a transparency between 15 to 40 cm as appropriate for fish culture.

Table 2. Mean values ($\pm$ SE) and range of water quality parameters observed during the study period.

Parameters	Treatment-1	Treatment-2	Treatment-3	F - ratio
Temperature (°C)	26.39 ± 0.25^a (21.2 – 29.6)	26.37 ± 0.27^a (20.8 – 30.1)	26.58 ± 0.26^a (21.0 – 29.8)	0.207
Transparency (cm)	23.31 ± 0.35^b (19.0 – 30.0)	25.43 ± 0.63^a (18.0 – 55.0)	24.50 ± 0.32^{ab} (20.0 – 31.0)	5.687
PH	(7.03 – 9.03)	(7.00 – 8.82)	(7.03 – 8.39)	2.958
DO (mg.l ⁻¹)	5.59 ± 0.07^a (4.31 – 6.79)	5.26 ± 0.10^b (3.65 – 7.49)	5.38 ± 0.09^{ab} (4.11 – 7.65)	4.025
Alkalinity (mg.l ⁻¹)	93.77 ± 2.70^a (60.0 – 182.0)	91.06 ± 2.34^a (41.0 – 134.0)	95.14 ± 3.18^a (56.0 – 220.0)	0.549

Figures in the same row having the same superscript are not significantly different.

The fishponds were alkaline with pH values ranging from 7.03 to 9.03, 7.00 to 8.82 and 7.03 to 8.39 in three treatments, respectively. These values showed significant differences among the treatments ($F = 2.958$). Hossain et al. (1997) obtained a pH range of 6.7 to 8.3 in fish ponds located in the adjacent areas, while Kohinoor et al. (1998) observed the pH range 7.18 to 7.24 in the research ponds of the Field Laboratory of Bangladesh Agricultural University, Mymensingh. The observed pH values of water ranging from 7.00 to 9.03 indicate that the experimental ponds were suitable for fish culture (Swingle 1967, Boyd 1982).

Dissolved oxygen (DO) varied from 3.65 to 7.65 $\text{mg}\cdot\text{l}^{-1}$ with mean values of 5.59 ± 0.07 , 5.26 ± 0.10 and 5.38 ± 0.09 $\text{mg}\cdot\text{l}^{-1}$ in treatments 1, 2 and 3, respectively. One way ANOVA showed significant differences among treatments ($F=4.025$). Oppenheimer et al. (1978) and Wahab et al. (1995) recorded similar dissolved oxygen values that ranged from 3.18 to 7.58 and 2.2 to 7.1 $\text{mg}\cdot\text{l}^{-1}$, respectively.

Total alkalinity ranged from 60.0 to 182.0, 41.0 to 134.0 and 56.0 to 220.0 $\text{mg}\cdot\text{l}^{-1}$ with mean values of 93.77 ± 2.70 , 91.06 ± 2.34 and 95.14 ± 3.18 $\text{mg}\cdot\text{l}^{-1}$ in three treatments, respectively. These values showed no significant differences among treatments ($F = 0.549$) and were within the ranges typically bound for producing fish (e.g. Oppenheimer et al. 1978). Bhowmic and Tripathi (1985) and Oppenheimer et al. (1978) found total alkalinity ranged from 64.85 to 85.36 and 19.4 to 92.6 $\text{mg}\cdot\text{l}^{-1}$, respectively in their research works.

All water quality parameters of the experimental ponds were found to be within the acceptable ranges for aquaculture and there was no abrupt change in any parameter of the pond water.

Plankton population

Mean abundance of plankton with their different groups is shown in table 3. Phytoplankton population mainly composed of Bacillariophyceae (4), Chlorophyceae (9), Cyanophyceae (7) and Euglenophyceae (3). Cyanophyceae was the dominant phytoplankton group, followed by Chlorophyceae, Euglenophyceae and Bacillariophyceae. Mean total phytoplankton ranged from 20.60 ± 1.33 to

Table 3. Groupwise mean plankton ($\pm$ SE) abundance of plankton numbers ($\times 10^3\text{cells}\cdot\text{l}^{-1}$) of pond water in different treatments.

Plankton group	Treatment-1	Treatment-2	Treatment-3
Bacillariophyceae	4.82 ± 1.38	3.04 ± 0.38	2.08 ± 0.39
Chlorophyceae	8.00 ± 0.96	7.60 ± 0.85	6.48 ± 0.81
Cyanophyceae	7.24 ± 0.90	6.89 ± 0.62	9.34 ± 1.41
Euglenophyceae	4.54 ± 0.75	3.07 ± 0.39	5.34 ± 0.72
Total Phytoplankton	24.60 ± 2.23^a	20.60 ± 1.33^a	23.24 ± 1.58^a
Crustacea	1.32 ± 0.17	0.82 ± 0.23	1.20 ± 0.21
Rotifera	3.32 ± 0.39	3.16 ± 0.36	3.84 ± 0.33
Total Zooplankton	4.64 ± 0.37^a	3.98 ± 0.44^a	5.04 ± 0.39^a
Total Plankton	29.24 ± 2.42^a	24.98 ± 1.48^a	28.28 ± 1.70^a

Figures in the same row having the same superscript are not significantly different.

$24.60 \pm 2.23 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ and the values were found to be not significantly different among treatments when compared using ANOVA. Wahab et al. (1994) reported 25 genera of phytoplankton belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and 5 genera of zooplankton belonging to Crustacea and Rotifera. Islam et al. (1997) recorded 10.2 to $34.0 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ plankton population in farmers' experimental ponds, and Kohinoor et al. (1998) recorded 22.50 to $27.83 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ of phytoplankton population.

Zooplankton population was represented by only two groups' viz. Crustacea (4) and Rotifera (4). The mean abundance of zooplankton varied from $3.98 \pm 0.44 \times 10^3$ to $5.04 \pm 0.39 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$, and showed no significant difference among treatments when compared using ANOVA. These results are supported by Islam et al. (1997) and Kohinoor et al. (1998), with their findings 1.9 to $5.4 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ and 5.20 to $6.34 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$, respectively.

Mean total plankton was $29.24 \pm 2.42 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$, $24.98 \pm 1.48 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ and $28.28 \pm 1.70 \times 10^3 \text{ cells} \cdot \text{l}^{-1}$ in T_1 , T_2 and T_3 , respectively and these numbers showed no significant difference among treatments.

Growth and production of fish

Details of growth parameters and production of fish are presented in table 4. Among all species, grass carp attained the maximum weight at harvest. Since the fish farmers supplied soft grass and banana leaves to feed grass carp regularly, grass carp showed a high average weight gain in all treatments.

The weight gain by rohu, catla and mrigal was better in T_1 , where no SIS was stocked. The lower weight gain of Indian major carps in other treatments may have been due to the competition for space and food in the presence of SIS. The growth of rohu and catla had been affected by adding mola in a similar study carried out by Kohinoor et al. (1998). Miah and Siddique (1992) reported that mola is an omnivore with higher preference for debris and plant foods. Natarajan et al. (1975) reported that chela appears to be an insect feeder but consumes algae and diatoms also. Both mola and chela may have exerted dietary competition to some extent in carp-SIS polyculture in rural ponds.

The average final mean individual weights of mola and chela in T_2 and T_3 , were 1.67g and 1.89 g, respectively. The harvest weights of mola and chela were less than the initial weights. This may be because these fishes bred and their numbers had therefore increased, which supports the findings of Kohinoor et al. (1998).

The survival rates of various species in different treatments were fairly high and varied from 84 to 87%, 80 to 84%, 80 to 88% and 72 to 76% for rohu, catla, mrigal and grass carp, respectively. Among the different treatments, there was no significant difference in the survival rates of rohu, catla, mrigal and grass carp.

The specific growth rate (SGR) of rohu, catla, mrigal and grass carp were found to vary from 1.48 to 1.58, 1.49 to 1.66, 1.61 to 1.68 and 2.17 to 2.20 (% bw·day), respectively. The higher SGR values of rohu, catla, and mrigal were observed in carp polyculture (T_1). Grass carp showed higher SGR in all

Table 4. Growth, survival and production of fish under three treatments during July 1999 to January 2000.

At harvesting	Fish species	At stocking			Survival (%)	Production (kg.ha ⁻¹ .7months ⁻¹ ± SE)		SGR (% bw.day ⁻¹)	
		Av. initial wt. (g)	No. of stocked	No of fish recovered		Av. final wt. (g)	Total wt.(kg)		Species wise
T ₁	G.Carp	9.20	561	424	896.2	380	346.5±42 ^{NS}	2,560 ±179 ^a	2.18
	Rui	10.00	3512	3085	275.7	850.7	754.1±58 ^{**}		1.58
	Catla	9.00	3512	2951	295.8	873.2	698.4±72 [*]		1.66
	Mrigal	8.70	3512	3112	298.2	928.0	761.4±60 ^{NS}		1.68
T ₂	G.Carp	9.20	318	230	934.7	215.0	358.2±29 ^{NS}	2,412 ±77 ^{ab}	2.20
	Rui	10.00	2012	1757	222.3	390.5	589.6±26 ^{**}		1.48
	Catla	9.00	2012	1610	206.4	332.4	486.9±40 [*]		1.49
	Mrigal	8.70	2012	1745	265.7	463.8	721.2±40 ^{NS}		1.63
	Mola	2.00	15900	92500	1.67	154.0	256.3±41		-
T ₃	G.Carp	9.20	270	202	876.2	177.0	315.3±25 ^{NS}	2,176 ±65 ^b	2.17
	Rui	10.00	1709	1439	231.7	333.5	605.5±27 ^{**}		1.50
	Catla	9.00	1709	1366	222.5	304.0	557.3±31 [*]		1.53
	Mrigal	8.70	1709	1371	256.3	351.4	633.6±37 ^{NS}		1.61
	Chela	2.50	13500	16,600	1.89	31.5	64.0±20		-

*Significant at 5% level, **Significant at 5% level; NS = Non significant.

treatments, possibly due to the availability of soft grass and banana leaves supplied by the farmers daily.

Fish production after seven months of culture was $2,560 \pm 179$, $2,412 \pm 77$ and $2,176 \pm 65$ $\text{kg} \cdot \text{ha}^{-1}$ in treatments 1, 2 and 3, respectively. Maximum fish production was obtained in T_1 , where only carps were stocked and lowest production was found in T_3 , where carps and chela were stocked. Intermediate fish production results were obtained in T_2 , where carps and mola were stocked. The production levels were found to be almost the same between T_1 and T_2 and showed no significant ($P < 0.05$) difference. T_3 appeared to give the lowest production and differed significantly ($P < 0.05$) from T_1 but there was no significant difference ($P < 0.05$) between T_2 and T_3 . It is clear from the present experiment that the stocking of mola and chela in large carp polyculture affected the growth of rohu and catla. The contributions of mola and chela to total fish production in this trail were 10.6% and 2.94%, respectively.

Average production values of 2,473, 3,882 and 3,354 $\text{kg} \cdot \text{ha}^{-1}$ for mola (*A. mola*), chola punti (*Puntius chola*) and colisa (*Colisha fasciata*), respectively were obtained in the monoculture of SIS (Mustafa 1991). Kohinoor et al. (1998) obtained a production of $1,127 \text{ kg} \cdot \text{ha}^{-1} \cdot 4 \text{ mos}^{-1}$ from the polyculture of carps with mola where the contribution of mola was $58 \text{ kg} \cdot \text{ha}^{-1} \cdot 4 \text{ mos}^{-1}$. Hossain et al. (1997) cultured the SIS chapila (*G. chapra*) with major carps and observed that the small fish exerted a negative affect on the production of carps. They obtained a production of $467.11 \text{ kg} \cdot \text{ha}^{-1} \cdot 6 \text{ mos}^{-1}$ from the polyculture of chapila with carps. All these trials were carried out as on-station research. In comparison to the above levels of fish productions, the fish production achieved in the on-farm trials in the rural farmers' pond situation was very encouraging and thus carp-SIS polyculture technology has a potential as a means of enhancing fish production and improving the nutritional status of rural pond owners.

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Propylene Phenoxetol as a Relaxant for the Pearl Oysters *Pinctada imbricata* and *Pinctada albina*

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Abstract

The responses of pearl oysters *Pinctada imbricata* and *Pinctada albina* to the relaxant, propylene phenoxetol (PP) were similar to those reported for other members of the genus. Wedges that keep the valves of oysters open were unnecessary as most valves opened readily in the presence of PP (2 mL L⁻¹ seawater). Relaxation generally occurred within 15 min and, upon removal from the relaxant bath, oysters recovered within 10 min without any sign of ill-effects. In general, both relaxation and subsequent recovery times decreased with increasing water temperature. The size of oysters had little effect on the time taken to open the valves in the presence of PP, the time to relax nor the time to recover after exposure. Prolonged exposure to PP (90 min) significantly increased the recovery time, but no mortality or apparent ill effects were observed in the week following exposure.

Introduction

In both pearl culture and pearl oyster research, the invasive nature of some procedures has led to the evaluation of potential relaxants to reduce stress to oysters (Tranter 1957, Hildemann et al. 1974, Dev 1994, Norton et al. 1996, 2000). In particular, relaxants have been suggested as a means of reducing oyster mortality and enhancing pearl quality by preventing muscle damage during nuclei insertion operations; reducing muscularly induced haemolymph loss and increasing the ease and accuracy of surgery and biopsy by preventing muscular contractions (Norton et al. 1996). Among the relaxants tested, propylene phenoxetol (PP) is particularly useful to relax the oysters *P. margaritifera* (Hildemann et al. 1974, Norton et al. 1996), *P. albina* (Norton et al. 1996) and *P. maxima* (Norton et al. 1996, Mills et al. 1997). In these species, 1.5 to 2.5 mL L⁻¹ PP produces relatively rapid relaxation (generally <15 min, Mills et al. 1997) with a short recovery period, although its effectiveness was reduced at lower temperatures (Norton et al. 1996).

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