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Mixed culture of fishes in seasonal ponds through fertilization and feeding

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Abstract

A study on mixed culture of mirror carp (*Cyprinus carpio* Lin.), tilapia (*Oreochromis niloticus* Lin.), silver carp (*Hypophthalmicthys molitrix* Val.) and Thai sharpunti (*Puntius gonionotus* Bleeker) in the ratio of 1:2:2:5 was conducted in 12 seasonal mini ponds (30 m^2 each) for 105 days. There were six treatments each with two replicates and each pond was stocked with a total of 100 fish. Rice bran and mustard oil cake were used as supplemental feed either in combination or alone in presence or absence of fertilizer. Fertilizers were used in the form of organic, inorganic or both. The best growth performance of mirror carp, tilapia and Thai sharpunti was obtained in treatment III which received both fertilizer (organic + inorganic) and rice bran while the highest growth of silver carp was obtained in treatment VI receiving only inorganic fertilizer. However, the overall best production (2450 Kg/ha) and economic return for the culture period was obtained in treatment VI followed by treatment III. The results are discussed in the light of water quality parameters.

Key words : Mixed culture, Seasonal ponds, Fertilizer, Feeding

Introduction

Against the backdrop of declining fish catches from open waters in Bangladesh and increasing malnutrition, excellent opportunities exist for small-scale aquaculture development in rural areas, where majority of households have ponds or ditches. These water resources are presently either unutilized or underutilized. Small farmers constitute the bulk of the population in Bangladesh and there is urgent need to improve the efficiency of utilization of limited resource base of these small farmers. Most farmers in rural areas have access to water bodies such as seasonal miniponds, ditches and canals which retains

water for 5 to 6 months (from June - November). Farmers can effectively utilize these water areas for fish culture either for their subsistence or as commercial enterprises.

To minimize the growing gap between demand and supply of fish low-cost feed ingredients and fertilizers should be used for increased production of fish. Mixed culture of several fast growing species such as mirror carp (*Cyprinus carpio* Lin.), red tiliapia (*Oreochromis niloticus* Lin.), silver carp (*Hypophthalmicthys molitrix* Val.) and Thai sharpunti (*Puntius gonionotus* Bleeker) of different feeding habits and behaviour can best utilize the above mentioned water bodies. Mixed culture can even show symbiotic effects, when one species improves the environmental conditions and food supply for others. Thus, the present study was undertaken to study the growth of some fast growing species in seasonal miniponds and to observe the effects of different fertilizers and supplemental feed on growth of fish in mixed culture.

Materials and methods

Experimental system

The experiment was carried out for a period of 105 days during August to November'94 in 12 earthen mini-ponds of size 30 m^2 each. The ponds were prepared by draining out water during summer. For convenience the ponds were numbered as 1 to 12. During the experiment the water depth was maintained at a maximum of 1.2 m using fine meshed PVC over flow pipe on the bank fixed 1.2 m above the pond bottom. Ponds were divided into six duplicated treatments as shown in Table 1

Table 1. Composition of various treatments used in the present study

Treatment No.	Treatments	Pond No.	Rate of application
I	Without feed and fertilizer	1,2	–
II	Rice bran + Mustard oil cake (1:1)	3,4	5% of fish body wt. daily
III	Fertilizer (Inorganic + Organic) + Rice bran	5,6	50g Urea + 50gTSP + 2.5kg cow-dung weekly; rice bran 5% of fish body wt. daily
IV	Fertilizer (Inorganic +Organic)	7,8	50g Urea + 50g TSP + 2.5 kg cow-dung weekly
V	Fertilizer (Organic)	9,10	5.0 Kg cow-dung weekly
VI	Fertilizer (Inorganic)	11,12	100g Urea + 100g TSP weekly

Inorganic= Urea and TSP (triple super phosphate)
Organic = Cow-dung

Stocking and sampling of experimental fish

Fingerlings of mirror carp, red tilapia, silver carp and Thai sharpunti were collected from Freshwater Station, Fisheries Research Institute (FRI), Mymensingh. Each of the pond was stocked with a total of 100 fish comprising mirror carp, red tilapia, silver carp and Thai sharpunti at the ratio of 1:2:2:5 with a mean initial weight of 8.2, 12.0, 12.8 and 2.2g respectively. Fortnightly sampling of at least 20% of the fish was done using a small seine net to ascertain fish body weight and also to adjust feeding rate. At the end of the experiment harvesting was done by total draining out of the ponds.

Water quality parameters

The water quality parameters such as temperature, pH, dissolved oxygen (DO), carbon dioxide, and alkalinity were monitored weekly. Water samples were collected from the ponds and measured for temperature (Hand held mercury thermometer) and pH (Corning pH meter), other parameters like dissolved oxygen, carbon dioxide, and alkalinity were measured by titrametric method (APHA 1981).

Plankton estimation

The plankton samples were collected using a 25 micron mesh plankton net and studied using a Sedgewick-Rafter cell and a binocular microscope (Olympus model BH-2). Planktons were grouped into phyotplankton and zooplankton. Planktons were expressed numerically per litre of water.

Statistical analysis

One way analysis of variance (ANOVA) was used for statistical analysis of the growth data followed by Duncan's Multiple Range Test to determine the significance of variation among the treatment means. Standard error (± S.E) of treatment means were calculated from the residual mean square in the analysis of variance.

Economic analysis

A simple economic analysis was carried out to estimate the net profit generated from this type of operation. The cost of different inputs was based on the Mymensingh whole sale retail market price (1994) for various inputs. However, the cost of leasing the ponds was not included. The average selling price of fish was considered at Tk. 50/-per Kg. An additional 7.5% on the top of total inputs has been included towards operating cost (ADCP 1983).

Results

Water quality parameters

The ranges of water quality parameters in different ponds monitored during the study period were: temperature 27-35^{0}C; pH 6.1-8.8; carbon dioxide 5.0-6.9 mg/l; alkalinity 47.5-105.0 mg/l. The DO content during early morning (06.00 h) varied between 1.3-3.3 mg/l while in the afternoon it varied between 6.0-13.4 mg/l.

Plankton

The mean abundance of plankton with their different groups has been shown in Table 2. Phytoplanktonic population was mainly composed of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and the zooplankton population consisted of Crustaceans and Rotifera. Chlorophyceae was found to be the most dominant phytoplankton group. Group Euglenophyceae ranked second and Cyanophyceae ranked third in respect of total count. Bacillariophyceae was the least abundant plankton and its mean abundance varied from $32x10^4$ to $66x10^4$/l.

The zooplankton population was represented by only two planktons *viz.* Crustaceans and Rotifera. The mean abundance of crustacean varied from $8x10^4$ to $14x10^4$/l while the abundance for Rotifera varied from $2x10^4$ to $9x10^4$/l. However, the overall mean abundance of plankton (phytoplankton + zooplankton) varied between $347x10^4$ to $621x10^4$/l with treatment VI showing the highest.

Growth performance of fish

The growth performance of mirror carp, red tilapia, silver carp and Thai sharpunti in terms of initial weight, final weight, weight gain, specific growth rate (SGR), survival rate and total production are shown in Table 3. Among the treatments the weight gain of mirror carp was significantly ($P<0.05$) the highest in treatment III receiving fertilizer (inorganic and organic) and rice bran.

Similarly, the highest growth of red tilapia was observed in treatment III. However, there was no significant differences ($P>0.05$) between the growth of red tilapia in treatment II (rice bran + mustard oilcake) and treatment VI (inorganic fertilizer).

Table 2. Group wise mean plankton ($x10^4$) count in per litre of water in different treatments

		Treatments					
A.	Phytoplankton	I	I	III	V	V	VI
	Bacillariophyceae	35	32	43	40	39	66
	Chlorophyceae	112	127	113	171	114	227
	Cyanophyceae	92	06	152	130	116	156
	Euglenophyceae	97	152	155	128	132	158
B.	Zooplankton						
	Crustacea	9	9	11	12	14	8
	Rotifera	2	4	8	8	9	6
	Total	347	400	482	489	85	621

Silver carp attained the highest growth among the experimental fish. The highest ($P<0.05$) growth of silver carp was attained in treatment VI (inorganic fertilizer) followed by treatments III, II and IV, V and I.

The highest growth of Thai sharpunti was obtained with treatment III followed by treatments II, VI, IV, V and I. However, there was no significant difference ($P>0.05$) between the growth of Thai sharpunti in treatments IV (inorganic + organic) and V (organic).

The specific growth rate (SGR) of mirror carp was between about 2 and 3 except in treatment I (1.41). The highest ($P<0.05$) SGR value was obtained with mirror carp in treatment III followed by treatment VI, II, V, IV and I. On the other hand, the SGR of red tilapia in different treatments were comparatively low which ranged between 1.28 to 1.93. The SGR of silver carp was significantly ($P<0.05$) highest in treatment VI (inorganic fertilizer). There was no significant differences ($P>0.05$) between the SGRs of silver carp in treatments II and III. The SGR values of silver carps ranged between 1.61 to 2.65. The SGR values of Thai sharpunti in different treatments ranged between 1.73 to 2.72.

The survival rate of various species in different treatments were fairly high (Table 3). There was no significant difference ($P>0.05$) between the survival rates of mirror carp in different treatments which ranged between 75 and 90%. In general, red tilapia showed the highest survival rate among all treatments. Tilapia in treatments II, III and VI showed 100% survival. There was no significant differences ($P>0.05$) between the survival of silver carp in different treatments which ranged between 77.5 to 90%. The survival rate of Thai sharpunti varied between 86 to 95% with treatment III showing the highest survival rate (Table 3).

Table 3. Growth, survival and production of fish in different treatments during the study period

	Treatments						
	I	I	III	IV	V	VI	± S.E
Initial wt.(g)							
a) Mirror carp	8.2[a]	7.9[a]	7.5[a]	8.1[a]	8.2[a]	7.8[a]	± 0.21
b) Red tilapia	12.1[a]	12.2[a]	12.0[a]	12.4[a]	12.1[a]	12.3[a]	± 0.35
c) Silver carp	12.5[a]	12.8[a]	12.9[a]	12.7[a]	13.0[a]	12.6[a]	± 0.23
d) Thai sharpunti	2.2[a]	2.0[a]	2.2[a]	1.9[a]	2.2[a]	2.1[a]	± 0.15
Final wt.(g)							
a) Mirror carp	36.1[f]	110.5[c]	150.5[a]	87.9[e]	150.1[d]	118.0[b]	± 0.79
b) Red tilapia	46.4[e]	82.3[b]	90.8[a]	72.6[c]	52.2[d]	86.2[b]	± 1.24
c) Silver carp	67.6[f]	132.4[c]	144.0[b]	118.0[d]	75.5[e]	202.6[a]	± 2.05
d) Thai sharpunti	13.5[e]	33.5[b]	38.4[a]	18.9[d]	17.5[d]	24.6[c]	± 0.58
Weight gain (g)							
a) Mirror carp	27.9[f]	102.6[c]	143.0[a]	9.8[e]	96.9[d] 1	10.2[b]	± 0.87
b) Red tilapia	34.3[e]	70.1[b]	78.8[a]	60.2[c]	40.1[d]	73.9[b]	± 1.14
c) Silver carp	55.1[e]	119.6[c]	131.1[b]	105.3[d]	62.5[e]	190.0[a]	± 2.14
d) Thai sharpunti	11.3[e]	31.6[b]	36.2[a]	17.0[d]	15.3[d]	22.5[c]	± 0.60
Specific growth rate (SGR)							
a) Mirror carp	1.41[e]	2.51[bc]	2.92[a]	2.27[d]	2.43[c]	2.59[b]	± 0.03
b) Red tilapia	1.28[d]	1.82[a]	1.93[a]	1.68[b]	1.39[c]	1.89[a]	± 0.03
c) Silver carp	1.61[e]	2.23[b]	2.30[b]	2.12[c]	1.68[de]	2.65[a]	± 0.02
d) Thai sharpunti	1.73[d]	2.68[a]	2.72[a]	2.19[bc]	1.97[cd]	2.34[b]	± 0.07
Survival rate (%)							
a) Mirror carp	75[a]	85[a]	75[a]	85[a]	90[a]	75[a]	± 6.12
b) Red tilapia	87.5[c]	100[a]	100[a]	97.5[ab]	95[b]	100[a]	± 1.40
c) Silver carp	77.5[a]	85[a]	85[a]	87.5[a]	80[a]	90[a]	± 3.23
d) Thai sharpunti	86[c]	94a[b]	95[a]	87[c]	88[bc]	90[abc]	±1.73
Total production (Kg/ha/105 days)	900	2133.3	2333	1683.3	1300	2450	

Figures in the same row having the same superscripts are not significantly (P>0.05) different

Standard error of treatment mean calculated from the residual mean square in the analysis of variance

Total production of fish shown in Table 3 which ranged between 900 and 2450 Kg/ha for the experimental period of 105 days. Treatment VI showed the highest production (2450 Kg/ha) followed by treatments III, II, IV, V and I. A

simple cost benefit analysis showed that treatment VI generated the highest net profit (TK.99,960/-)/ha/105 days followed by treatments III, II, IV, V and I (Table 3).

Discussion

The basic principles of polyculture involves the idea that when compatible coinhabiting species of different feeding habits are cultured in the same pond, all the food niches are utilized without detriment to one another. Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of sufficient fish food organisms. The water quality parameters measured in different treatments throughout the experimental period were found to be more or less similar and all of them were within the acceptable ranges for fish culture. Lakshmanan *et al.* (1971) made a fortnightly observations on quality parameters in composite culture of Indian major carps for one year and recorded pH value of 6.0 - 9.3 ; total alkalinity value of 19.4 - 78.2 mg/l.

Dewan *et al.* (1991) in a study with Indian and Chinese carp in polyculture found a surface temperature of 30.2 - 34.0°C and a pH range of 6.6 - 8.8 which is more or less similar to the present study. The range of DO values recorded in the present study in the early morning was very low (1.6 - 3.0 mg/l). However, the range of DO values during afternoon was quite high ranging from 6 - 13.6 mg/l. The low DO level in the early morning might be due to the consumption of DO by fish biomass since no oxygen is produced by photosynthesis during night and utilization of oxygen for decomposition of organic matter in pond bottom.

The ranges of alkalinity observed in all treatments during study period were good. Moyle (1946) reported that pond and lakes with a range of total alkalinity of 40.0 - 90.0 mg/l are of medium to highly productive. Bhuiyan (1970) also stated that the total alkalinity of medium productive water ranged from 25 - 100 mg/l. The range of alkalinity values in the present study varied between 47.5 and 105.0 mg/l. Hence, the ponds are said to be medium to highly productive.

The phytoplankton population composed of four groups e.g. Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae reflected usual composition in the tropical fish pond (Dewan *et al.* 1991, Wahab *et al.* 1994). The highest plankton abundance was recorded in treatment VI receiving only inorganic (Urea + TSP) fertilizers followed by treatment IV receiving both organic and inorganic fertilizers. The plankton population in treatment III (inorganic + organic fertilizer + rice bran) was more or less similar to that of treatment IV. The plankton abundance in different treatments recorded in the present study was much lower than that reported by Dewan *et al.* (1991) and Wahab *et al.*(1994). This might be due to the fact that rate of fertilization used by Wahab *et al.* (1994) was 2 to 3 times higher than those used in the present

study while the stocking density of fish (33,000/ha) in the present study was much higher than those (15,000/ha) used by Wahab *et al.* (1994). No plankton bloom was observed in experimental ponds during the study period except that in treatment VI which showed a slight bloom. However, this bloom diminished within one or two days. The zooplankton population was represented by two groups viz. Crustaceans and Rotifera. The overall abundance of zooplankton was low. However, treatments IV and V receiving organic fertilizer showed slightly higher abundance of zooplankton.

The highest weight gain of silver carp was attained in treatment VI receiving higher dose (200g/week/pond) of inorganic fertilizer. Treatment VI also showed the highest total production (2450 Kg/ha) among all the treatments. The overall production ranged from 900-to 2450Kg/ha in different treatments for a culture period of 105 days. Lakshmanan *et al.* (1971) reported a production ranging from 2230 to 4209 Kg/ha/yr in a 7 species composite culture of Indian and Chinese carps with the application of fertilization and supplemental feeding. Murty *et al.* (1978) reported a net fish yield of 2275.37 Kg/ha/yr with fertilization alone as against an yield of 3558.58 Kg/ha/yr with fertilization and feeding.

A number of factors can affect the amount of available natural food. One of the major determinant is, of course, the productivity of the pond, whether natural or induced by inorganic or organic fertilizers. The inter-species association in polyculture can also affect the production of natural food, through competition among the species and its availability to the fish. Hepher (1989) reported that silver carp at high densities (1300 and 2600/ha) in polyculture with bottom feeding fish (common carp, 1000/ha; tilapia hybrid, 1500/ha) grew better than silver carp stocked at the same density in monoculture, although the concentration of algae was higher in the later. Milstein *et al.* (1985) explained this by overgrazing on the larger algae and zooplankton in the monoculture ponds, which gave rise to the development of large number of very small algae. In the polyculture systems, the bottom feeding fish by their burrowing action cause an "up welling" of nutrients. This stimulates the production of large number of algae to the advantage of silver carp, which therefore, grew better in presence of bottom feeding fish.

The growth of mirror carp, red tilapia and Thai sharpunti were the highest ($P<0.05$) in treatment III but the overall production of fish was second highest (2333 Kg/ha) in treatment III receiving supplemental feed (rice bran) and fertilizer (Inorganic + Organic). The use of fertilizer in combination with supplementary feeding in pond systems may be advantageous because it permits the use of higher fish and shrimp stocking densities and facilitates faster fish and shrimp growth. For example, Sinha (1979) reported fish production (Indian and Chinese carp polyculture) in fresh water ponds in India to be 1053 Kg/ha/yr with no fertilizer or feed inputs, 1398-2303 Kg/ha/yr with organic and inorganic fertilizer inputs 3314-4000 Kg/ha/yr with supplementary feed inputs (mixture of rice bran

oilcake; 1:1) and 4244-5506 Kg/ha/yr with both fertilizer and supplementary feed inputs. Furthermore, the operating costs of fish production are reduced by use of fertilizer (manure) and feed inputs (Shang and Costa-piere 1983).

The growth of red tilapia and Thai sharpunti in treatment II ranked second and mirror carp and silver carp ranked third among the treatments. The overall production of fish in treatment II receiving supplemental feed (mustard oilcake + rice bran) also ranked third (Table 3). In supplemental feeding aquaculture, feeding itself through the accumulation of residues and faeces has manuring effect and increases the amount of available natural food in the pond. The contribution of natural food organisms within semi-intensive pond farming systems can not be under emphasized. For example, Szumiec (1969) estimated that the contribution of natural food as 30% of the food ration for common carp in a supplementary feeding schedule. The overall lower growth and production of fish in treatment II compared to treatment VI (Inorganic fertilizer) in the present study might be due the low production of natural food in treatment II compared to treatment VI.

The overall low growth and production of fish in treatment V receiving organic manure in treatment V may be due to the fact that although manures are considered largely as indirect feed, they are expected to be far less effective than that of direct ones, since at every transition in trophic level in a recycling process, about 90% of the energy and nutrients become unavailable (Wohlfarth and Schroeder 1979). On the contrary, Zhu *et al.* (1990) reported an increased net yield of 10.2 Kg/ha/day in Chinese integrated farm ponds as a result of manure application.

The mean survival rate for various fish in different treatments in the present study varied between 82 and 91% which were higher than the survival rates reported by Wahab *et al.* (1991) for Indian major carps in polyculture where supplemental feed (mustard oilcake + rice bran, 2:1) was given. Lakshmanan *et al.* (1971) observed similar survival rate of 80% with seven species composite culture of Indian and Chinese carps in which ponds were fertilized with both organic and inorganic manures at short interval and fish were fed daily with a mixture of mustard oilcake and rice bran.

The result of the present study demonstrated that in a composite culture system growth of silver carp was markedly enhanced by the application of inorganic fertilizer. However, growth of other species (mirror carp, Thai sharpunti and red tilapia) were higher when receiving supplemental feed and fertilizer. The result of the present study suggests that above mentioned species can successfully be reared in seasonal ponds.

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