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Polyculture of carps using over-wintered fingerlings under different stocking densities

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Abstract
An on-farm trial was undertaken in twelve earthen ponds (1200-1600 m^2) to evaluate the growth and production of over-wintered fingerlings of rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) in polyculture at three stocking densities. The stocking densities were 2,250; 3,250 and 4,250 fish/ha in treatment-1, treatment-2 and treatment-3, respectively. Fish in all ponds were fed with rice bran and mustard oil cake at the ratio of 3:1. Fish production obtained in three treatments were 2325±74.75, 2620±49.66 and 2982±171.52 kg/ha. The results demonstrated higher mean growth in T-1 than in T-2 and T-3. However, the highest production as well as net benefit was obtained in treatment-3.

Introduction

Carp polyculture in Bangladesh is a traditional and popular practice of fish production, where optimum utilization of aquatic space, manure and feed take place, as different fish species have different feeding habits and living habitats (Miah *et al.* 1997). Fish production in polyculture is affected by species, stocking density, pond fertilization, artificial feed as well as ecological conditions. The quality and size of carps seed are also considered as the critical input for the success of carp polyculture (Tripathi 1990, Mohanty 1995).

Farmers in this country usually stock their ponds in the months of June to August with newly nursed fry/fingerlings at a comparatively higher stocking densities (6,000-10,000/ha) and obtain fish production of about 3 to 4 tones/ha/year (Ahmed 1993). With this management, fish usually attain an average size of 500-600 g in a year, as the total grow-out period includes 3-4 months of the winter period which hinders the growth of fish. Generally, in the fish market, carps of 500-600 g individual weight obtain significantly lower price than those of >1.0 kg or more. In addition, the consumers have a higher preference for fish >1.0 kg of individual weight. However, production of maximum individual weights of carp up to >1.0 kg in a year can not be achieved with the existing typical polyculture system in Bangladesh. It has been suggested that this problem may be overcome if the fry/fingerlings produced in a season are reared at a higher density over the winter period and stocked into the grow-out ponds at lower densities in the next year at the onset of the warmer period (late February to early

March). By this means the fish may get a longer warm period and grow to a larger size at harvest. It has been reported that in India, farmers have been stocking their grow-out ponds with over-wintered carp fingerlings at a low stocking density and producing about 6-7 tons of fish/ha/yr having an individual weight of about 1.5-2.0 kg. Unfortunately, no experimental studies or adoption of this type of polyculture management system have been undertaken in Bangladesh. With this view, the present experiment has been undertaken to observe the adoption of this management technique and explore the possibilities of density effects on the production of carp with maximum individual weight and per capita maximum yield in a polyculture system using fingerlings reared over the winter period at high level stocking density with low input.

Materials and methods

Pond preparation

The experiment was conducted in 12 perennial ponds of 1200 to 1600 m^2 each at Boilor Union, Trishal Upa-zilla, Mymensingh during the period of April to October 2001. Before stocking, rotenone was used at the rate of 7,500 kg/ha in all experimental ponds to eradicate the all sorts of fish species. Ponds were then treated with lime at the rate of 250 kg/ha. Five days after liming, ponds were fertilized with cow dung (raw form) at the rate of 1,000 kg/ha.

Stocking of fish

Over-wintered fingerlings (fry reared in a nursery pond at 200,000 fish/ha from September 2000 to February 2001, covering the winter season) were stocked 3 days after fertilization. The experimental ponds were divided into three treatment groups for three stocking densities of 2,000 (T-1); 3,000 (T-2) and 4,000/ha (T-3) with rohu, catla and mrigal at the ratio of 1:1:1. Grass carp was stocked in all the treatments at the density of 250 individuals/ha as an additional species.

Post stocking management

All treatment groups were subjected to the same regime of feed application. Supplementary feed was prepared using commonly available feed ingredients *viz.* rice bran and mustard oil cake at the ratio of 3:1. The prepared semi-moist feed was supplied to the stocked fishes regularly at the rate of 2-3% of the standing crop of fish. A sufficient amount of green soft grass and banana leaves was supplied regularly for feeding grass carp. The ponds were sampled monthly by using a seine net for weighing approximately 20% of the fish of each species to measure the growth, assess the health status and adjust the amount of feed.

Analysis of water quality parameters

Water quality parameters like water temperature (°C), dissolved oxygen (mg/l), pH and total alkalinity (mg/l) were monitored weekly at around 9.00-10.00 am. Standard procedures (APHA 1992) were followed in analysing the water samples.

Enumeration of plankton

Plankton samples were collected monthly from all experimental ponds. Collection of plankton samples was made following the method of Dewan *et al.* (1991). Identification and enumeration of plankton were performed following the methods of Ward and Whipple (1962) and Bellinger (1992).

Harvesting of fish

After seven months of culture, all ponds were harvested through repeated seine netting and lastly by draining out of water. After harvesting, the number of fish harvested, species, individual weights and gross total weight were recorded to estimate the survival rate and production.

Statistical analysis

Data were analysed using ANOVA (one way) followed by Duncan's New Multiple Range Test (DMRT) to identify the level of variation among the treatments. The statistical package, Statgraphics Version -7 was applied to compute and analyse the data.

Results and discussion

Water quality parameter

The overall mean values of each water quality parameter in different treatments are presented in Table 1. The range of water temperature as observed in the experimental ponds appeared to be suitable for fish culture, agreeing with the findings of Hossain *et al.* (1997), Haque *et al.* (1998) and Wahab *et al.* (2001).

Table 1. Mean ±SE values (range) of water quality parameters in different treatments

Parameters	Treatment-1	Treatment-2	Treatment-3
Water temperature (°C)	31.85 ± 3.24^{a} (24.20 - 33.80)	31.09 ± 2.98^{a} (24.00 - 33.60)	31.95 ± 2.79^{a} (24.70 - 33.90)
Transparency (cm)	30.11 ± 6.88^{a} (18.20 - 36.45)	32.81 ± 7.94^{a} (20.4 - 39.11)	36.84 ± 9.49^{b} (20.9 - 45.5)
pH	6.89 to 8.11	6.66 to 8.20	6.88 to 8.50
Dissolved oxygen (mg/L)	5.96 ± 1.85^{a} (4.55 - 8.21)	5.78 ± 1.47^{a} (4.20 - 7.94)	5.18 ± 1.84^{b} (3.96 - 8.01)
Alkalinity (mg/L)	125 ± 12.54^{a} (98 - 145)	142 ± 15.91^{b} (102 - 152)	135 ± 13.25^{b} (95 - 164)

*Values in the same row having the same superscript letter are not significantly ($P<0.05$) different

Mean values of transparency were 30.11±6.88, 32.81±7.94 and 36.84±9.49 cm in T-1, T-2 and T-3, respectively where, T-1 and T-2 showed significant differences ($P<0.05$) from treatment-3 but there was no variation between T-1 and T-2. Boyd (1982) recommended a transparency between 15-40 cm as appropriate for fish culture. Wahab *et al.* (1994) reported that the transparency of productive water bodies should be 40 cm or less. The transparency values recorded in this study were within the productive range. pH of pond water under different treatments were found slightly acidic to slightly alkaline. Typical culture pond pH values range between 7.1 to 9.3 (Azim *et al.* 1995, Wahab *et al.* 2001). The mean values of dissolved oxygen concentration were 5.96±1.85, 5.78±1.47 and 5.18±1.84 mg/L, in three treatments. Dissolved oxygen concentrations of 3.5 -12 mg/L in pond waters have been reported by several authors (Ali *et al.* 1982, Mumtazuddin *et al.* 1982, Wahab *et al.* 2001 and Kohinoor *et al.* 2001), which were similar to those in the present study. Total alkalinity of water of the experimental ponds was found to range from 98 to 145 mg/L in T-1, 02-152 mg/L in T-2 and 95-164 mg/L, in T-3. The mean values for the above treatments were 125±12.54, 142±15.91 and 135±13.25 mg/L, respectively. The average total alkalinity values were above 100 mg/L in some ponds of Bangladesh Agricultural University Campus ponds (Paul 1998 and Kohinoor *et al.* 2001). Therefore, the total alkalinity values recorded in the present study were within the suitable range for fish production.

Net plankton

The overall mean values of plankton with their different groups are presented in Table 2. Between the two groups of plankton, the phytoplankton was found to dominate over zooplankton. The population of phytoplankton was about 8-9 times higher than that of zooplankton. Jana (1973) reported that phytoplankton population were three times higher than the zooplankton. Many researchers in contrast reported that the zooplankton might suppress phytoplankton (Hossain *et al.* 1997, Kohinoor *et al.* 2001 and Wahab *et al.* 2001). The planktonic abundance in different treatments in the present study was much lower than those reported by several authors (Hossain *et al.* 1997, Kohinoor *et al.* 2001). The lower planktonic populations observed in the present experiment were presumably due to the fact that no fertilizer was applied in the ponds except during pond preparation.

Table 2. Mean±SE numbers (10^3/l) of plankton of different groups in different treatments

Parameters	Treatment-1	Treatment-2	Treatment-3
Bacillariophyceae	1.31±0.31	1.07±0.12	1.20±0.26
Chlorophyceae	5.14±1.90	5.11±0.96	4.22±1.02
Cyanophyceae	2.51±0.70	2.06±1.05	2.20±1.18
Euglenophyceae	0.89±0.45	1.55±0.72	0.99±0.13
Total phytoplankton	9.85±2.89a	9.79±3.80a	8.61±1.50b
Crustacea	0.45±0.15	0.39±0.12	0.41±0.16
Rotifera	0.33±0.15	0.31±0.12	0.29±0.16
Total zooplankton	0.78±0.42a	0.70±0.37b	0.66±0.61b

*Values in the same row having the similar superscript letter are not significantly ($P<0.05$) different

Growth of fish

Details of stocking, harvesting, survival and production of fish species are presented in Table 3. On the basis of final growth attained by each species, it was observed that among all the species under the three treatments, the highest final average weight was attained by catla in T-1. Catla reached an average weight of 1,649±143.37g in T-1, 1114±140.34g in T-2, and 830.40±88.74g in T-3. In typical polyculture systems, the harvest weight of catla has been reported to range from 213 to 955 g in Bangladesh (Ahmed and Alam 1989, Uddin *et al.* 1994, Hossain *et al.* 1994 and Ali *et al.* 1997).

The average weight at harvest attained by rohu was 746.15±52.99, 633.14±55.08 and 614.40±97.61 g in T-1, T-2, and T-3, respectively. In another study, the growth rates of rohu varied from 248.20 to 736.90 g/10 months (Ahmed 1993). A wide variation in the growth of rohu ranging from 294 to 660 g has been reported (Hossain *et al.* 1994, Rahman *et al.* 1995, Ali *et al.* 1997 and Miah *et al.* 1997).

At harvest, the average weights attained by mrigal were 789.24±75.33, 726.53±100.29 and 652±69.20 g in T-1, T-2, and T-3, respectively. Ahmed and Alam (1989) observed the growth rate of this species in the range of 380 to 584 g/ 10 months. In another study, the growth rate of mrigal was found to vary from 430 to 741 g in one year (Ahmed 1993), whereas Mazid *et al.* (1997) observed 460 to 860g weight gains in 10 months culture period.

In contrast to the other species, grass carp showed very similar growth patterns in all the treatments, with no significant (P>0.05) differences. The growth of grass carp in other studies has been reported to vary from 447 to 1,469 g/year (Ahmed 1993, Miah *et al.* 1997, Ali *et al.* 1995 and Ali *et al.* 1997).

In the present investigation, it has been found that the average harvest weight of all species was higher accept grass carp than those reported in the literature. This is might be attributed to the fact that the over-wintered fingerlings were stocked at low densities so they grew very fast. In fact, the over-wintered fingerlings were in stressed condition in the nursery ponds. When stocked at lower densities in the experimental ponds they showed rapid growth and within seven months attained a weight of 800 to 1600g. It was also observed that the harvest weights of all species in T-1 were higher than those of T-2 and T-3 (Table 3). Since the stocking density was less in T-1 than others, the fish in T-1 grew with more space and sufficient natural food.

Survival rates in the different treatments were fairly high and did not vary significantly among the treatments for any of the four species. The main factors that may have led to the high survival rates were proper stocking of large sized fingerlings, freedom from predation, favourable ecological conditions and proper feeding. Chaudhury *et al.* (1978) emphasised the importance of these factors in governing the survival.

After seven months culture period, the production levels obtained were 2,325±74.85, 2,620±59.89 and 2,982.00±71.52 kg/ha from T-1, T-2 and T-3, respectively (Table 3). The highest production was obtained from T-3, where carp were stocked at a higher stocking density. The lowest production of 2,325 kg/ha was obtained with T-1 where carp were stocked at 2,250 fish/ha. The relative contributions of different fish species in the different treatments are illustrated in Fig. 1. It is clear that the contribution of catla in all the treatments to the total production was the highest and that of rohu was the lowest. Mrigal was the second contributor to all the treatments. The production level showed significant difference ($P<0.05$) among treatments when analysed statistically. The production of T-3 was significantly ($P<0.05$) higher than T-2 and T-3 while T-2 and T-3 also showed a significant ($P<0.05$) difference.

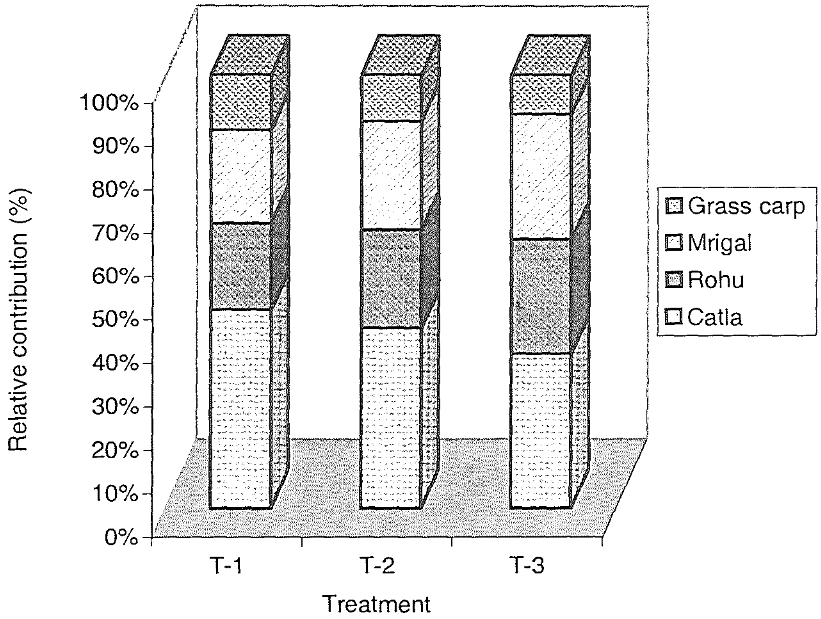

Fig.1. Relative contribution of different fish species in different treatments.

The range of production from the traditional polyculture of carps in Bangladesh was 3,119 to 4,067kg/ha/yr (Dewan *et al.* 1988, Ameen *et al.* 1983, Uddin *et al.* 1994, Miah *et al.* 1993, Hossain *et al.* 1994, Miah *et al.* 1997 and Mazid *et al.* 1997). Although the level of fish production in the present study can not be considered as very high in comparison to the other results quoted above, the production obtained in this experiment within seven months was very encouraging in terms of maximum individual weights attained.

Cost and benefit analysis

A simple cost and returns analysis of the different treatments is shown in Table 4. The operational cost involved the cost of pond lease, repairing, pond preparation, fingerlings, feed, fertilizer and fish harvesting cost. The production costs in T-1, T-2 and T-3 were Tk. 98,000, Tk. 100,688 and 109,515 in T-3, respectively. The total production cost was the highest in T-3 followed by T-2 and T-1. A net benefit of Tk. 93,755 was obtained from T-3, followed by Tk. 89, 602 and 87,971 from T-1 and T-2, respectively. Other values for net benefit in polyculture of carps ranged from Tk. 88,745 to 93,805 /ha/10 months (Miah *et al.* 1993), Tk. 41,788 to 49,698/ha/yr (Hossain *et al.* 1994), Tk.52, 015 to 87,621/ha (Alam *et al.* 1995) and Tk. 62,278 to 95,006/ha/11 months (Mazid *et al.* 1997).

The findings of the present trial have shown that the both fish production and net profit can be increased through polyculture of carps with over-wintered fingerlings. However, the lower stocking density and better management using fertilization and supplementary feeding in optimum amounts are the two key factors for obtaining higher production with individual large size fish of >1 kg in a shorter culture period.

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