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Effects of feeding schedule on growth, production and economics of pangasiid catfish (*Pangasius hypophthalmus*) and silver carp (*Hypophthalmichthys molitrix*) polyculture

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Abstract

An experiment was carried out to evaluate the effects of feeding schedule on growth, production and economics of pangasiid catfish (*Pangasius hypophthalmus*) and silver carp (*Hypophthalmichthys molitrix*) polyculture in nine earthen ponds for a period of 135 days. There were three treatments (T) each with three replications. Species composition (1:1) and stocking density (25,000 fish/ha) were same in all treatments. A commercially available pelleted feed was given only for pangasiid catfish with same feeding rate in all treatments but the feeding frequency was different. The feeding rate was 10%, 8%, 7%, 6 %, 5%, 4% which was consecutively adjusted after each fortnightly sampling and 3% for the last 4 weeks of the study period. Feeding frequencies was once a day in T_1, two times a day in T_2 and three times a day in T_3. The average weight gain of pangasiid catfish and silver carp in T_3 (376.69 g and 81.02 g) was significantly higher (P<0.05) than those of T_2 (330.25 g and 58.35 g) and T_1 (261.76 g and 42.89 g). The survival rate was 95.2, 96.0 and 96.8% for pangasiid catfish and 83.2, 85.2 and 86.0% for silver carp in T_1, T_2 and T_3, respectively. The net production of fish in T_3 (5,430.64 kg/ha) was significantly higher (P<0.05) than those of T_2 (4,584.70 kg/ha) and T_1 (3,562.89 kg/ha). Significantly highest net return (Tk. 68,533.54/ha with benefit cost ratio of 1.36) was achieved from T_3 followed by T_2 (Tk. 40,080.56/ha with benefit cost ratio of 1.22) and T_1 (Tk. 13,786.67/ha with benefit cost ratio of 1.08). The present research findings suggest that an increase of feeding frequency has positive effect on growth and production of pangasiid catfish and silver carp.

Keywords: Feeding schedule, Economics, Pangasiid catfish, Silver carp, Polyculture

Introduction

In aquaculture, diet is often considered as the single largest cost item and can represent over 50% of the operating cost in intensive aquaculture (El- Sayed, 1999). The general approach adopted to reduce diet cost has been to develop low-cost diets by replacing the costly fish meal components with cheaper plant protein sources (Jackson *et al.,* 1982; Hossain and Jauncey, 1989; Webster *et al.,* 1992). Apart from developing low-cost diets, different feeding management strategies and/ or good husbandry methods can also lead to significant saving in diet cost. Information on the optimum feeding regimes/schedules of cultured fish is important in achieving efficient production and to ensure best FCR (feed conversion ratio) and weight gain of cultured organism. An important step in the feeding strategy is to determine the optimal frequency of feeding.

The pangasiid catfish (*Pangasius hypophthalmus*) is one of the fast-growing and popular fish species in some Asian countries. This exotic species gained much popularity in Bangladesh because of its rapid growth, easy culture system, high disease resistance and tolerance to a wide range of environmental change (Bardach *et al*., 1972; Stickney, 1979; Sarkar *et al*., 2007). Pangasiid catfish are cultured completely on supplemental feed. Commercial culture and production of pangasiid catfish has recently been expanded dramatically but profit is decreasing gradually due to a number of reasons of which increased feed cost and improper management practices are important. Due to the use of large quantity of supplemental feed, pond water receives high quantity of inorganic nutrients from the microbial decomposition of unused fish feed and metabolic wastes. These nutrients favour excessive production of phytoplankton in pond water that can support additional number of planktivorous fishes without further feed or management cost. But in practice, they remain unutilized or less utilized and form algal blooms which in turn cause many unexpected problems such as decline in dissolved oxygen, reduced fish growth and off-flavour in pangasiid catfish flesh. Such problem in monoculture of pangasiid catfish could be avoided by using a polyculture approach.

Silver carp is generally considered as a planktivorous fish (Cremer and Smitherman, 1980; Spataru *et al*., 1983). This planktivorous species could be cultured with pangasiid catfish for the management of phytoplankton. Pangasiid catfish and planktivorous silver carp polyculture can improve the water quality by grazing down the phytoplankton by the latter species and enhance the growth of former species. It also helps to gain an extra crop of silver carp without incurring additional cost, making aquaculture more profitable to farmers (Sarkar *et al*., 2006; 2008). Though polyculture techniques of pangasiid catfish with carps are developing in Bangladesh, there are very few literatures available on the quantification of feeding regime of pangasiid catfish (*P. hypophthalmus*) both in monoculture and polyculture systems. Therefore, the present study was undertaken with a view to develop a standard feeding schedule for pangasiid catfish in co-culture of pangasiid catfish and silver carp for maximizing fish growth and minimizing feed wastage and cost of fish production.

Materials and Methods

Experimental site and pond facilities

The experiment was carried out for a period of 135 days from 24 July to 5 December in nine equal sized (each 200 m^2, 1.6 m depth), rain-fed, rectangular experimental ponds situated in the Field Laboratory, Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

Pond preparation

The ponds were drained out completely and left exposed to sunlight for about 15 days. All ponds were treated with lime at the rate of 1 kg/decimal 14 days before stocking of fish fingerlings.

Collection of experimental fish

All the fingerlings with mean initial length and weight of 130.73 cm and 9.87 g in case of pangasiid catfish and 13.15 cm and 19.25 g in case of silver carp respectively were procured from a local fry trader.

Experimental design and feeding

The experiment was carried out with three treatments each with three replications. The fingerlings of pangasiid catfish and silver carp were stocked with same species composition (1:1) and stocking density (25,000 fishes/hectare) in all treatments. The feeding rate was same in all treatments but frequency was different. The feed was supplied according to percent of the body weight of only pangasiid catfish and it was 10%, 8%, 7%, 6 %, 5%, 4% consecutively adjusted after each fortnightly sampling and 3% for the last 4 weeks of the study period. Feeding frequencies was once a day (morning at 9:00 a.m.) in T_1, two times a day (morning at 9:00 a.m. and afternoon at 5:00 p.m.) in T_2 and three times a day (morning at 9:00 a.m., midday at 1:00 p.m. and afternoon at 5:00 p.m) in T_3. A commercial pelleted feed produced by “Quality Fish Feed Ltd.” having 28% protein and 7% lipid was used. The feeds were thrown over the pond water by hand and on a particular site of the pond regularly. About 20% of the total fish were sampled fortnightly by a seine net to monitor the fish growth and to adjust feeding rates. The weight of fish during sampling was measured by using a portable digital balance.

Water quality parameters

The water quality parameters such as temperature, dissolved oxygen (DO) and pH were recorded fortnightly. The temperature and dissolved oxygen of the ponds were determined by a DO meter (YSI, model 58, USA). Water pH was recorded by a pH meter (Jenway, model 3020, UK). Chlorophyll-*a* (µg/l) was measured at monthly interval. Chlorophyll-*a* was determined using a spectrophotometer after acetone extraction (Greenberg *et al.,* 1992).

Statistical analysis

For the statistical analysis of data, single factor analysis of variance (ANOVA) of the mean values of growth, survival and yield was done using Randomized block design (RBD). The mean values were compared according to DMRT test (Gomez and Gomez, 1984). Significance was assigned at 0.05% level.

Economic analysis

An economic analysis was conducted to estimate the net profit from different treatments. The analysis was based on local market prices for harvested fish and all other items. The cost of leasing ponds was not included in the total cost. The net return was measured by deducting the gross cost from the gross return per hectare. The benefit cost ratio was also measured as a ratio of net benefit to gross cost.

Results and Discussion

Water quality parameters

Water quality parameters (mean ± SD) measured throughout the experimental period are presented in Table 1.

Table 1. Mean (±SD) values of water quality parameters of experimental ponds under three treatments. Data within parentheses indicates ranges

Parameters	T_1	T_2	T_3
Temperature (ºC)	28.92± 0.02 (21.4-33.7)	28.91± 0.01 (21.4-33.7)	28.98± 0.01 (21.5-33.8)
Transparency (cm)	35.63±1.05[a] (22.65-47.56)	33.52±1.42[ab] (20.46-45.48)	31.89±1.89[c] (17.16-43.25)
Dissolved oxygen (mg/l)	4.28±0.03[c] (3.54-5.20)	4.38±0.03b[c] (3.72-5.28)	4.55±0.12[a] (3.88-5.57)
pH	7.43[a] (6.74-8.46)	7.35[b] (6.54 –8.33)	7.24[c] (6.63-8.26)
Chlorophyll-a (µg/l)	157.52±7.35[b] (70.70-252.14)	181.45±8.88[a] (94.66-304.41)	196.92±8.72[a] (102.23- 306.64)

Figures in the same row having same superscript are not significantly different (P<0.05)

Growth and production performances

The growth performances of pangasiid catfish and silver carp in terms of initial weight, final weight, weight gain, specific growth rate, feed conversion ratio, survival rate and total production are shown in Table 2. Mean weight gains of pangasiid catfish and silver carp were 261.76 g and 42.89 g in T_1, 330.25 g and 58.35 g in T_2 and 376.69 g and 81.02 g in T_3 respectively. There was a significant variation of mean weight gain of both species (P<0.05) among the treatments (Table 2). SGR (% per day) value of pangasiid catfish and silver carp were 2.46 and 0.86 in T_1, 2.62 and 1.03 in T_2 and 2.71 and 1.23 in T_3 and there was a significant difference (P<0.05) among the treatments.

The average feed conversion ratio (in case of pangasiid catfish) was 2.40, 2.22 and 2.07 in T_1, T_2, and T_3, respectively. The feed conversion ratio (FCR) was measured from only the total net production of pangasiid catfish and feed used among the treatments. The mean survival rate was 95.2, 96.0 and 96.8% for pangasiid catfish and 83.2, 85.2 and 86.0% for silver carp in T_1, T_2 and T_3, respectively. The survival rate of pangasiid catfish did not show any significant variation among the treatments, but in case of silver carp the survival rate in T_1 was significantly lower (P<0.05) than T_2 and T_3.

The gross production of fishes in terms of kg/ha/135 days was higher (5,757.01 kg) in T_3 followed by T_2 (4,908.16 kg) and T_1 (3,880.54 kg) and they were significantly (P<0.05) different (Table 2). A simple economic analysis of the culture operation showed that T_3 having three times feeding frequency generated the maximum benefit and net return of Tk. 68,534/ha/135days and Benefit Cost Ratio (BCR) of 1.36 followed by Tk.40,081/ha/135days with BCR value of 1.22 in T_2, and Tk.13, 787/ha/135days with BCR value of 1.08 in T_1 (Table 3).

Table 2. Growth performance, production (mean ± SD) and survival of pangasiid catfish and silver carp in different treatments

Parameters	Species	T_1	T_2	T_3
Initial length (cm)	Pangasiid catfish	10.73	10.73	10.73
	Silver carp	13.15	13.15	13.15
Final length (cm)	Pangasiid catfish	29.86 ± 0.20	31.79 ± 0.11	32.94 ± 0.16
	Silver carp	17.72 ± 0.37	20.20 ± 0.23	22.12 ± 0.15
Initial weight (g)	Pangasiid catfish	9.87	9.87	9.87
	Silver carp	19.25	19.25	19.25
Final weight (g)	Pangasiid catfish	271.63 ± 7.84	340.12 ± 4.91	386.55 ± 6.83
	Silver carp	62.14 ± 4.29	77.60 ± 4.09	100.27 ± 4.29
Weight gain (g)	Pangasiid catfish	261.76 ± 7.84^c	330.25 ± 4.91^b	376.69 ± 6.83^a
	Silver carp	42.89 ± 4.29^c	58.35 ± 4.09^b	81.02 ± 7.29^a
%Weight gain (g)	Pangasiid catfish	2652.04 ± 79.48^c	3346.03 ± 49.74^b	3816.48 ± 69.20^a
	Silver carp	222.80 ± 22.29^c	303.13 ± 21.26^b	420.90 ± 37.87^a
SGR (% day)	Pangasiid catfish	2.46 ± 0.02^c	2.62 ± 0.012^b	2.71 ± 0.012^a
	Silver carp	0.86 ± 0.049^c	1.03 ± 0.041^b	1.23 ± 0.05^a
FCR	Pangasiid catfish	2.40 ± 0.06^c	2.22 ± 0.03^b	2.07 ± 0.02^a
Survival rate (%)	Pangasiid catfish	95.2 ±1.18	96.0 ± 1.43	96.8 ±1.42
	Silver carp	83.2 ± 3.96^b	85.2 ± 2.46^a	86.0 ± 3.26^a
Production (kg/ha/135 days)	Pangasiid catfish	3233.45 ±131.88	4081.15 ± 66.08	4677.31 ± 106.77
	Silver carp	647.10 ± 62.33	827.01 ± 58.77	1079.70 ± 105.69
Total production (kg/ha/135 days)	Pangasiid catfish + Silver carp	3880.54 ± 71.29^c	4908.16 ± 116.74^b	5757.01 ± 192.03^a

Mean values with different superscripts in the same row were significantly different (P<0.05)

Table 3. Economic analysis of fish production

Parameters	T_1	T_2	T_3
Input cost/hectare (in Taka)			
Fingerlings cost	40,000	40,000	40,000
Feed cost	1,12,088 ± 3566	1,32,037 ± 1542	1,41,782 ± 2286
Pond preparation and maintenance cost	8,750	8,750	8,750
Gross cost	1,60,838 ± 3566	1,80,781 ± 1542	1,90,532± 2286
Return /hectare (in Taka)			
Gross income from sale (Tk. 45/kg)	1,74,625 ± 32085	2,20,8675 ± 52535	2,59,0655 ± 8642
Net income from sale	13,787± 1650^c	40,081 ± 4947^b	68,534 ± 6879^a
BCR (Benefit cost ratio)	1.08 ± 0.01^c	1.22 ± 0.03^b	1.36 ± 0.03^a

Leasing cost for pond is not included
Figures in the same row having same superscript are not significantly different (P<0.05)

Feeding frequency had a significant effect on food consumption, growth and production in pangasiid catfish. By the end of the experiment, fish fed at higher feeding frequencies had gained significantly more weight and added more length than fish fed at lower feeding frequencies. Fish fed at higher frequencies consumed larger quantities of food than those fed less often, but individual meal size was smaller. This is consistent with studies conducted on other species (Ishiwata, 1969), where fish fed fewer meals per day tend to eat more per meal. Fish accomplished this by increasing stomach volume and became hyperphagic (Grayton and Beamish, 1977; Jobling, 1982; Ruohonen and Grove, 1996). However, although fish fed at higher frequencies consumed larger quantities of food, when the interval between meals is short, the food passes through the digestive tract more quickly, resulting in less effective digestion (Liu and Liao, 1999). Thus, determining the optimal feeding frequency is important.

The water quality parameters measured in ponds of different treatments were found to be more or less similar and all of them were within the acceptable range for fish culture. The water temperature ranged from 21.4ºC to 33.8ºC because the study was conducted from July to December that covered part of summer and part of winter season. The mean values of pH were 7.43, 7.35 and 7.24 in ponds of T_1, T_2 and T_3, respectively, which indicate good productive conditions. The neutral to slightly alkaline pH in the cultured pond were possibly due to local soil condition and natural waters. Moreover, the initial lime treatment during pond preparation possibly helped in maintaining carbon buffer system in the pond water.

The mean DO contents ranged from 3.54 to 5.57 mg/l. The fluctuation of DO value might be due to alteration in the rate of photosynthesis in ponds and oxygen consumption by fish and other decomposer microorganisms. The lowest average value of DO was found in T_1 (4.28 mg/l). It might be due to higher organic content from higher amount of unutilized feed. The highest average value of dissolved oxygen (4.55 mg/l) was found in T_3 that was possibly due to less organic decomposition of supplied feed.

Chlorophyll-*a* concentration indicates the biological productivity of a water body. The mean chlorophyll-*a* values recorded were 196.92, 181.45 and 157.52 µg/l in T_1, T_2 and T_3, respectively. The highest chlorophyll-*a* value was found in T_1 that might be due to the higher concentration of phytoplankton, resulted in due to availability of nutrients from unused food particles and fish metabolic wastes. Khatrai (1984) also found a positive relationship between phytoplankton growth and chlorophyll-*a* content. The lower mean value was observed in T_3, which might be due to lower abundance of microalgae. Better utilization of supplied feed in this treatment might have resulted lower nutrient supply for microalgal growth in comparison to other treatments.

The weight gain and % weight gain (376.69 g and 3816.48%) by pangasiid catfish in T_3 were significantly higher than T_2 (330.25 g and 3346.03%) and T_1 (261.76 g and 2652.04%). Again in case of silver carp T_3 also showed significantly higher mean weight gain (81.02 g) and % weight gain (420.90%) followed by T_2 (58.35 g and 303.13 %) and T_1 (42.89 g and 222.80%), respectively. The better weight gain attained in T_3 may be due to proper utilization of both natural and supplementary feed by the fishes and also due to good water quality conditions maintained through proper feeding frequency of three times a day. It was reported that the wastage of food particles enhances the nutrient concentration of water, which help in increase of plankton and deteriorate water quality (Lin and Diana, 1995; Lin *et al*., 1990). The weight gains of silver carp obtained in the present study were more or less similar with the findings of Azad *et al*. (2004).

The fortnightly average specific growth rate (SGR %/day) of fishes was found to increase more or less rapidly at the beginning of the experiment and then slowed down after October till the end of the experiment. Relatively slower SGR toward the end of the experiment might be due to the reduction of water temperature for seasonal change. Mean SGR (% per day) value of pangasiid catfish in the present study were 2.46, 2.62, and 2.71 in T_1, T_2 and T_3, respectively. This value is more or less similar with the findings of Azad *et al.* (2004), but slightly lower than the findings of Hung *et al*. (1998) and Azimuddin *et al*. (1999). This might be due to lower temperature during the last two months of the study period. In the present study mean SGR (% per day) value of silver carp were 0.86, 1.03 and 1.23% in T_1, T_2 and T_3, respectively, which were significantly ($P<0.05$) different from each other.

The mean survival rate of pangasiid catfish and silver carp in different treatments varied between 95.2 to 96.8 % which is more or less similar with the findings of Ali *et al*. (2005) but higher than that reported by Azad *et al*. (2004). The higher survival rate of pangasiid catfish might be due to the relatively larger size of fingerlings (9.87 g) stocked. The mean survival rate of silver carp varied between 83.2 to 86.0%.

Pelleted feed was given only for pangasiid catfish. So, FCR were calculated only for pangasiid catfsh. The average FCR values were 2.40, 2.22 and 2.07 in T_1, T_2 and T_3, respectively, which were significantly ($P<0.05$) different from each other. Kader *et al*. (2003) found FCR value of 1.54 fed commercial feed (Quality fish feed Ltd.) in case of pangasiid catfish monoculture. Azimmuddin *et al*. (1999) found FCR value of 1.73 to 2.04 for *P. sutchi*. In the present study the FCR of *P. hypophthalmus* is more or less satisfactory. Pathmasothy and Jin (1987) found similar to higher FCR values (2.27 to 3.66) using comparatively high protein diet (32% protein).

After 135 days, the gross production of fishes in terms of kg/ha/135 days was higher (5,757.01 kg) in T_3, followed by T_2 (4,908.16 kg) and T_1 (3,880.54 kg). The reasons behind the highest production in T_3 might be due to proper utilization of supplied feed. Kader *et al*. (2003) obtained production of pangasiid catfish 3,062.01 kg/ha in 70 days fed commercial feed (Quality Fish Feed Ltd.), which was slightly lower than the present study. Better production obtained in the present study might be due to prolonged culture period and productivity of the ponds. Ahmed *et al.* (1996) obtained production of 339.39 kg/ha for *P. pangasius*. Their production is very low compared to this ones.

The economic analysis revealed that T_3 could generate maximum profit of Tk 68,534/ha/135 days and BCR value of 1.36 which was significantly higher than T_2 (Tk. 40,081/ha/135 days and BCR value of 1.22) and T_1 (Tk.13,787/ha/135 days and BCR value of 1.08). Kader *et al*. (2003) obtained net profit of Tk.31,004/ha/70 days from monoculture of pangasiid catfish fed commercial feed (Quality Fish Feed Ltd.). Their profit is lower than the profit of this study. Higher profit was found in this study might be due to higher individual weight of fish resulted from rearing in prolonged time compared to that study.

From the findings of the present study, it may be concluded that feeding three times a day is better than two times or one time a day for getting higher growth of fish, net income and optimum utilization of the given feed.

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