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Effect of feeding frequency on growth, survival and feed utilization in fingerlings of *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) in outdoor rearing systems

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Abstract

Fingerling rearing of Indian major carps, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*, were conducted in concrete tanks under a polyculture system at a density of 0.3 million fry ha^{-1} to evaluate the effect of one, two or three feedings per day on growth, survival and feed utilization. Fry were fed with formulated supplementary diet at 10% of biomass per day during the first 15 days, followed by 8% in the next 15 days and 6% thereafter, for 60 days. Feeding of fish three times daily led to higher growth (103.9 $\pm$ 8.5 mm/10.3 $\pm$ 2.4 g) than those feeding twice (100.2 $\pm$ 4.8 mm/9.9 $\pm$ 1.5 g) or once (97.2 $\pm$ 9.8 mm/9.4 $\pm$ 2.1 g) daily, although the values were not significantly different ($P > 0.05$). Survival rate ranging between 72.3% and 75.1% also did not vary significantly ($P > 0.05$) among the treatments. However, higher feeding frequencies resulted in better feed utilization as evident from decreasing feed conversion ratio values. The present study suggested requirement of a higher feeding frequency for rohu compared with catla and mrigal.

Keywords: feeding frequency, growth, survival, carps, fingerlings

Introduction

Fish subsist primarily on supplementary feed at high rearing densities. The strategy for supplementary feeding is thus an important consideration in the context of increasing intensive carp culture. Among the different feed management measures proven to maximize the benefit of supplementary feeding, feeding frequency is an important factor as reported for several fish species (Charles, Sebastian, Raj & Marian 1984; Chiu, Sumagaysay & Sastrillo 1987; Carlos 1988; Kiron & Paulraj 1990; Tung & Shiau 1991; Hung, Tuan & Lazard 2001; Dada, Fagbenro & Fasakin 2002). Most of these results are based on laboratory trials. However, the contribution of natural fish food organisms in the culture environment cannot be ignored while assessing their production performance, especially during seed rearing.

Polyculture of the three Indian major carps, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*), is a common practice in the Indian sub-continent, both in fingerling rearing and grow-out production. The food and feeding habit of these three species are similar in their early stages of life, although these differ in adults. In view of this, the optimum feeding frequencies is expected to be similar for these three species. Although the daily ration of supplementary feed provided in split meals has shown to increase the feed utilization as well as the production performance of fish, such influence of frequency feeding may not be similar in the presence of natural fish food under field conditions. In this context, the present outdoor experiment was conducted to assess the optimum feeding frequency during fingerling rearing of the three species under polyculture.

Materials and methods

Site description and tanks preparation

The experiment was carried out at the Fish Farm of the Central Institute of Freshwater Aquaculture, Bhubaneswar, India (Latitude 20°11′06″–20°11′45″N, Longitude 85°50′52″–85°51′35″E) for a period of 60 days in concrete tanks with 50 m^3 water (10 m × 5 m × 1 m), each provided with a 10 cm soil base. The tanks were filled with filtered pond water up to a 1.0 m level 10 days before stocking, and subsequently water loss because of evaporation was compensated to maintain the same level throughout the study. Each tank was fertilized with raw cattle dung at five tonnes ha^{-1}, of which 60% was applied one week before stocking and the remaining quantity was applied in equal amounts fortnightly. In addition, inorganic fertilizers urea (46% N) and single super phosphate (18% P) at 50 and 75 kg ha^{-1} in 60 days crop, respectively, were applied as nitrogen and phosphorus sources, fortnightly in equal split doses, with the first dose applied 3 days before stocking the fry.

Experimental procedures and management

The tanks were stocked with catla (37.58 ± 2.75 mm/0.53 ± 0.12 g), rohu (36.28 ± 2.65 mm/0.47 ± 0.11 g) and mrigal (44.67 ± 1.76 mm/0.78 ± 0.07 g) fry at a combined density of 0.3 million ha^{-1} at a 1:1:1 stocking ratio, i.e. 500 fry of each species. Before being stocked into the tank, the fry were given a short dip in a mild $KMnO_4$ solution as a prophylactic measure.

The fry were provided with powdered supplementary feed, whose ingredients and proximate composition are presented in Table 1. Proximate and energy analysis of feed was carried out for moisture, total ash, crude protein, crude fat (ether extract) and gross energy content following standard methods (AOAC 1990). Feed with a crude protein content of 30.49%, lipid 4.95% and energy of 4.42 kcal g^{-1} was provided at 10% of biomass per day for the first 15 days, 8% for the next 15 days and 6% for the last 30 days. Feed ration was adjusted fortnightly after estimating the biomass through intermediate samplings and at the assumed survival level of 80 %. The daily feed ration for each of the treatment tanks was distributed in one (T-I), two (T-II) and three (T-III) equal amounts (frequencies) in triplicate treatments T-I, T-II and T-III, respectively, while tanks without supplementary feed served as control (C). The feeding frequency and schedule followed in different treatments are presented in Table 2.

Table 1 Feed ingredients and proximate composition of the compounded feed

Ingredients	%	Proximate composition of feed	
Groundnut oil cake	40	Moisture (%)	8.65
Rice bran	39	Crude protein (% dry matter)	30.49
Soybean meal	15	Lipid (% dry matter)	4.95
Fish meal	5	Ash (% dry matter)	12.20
Vitamin–mineral premix	1	Energy (kcal g^{-1})	4.42

Table 2 Daily feeding frequency and time of feeding in different treatments

Treatment	Frequency	Feeding time
Control	Nil	Nil
T-I	One	07:30 hours
T-II	Two	07:30 and 16:30 hours
T-III	Three	07:30, 12:00 and 16:30 hours

Water samples were collected from the tanks between 08:00 and 09:00 hours at 15-days intervals to measure important parameters. While water temperature, transparency, dissolved oxygen and pH were measured *in situ*, the total alkalinity, total hardness, free carbon dioxide, total ammonia-nitrogen (NH_3+NH_4^+), nitrite–nitrogen, nitrate–nitrogen and phosphate–phosphorus were measured following standard methods (APHA 1998). Plankton samples were collected by filtering 50 L of water from each tank with a bolting silk net (No. 25, mesh size 0.064 mm) and were analysed by direct census (Jena, Ayyappan & Aravindakshan 2002). Sediment samples collected before stocking and after final harvest were analysed for pH (LI-120 pH meter Elico, Hyderabad, India), conductivity (Systronics 909 conductivity meter, Systronics, Ahemadabad, India), organic carbon (Walkley & Black 1934), available phosphorus (Troug 1930) and available nitrogen (De 1962).

Performance evaluation of fish

Periodic sampling of fish was performed to assess the growth and health performances of the species fortnightly. The mean length and weight were obtained from random samples of 25 individuals of each fish species. Further, the final mean length, weight and survival levels of each species of fish were recorded at the time of harvesting.

Because of the difficulties involved in estimating the feed utilization in field trials of this kind, the amount of feed provided is considered as feed consumed for calculation of feed conversion ratio, calculated as: FCR = dry weight of feed/net biomass gain, where net biomass gain = final fish biomass − initial biomass stocked.

Specific growth rate (SGR) was calculated using the following formula:

$$SGR(\%\ d^{-1}) = \frac{\ln \text{final weight} - \ln \text{initial weight}}{\text{Number of experimental days}} \times 100$$

Statistical analysis

The data were analysed using PC-SAS program for Windows, release V6.12 (SAS Institute Inc., Cary, NC, USA), to assess the level of significance at the 5% level. Analysis of variance was performed with the parametric procedure of 'general linear model (GLM)'. Duncan's multiple-range test for variables was used for comparison of the treatments.

Results and discussion

The water and sediment characteristics of the treatment tanks recorded during the fingerling rearing are presented in Table 3. Temperature, pH, dissolved oxygen, total alkalinity and inorganic nutrients of water and soil organic carbon, available nitrogen and phosphorus were within the optimum range for the growth of these carp species (Banerjea 1967; Jana & De 1988, 1993; Jena, Aravindakshan & Singh 1998; Jena, Aravindakshan, Chandra, Muduli & Ayyappan 1998). Fertilization measures carried out fortnightly ensured sustained growth of higher plankton concentration (3073–7224 nos L^{-1}) in the tanks throughout the study period.

The growth indices of the fingerlings are presented in Table 4. All the treatments, irrespective of species, recorded significantly higher growth ($P<0.05$) than that of control. In catla, treatment with two times feeding per day yielded significantly higher ($P<0.05$) growth (length/weight) than feeding once, while feeding thrice daily resulted in an intermediate growth. However, feeding thrice daily resulted in significantly higher ($P<0.05$) growth in rohu than feeding once or twice daily. Growth in length and weight in all the three treatments for mrigal, though, did not differ significantly ($P>0.05$). The present study indicated the requirement of a higher feeding frequency for rohu compared with catla and mrigal. Improved growth performances of fish with feeding thrice per day were reported by Charles *et al.* (1984) in *Cyprinus carpio*, Mollah and Tan (1982) in *Clarias macrocephalus*, Kiron and Paulraj (1990) in *Liza parsia* and Ruohonen, Vielma and Grove (1998) in *Oncorhynchus mykiss* and Marian, Ponniah, Pitchairaj and Narayanan (1982) in *Heteropneustes fossilis*, Sampath (1984) in *Channa striatus* and Kaiser, Weyl and Hecht (1995) in *Clarias gariepinus* larvae and juveniles. These workers reported that feeding frequency had no significant effect on the growth of the fish. Comparison of the fish biomass production, though, revealed maximum yield in T-III with feeding thrice daily followed by feeding twice (T-II) and once (T-I); daily, no

Table 3 Variations in water and soil quality parameters in experimental treatments*

Parameters	T-I	T-II	T-III	TC
Water quality parameters				
Temperature (°C)	27.3 ± 4.2	27.3 ± 4.4	27.3 ± 4.4	27.3 ± 4.2
pH	8.1 ± 0.3	7.8 ± 0.3	8.0 ± 0.2	8.2 ± 0.2
Dissolved oxygen (mg L^{-1})	4.2 ± 1.0	4.2 ± 1.3	4.0 ± 1.2	5.0 ± 0.6
Transparency (cm)	24 ± 2	27 ± 3	25 ± 2	27 ± 3
Free carbon dioxide (mg L^{-1})	6.8 ± 1.8	4.2 ± 1.3	5.0 ± 2.3	3.2 ± 1.3
Total alkalinity (mg $CaCO_3$ L^{-1})	121 ± 5	116 ± 6	125 ± 5	124 ± 7
Total hardness (mg $CaCO_3$ L^{-1})	106 ± 5	96 ± 8	107 ± 6	102 ± 7
Ammonia–nitrogen (mg L^{-1})	0.20 ± 0.8	0.23 ± 0.8	0.19 ± 0.08	0.17 ± 0.06
Nitrite–nitrogen (mg L^{-1})	0.015 ± 0.005	0.020 ± 0.006	0.020 ± 0.006	0.020 ± 0.006
Nitrate–nitrogen (mg L^{-1})	0.39 ± 0.06	0.39 ± 0.05	0.39 ± 0.05	0.38 ± 0.04
Phosphate–phosphorus (mg L^{-1})	0.68 ± 0.16	0.81 ± 0.12	0.81 ± 0.11	0.71 ± 0.19
Plankton (nos L^{-1})	5021 ± 1320	4681 ± 975	5734 ± 1490	4259 ± 1186
Soil quality parameters				
pH	7.0 ± 0.2	7.1 ± 0.2	7.2 ± 0.1	7.2 ± 0.1
Conductivity (μ℧)	220 ± 65	277 ± 101	213 ± 93	270 ± 92
Organic carbon (% C)	1.6 ± 0.2	1.9 ± 0.2	1.9 ± 0.2	1.6 ± 0.2
Available phosphorus (mg P_2O_5-P 100 g^{-1})	3.8 ± 0.6	4.3 ± 0.3	4.4 ± 0.5	4.3 ± 0.5
Available nitrogen (mg N 100 g^{-1})	18.5 ± 2.5	18.5 ± 2.2	18.2 ± 1.8	18.2 ± 1.8

*Figures indicate means ± SD.

Table 4 Growth performance of Indian major carps species reared in outdoor concrete tanks*

Treatment	Species	Harvested size: Length (mm)	Harvested size: Weight (g)	Survival (%)	SGR (% day^{-1})	FCR
Control	Catla (C)	67.2 ± 13.6^{c}	4.7 ± 0.9^{c}	26.2 ± 8.3	3.62 ± 0.29^{b}	
	Rohu (R)	81.0 ± 15.5^{m}	6.1 ± 1.0^{n}	70.3 ± 3.4	4.26 ± 0.26^{m}	
	Mrigal (M)	86.4 ± 8.3^{q}	5.4 ± 1.2^{q}	81.8 ± 0.8	3.20 ± 0.41^{q}	
	C+R+M	76.8 ± 9.9^{y}	5.4 ± 1.1^{y}	59.4 ± 4.2^{b}	3.82 ± 0.54^{y}	–
T-I	Catla	87.0 ± 13.5^{b}	6.9 ± 0.1^{a}	62.5 ± 4.9	4.27 ± 0.02^{a}	
	Rohu	97.8 ± 12.8^{l}	9.6 ± 0.1^{k}	79.1 ± 5.3	5.02 ± 0.02^{k}	
	Mrigal	109.1 ± 8.7^{p}	11.7 ± 0.4^{p}	83.7 ± 7.0	4.51 ± 0.06^{p}	
	C+R+M	97.2 ± 9.8^{x}	9.4 ± 2.1^{x}	75.1 ± 3.8^{a}	4.60 ± 0.33^{x}	2.31 ± 0.10^{x}
T-II	Catla	94.3 ± 9.2^{a}	7.9 ± 0.1^{b}	60.9 ± 3.1	4.51 ± 0.02^{a}	
	Rohu	100.6 ± 10.2^{l}	10.8 ± 0.4^{l}	68.3 ± 5.4	5.22 ± 0.06^{kl}	
	Mrigal	105.4 ± 6.6^{p}	10.9 ± 0.1^{p}	87.7 ± 5.7	4.39 ± 0.05^{p}	
	C+R+M	100.2 ± 4.8^{x}	9.9 ± 1.5^{x}	72.3 ± 2.7^{a}	4.71 ± 0.39^{x}	2.28 ± 0.13^{x}
T-III	Catla	93.4 ± 15.7^{ab}	7.1 ± 0.2^{ab}	59.1 ± 3.0	4.33 ± 0.04^{a}	
	Rohu	106.4 ± 10.4^{k}	11.9 ± 0.2^{m}	79.4 ± 5.4	5.38 ± 0.03^{l}	
	Mrigal	111.7 ± 8.6^{p}	11.8 ± 0.5^{p}	83.4 ± 2.1	4.53 ± 0.08^{p}	
	C+R+M	103.9 ± 8.5^{x}	10.3 ± 2.4^{x}	74.6 ± 3.8^{a}	4.64 ± 0.43^{x}	2.10 ± 0.08^{x}

Means bearing different superscripts for each species or species combination in a column differ significantly ($P < 0.05$).
*Figures indicate mean ± SD.
SGR, specific growth rate; FCR, feed conversion ratio.

significant difference ($P < 0.05$) was recorded among them, thus showing the feeding frequency in polyculture system under field conditions is less important. The present study revealed that feeding of fish once daily may be sufficient in carp fingerling reard under a polyculture system, where intermittent fertilization contributes to sustained natural productivity as evident from the high plankton counts in the treatment tanks (Table 3).

Analysis of growth performances between the three species under a polyculture system revealed higher growth of mrigal in all the three treatments followed by rohu and catla (Table 3). Jena, Mukhopadhyay and Aravindakshan (1999) reported a similar growth pattern for these three carps while evaluating a formulated diet under field conditions.

The study revealed that feeding frequency did not significantly ($P > 0.05$) influence the survival of Indian major carp fingerlings. The survival level recorded in the control was significantly lower ($P < 0.05$) than the treatment groups, attributed to insufficiency of the natural food at such a high stocking density in the former. Similar observations were also reported by Jarboe and Grant (1996) working with *Ictalurus punctatus* and Dada *et al.* (2002) in *Heterobranchus bidorsalis*. However, Carlos (1988), Chua and Teng (1978) and Goldan, Popper and Karplus (1997) showed that feeding frequency had significant effects on the survival rate of different fish species of *Aristichthys nobilis*, *Epinephelus tauvina* and *Sparus aurata*.

In the present study, although feeding thrice daily showed the lowest FCR followed by feeding twice and once daily, no significant difference ($P > 0.05$) was observed among the values, reaffirming the view of Jarboe and Grant (1996), Velasco, Lawrence and Castille (1999) and Dada *et al.* (2002), who found no significant influence of feeding frequency on FCR in different fish species. Studies carried out with different fish species have shown that the optimum feeding frequency varied with the species, once a day (Marian *et al.* 1982; Sampath, 1984); twice a day (Andrews & Page 1975; Dada *et al.* 2002); three times a day (Charles *et al.* 1984; Kiron & Paulraj 1990); and six times a day (Tung & Shiau 1991). Most of these earlier studies on different fish were confined to laboratory trials, where supplementary feed was the only source of food. However, the present experiment, conducted under field conditions with the contribution of natural food to a great extent, suggested that a higher feeding frequency may not be advantageous over feeding once in carp fingerling reared under a polyculture system.

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