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EFFECT OF RESTRICTED FEEDING REGIMES ON COMPENSATORY WEIGHT GAIN AND BODY TISSUE IN FRY OF THE INDIAN MAJOR CARP *CIRRHINUS MRIGALA* (HAMILTON, 1822)

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Abstract

An 8-week experiment was conducted to examine the effect of restricted feeding on compensatory weight gain and body tissue changes in fry of the Indian major carp, *Cirrhinus mrigala*. During the period of feed restriction, the control group was fed to satiation twice a day while feed for the three other groups was completely withheld for 1, 2, or 4 weeks. During the subsequent re-alimentation period, all groups were fed to satiation. At the end of the experiment, fish deprived of feed for two weeks had a significantly (p<0.05) higher body weight (5.40±0.20 g) and lower FCR (3.40±0.20) than the control group (4.55±0.10 g and 6.75±0.02, respectively). At the end of the experiment, there were no significant differences in dry matter, protein, lipid, or ash contents among groups, except that fish deprived of feed for four weeks had a significantly (p<0.05) lower protein content than fish in the other treatments.

Introduction

Compensatory growth is defined as the increase in growth rate that follows a period of undernutrition (Hayward et al., 1997; Wang et al., 2000). Compensatory growth occurs in vertebrates and invertebrates (Russell and Wootton, 1992) and can involve increases in the food consumption rate (hyperphagia) or growth efficiency (Jobling, 1994). The relatively few studies of compensatory growth in fish emphasize physiology and ecology as well as aquaculture (Dobson and Holmes, 1984). Compensatory growth in fish is not only of interest to scientists and biologists but also can have application in aquaculture

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(Hayward et al., 1997); appropriate exploitation of this phenomenon may result in increased feed intake, growth rate, and/or feed conversion efficiency.

Studies on compensatory growth in fish have yielded inconsistent results. While compensation was observed in most studies (Russell and Wootton, 1992; Jobling, 1995; Kim and Lovell, 1995; Hayward et al., 1997), a limited capacity for compensatory growth was reported in others (Schwarz et al., 1985; Pirhonen and Forsman, 1998). *Cirrhinus mrigala*, one of the commercially important Indian major carps, has a good local market and demand. The purpose of the present study was to examine whether compensatory growth following feed restriction occurs in fry of *C. mrigala*.

Materials and Methods

The experiment was carried out at the laboratory of the Taraporevala Marine Biological Research Station in Mumbai. *Cirrhinus mrigala* fry were obtained from Aarey, Goregaon Government Fish Seed Farm, Mumbai. The 240 fry were held in aquaria (60 x 30 x 30 cm) with a water capacity of 45 l at a rate of 15 fry per aquarium and fed a pelleted dry feed (Table 1) for one week of acclimation prior to the experiment. The proximate composition of the feed was estimated by standard methods (AOAC, 1983). The experiment was designed to compare growth, feed intake, feed conversion ratio, and carcass composition among fry exposed to different lengths of feed restriction and an unrestricted control. The experiment was conducted in triplicate. Prior to the start of the experiment, fry (0.50 g) were starved for two days and randomly distributed into 12 tanks at 15 fry per tank. Fry from the same lot were randomly used for analysis of initial body composition by standard methods (AOAC, 1983).

The experiment was divided into two phases and lasted for eight weeks. During the first phase (restriction phase), the control was fed regularly to satiation and feed for the fry in the other three treatments was restricted for 1, 2, or 4 weeks. At the end of the restriction phase, five fry from each tank were randomly collected for analysis of body composition. The remaining ten fry were used for the second phase - re-alimentation. During the re-alimentation phase, all fry were fed to satiation. At the end of the re-alimentation period, the fry were starved for one day and five fry from each tank were randomly collected for analysis of the final body composition. The length and weight of the fry were recorded at the end of the feed restriction period and at the end of the experiment. Weight gain, length gain, feed conversion ratio, and absolute growth rate were calculated according to Fu et al. (1998). Sampled fry were autoclaved, homogenized, dried at 70°C in a hot air oven, and held at 5°C in a refrigerator until analysis.

Table 1. Formulation and proximate composition of diet.

Ingredient	*% of wet wt*
Fish meal	60.0
Soybean meal	24.0
Egg (whole)	8.33
Cod liver oil	5.0
Mineral premix*	1.0
Vitamin premix*	1.67
Proximate composition (%, mean±SE; n=3)	
Crude protein	42.8±0.02
Crude lipid	8.02±0.01
Ash	12.0±0.04
Moisture	8.0±0.01

* according to Halver (1976)

Water was exchanged at a daily rate of 50% of the total volume of the tanks to flush out excreta and unused feed and replenish fresh water. Water quality parameters were recorded on alternate days and ranged temperature 24-26°C, pH 7.1-7.2, dissolved oxygen 5.3-5.8 mg/l. Water samples were analyzed for total ammonia using a Spectroquant Nova 30 photometer (Merck, Darmstadt, Germany), pH was measured with a pH Scan 1 WP1 (range 1-15, accuracy±0.2; Eutech

Instruments, Singapore), and dissolved oxygen was measured by the titration method (APHA, 1985). The ammonia concentration ranged 0.0015-0.0020 mg/l and was not lethal for the fish.

Data were subjected to statistical analysis (Snedecor and Cochran, 1967) using a completely randomized design. Differences between treatments were tested by analysis of variance (ANOVA). Duncan's multiple range test was used for multiple comparison. Differences were regarded significant when $p<0.05$.

Results

Although there were no significant differences among treatment groups in initial body weight, differences were significant at the end of the feed restriction period. At the end of the re-alimentation period, the weights of the groups deprived for one and two weeks did not significantly differ from each other but both differed from the group deprived for four weeks and the control (Table 2). The feed conversion ratio of the fry deprived for two weeks was significantly better than in the control. Final survival in the control and 1-week treatment did not differ significantly but survival in the 4-week treatment was significantly lower than in the others. At the end of the restriction period, ash content was higher and dry matter, protein, and lipid contents lower in the food-deprived fry (Table 3). At the end of the re-alimentation period, no significant differences were observed among dry matter, protein, lipid, and ash contents, except for the significantly lower protein content in the 4-week deprivation group.

Discussion

As the body weight of feed-restricted fry is usually smaller than that of control fry (Jobling, 1983; Cui and Wootton, 1988; Russell and Wootton, 1992), a higher feed intake, faster growth rate, and better feed conversion ratio would be expected among the feed-restricted fry at the start of the re-alimentation period. In the present study, feed-restricted fry had a significantly higher growth rate and better feed conversion ratio. Hyperphagia (Jobling et al., 1994) and improved feed efficiency (Russell and Wootton, 1992; Jobling et al., 1994; Qian et al., 2000) may be the major contributors to the higher compensatory growth rate. Many studies of compensatory growth have shown the ability to elicit above normal growth rates in fishes and other animals (Russell and Wootton, 1992; Broekhuizen et al., 1994). Hayward et al. (1997) reported that compensatory growth can be used to significantly increase the final weights of hybrid sunfish beyond that of the contol. Complete compensation was reported within three weeks of refeeding in 1-2 g minnows (*Phoxinus phoxinus*) after 16 days of deprivation (Russell and Wootton, 1992) and in 16-120 g rainbow trout after three weeks of deprivation (Dobson and Holmes, 1984).

Alternating phases of rapid and slow growth were reported in rainbow trout *Onchorhynchus mykiss* Walbaum (Wagner and McKeown, 1985) and coho salmon *O. kisuteh* Walbum (Fabridge and Leatherlan, 1987). Thus the decreased growth in the control fry during the later part of the present study may have been caused by a decrease in the protein gain but not in the lipid gain. Compensatory growth in the present study was accompanied by an improved feed conversion ratio but this improvement was not caused by higher digestibility or reduced activity (Qian et al., 2000; Wang et al., 2000). Rather, it was due to the dependency of the growth rate on body size (Jobling, 1983).

On the basis of the data obtained in this study, it can be concluded that *C. mrigala* fry are able to achieve complete growth compensation within 6-8 weeks following feed deprivation for 1-2 weeks.

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Table 2. Growth and feed conversion ratio (FCR) by treatment (mean±SE; n=3).

	Food deprivation			
	Control (no restriction)	*One week*	*Two weeks*	*Four weeks*
Body length (cm)				
Initial	3.67±0.02	3.67±0.04	3.67±0.04	3.60±0.03
After restriction	4.65±0.10[a]	4.10±0.21[b]	3.85±0.12[c]	3.71±0.12[d]
Final	5.40±0.01[a]	5.50±0.12[a]	5.65±0.35[a]	4.00±0.65[b]
Body weight (g)				
Initial	0.50±0.01	0.50±0.01	0.50±0.05	0.50±0.02
After restriction	3.10±0.15[a]	2.10±0.20[b]	1.65±0.12[c]	0.45±0.03[d]
Final	4.55±0.10[a]	5.37±0.15[b]	5.40±0.20[b]	2.50±0.10[c]
Daily increment (g/d)				
Restriction period	0.09±0.15[a]	0.06±0.10[b]	0.04±0.11[b]	0.00±0.0[c]
Re-alimentation period	0.05±0.20[a]	0.11±0.15[b]	0.13±0.20[b]	0.07±0.50[c]
Overall	0.07±0.15[a]	0.08±0.10[a]	0.09±0.11[a]	0.03±0.70[b]
Survival (%)				
Restriction period	100±0.02[a]	96±0.05[b]	90±0.03[c]	60±0.05[d]
Re-alimentation period	95±0.02[a]	100±0.08[b]	98±0.05[c]	70±0.10[d]
Overall	97.5±0.02[a]	98±0.07[a]	94±0.04[b]	65±0.07[c]
FCR	6.75±0.02[a]	3.51±0.11[b]	3.40±0.20[b]	8.45±0.30[c]

Values in a row bearing different superscripts differ significantly at $p<0.05$.

Table 3. Body tissue changes in *Cirrhinus mrigala* fry at the end of the feed restriction period and at the end of the re-alimentation period (% dry basis; means±SE; n=3).

Treatment	*Dry matter*	*Protein*	*Lipid*	*Ash*
Initial	28.0±1.00	14.00±0.04	6.50±0.10	3.00±0.20
At the end of feed restriction				
Control (no restriction)	30.00±1.20	14.59±1.00[a]	6.20±0.51	2.97±0.15
One week	28.20±0.50	13.60±0.55[a]	5.82±0.20	3.50±0.50
Two weeks	26.13±0.75	13.09±0.70[a]	5.69±0.21	3.85±0.25
Four weeks	23.14±1.20	9.00±0.65[b]	4.12±0.70	4.10±0.70
Final				
Control (no restriction)	34.57±1.20	14.65±0.51	7.00±1.50	2.80±0.72
One week	31.95±0.55	14.71±0.10	6.52±0.20	3.00±1.50
Two weeks	31.80±0.25	14.95±1.00	6.00±1.00	3.30±0.50
Four weeks	32.15±0.25	11.58±1.20	6.20±0.50	3.90±0.75

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