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EFFECT OF RESTRICTED FEEDING REGIMES ON COMPENSATORY WEIGHT GAIN AND BODY TISSUE COMPOSITION IN *CIRRHINUS MRIGALA* (HAMILTON) FRY

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Abstract

An experiment was conducted to examine the effect of restricted feeding on compensatory weight gain and body tissue composition in *Cirrhinus mrigala* fry. The control group was fed to satiation twice a day throughout the 8-week experiment. Feed for the other three groups was restricted for one, two, or four weeks. When reinstated, feed was given to satiation. Fish deprived of feed for two weeks had significantly (p<0.05) higher body weight (5.40±0.20 g) and lower FCR (3.40±0.20) than those of the control (4.55±0.10 g and 6.75±0.02, respectively). At the end of the re-alimentation period, there were no significant differences in dry matter, protein, lipid, or ash contents except that protein content in fish deprived of feed for four weeks was significantly (p<0.05) lower than in fish of other treatments.

Introduction

Compensatory growth is defined as the increase in growth rate following a period of undernutrition (Dobson and Holmes, 1984; Hayward et al., 1997; Wang et al., 2000). Compensatory growth occurs in both vertebrates and invertebrates (Russell and Wootton, 1992) and can involve increases in food consumption rate (hyperphagia) and growth efficiency (Jobling, 1994). The relatively few studies of compensatory growth in fish have emphasized 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 has application in aquaculture (Russell and Wootton, 1992; Jobling et al., 1993, 1994;

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Hayward et al., 1997), as exploitation of this phenomenon may result in increased feed intake, growth rate, and feed efficiency.

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

Materials and Methods

The 8-week experiment was carried out at the Taraporevala Marine Biological Research Station laboratory in Mumbai using *C. mrigala* fry obtained from the Aarey, Goregaon, Government Fish Seed Farm in Mumbai. Prior to the experiment, 240 fry were held in 45-l glass aquarium tanks (45 x 23 x 23 cm) for one week acclimation. The fry were fed a pelleted dry feed (Table 1) during this period. 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 periods of feed restriction and a control. The experiment was conducted in triplicate and three tanks were randomly assigned to each of the four treatments. At the beginning of the experiment, 180 mrigala fry weighing 0.50 g were starved for two days and randomly distributed among 12 tanks (described above) at 15 fry per tank. Some fry from the same lot were randomly used to analyze initial body composition by standard methods (AOAC, 1983).

The daily water exchange rate was 50% of the total tank volume to flush out excreta and unused feed and to replenish the tanks with fresh water. Water samples were analyzed on alternate days for total ammonia using a Spectroquant Nova 30 photometer (Merck, Darmstadt, Germany), pH using a pH Scan 1 WP1 (range 1.0-15.0±0.2 pH; Eutech Instruments, Singapore), and dissolved oxygen by the titration method (APHA, 1985). Temperature was 24-26°C, pH 7.1-7.2, and dissolved oxygen 5.3-5.8 mg/l. The ammonia concentration ranged 0.0015-0.0020 mg/l and was not lethal for the fish.

The first phase of the experiment involved complete (100%) feed restriction of experimental groups for 1, 2, or 4 weeks while the control fry were regularly fed to satiation. At the end of this phase, the fry were starved for one day and five fry from each tank were randomly collected for analysis of body composition. During the second phase (the re-alimentation period), the remaining 10 fry in each tank were fed to satiation. At the end of this phase, the fry were starved for one day and five fry from each tank were randomly collected for final body composition.

Table 1. Ingredients (%) and proximate composition (%; means±SE) of diet for *Cirrhinus mrigala* fry (n = 3).

Ingredient	*%*
Fishmeal	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	
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)

Analyzed fry were collected, autoclaved, homogenized, dried to a constant weight at 70°C in a hot air oven, and held at 5°C in a refrigerator until analysis. The length and weight of the fry were recorded at the end of the feed restriction period and at the end of the experiment, i.e., at the end of the re-alimentation period. Weight and length gains, absolute growth rate, survival, and feed conversion ratio were calculated according to Fu et al. (1998).

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 comparisons. Differences were regarded as significant when $p<0.05$.

Results

There were no significant differences in initial body weight among treatment groups at the start of the experiment, but all groups significantly differed at the end of the feed restriction period (Table 2). On the contrary, at the end

Table 2. Growth, survival, and food conversion ratio (FCR) of *Cirrhinus mrigala* fry after feed restriction for different periods (means±SE, n = 3).

	Restriction			
	None	*1-week*	*2-week*	*4-week*
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]
After resumption of feeding	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]
After resumption of feeding	4.55±0.10[a]	5.37±0.15[b]	5.40±0.20[b]	2.50±0.10[c]
Absolute growth rate (g/d)				
After restriction	0.09±0.15[a]	0.06±0.10[b]	0.04±0.11[b]	0.00±0.0[c]
After resumption of feeding	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 (%)				
During restriction	100±0.02[a]	96±0.05[a]	90±0.03[a]	60±0.05[b]
During resumption of feeding	95±0.02[a]	100±0.08[a]	98±0.05[a]	70±0.10[b]
Overall	97.5±0.02[a]	98±0.07[a]	94±0.04[a]	65±0.07[b]
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 with different superscripts differ significantly ($p<0.05$).

of the re-alimentation period, the weights of 1-week and 2-week fry were significantly higher than the control and 4-week fry. Similarly, the feed conversion ratios of the one and 2-week fry were significantly better than in the control and 4-week groups. Survival in the control, 1-week, and 2-week groups did not significantly differ from each other but were all significantly higher than in the 4-week group.

At the end of the feed restriction period, ash concentration tended to be higher while dry matter, protein, and lipid concentrations tended to be lower the longer the duration of deprivation (Table 3). No significant differences were observed among dry matter, protein, lipid, or ash contents at the end of re-alimentation period, except for fish deprived for four weeks where the protein concentration was significantly lower than that of other treatments.

Discussion

The fish mortality pattern suggests that no deaths occurred due to lack of space or poor water quality. Rather mortality could have been due to frequent disturbances (daily addition and removal of food) and fish handling (weight and length measurements). Similar observations were recorded by Hayward et al. (1997) in the case of hybrid sun fish, Jobling et al. (1994) in Atlantic cod, and Wang et al. (2000) in hybrid tilapia. In the 4-week deprivation treatment, the lower survival was mainly due to starvation for a longer period.

Because of the dependency of growth rate on body size and since the body weight of feed-restricted fry is usually lower than that of control fish at the start of the re-alimentation period, a higher feed intake, faster growth rate, and better feed conversion ratio would be expected among feed-restricted fry

Table 3. Body tissue composition of *Cirrhinus mrigala* fry with feed restricted for different periods (means±SE; n = 3; dry weight basis)*.

	Restriction			
	None	*1-week*	*2-week*	*4-week*
After restriction				
Dry matter	30.0±1.20	28.20±0.50	26.13±0.75	23.14±1.20
Protein	14.59±1.0	13.60±0.55	13.09±0.70	9.00±0.65
Lipid	6.2±0.51	5.82±0.20	5.69±0.21	4.12±0.70
Ash	2.97±0.15	3.50±0.50	3.85±0.25	4.10±0.70
After re-alimentation phase				
Dry matter	34.57±1.2	31.95±0.55	31.80±0.25	32.15±0.25
Protein	14.65±0.51^a	14.71±0.10^a	14.95±1.0^a	11.58±1.2^b
Lipid	7.0±1.50	6.52±0.20	6.00±1.00	6.20±0.50
Ash	2.80±0.72	3.00±1.50	3.30±0.50	3.90±0.75

Different superscripts indicate significant differences at $p<0.05$.

* Initial composition was 28.0±1.0 dry matter, 14.0±0.04 protein, 6.5±0.1 lipid, and 3.0±0.20 ash.

(Jobling, 1983; Cui and Wootton, 1988; Russell and Wootton, 1992). Indeed, in the present study, feed-restricted fry had a significantly higher growth rate during the re-alimentation period and a better feed conversion ratio than the control, indicating growth compensation. 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 high growth rate during compensatory growth.

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 represented a slow phase caused by endogenous factors.

Preferential accretion of lean body mass would be expected to be accompanied by a better feed conversion ratio than depositing body fat (Jobling et al., 1994; Qian et al., 2000) but compensatory growth was not accompanied by improved feed conversion ratio in tilapia (Wang et al., 2000). Compensatory growth in the present study was accompanied by an improved feed conversion ratio but this was not caused by higher digestibility or reduced activity (Qian et al. 2000; Wang et al., 2000).

On the basis of the data obtained in this study, it can be concluded that *C. mrigala* fry achieve complete growth compensation within 6-7 weeks following feed deprivation for 1-2 weeks with a 3-4% savings of feed expenditures. However, fry deprived of food for 4 weeks are unable to catch up to the growth of control fish within four weeks following feed restriction.

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