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Compensatory growth in the Chinese longsnout catfish, *Leiocassis longirostris* following feed deprivation: Temporal patterns in growth, nutrient deposition, feed intake and body composition

Xiaoming Zhu[a], Shouqi Xie[a,*], Wu Lei[a], Yibo Cui[a], Yunxia Yang[a], R.J. Wootton[b]

[a]*State Key Laboratory of Freshwater Ecology and Biotechnology, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, Hubei Province, 430072, P.R. China*

[b]*Institute of Biological Science, University of Wales, Aberystwyth, SY23 3DA, Wales, UK*

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Abstract

To investigate the compensatory growth responses of the carnivorous Chinese longsnout catfish a 7-week study was performed at 28 °C. Juvenile longsnout catfish weighing a mean of 13.14 g were starved for 0 (control), 1 (S1) or 2 (S2) weeks and then re-fed to satiation for 4 weeks. Weekly changes in specific growth rate, feed intake and body composition were monitored during re-feeding. No significant difference was found in final body weight among the three groups, indicating complete compensation in the starved fish. The deprived groups caught up in body weight with that of the control within 2 weeks of re-feeding. Body concentrations of protein, lipid and energy were restored to control levels within 1 week of re-feeding. In the first week of re-feeding, specific growth rates of body weight, lipid, protein and energy contents were significantly higher in the deprived fish than in the control. In the second week of re-feeding, the specific growth rate of protein content of the S2 group was still higher than in the control. In the third week of re-feeding, the growth rates for lipid and energy content of the deprived fish dropped below that of the control, but were elevated again during the last week of the experiment. Feed intake was higher than the control level in the first week of re-feeding in the S2 group, but no significant difference was found between the S1 group and control. Growth efficiency in the S2 group was significantly higher than in the controls for the first week of re-feeding. The results were compatible with the hypothesis that compensatory growth restores the ratio of fat to lean body mass ratio in the deprived fish.

Keywords: Compensatory growth; Temporal pattern; Feed intake; Growth rate; Body composition; Chinese longsnout catfish

1. Introduction

Compensatory growth is a period of unusually fast growth shown by individuals encountering abundant food following a period of deprivation (Wilson and Osbourn, 1960; Jobling et al., 1994; Ali et al., 2003).

* Corresponding author. Fax: +86 27 68780667.
E-mail address: sqxie@ihb.ac.cn (S. Xie).

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Compensatory growth in fish is usually accompanied by hyperphagia (an increase in appetite) and sometimes improved growth efficiency (see review in Ali et al., 2003). Compensatory growth is of interest in aquaculture, because an understanding of its dynamics may allow the design of feeding schedules that improve growth rates (Hayward et al., 1997). The mechanism of compensatory growth is poorly understood. Russell and Wootton (1992) used the cybernetic model of Hubbell (1971) and Calow (1976) to explain the mechanism of compensatory growth. A related lipostat model, proposed by Jobling and Johansen (1999), suggests that the ratio of fat to lean body mass (LBM) is an indicator of nutritional status. A decrease in the fat:LBM ratio would result in compensatory growth responses, and restoration of the ratio to the control level would result in the termination of compensatory growth. A rigorous test of the lipostat model requires frequent monitoring of the changes in body composition during compensatory growth.

Although a majority of studies of compensatory growth in fish have used cold-water species, especially salmonids (Ali et al., 2003), some studies have also identified the phenomenon in warm-water species. For example, after a single period of 1 or 2 weeks of feed deprivation, the gibel carp can show full compensation when returned to a satiation ration (Qian et al., 2000; Xie et al., 2001). Compensatory growth has also been demonstrated in the channel catfish a species important in aquaculture in the USA (Kim and Lovell, 1995; Gaylord and Gatlin, 2000, 2001; Chatakondi and Yant, 2001).

The Chinese longsnout catfish is a warm-water, carnivorous species and the optimum water temperature for growth is 25–30 °C (Xiong and He, 1994). It is a focus of current aquaculture interest because of its high market value in China. The purpose of the present study was to investigate the temporal patterns in growth, feed intake and body composition in the Chinese longsnout catfish upon re-feeding following 1 or 2 weeks of feed deprivation.

2. Materials and methods

Longsnout catfish, *Leiocassis longirostris*, were obtained from the Chinase Longsnout Catfish Hatchery Farm, Hubei, P.R. China about 2 months after hatching. They were reared in a recirculation system for one month prior to the start of the experiment. Two weeks before the start of the experiment, 160 fish were transferred to 80 Plexiglas tanks (surface area 650 cm^2; water volume 26 l). These containers were perforated and four containers were placed in a 300 l fibreglass tank, which was part of a re-circulation system. Water temperature was controlled using a heater linked to a thermostat. Water temperature was increased to 28 °C at 2–3 °C per day and the fish were maintained at this temperature for a further week before the experiment started. Photoperiod was 12L:12D. Aeration was provided intermittently for 30 min every hour. Dissolved oxygen was >6 mg l^{-1}, and NH_4–N was below 0.5 mg l^{-1}. The fish were fed to satiation twice a day on experimental, formulated pellets (Table 1) during 1-month acclimatisation to the experimental diets.

The experiment lasted for 7 weeks. Initially, the fish were starved for 1 day to empty the gut. All the fish were then pooled, and 78 fish (average weight

Table 1
Formulation and proximate composition of the experimental diet

Ingredient	(% wet weight)
White fish meal (USA)	66.3
Fish oil	2.5
α-starch	2.0
Corn starch	15.6
Vitamin premix[a]	0.8
Mineral premix[b]	5.0
Cellulose	7.0
Cr_2O_3	1.0
Proximate composition (% or kJ g^{-1} dry matter)	
Crude protein	43.44
Crude lipid	7.31
Ash	18.59
Energy	17.55

[a] Vitamin mixture contained the following vitamins per kg of feed: vitamin A, 5500 I.U.; vitamin D_3, 1000 I.U.; vitamin E, 50 I.U.; vitamin K, 10 I.U.; choline, 550 mg; niacin, 100 mg; riboflavin, 20 mg; pyridoxine, 20 mg; thiamin, 20 mg; D-calacium pantothenate, 50 mg; biotin, 0.1 mg; foliacin, 5 mg; vitamin B_{12}, 20 μg; ascorbic acid, 100 mg; vitamin C, 100 mg; inositol, 100 mg.

[b] Mineral mixture contained the following minerals per kg of feed: NaCl, 500.0 mg; $MgSO_4 \cdot 7H_2O$, 7500.0 mg; $NaH_2PO_4.2H_2O$, 12500.0 mg; KH_2PO_4, 16000.0 mg; $Ca(H_2PO_4)_2 \cdot H_2O$, 10000.0mg; $C_6H_{10}CaO_6 \cdot 5H_2O$, 1750.0 mg; $FeSO_4$, 1250.0 mg; $ZnSO_4 \cdot 7H_2O$, 176.5 mg; $MnSO_4 \cdot 4H_2O$, 81.0 mg; $CuSO_4 \cdot 5H_2O$, 15.5 mg; $CoCl_2 \cdot 6H_2O$,0.5 mg; KI, 1.5 mg; starch, 225.0 mg.