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Notes

The Effects of Different Feeding Strategies on the Growth of Young Nile tilapia, *Oreochromis niloticus* L., in a Freshwater Recirculating System during Summer

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We evaluated the effects of different feeding strategies on the growth of young Nile tilapia, *Oreochromis niloticus* L., in a freshwater recirculating system during summer. Each of twenty fish (Mean body weight±SD; 37.7±0.10 g) were randomly distributed into each of 24 tanks. Eight treatments were prepared in triplicate. Control fish were hand-fed commercial feed twice daily without starvation. The other seven treatments employed different feeding and starvation strategies ranging from 1 day starved and 1 day fed (1DS+1DF) to 7 days starved to 7 days fed (7DS+7DF). All fish survived to the end of the 44-day feeding trial. The amount of food supplied was highest for the control fish in the control. Food supplied to fish in the 3DS+3DF and 4DS+4DF treatments was significantly lower than that of fish in the 1DS+1DF and 2DS+2DF treatments, but significantly higher than that of fish in the 5DS+5DF, 6DS+6DF and 7DS+7DF treatments. The weight gain of control fish was significantly higher than that of fish in other treatments. Feed efficiency ratio (FER) for fish in the 7DS+7DF treatment was significantly higher than that of fish in the control group, but it did not differ from that of fish in the 1DS+1DF and 2DS+2DF treatments. We concluded that young Nile tilapia raised with different starvation and feeding regimes during the summer in a freshwater recirculating system did not catch up in growth to fish fed daily. However, the enhanced FER of Nile tilapia in the 7DS+7DF, 2DS+2DF, and 1DS+1DF treatments partly explains the compensatory growth of the fish, although their weight gain was relatively low.

Key words: *Nile tilapia*, Compensatory growth, Feeding strategy, Starvation, Feeding, Feed efficiency ratio

Introduction

A feeding strategy leading to compensatory growth of fish (a rapid or faster than normal growth rate resulting from refeeding after starvation or under-nutrition is effective in increasing fish production and improving feed efficiency by elevating feeding activity after feed realimentation. This technique may also reduce water pollution by reducing the metabolism of fish as well as cut fish production costs during starvation.

Earlier studies on the compensatory growth of fish were investigated in coldwater fish, such as salmonids (Bilton and Robins, 1973; Dobson and Holmes, 1984; Miglavs and Jobling, 1989; Quinton and Blake, 1990; Jobling and Koskela, 1996). In these studies, when fish were re-fed after fasting, excessive amounts of feed were supplied, commonly resulting in poor feed efficiency. Recently, beneficial effects of compensatory growth have also been reported in warmwater fish, such as channel catfish *Ictalurus punctatus* (Gaylord and Gatlin, 2000, 2001), hybrid tilapia, *Oreochromis mossambicus* × *O. niloticus* (Wang et al., 2000) and gibel carp *Carassius auratus gibelio* (Qian et al., 2000; Xie et al., 2001). The effects of different feeding strategies leading to compensatory growth on the production of olive flounder, *Paralichthys olivaceus*, have also been reported (Cho and Lee, 2002; Kim et al., 2002). Kim et al. (2002) reported

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that in the 8-week feeding trial, the growth and feed efficiency ratio of juvenile flounder were not affected by daily or alternative-day feeding strategies, and they suggested that an alternate-day feeding regime was superios for flounder production.

For Nile tilapia, *Oreochromis niloticus*, several feeding trials to determine dietary nutrient requirements, feeding frequency, feeding ratios, feed type, and the effect of substituting other protein sources for fishmeal have been performed (El-Sayed, 1998; Hafedh, 1999; Kim and Jo, 1999; Cruz and Ridha, 2001; Cho and Jo, 2002; El-Sayed, 2002; Santiago and Laron, 2002). However, no study has examined the effects of different feeding strategies on the growth of Nile tilapia. Our objective was to determine these effects on the summer growth of young Nile tilapia using a recirculating system.

Materials and Methods

The feeding trial was conducted in a freshwater recirculating system at Pukyong National University, Busan, Korea. Twenty-four rectangular glass tanks (60×90×60 cm water volume, 220 L) were used, and the water exchange rate per tank was 10 L/min. Each tank received 20 randomly distributed fish (mean body weight±SD; 37.7±0.10 g).

Eight treatments in triplicate were used. The control tilapia were hand-fed twice daily 7 days a week at 09:30 and 17:30 with commercial feed containing 30% crude protein and 4% crude lipid (Woosung Feed Co. Ltd., Korea). Seven treatments consisted of various starvation and feeding regimes: 1 day starved and 1 day fed (1DS+1DF), 2 days starved and 2 days fed (2DS+2DF), 3 days starved and 3 days fed (3DS+3DF), 4 days starved and 4 days fed (4DS+4DF), 5 days starved and 5 days fed (5DS+5DF), 6 days starved and 6 days fed (6DS+6DF) and 7 days starved to 7 days fed (7DS+7DF).

Fish were acclimated for 3 days before the initiation of the feeding trial and fed twice daily with commercial feed during the acclimation period. After initiation of the feeding trial, the total weight of the fish in each tank was measured at 1-week intervals to determine the daily feed allowance, which was 3% of total weight of the fish. Since the feeding trial was performed during the summer, the water temperature ranged from 23.1 to 29.0℃ (mean temperature±SD; 26.2±1.50℃). The feeding trial lasted for 44 days.

All data were statistically analyzed by one-way ANOVA and Duncan's multiple range test (Duncan, 1955) at the significance level of P=0.05, using SAS version 6.12 (SAS Institute, Cary, NC, USA).

Results and Discussion

The amount of feed supplied (g/fish), weight gain (g/fish) and feed efficiency ratio (FER) of Nile tilapia with different feeding strategies are given in Table 1. At the end of the 44-day feeding trial, survival was 100% for all treatments and was not significantly (P>0.05) affected by the different feeding strategies. Similarly, survival did not vary among hybrid tilapia fed daily for 8 weeks or fish re-fed after 1-, 2- and 4-week fasting (Wang et al., 2000), or gibel carp fed daily for 8 weeks and fish re-fed after fasting for 1 or 2 weeks (Xie et al., 2001).

The control Nile tilapia received the most food. The amount of feed supplied to the 3DS+3DF and 4DS+4DF was significantly (P<0.05) lower than that of the 1DS+1DF and 2DS+2DF treatments, but significantly (P<0.05) higher than that of the 5DS+5DF, 6DS+6DF and 7DS+7DF treatments. Nile tilapia in the 7DS+7DF treatment received the least food.

The control Nile tilapia had a significantly (P<0.05) higher weight gain than fish in all other treatments. The weight gain of fish in the 1DS+1DF and 2DS+2DF treatments was significantly (P<0.05) higher than that of fish in the remaining five treatments. Fish in the 5DS+5DF treatment had the lowest weight gain. The lower weight gain of the experimental Nile tilapia compared the control fish probably resulted from their food being limited to 3% of the total weight of fish in each treatment throughout the trial. One study reported the growth of channel catfish that experienced any period of starvation did not catch up that of fish fed daily throughout the feeding trial (Gaylord et al., 2001). The 6-week trial reported by these authors compared fish fed to satiation twice daily to fish that were re-fed to satiation twice daily for 11, 9 and 7 days after 3-, 5- and 7-day fasting period, respectively, in consecutive 2-week intervals. Another study found that, unlike the results of our study, the weight gain of juvenile flounder fed three times daily in alternate days was similar to that of fish fed three times daily for 8 weeks (Kim et al., 2002). The ability of fish to achieve compensatory growth varies depending on fish species, fish size (age), rearing temperature, duration of feeding trial, feeding ratio, and other factors (Bilton and Robins, 1973; Jobling and Koskela, 1996; Rueda et al., 1998;

Table 1. Amount of feed supply (g/fish), weight gain (g/fish) and feed efficiency ratio (FER) of Nile tilapia subjected to different feeding strategies for 44 days[1] (Mean±SE)

	Initial body weight (g/fish)	Final body weight (g/fish)	Days of feeding (days)	Amount of feed supply (g/fish)	Weight gain (g/fish)	FER[2]
Control[3]	37.6±0.09	94.8±0.35	44	76.6±0.54[a]	57.2±0.26[a]	0.75±0.002[b,c,d]
1DS+1DF[4]	37.8±0.04	67.3±2.83	22	30.7±0.62[b]	29.6±2.87[b]	0.96±0.076[a,b,c]
2DS+2DF[5]	37.5±0.06	67.6±1.32	21	30.5±0.40[b]	30.1±1.37[b]	0.99±0.038[a,b]
3DS+3DF[6]	37.8±0.09	59.2±2.18	21	28.0±0.29[c]	21.5±2.27[c]	0.77±0.078[b,c,d]
4DS+5DF[7]	37.7±0.02	56.9±0.92	20	27.1±0.24[c]	19.2±0.92[c]	0.71±0.028[c,d]
5DS+5DF[8]	37.8±0.04	54.4±1.93	20	24.8±0.39[d]	16.6±1.95[c]	0.67±0.081[d]
6DS+6DF[9]	37.7±0.12	57.3±3.77	18	25.0±0.48[d]	19.7±3.65[c]	0.78±0.135[b,c,d]
7DS+7DF[10]	37.8±0.13	59.4±1.58	21	18.1±0.22[e]	21.6±1.58[c]	1.19±0.093[a]

[1]Different superscript letters within a same column are significantly different ($P<0.05$); [2]FER (feed efficiency ratio)=Wet weight gain of fish/amount of dry feed supply; [3]Control: 0 day starved+7 days fed; [4]1DS+1DF: 1 day starved+1 day fed; [5]2DS+2DF: 2 days starved+2 days fed; [6]3DS+3DF: 3 days starved+3 days fed; [7]4DS+4DF: 4 days starved+4 days fed; [8]5DS+5DF: 5 days starved+5 days fed; [9]6DS+6DF: 6 days starved+6 days fed; [10]7DS+7DF: 7 days starved+7 days fed.

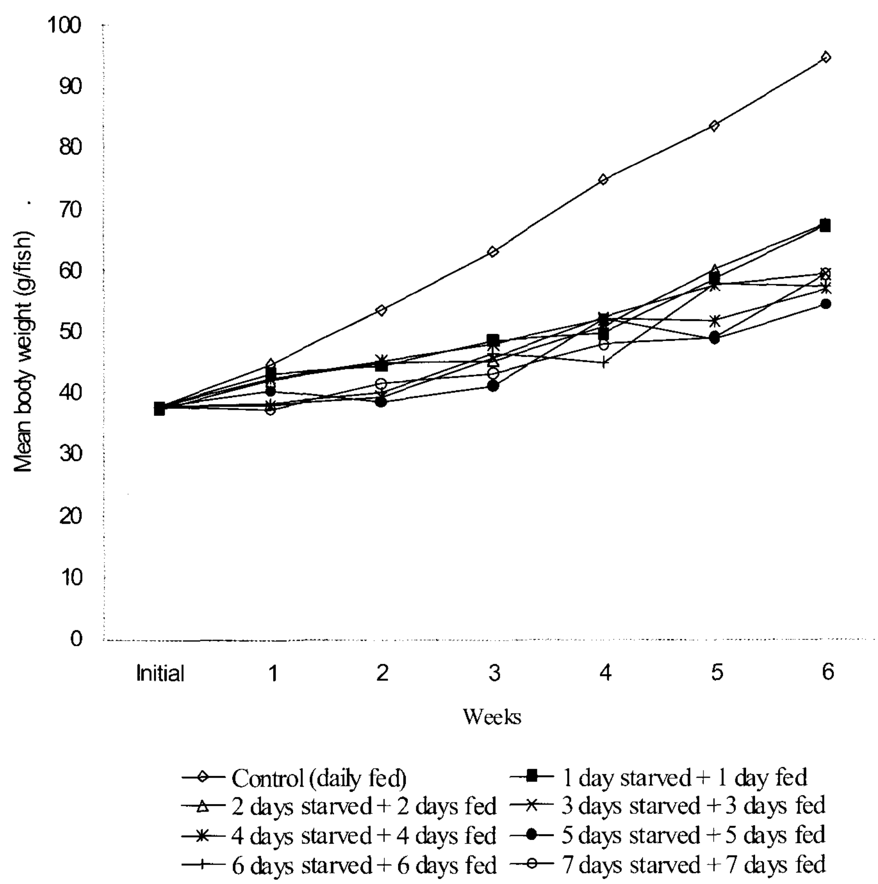

Fig. 1. Change in mean body weight (g/fish) of Nile tilapia exposed to different feeding strategies for 44 days.

Saether and Jobling, 1999; Gaylord and Gatlin, 2000; Wang et al., 2000; Zhu et al., 2001).

Fig. 1 illustrates the changes in the mean body weight of Nile tilapia over 44 days under different feeding regimes. After initiation of the feeding trial, the control fish grew significantly more than the other fish did, and the gap in growth grew larger by the end of the feeding trial.

FER for Nile tilapia in the 7DS+7DF treatment was significantly ($P<0.05$) higher than that for control fish, but it did not differ from that for fish 1DS+1DF and 2DS+2DF treatments. Fish in the 5DS+5D Ftreatments had the lowest FER. The improved FER for Nile tilapia for the 7DS+7DF, 2DS+2DF and 1DS+1DF treatments partly explains the compensatory growth of Nile tilapia in this study, although the growth of the fish in these treatments was inferior to that of the control fish. Similarly, an improved FER for fish undergoing compensatory growth has been observed by other investigators (Gaylord and Gatlin, 2000; Qian et al., 2000; Gaylord et al., 2001; Cho and Lee, 2002; Kim et al., 2002). However, FER of hybrid tilapia did not improve, although compensatory growth did occur (Wang et al., 2000).

Based on our results, we conclude that young Nile tilapia subjected to different feeding strategies involving starvation and re-feeding could not catch up in growth to fish fed daily in a freshwater recirculating system in the summer feeding trial. However, the improved FER for Nile tilapia in treatments of 7DS+7DF, 2DS+2DF, and 1DS+1DF partly explains the compensatory growth of the fish, although their weight gain was relatively low.

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