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Full Length Research Paper

Effects of different feeding strategies on the growth of young rainbow trout (*Oncorhynchus mykiss*)

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This study investigated the effects of different feeding strategies on the growth, conditions and food conversion rate of young rainbow trout (*Oncorhynchus mykiss*). The groups set up are as follows: a control group (Gc), which was fed every day for the week, a group with no feeding on Monday and Thursday ($G_{Mon\text{-}Thu}$), a group with no feeding on Saturday and Sunday ($G_{Sat\text{-}Sun}$), and a group that alternated feeding one day and no feeding the next ($G_{F\text{-}NF}$). At the end of the study, the mean (±SD) weight and food conversion ratio of groups were found to be: 83.51 ± 5.43 g and 1.09; 87.38 ± 5.95 g and 1.14; 83.50 ± 5.97 g and 1.15; and 76.66 ± 4.56 g and 1.26, respectively. Group $G_{F\text{-}NF}$ showed significantly slower growth than the others, and it exhibited a higher food conversion ratio value than groups $G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$ ($P<0.05$). The condition factors of the groups were similar ($P>0.05$). This study showed that the two groups that did not feed for two days a week ($G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$) did not exhibit negative growth performance, whether they were not fed on consecutive days or different days of the week, while group $G_{F\text{-}NF}$ exhibited negative growth performance.

Key words: Rainbow trout, feeding strategy, food conversation rate.

INTRODUCTION

In aquaculture, using appropriate feeding management is necessary to gain an economic advantage and to maximize growth and feed conversion efficiency. Improper feeding or feeding strategies, together with low growth and feed conversion efficiency, have been identified as potential causes of extra labor cost (Wu et al., 2004). If animals are subjected to starvation or limited feeding for a period of time, and are then given sufficient feeding, they exhibit compensatory growth, which results in faster growth than continually fed animals. This method has been proposed as a management tool to reduce feeding costs. In many fish species, various methods of starvation or limited feeding have been used to investigate compensatory growth. Some of the factors underlying rapid growth during compensatory growth phases include excessive appetite and increased feed conversion efficiency observed in fish after their feed has been limited (Russell and Wootton, 1992; Boersma and Wit, 1997). In other words, compensatory growth is defined as a physiological process that makes use of a period of limited development for an organism, usually caused by low feed consumption, for the purpose of accelerating the growth process (Hornick et al., 2000; Metcalfe and Monaghan, 2001).

The goal of the compensatory growth response is to achieve the same size as that of an organism which does not experience any period that suppresses growth. An organism living under ideal conditions is always considered to be of optimal size. Therefore, when the compensatory response diminishes, the effectiveness of the compensation can be measured by the ratio of the animals exhibiting compensatory growth and the control animals (Ali et al., 2003). In the case of full compensatory growth, animals which are starved sooner or later reach the same size of their peers of the same age which are fed continuously. In the case of partial compensatory growth, the starved animals do not reach the size of their peers who are not starved, but when they are fed again, they exhibit fast growth and better relative feeding efficiency. Excessive compensatory growth is observed when the

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animals that are exposed to limited feeding grow more than the animals whose feed are not limited at the same age. This compensatory growth is so strong that animals exposed to varying amounts of nutrients show higher growth than animals which have a continuous food supply. This type of compensatory growth has only been observed rarely (Hayward et al., 1997). If fish whose feeding is restarted do not continue to show growth at the end of the period of starvation, compensatory growth does not occur (Ali et al., 2003).

This study investigated the effects of different strategies of feeding on the growth performance of rainbow trout (*Oncorhynchus mykiss*) fry. The goal of this compensatory strategy when applied to feeding fish was to achieve positive contributions such as reducing labor costs and improving the feed conversion ratio.

MATERIALS AND METHODS

The trials were carried out in Gurpinar Sifa trout farm, located at Yukari Kaymaz neighborhood of Gurpinar District in Van Province, Turkey. This study implemented the method of randomly selected parcels (Yildiz and Bircan, 1991). This study consisted of four separate groups with 3 repetitions, for a total of 12 groups. The groups were set up as follows: a control group (G_C), which was fed every day of the week, a group with no feeding on Monday and Thursday ($G_{Mon\text{-}Thu}$), a group with no feeding on Saturday and Sunday ($G_{Sat\text{-}Sun}$), and a group that alternated one day feeding and had no feeding one day ($G_{F\text{-}NF}$). Fifty (50) fingerlings (averaging 10.44 ± 0.40 g in weight and 10.80 ± 0.67 cm in length) were placed in each fiber glass tank. Before the experiment, fish were allowed to adapt to the experimental conditions for one week.

The study used extruded trout feed (3 mm, 47% crude protein, 19% crude fat, 4000 kcal/kg), manufactured by Ekobio Company. The experiment was performed for 120 days. During the experiment, daily water temperature, dissolved oxygen and pH value were recorded.

In order to handle individual fish to determine their length and weight, anesthesia was performed as described by Kanyilmaz et al. 2007 (17 g grinded cloves mixed with 100 L of water, followed by waiting for 5 to 10 min).

At the end of this study, the average weight (W), feed conversion ratio (FCR), condition factor (C), survival rate (SR), hepatosomatic index (HSI), ratio of internal organs (IO) and visceral fat (VF) were calculated (Hepher, 1990). K-5, Duncan's test, normality and the Arc-Sin package programs were used for statistical analysis.

RESULTS

Natural spring water was used in the experiment. The water temperature varied from 10 to 12°C, and the average temperature was calculated to be 11.2 ± 0.4°C. Dissolved oxygen and pH was found to be 8.5 mg/l and 7.4, respectively.

A comparison of the trial groups revealed that the lowest weight gain was observed in group $G_{F\text{-}NF}$. No statistically significant difference was observed with regard to average weight between the group which was fed every day of the week, the group which was not fed for two days (Monday and Thursday), and the group that was not fed on Saturday and Sunday ($G_{Sat\text{-}Sun}$). Among the experimental groups, the difference in average weight was found to be significant between group $G_{F\text{-}NF}$ and the other groups ($P<0.05$). The differences started to become evident in the second month of the experiment (Table 1). Groups according to the trial periods and the average body weight values are given in graphic (Figure 1).

A comparison of the conversion rates in the trial groups at the end of the study revealed that the lowest rate of feed conversion was seen in the control group, while the highest feed conversion rate was found in the group that alternated feeding one day and no feeding the next. The feed conversion ratios in groups $G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$ were found to be close (Table 2).

At the end of the experiment, a sample of ten fish was taken from each group randomly, and HSI, internal organ, visceral fat and carcass rates were calculated for the trial groups (Table 2). A comparison of HSI, internal organ, visceral fat and carcass ratios for the trial groups indicated that the lowest values of HSI, visceral fat and carcass ratios were found in the group that was fed on alternating days. This group was also found to have the highest level in terms of internal organ ratio. In the control group, which was fed every day of the week, the visceral fat and carcass ratio were the highest. In groups $G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$, no statistically significant difference was seen in the HSI ratio ($P>0.05$).

No death was observed in any of the groups during the trial period. Furthermore, abnormal behavior due to feeding was not encountered in the groups during the experiment. However, some stressful behavior was observed in group $G_{F\text{-}NF}$.

DISCUSSION

When the average weight of the trial groups increased, the lowest weight gain was observed in group $G_{F\text{-}NF}$, thus indicating lower compensatory growth. No statistically significant difference in average weights was observed between the group which was fed every day of the week, the group which was not fed two days of the week (Monday and Thursday) and the group that was not fed on Saturday and Sunday ($G_{Sat\text{-}Sun}$) ($P>0.05$). It has been reported that when trout is not fed for two days of the week, either consecutively or with an interval of 2 to 3 days, the animals are able to make up the difference. In studies carried out on a variety of fish species that lost body mass as a result of lack of food, it was reported that the difference in weight was eliminated by consuming an extra amount of feed when they were fed again (Dobson and Holmes, 1984; Quinton and Blake, 1990; Bull and Metcalfe, 1997; Nicieza and Metcalfe, 1997; Wang et al., 2000; Abdel-Tawwab et al., 2006; Blake and Chan 2006; Eroldogan et al., 2006; Sevgili 2007; Bascinar et al., 2008). Data given by these earlier studies are in line with the aforementioned results.

A comparison of the average feed conversion ratios in

Table 1. Growth parameters of experimental groups; average weight (W±SE), length (L±SE), condition factor (C±SE) and feed conversion rate (FCR), (n = 50).

Period (day)	Growth parameter	Experimental group			
		G_C	$G_{Mon-Thu}$	$G_{Sat-Sun}$	G_{F-NF}
0	W± SE	11.12±0.48	11.78±0.41	10.68±0.37	11.15±0.27
	L± SE	9.60±0.15	9.94±0.12	9.55±0.10	9.47±0.11
	C± SE	1.33±0.01	1.34±0.01	1.32±0.01	1.38±0.01
30	W± SE	27.45±2.50^{ab}	32.17±2.38^{a}	26.32±2.77^{b}	26.41±1.70^{b}
	L± SE	12.31±0.19	13.13±0.18	12.39±0.18	12.48±0.14
	C± SE	1.34±0.01	1.36±0.01	1.34±0.01	1.33±0.01
60	W± SE	49.84±3.60	49.78±3.40	48.11±260	38.57±3.60
	L± SE	14.90±0.19	15.25±0.19	14.84±0.19	14.07±0.19
	C± SE	1.35±0.01	1.37±0.01	1.35±0.01	1.35±0.01
90	W± SE	64.40±5.43	62.17±5.95	61.95±5.97	59.37±4.56
	L± SE	16.37±0.24	16.73±0.26	16.44±0.25	16.39±0.20
	C± SE	1.33±0.01	1.33±0.01	1.33±0.01	1.37±0.01
120	W± SE	83.51±5.43^{a}	87.38±5.95^{a}	83.50±5.97^{a}	76.66±4.56^{b}
	L± SE	18.37±0.24	18.57±0.26	18.22±0.25	17.58±0.20
	C± SE	1.33±0.01	1.33±0.01	1.33±0.01	1.37±0.01
Overall	C± SE	1.34±0.01^{a}	1.35±0.01^{a}	1.33±0.01^{a}	1.34±0.01^{a}
	FCR	1.09	1.14	1.15	1.26

Different letters show that there is statistical difference ($p<0.05$). G_C, Control group; $G_{Mon-Thu}$, group with no feeding on Monday and Thursday; $G_{Sat-Sun}$, group with no feeding on Saturday and Sunday; G_{F-NF}, group that alternated one day feeding and had no feeding one day.

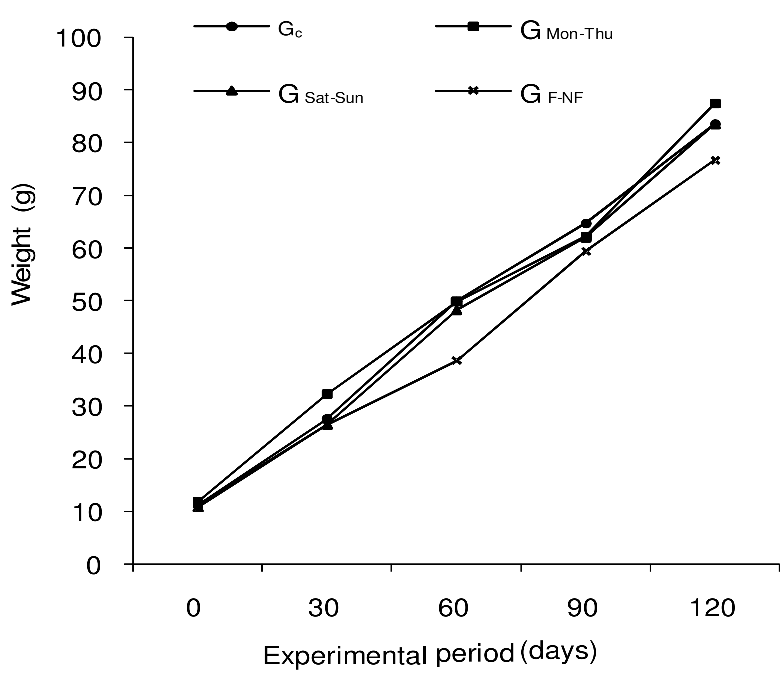

Figure 1. The growth as mean weight of experimental fish during the period.

Table 2. HSI, internal organ, visceral fat and carcass rate of experimental groups (%).

Parameter (%)	Experimental group			
	G_C	$G_{Mon\text{-}Thu}$	$G_{Sat\text{-}Sun}$	$G_{F\text{-}NF}$
HSI	1.06	1.13	1.10	0.98
Internal organ	13.16	17.00	14.68	17.37
Visceral fat	2.05	1.80	1.63	1.45
Carcass	83.79	80.12	83.08	79.64

the trial groups revealed that the control group had the lowest feed conversion rate, while the highest feed conversion rate was observed in the group that was fed every other day. Feed conversion rates were found to be similar in groups $G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$. Bascinaret al. (2008) reported that $G_{F\text{-}NF}$ had the highest FCR, while another group which had not been fed on Wednesdays and Sundays had the lowest FCR. Unusual growth has been reported in many species of fish after some cases such as famine, limited food intake, disease and so on (Jobling and Koskela, 1996; Nikkiet al., 2004).

A comparison of HSI, internal organ, visceral fat and carcass ratios in the trial groups at the end of the trial revealed that the lowest value of HSI, visceral fat and carcass ratio was found in the group that was fed on alternating days. This same group ($G_{F\text{-}NF}$) also had the highest level in terms of internal organ ratio. The visceral fat and carcass ratio was found to be the highest in the control group, which was fed every day of the week. In groups $G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$, no statistically significant difference was observed in the HSI ratio (P>0.05) (Table 2). Similar studies showed that limited feeding resulted in a decrease in the rate of HSI and increase in the ratio of internal organs (Hossu et al., 2001; Kim et al., 2001).

As a result, when feeding rainbow trout fry with an average weight of 10 g, the method used for group $G_{F\text{-}NF}$ was seen to have a negative effect on FCR with increased FCR values. Also, we can say that feeding every day or not feeding for two days a week ($G_{Mon\text{-}Thu}$ and $G_{Sat\text{-}Sun}$) makes no difference in terms of average weight gain and feed conversion, while the latter can reduce the cost of labor.

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