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EFFECTS OF RESTRICTED FEEDING ON PERFORMANCES OF RAINBOW TROUT *(ONCORHYNCHUS MYKISS)*

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ABSTRACT: Rainbow trout (104.8±0.15g), *Oncorhynchus mykiss,* were fed a commercial extruded pellet for 7 weeks to investigate the effect of restricted feeding on performances. Three restricted feeding were tested: two day intervals (TDI), every other day (EOD) and twice a day (TD). Fish were held in fresh water at 9-13°C from January 16 to March 4, 2004. Feed conversion rate (FCR) were TDI and TD groups 1.33±0.03 and EOD group 1.54±0.03, protein efficiency ratio (PER) were TDI group 1.88±0.04, EOD group 1.59±0.03 and TD group 1.85±0.04, respectively. Although FCR was the same between TDI and TD, there was a significant differences in weight gain, relative growth rate (RGR) and specific growth rate (SGR) between the groups. These group evaluated the food at the same rate but since the given food amount were different, the weight gain, SGR and RGR of TD were the highest dependent to the food amount. Although the FCR was good in restricted fed fish, the taken feed amount sigificantly affected the growth parameters of fish. Relative growth rate (RGR), weight gain and specific growth rate (SGR) were lower in TDI and EOD groups. Both specific growth rate and relative growth rate increased with number of restricted feeding. The restricted feeding influenced the chemical composition of the fish. The lipid, moisture and protein content of fish increased when the fish were fd twice a day (TD group). In terms of SGR and RGR, it can be concluded that the best growth rate was obtained from the fish fed twice a day (TD) and every other day (EOD) feeding for rainbow trout at 9-13ºC.
Keywords: Restricted feeding, growth, feed efficiency, rainbow trout, *Oncorhynchus mykiss*

GÖKKUŞAĞI ALABALIĞININ *(ONCORHYNCHUS MYKISS)* PERFORMANSI ÜZERİNE SINIRLI YEMLEMENİN ETKİLERİ

ÖZET: Gökkuşağı alabalığı, (O*ncorhynchus mykiss*) (104.8±0.15g), performansı üzerine sınırlı yemlemenin etkilerini araştırmak için 7 hafta süresince ticari ekstrüde yemle yemlenmiştir. Her gün (TD), gün aşırı (EOD) ve üç günde bir (TDI) olmak üzere üç farklı yemleme frekansı uygulanmıştır. Balıklar 16 Ocak-4 Mart 2004 tarihleri arasında, 9-13ºC su sıcaklıklarında tatlı suda tutulmuştur. Yem dönüşüm oranları TD ve TDI gruplarında 1.33±0.03 ve EOD grubunda 1.54±0.01, Protein verimlilik oranları TDI grubunda 1.88±0.04, EOD grubunda 1.59±0.03 ve TD grubunda 1.85±0.04 arasında kaydedilmiştir. FCR değerleri TDI ve TD grupları arasında aynı olmasına rağmen, bu gruplar arasında ağırlık kazancı, spesifik büyüme oranı (SGR) ve oransal büyüme oranı (RGR) arasında önemli farklılıklar vardır. Bu gruplar yemi aynı oranda değerlerdirmişler fakat verilen yem miktarları farklı olduğu için yem miktarına bağlı olarak TD grubunda ağırlık kazancı, SGR ve RGR en yüksek kaydedilmiştir. Sınırlı oranda yemlenen balıkların yem değerlendirimi ne kadar iyi olsa da aldıkları yem miktarları balıkların büyüme parametrelerini oldukça önemli bir şekilde etkilemektedir. Oransal büyüme oranı (RGR), ağırlık kazancı ve spesifik büyüme oranı (SGR) EOD ve TDI gruplarında ise daha düşük bulunmuştur. Hem spesifik büyüme oranı hem de oransal büyüme oranı yemleme frekansının artışıyla birlikte artış göstermiştir. SGR ve RGR değerlerine bakılarak, gökkuşağı alabalığın için en iyi büyüme oranının 9-13ºC de her gün iki kez (TD) ve gün aşırı iki kez (EOD) yemlemeden elde edildiği sonucuna varılabilir.
Anahtar Kelimeler: Sınırlı yemleme, büyüme, yem yeterliliği, gökkuşağı alabalığı, *Oncorhynchus mykiss*

1. INTRODUCTION

Feed and feeding are among the most important factors influencing growth, feed utilization and tissue composition of the fish in intensive culture (Okumuş and Mazlum, 2003). Efficient production and growth of fish depend on feeding the best possible diets at levels not exceeding the dietary needs (Charles et al., 1984).

Many studies, focusing mainly on salmonids, have been conducted on the effect of feeding level on fish growth. Determination of the feeding level should optimize nutrient availability to fish under given culture and environmental conditions (Pouomagne and Mbongbland, 1993). In fish culture practices, studies on the amount and frequency of feeding are aimed at identifying the optimum levels of both, so that the feeding cost are minimized (Charles et al., 1984).

Increased feeding frequency has been shown to improve the growth of various fish species. Two or three feeding a day have been found to be sufficient for maximum growth of a number of different fish species (Ruohonen et al., 1998). Identification of optimum feeding frequencies for cultivable fish species would help to reduce feed wastage and maximize conversion efficiency (Sampath, 1984). Fish should be fed carefully in production units to allow all fish to have the opportunity to obtain sufficient feed for maximum growth but to avoid overfeeding. Overfeeding reduces feed efficiency and increases the concentration of nutrients in the discharge from the culture operation (NAP, 1993).

The purpose on this study was to investigate (feed conversion rate, protein efficiency rate, growth performance, body composition and bio-economy) the effects of restricted feeding on growth of rainbow trout performance.

2. MATERIALS AND METHODS

2.1.Experimental fish

The rainbow trout (104.8±0.15 g) were obtained from a commercial farm in Samsun, Turkey. The fish were transported to the research unity of the Faculty of Fisheries, University of Ondokuz Mayis in Sinop and were placed to acclimatize in four circular tanks (approximately, water volume 300 lt; 60 cm in high; 80 cm. in diameter). During the acclimatization, fish were fed the experimental diet to satiation twice a day at 09:00 and 16:00 hours. After acclimatization, fish were fasted for one day, batch weighted and randomly distributed among nine fiberglas circular tank at fiberglass circular tanks at a density of 14 fish per tank.

During the experiment, continuous water (Temperature 9-13ºC; O2 7-8mgL^{-1}; pH 7-8; water flow 3 L min^{-1}) was used into each tank.

2.2.Experimental diet

A commercial feed was used in this study dry matter 92%, 40% crude protein, 18% crude lipid and 6.8% crude ash which were analysed in the laboratory (Table 1).

Table 1. Chemical composition of the experiment diet

Proximate Composition	Contents (g 100 g^{-1} wet matter)
Dry Matter (%)	92.48±0.11
Crude Protein (%)	40.23±0.21
Crude Lipid (%)	18.06±0.04
Crude Ash (%)	6.85±0.18
Moisture (%)	7.52±0.11

Values in a column with different superscripts are significantly different at the 5% level.

2.3.Feeding regime

Three restricted feeding were tested: every day (ED), every other day (EOD) and two day intervals (TDI). The experiment was carried out from January 16 to March 4, 2004. Fish were individually weighed every two weeks during the trial. The fish in the all groups were fed 2% of their body weight per day under a natural light regime.

The amount of food distributed was evaluated every two weeks after the weighing of the fish. At the end of the experiment, fish were individually weighed after 1-day fasting.

Specific growth rate (SGR;%/day), feed efficiency ratio (FCR), weight gain, protein efficiency rate and other parameters were calculated using formula outlined by Riche et al. 2004, Türker et al., 2005 and Jobling et al., 1998.

2.4.Chemical analysis

Proximate composition of wet matter, crude protein, crude lipid, ash and moisture were determined for the diet and the fish. Body composition analyses were performed on an initial sample of 6 fish and on groups of 18 fish which were sampled from each treatment at the end of the experiment. Two fish from each tank or replicate were sampled randomly. The fish were sacrified immediately and then homogenized. Homogenized fish meats were stored at -25ºC for proximate analyses. Crude protein was determined using the Kjeldahl method (Auto Kjeldahl System, Buchi B-324/435/412, Switzerland); crude lipid was determined gravimetrically following ether extraction, moisture by oven drying (105ºC for 24h) and crude ash by combustion at 550ºC for 4h (AOAC, 2000).

2.5.Statistical analysis

One-way analysis of variance (ANOVA) was used to test the effect of restricted feeding. Tukey's multiple procedure was used to compare the differences among mean values. Differences were regarded as significant when P<0.05.

3. RESULTS

Body composition content associated with different restricted feeding are shown in Tablo 2. There was no significant difference in ash content for the fish subjected to different restricted feeding (P>0.05). Significant differences were observved in the crude lipid contents (P<0.05). Whole body lipid content was the lowest in the group fed TDI (2.52) as compared to the other experimental restricted feeding. The protein content was the highest in the group fed ED and significantly higher than the others (P<0.05).

According to initial volume, final wet weight gain only fish feeding twice a day (TD) was observed significantly different (P<0.05). Wet weight gain of fish and feed intake increased with increasing restricted feeding.

Cumulative wet weight gain was significantly affected by restricted feeding during the experiment. At the end of the experiment, the fish fed TD had gained significantly more weight (P<0.05). There were significant differences between fish fed the lower feeding (EOD and TDI) and fish fed the higher feeding (TDI) (P<0.05). Avarage fish growth and differences throughout the study is presented in Table 3.

Both RGR (%) and SGR (%/day) were significantly higher (P<0.05) in fish fed TD than for fish fed EOD and TDI (Tablo 3).

Daily dry feed intake, Daily dry protein intake, Daily dry feeding rate and ANPR were significantly higher (P<0.05) in fish fed TD than for fish fed EOD and TDI. Feed conversion rate (FCR) and protein efficiency ratio (PER) did not differ between TDI and TD groups (P>0.05), but differ between EOD group and other groups (P<0.05) (Table 4).

There were no significant effects of treatment on feed conversion rate (FCR) and protein efficiency ratio (PER) between TDI and TD groups (P>0.05). The differences between EOD group and other groups (TDI and TD groups) were statistically significant (P<0.05).

No mortality was observed in any treatment. Economical analyses of the feed for the fish fed TDI, EOD and TD are summarized in Table 5.

4. DISCUSSION

This study has shown that trout performances can be significantly influenced by feeding regimes that strongly affect the amount of feed ingested. The best growth performances and feed utilization were achieved by feeding rainbow trout twice a day (TD), every other day (EOD) and two day intervals (TDI), respectively.

Optimum feeding frequency for maximum growth of fish generally depends upon fish size, age and culture conditions including water temperature, food quality and amount of food provided (Wang et al., 1998; Lee et al., 2000). In this study, with the increase of feeding frequency and of the amount of feed ingested the growth rate of fish increased. These results are similar to those found in earlier reports (Charles et al., 1984; Wang et al., 1998) and demonstrated a significant effect of feeding frequency and food intake on growth. At the end of the experiment, the fish fed twice a day (TD) were larger than the fish fed every other day (EOD) and two day intervals (TDI) (Table 4).

Table 2. Effect of restricted feeding on body composition of rainbow trout

Restricted Feeding	Moisture (%)	Crude Protein (%)	Lipid (%)	Ash (%)
Initial	79.43±0.26	16.93±0.08	2.69±0.40	1.14±0.19
TDI[1]	78.53±0.26^{a}	16.16±0.17^{a}	2.52±0.17^{a}	1.72±0.11^{a}
EOD[2]	76.13±0.20^{a}	16.91±0.21^{a}	4.50±0.74^{b}	1.71±0.13^{a}
ED[3]	74.03±0.08^{b}	18.52±0.42^{b}	5.74±0.11^{c}	1.71±0.08^{a}

Values in a column with different superscripts are significantly different at the 5% level.
[1.] TDI : Two Day Intervals
[2.] EOD : Every Other Days
[3.] ED : Every Day

Table 3. Growth performance and survival of rainbow trout Fed TDI, EOD and TD

	TDI	EOD	TD
Initial wet weight (g)	105.09 ± 0.28	104.60 ± 0.30	104.97 ± 0.15
Final wet weight (g)	129.68 ± 2.31^{a}	138.65 ± 2.51^{b}	192.74 ± 3.93^{c}
Weight gain (g)	24.59 ± 0.41^{a}	33.79 ± 0.26^{b}	86.44 ± 0.35^{c}
Relative growth rate (%)	23.39 ± 2.36^{a}	32.42 ± 2.73^{b}	83.62 ± 3.91^{c}
Specific growth rate (%/day)	0.47 ± 0.04^{a}	0.62 ± 0.05^{a}	1.35 ± 0.05^{b}
Survival (%)	100	100	100

Values (mean ±SD) with different superscripts in the same row are significantly different at the 5% level.
Specific growth rate=% increase in body weight per day=[(ln final wet weight – ln initial wet weight) / days] * 100
Relative growth rate = % increase in weight = (final wet weight – initial wet weight / initial wet weight) * 100

Table 4. Efficiency parameters for rainbow trout fed a commercial diet to different restricted feeding groups

	TDI	EOD	TD
Total feed intake (g)	460.57 ± 18.15	735.38 ± 11.52	1638.60 ± 38.34
Daily dry feed intake (g/fish)	0.73 ± 0.04^{a}	1.17 ± 0.03^{b}	2.60 ± 0.02^{c}
Daily dry protein intake (g/fish)	0.29 ± 0.01^{a}	0.47 ± 0.01^{b}	1.04 ± 0.02^{c}
Daily dry feeding rate (%)	0.48 ± 0.08^{a}	0.96 ± 0.01^{b}	1.75 ± 0.03^{c}
Feed conversion rate	1.33±0.09^{a}	1.54 ± 0.11^{b}	1.33 ± 0.03^{a}
Protein efficiency rate	1.88 ± 0.18^{a}	1.59 ± 0.12^{b}	1.85 ± 0.04^{a}
ANPR (%)	23.81± 0.11^{a}	26.89 ± 0.32^{b}	38.07 ±1.04^{c}

Values (mean ±SD) with different superscripts in the same row are significantly different at the 5% level.
Feed conversion rate = feed consumption / weight gain
Protein efficiency rate = wet weight gain in g / protein intake
Protein retention = final body protein in g – initial body protein in g
Apparent net protein retention = [(final weight in g x final body protein in %) – (initial weight in g x initial body protein in %) / protein intake in g] x 100

Table 5. Economical analyses[1] of the feed for the fish fed twice a day (TD), every other day (EOD) or two day intervals (TDI)

	TDI	EOD	TD
Mean weight gain (kg)	0.344	0.473	1.164
Feed supply (kg/fish)	0.460	0.735	1.639
Feeding cost (EU/kg)	0.308	0.493	1.098
Total initial biomass cost (EU)	15.758	15.683	15.740
Total final biomass cost (EU)	19.446	20.788	28.899
Profit	3.380	4.612	12.060
Gain biomass	1.033	1.430	3.686

[1]: All other costs are assumed same for all groups and ignored
Price of feed: 0.67 EU/kg
Price of fish: 3.51 EU/kg
Feeding cost = feed supply x price of feed
Feed cost as % of profit = feeding cost / profit
Gain biomass = Final weight – initial weight
Profit = (Total final biomass cost - Total initial biomass cost) - feeding cost

In general, increased feeding rates had little effect on the proximate composition of the fish (Storebakken et.al., 1991). The present study, lipid content of the fish increased significantly with increasing mount of feeding day and intake. Rouhonen et al. (1998) found that the proportion of lipid in growth increased with increased number of feeding. A positive relationship between tissue lipid content and weight were also found by Johansson et al. (1995).

In this study, restricted feeding had a significant effect on ANPR and daily feed intake of the fish. The values of ANPR were significantly different between all groups (P<0.05). ANPR increased with increasing protein retention and feeding. A similar conclusion was reported by Yigit et al. (2002). Daily feed intake increased with the increase of mount of feeding day in the present study and there were significant differences among all group. Similar conclusions were reported by other studies (Valente et al., 2001; Rouhonen et al., 1998; McCarthy et al., 1992; Yiğit et al., 2002 for rainbow trout; Zhou et al., 2003; Ogata et al.,2002; Sanchez-Muros et al., 2003 for other species).

Relative growth rate was statistically different among (P<0.05). Yiğit et et al., (2002) reported that relative growth rate increased significantly using diets characterized by high lipid content. Since the present study used 18% the dietary lipid content, RGR increased significantly all of the groups.

Daily feeding rate increased with increasing feeding frequency and daily feed intake (Sampath, 1984; Charles et al., 1984; Zhou et al., 2003). Feeding rates must be chosen to improve efficiency in fish production. Less feed would be required for maintenance of the smaller body size. Thus, cost per fish could be effectively reduced. In present study, more suitable feeding rates were observed in fish fed TD (Grayton et al., 1977; Kono et al., 1971).

Feed efficiency and SGR increased significantly with increasing mount of feeding day and fish fed TD showed the best feed utilization. Therefore, the high growth in the fish fed TD was achieved by the improvement of feed utilization. There was no significant difference between feed efficiency and SGR for every two days and every other day treatments. The SGR observed that in fish fed higher feeding frequency increased and in fish fed lower feeding frequency decreased (Pantazis et al., 2003).

Feed efficiency increased with the increase of mount of feeding day in this study, which is consistent with other reports (Charles et al., 1984; Zhou et al., 2003; Lee et al., 2000). Some authors also reported no effects of feeding frequency on feed efficiency (Wang et al.,1998; Ogata, 2002; Lee et al., 2000). Increased feed efficiency by increasing feeding frequency may be due to exess surfacing activity (Sampath, 1984).

FCR and PER were not affected significantly by restricted feeding methods. Similar conclusions were reported by Wang et al. (1998) Sveier and Lied (1998) and Yigit et al. (2002). In the present study, feeding rates carried out higher than determined values in the feeding table. Since fish were fed higher than normal values and used different feeding frequencies. Obtained a piece of feed by fish were thrown outside via feces without digestion. Thus, reduced be turned ratio from feed to meat and feed conversion ratio values could be higher than normal values.

Optimal water temperature for rainbow trout were between 12-18ºC (Çelikkale, 1994). The present study water temperature recorded between 9-13ºC. Alanara (1992) reported a positive relationship between FCR and water temperature.

The economical analysis of the feed for the fish fed TDI, EOD and TD showed that both the cost of the feed and profit feed supply in TD group was the best. In this situation, it recommended that the fed every day (TD) were the best economically for rainbow trout.

In the present study the best growth performance, feed utilization and feeding cost was the lowest of the group TDI and it was the lowest weight, while it was the highest for the group TD which had the highest final body weight (Table 4).

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