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The Effect of Feeding Frequency on Growth Performance and Feed Conversion Rate of Black Sea Trout (*Salmo trutta labrax* Pallas, 1811)

Nadir Başçınar[1],*, Eyüp Çakmak[2], Yahya Çavdar[2], Nilgün Aksungur[2]
[1] Karadeniz Technical University, Faculty of Marine Sciences, Department of Fisheries, 61530 Çamburnu, Trabzon, Turkey.
[2] Ministry of Agriculture and Rural Affairs, Central Fisheries Research Institute, P.O.B. 129, 61001, Trabzon, Turkey.

* Corresponding Author: Tel.: +90. 462 752 28 05; Fax: +90. 462 752 21 58;
E-mail: nbascinar@ktu.edu.tr

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Abstract

Growth, feed consumption and conversion ratios of Black Sea trout (*Salmo trutta labrax* Pallas, 1811) subjected to daily feeding frequencies were evaluated. The trial performed using 360 fish with a mean weight of 155.9±31.56 g was sampled, counted and divided equally to nine tanks. The three treatments (namely, daily feeding frequencies of one - F1, two - F2 and three - F3) were each applied to three tanks. Mean live weights of the fish in trial groups reached 201.7±3.42 g, 202.7±3.18 g and 217.6±2.54 g at the end of the trial in groups F1, F2 and F3, respectively. Growth data indicated that, the final live weight and SGR values of group F3 were significantly higher than those of the other groups ($P<0.01$). The best (lowest) mean FCR was obtained from once daily feeding (F1) ($P<0.05$). Condition factors (CF) showed similar values. It seems that, Black Sea trout fed once a day grow lower than those fed two or three times a day, but FCR was the best than the other groups.

Key words: Black Sea trout, *Salmo trutta labrax*, feeding frequency, growth, feed consumption and conversion ratios, condition factor.

Introduction

Growth and feed conversion are two critical variables determining the success in fish culture. Nutrition is one of the most important factors influencing the ability of cultured fish to exhibit its genetic potential for growth and reproduction. They are also greatly influenced by factors such as behaviour of fish, quality of feed, daily ratio size, feed intake or water temperature. Since the feed cost accounts approximately 40-60% of the operating costs in intensive culture systems (Anderson *et al.*, 1997), the economic viability of the culture operation depends on the feed and feeding frequency. It means that nutritionally well-balanced diets and their adequate feeding are the main requirements for successful culture operations. Commercialized feed presented to cultured species is not only nutritionally well-balanced, but also readily ingested with minimum waste production and digested and converted to live weight in a predictable manner (Okumuş, 2000; Hasan, 2001).

Each species has its particular food preferences and feeding behaviours. Feeding behaviour of fish is quite complex. Feeding and ingesting are the final result of a number of interacting factors between the fish (senses and hormonal systems) and its environment (stock density, size range or variability, season, day length, time of the day). In general, feed management or feeding techniques have two main objectives:

i) to encourage rapid and positive consumption and thus reducing leaching of nutrients wastage;

ii) to provide greater potential for growth by minimising the metabolic costs.

The amount of the daily feed ratio, frequency and timing of the feedings and presentation of the predetermined ratio are the key factors of feed management strategies, influencing the growth and feed conversion (Jobling, 1995; De Silva and Anderson, 1995; Goddard, 1996). Thus these may be accepted as the major tools for materialising above-mentioned objectives.

Kaushik and Gomes (1988) observed that even under maintenance or zero growth conditions, frequent feeding reduced excretory losses of nitrogen, optimising the amount of nutrients and metabolic fuel made available for growth. Optimal feeding frequency may vary depending on species, age, size, environmental factors, husbandry, and feed quality (Goddard, 1996). Chiu (1989) summarised some of the experimental data available on feeding frequency at which optimal growth was observed in different fish species. The author noted the daily feeding frequency for rainbow trout fingerlings on 7.6-16.0 g. Piper *et al.* (1982) suggested three times daily feeding for 15.1-45.0 g rainbow trout fingerlings.

The limited information available suggests that optimum feeding rates and frequencies should be determined for each species and different sizes of the same species cultured under various environmental and husbandry conditions. Black Sea trout is a new finfish species for intensive aquaculture (Tabak *et al.*, 2001) and, the present study aimed at determining optimum daily feeding frequencies of Black Sea trout (*Salmo trutta labrax*).

Materials and Methods

The trial was conducted at Altındere Trout Research Station, Unit of Central Fisheries Research Institute beginning from 14 July 2005 to 14 October 2005. Nine fibreglass experimental tanks, each with a full volume of 400 L, were used in the experiment. Approximately 0.3 m^3 of the tanks were filled with water and used during the study. Water supply varied from 6 to 10 litres per minute depending on fish size, stocking density and water temperature. Three hundred and sixty portion size Black Sea trout, two years old, weighing 155.9±31.56 (155-211) g were sampled, counted and divided equally to nine tanks. The three treatments (namely, daily feeding frequencies of one - F1, two - F2 and three - F3) were each applied to three tanks, randomly allocated; so the trial was run in three replicates of 40 fish each. The fish were kept in tanks for acclimatization at experimental conditions for 7 days before the trial started. After the groups were allocated and acclimatised, each fish was weighed (±0.01 g) individually to obtain the initial weight of the groups. The initial stocking density for all groups was 17.8 kg/m^3.

Fish were fed with commercial 4.0 mm extruded trout feed manufactured by Abalıoğlu Yem, Denizli, Turkey. CP: 45%, CL: 20%, ME: 2400 kcal/kg was used throughout the trial. The feeding was conducted manually once (1 p.m.), twice (9 a.m. and 5 p.m.) and three times (9 a.m., 1 p.m. and 5 p.m.) a day to visible satiation. Accumulated feed and faecal waste were removed from tanks by drooping outlet pipes with elbows. Daily feed consumption (feed given to fish), mortality and basic water quality parameters (temperature and dissolved oxygen) were recorded. Dead fish were weighed and replaced immediately with similar size specimens. Growth was followed by bulk-weighing (±1 g) the fish in each tank at approximately one-month intervals. In addition, all the fish were weighed individually at the end of the experiment. Total lengths (±1 mm) of the fish were also measured using von Boyer trough and were used to calculate condition factors. After those fish had been anaesthetised using 50 ppm Benzocaine, they were handled individually (weighted and/or measured).

From the data obtained during the periods, specific growth rates ($SGR=[(\ln W_t-\ln W_0)/t]x100$), changes in biomass (kg/m^3), feed consumption (FC=[Feed consumed per day / Mean body weight] x 100) as % of average daily biomass, feed conversion ratios ($FCR=FC/\Delta W$), food efficiency (FE=food intake/weight gain), condition factor ($CF=[(W/L^3)x100]$), variation in size (CV=SDx100/mean W) were determined. All data were subjected to one-way analysis of variance (ANOVA) and differences between means compared by the Tukey test at a 95% confidence interval ($P<0.05$).

Results

Mean water temperature and dissolved oxygen content ranged from 8.5 to 18.0°C (Figure 1) and from 8.2–9.8 mg/l, respectively.

Mean live weights of the fish in groups F1, F2 and F3 reached 201.7±3.42 g, 202.7±3.18 g and 217.6±2.54 g at the end of the trial (Figure 2; Table 1), respectively. It means mean live weights of the groups increased between 29.2% and 39.8% in 91 days.

Specific growth rates (SGR) exhibited clear fluctuations ranging from 0.14 to 0.40 with overall mean values of 0.27, 0.28 and 0.36% in groups F1, F2 and F3, respectively (Table 1). The growth data clearly indicated that the final live weight and SGR values of group F3 were significantly higher than those of other groups ($P<0.01$).

Condition factor was checked only at the beginning and end of the study. Differences among the groups were not significant (Table 1).

The trial started with initial densities of 17.79 – 17.83 kg/m^3 and reached final densities of 23.07, 23.18 and 25.09 kg/m^3 in order to increase feeding frequency (Table 1).

Daily feed consumption and conversion rates were presented in Table 1. Mean values declined with the decrease of feeding frequency whereby resulting in significant differences amongst all three groups ($P<0.05$). Considering the feed conversion, the best (the lowest mean) FCR was obtained from once daily feeding (F1) followed by three and two feedings (Table 1).

Coefficient of variation for weight was 19.1±3.73%, 20.3±0.63% and 17.9±0.83% at the end of the trial in groups F1, F2 and F3, respectively, and did not significantly increase over time and feeding frequency.

Discussion

Black Sea trout were subjected to different daily feeding frequencies. Feeding was manually performed by visual satiation of the fish in groups. The highest weight gain was obtained ($P<0.05$) by feeding the fish frequently (three times a day), thus providing more feed. It is evident that a higher growth rate depends on both higher and more frequent daily feed supply. The significant differences in daily feed consumption rates also indicate a feed restriction in less frequently fed groups.

In general, feed conversion improves increasing feeding frequency (Goddard, 1996). It also declines increasing feed supply until a particular rate and then starts increasing rapidly. The lowest particular levels are accepted as the optimal feeding rate and

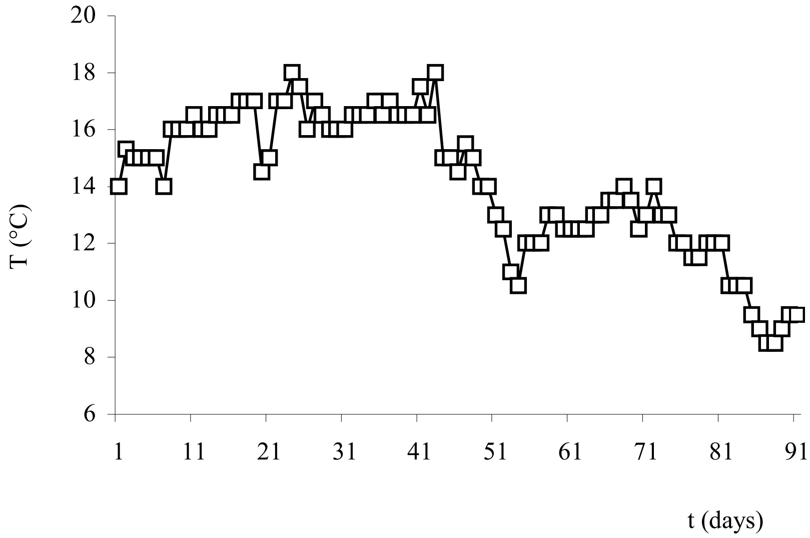

Figure 1. Variations in water temperature during the trial.

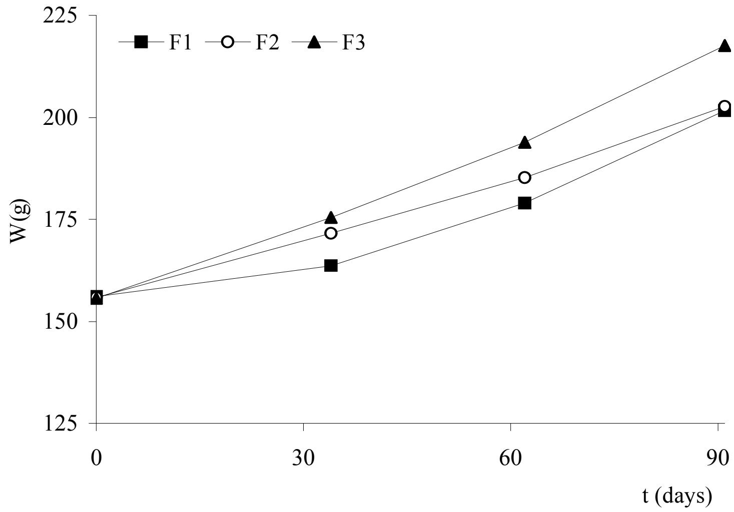

Figure 2. The growth as mean weight of experimental fish during the period.

Table 1. Live weight (W), specific growth rates (SGR), condition factor (CF), feed consumption (FC, % of live weight), feed conversion ratio (FCR; food intake/weight gain), food efficiency (FE; weight gain/food intake) and stocking density (D) values of rainbow trout fingerlings during the trial ($_i$: initial and $_f$: final values)

Parameters	F1	F2	F3	ANOVA
W_i	156.1±0.40	155.9±0.21	155.7±0.38	NS
W_f	201.7±3.42 ^{a}	202.7±3.18 ^{a}	217.6±2.54 ^{b}	**
SGR (%/day)	0.27±0.021 ^{a}	0.28±0.023 ^{a}	0.36±0.012 ^{b}	**
CF_f	1.13±0.072	1.11±0.076	1.15±0.068	NS
FC (%W/day)	0.41±0.039 ^{a}	0.62±0.022 ^{b}	1.25±0.034 ^{c}	**
FCR	1.45±0.101 ^{a}	1.74±0.093 ^{b}	1.77±0.105 ^{b}	*
FE	0.69±0.029 ^{a}	0.57±0.033 ^{b}	0.56±0.35 ^{b}	**
D_f (kg/m^3)	23.07±0.391 ^{a}	23.18±0.364 ^{a}	25.09±0.284 ^{b}	**

NS: No significant, *: P<0.05, **: P<0.01

frequency. However, the amount of food presented to fish varied with the feeding frequency in this study, obtaining the lowest feed conversion in the least frequently fed fish (F1). According to De Silva and Anderson (1995), when these fish are fed to satiation, they do not tend to eat again until the stomach is almost completely evacuated. Therefore, a feeding frequency of once a day is often more than sufficient. Condition factor, which is related to both growth and feeding, was another variable checked in the study. There were no differences between condition factor values amongst the groups.

Feed conversion ratios also showed clear temporal variation during the trial period; and the values for F1 group (1.18) declined considerably towards the end of the trial.

Feeding rates, growth and food conversion are the major variables for the commercial aquaculture enterprises. An understanding of the relationships between these is fundamental in optimising feeding the fish. Unfortunately, the maximum growth and the lowest feed conversion ratios do not coincide at the same feeding rate. The lowest feed conversion occurs at feeding rates below those at which maximum growth occurs (De Silva and Anderson, 1995; Goddard, 1996). Thus it is evident that there is a range of possible feeding rates, choices, which depend on whether maximum growth, optimal food conversion, or a balance between the two is sought. Daily feeding frequency is a useful tool particularly when balance between maximum growth and optimal food conversion is aimed. A high feeding rate and frequent feeding lead to the best performance (Stickney, 1994).

Minimizing inter-individual variation in food consumption and growth of cultured fish contributes to maximizing production efficiency, reducing food wastage, and improving water quality. It is well known that social interactions and dominance hierarchy formation can lead to suppression of food intake and growth in subordinate individuals (McCarthy *et al.*, 1992; Jobling and Baardvik, 1994). Fish feed intake assumed that dominant fish eat most food and subordinate fish eat little or nothing (Metcalfe, 1986; McCarty *et al.*, 1992; Damsgåd *et al.*, 1997). In those studies, the coefficients of variation for weight showed increasing tendency; but in this study, they were not affected due to feeding frequency. It was reported that coefficients of variation for weight increased over minimum feeding frequency in sunfish (Wang *et al.*, 1998) and rainbow trout (Başçınar *et al.*, 2001), but there were no significant differences between feeding frequency treatments in Arctic charr (Petursdottir, 2002), and halibut (Schnaittacher *et al.*, 2005).

Conclusion

- Feeding more than once and twice a day (three times) increased growth performance.
- Feed conversion rate was better in once-daily feeding than twice or three times.
- Feeding frequency did affect neither the condition factor, nor the coefficients of variation for weight.

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