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GROWTH AND FEED CONSUMPTION OF YOUNG RAINBOW TROUT *(ONCORHYNCHUS MYKISS)* EXPOSED TO DIFFERENT PHOTOPERIODS

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Abstract

A feeding experiment was carried out in a brackish water (18 ppt) flow-through system to determine the effects of different photoperiods (light hours/dark hours; L/D) on feed intake and growth performance of young rainbow trout (*Oncorhynchus mykiss*). Duplicate groups of fish (35.32 g avg body wt) were exposed to a natural photoperiod, a long photoperiod (16L/8D) or a continuous photoperiod (24L/0D) for 60 days and fed to satiation twice a day. The growth rate, daily feed intake and feeding rate in the natural photoperiod were significantly lower ($p<0.05$) than in the long and continuous photoperiod groups. Growth was highest in the continuous photoperiod, but did not significantly differ from the long photoperiod. The feed conversion ratio, feed efficiency and gross efficiency in the long and continuous photoperiods were slightly better (about 5-7%) but did not significantly differ ($p>0.05$) from the natural photoperiod. Survival was not significantly ($p>0.05$) affected by the treatment. For better growth and a lower food conversion rate, the long photoperiod is recommended for young rainbow trout.

Introduction

Light intensity has been used in various fish species over recent years. Additional light exposure during winter and spring enhances growth (Boujard and Leatherland, 1992a; Silva-Garcia, 1996; Porter et al., 1999; Endal et al., 2000) and can reduce the incidence of sexual maturation in salmonids (Porter et al., 1999). One benefit of enhanced growth is that the time required to reach market size is shorter, allowing the fish to be harvested before sexual maturation reduces flesh quality and growth, and increases mortality

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(Taranger, 1993). Photoperiod manipulation has also been used in rearing larvae (Fielder et al., 2002; Puvanendran and Brown, 2002) where the benefit of enhanced growth is that less time is required to reach market size.

There is little information on the relationship between photoperiod and growth in young rainbow trout (Boujard and Leatherland, 1992a). Further, most studies on the effects of light regimes on fish growth were carried out in ambient sea water of 33 ppt salinity. The present study was carried out in brackish water of 18 ppt salinity. The aim was to evaluate the effect of light intensity on the growth rate of rainbow trout in intensive culture conditions.

Materials and Methods

Fish stock, rearing conditions and experimental design. Rainbow trout were obtained from a commercial trout farm (Akbalik Co., Bafra, Samsun, Turkey) and transported to the marine facilities at the Faculty of Fisheries of the University of Ondokuz Mayis in Sinop, Turkey (42° N). The fish were acclimated to the experimental conditions for two weeks prior to the start of the experiment. During the acclimation period they were fed a commercial fishmeal-based extruded rainbow trout diet (diameter 3 mm; 45% crude protein; 20% crude lipid; 15% nitrogen free extract; 20 kJ/g diet gross energy).

After the acclimation period, two hundred and four rainbow trout (35.32 g mean wt) were randomly assigned to six identical 50 l rectangular polypropylene tanks with a water volume of 45 l, running sea water at 1.5 l/min (salinity 18 ppt), a temperature of 10.77±1.74ºC and one airstone. Two groups of 34 rainbow trout were reared in each of three photoperiods for 60 days. The natural photoperiod, which served as the control, was 10L/14D at the beginning of the study (February) and 13L/11D at the end of the study (April).The long photoperiod was 16L/8D and the continuous photoperiod was 24L/0D. Each tank with a long or continuous photoperiod was enclosed within a box of black plastic sheeting to prevent the escape of light to the surrounding tanks and to enable complete isolation from natural light. Illumination was supplied by daylight fluorescent tubes (20 W) suspended 30 cm above the water surface and automatically controlled.

The same diet that was used during the acclimation period was offered during the experiment. All groups were hand-fed to satiation twice daily during natural daylight hours. Fish were considered satiated when they began to ignore the feed.

Sampling, data analysis. Fish were individually weighed at the beginning and at the end of the experiment and every 20 days during the trial. Feed was withheld one day before weighing.

All results are expressed as means±SD. The statistical significance of differences between measured parameters was computed using analysis of variance (ANOVA, SPSS 10.0 for Windows). Duncan's new multiple range test (SPSS 10.0 for Windows, General Linear Model - Univariate procedure, Post Hoc Tests) was used to determine significant differences between individual treatments when ANOVA detected that factors were significant at a $p<0.05$ level. Prior to analysis by ANOVA or post-hoc multi-comparison test, data expressed in percent were arcsinus transformed.

Results

Mean weights of all trout in all treatments increased during the experiment. By the end of the experiment, fish exposed to the long or continuous photoperiod were significantly ($p<0.05$) larger than those exposed to the natural photoperiod (Table 1). The final body weights of the fish in the long and continuous photoperiods did not differ significantly from each other. Individuals in these treatments were 10-12% higher than those in the control (natural) group. Although growth in the long and continuous photoperiods began to differ from growth in the natural photoperiod by day 40 (Fig. 1), they differed significantly only at the end of the 60-day experiment.

The SGRs in the long and continuous photoperiods were high throughout the experiment (Fig. 2). The SGR in the natural photoperiod was similarly high during the first 20

Table 1. Growth, feed efficiency and survival of rainbow trout reared under different photoperiod regimes for 60 days.

	Photoperiod regime		
	Natural	*Long (16L/8D)*	*Continuous (24L/0D)*
Initial wet weight (g)	34.97 ± 0.75^a	35.34 ± 0.61^a	35.65 ± 0.79^a
Final wet weight (g)	78.39 ± 2.04^a	86.40 ± 3.29^b	87.87 ± 1.72^b
Growth rate (%)[1]	124.15 ± 1.05^a	144.45 ± 5.15^b	146.50 ± 3.22^b
Daily feed intake (g/fish)[2]	0.76 ± 0.05^a	0.85 ± 0.04^b	0.86 ± 0.03^b
Daily feeding rate (%)[3]	1.34 ± 0.07^a	1.40 ± 0.02^b	1.39 ± 0.09^b
Feed conversion ratio[4]	1.04 ± 0.05^a	0.98 ± 0.01^a	0.98 ± 0.06^a
Feed efficiency (%)[5]	96.14 ± 4.42^a	102.13 ± 1.76^a	102.58 ± 4.95^a
Gross efficiency[6]	1.00 ± 0.05^a	1.07 ± 0.01^a	1.08 ± 0.06^a
Survival (%)	95.59 ± 2.08^a	91.18 ± 4.16^a	94.12 ± 4.16^a

Values (means±SD) in a row with different superscripts are significantly different at the 5% level.
[1] Growth rate = % increase in weight = [(final wet weight - initial wet weight)/initial wet weight] x 100
[2] Daily feed intake (g/fish) = (g wet feed intake/number of fish)/day
[3] Daily feeding rate (%) = {g daily feed intake/[(final weight + initial weight)/2]} x 100
[4] Feed conversion ratio = g wet feed intake/g wet weight gain
[5] Feed efficiency (%) = 100/feed conversion rate
[6] Gross efficiency = specific growth rate/daily feeding rate

days. However, at forty days, it dropped about 25% below the value on day 20 and was 20% lower than those recorded in the other two groups. The relative SGR (RSGR) was the same for all treatments during the first 20 days. Thereafter, the RSGRs for the long and continuous photoperiods were about 120% higher than the value of the natural photoperiod. By the end of the experiment, the SGRs and the RSGRs of the fish in the long and continuous photoperiods were significantly ($p<0.05$) higher than those of the fish in the natural photoperiod.

The daily feed intake and feeding rate were significantly ($p<0.05$) affected by the photoperiod (Table 1). The fish with the lowest growth rate (natural photoperiod) also had the lowest feed intake. The feed conversion ratio, feed efficiency and gross efficiency improved as the number of daylight hours increased but they did not differ significantly ($p>0.05$) among treatments. Survival did not differ significantly ($p>0.05$) among the groups, showing that the photoperiods in this study did not affect the mortality rate of the fish.

Discussion

The present study shows that rainbow trout growth can be modified by manipulating the photoperiod. Similarly, previous studies have shown that the growth rate of salmonids can be markedly affected by the photoperiod under which they are maintained. Clarke and Shelbourn (1986) found that underyearling

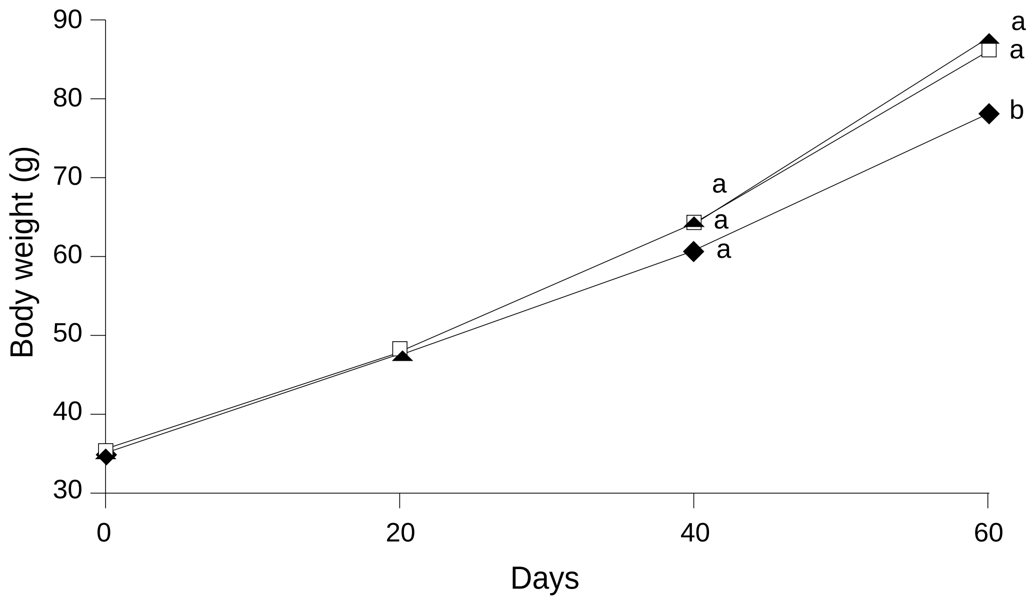

Fig. 1. Body weight of rainbow trout reared under a natural (◆), a long (16L/8D; □) or a continuous (24L/0D; ▲) photoperiod. Data are means±SD. Points with different letters are significantly different within groups (p<0.05).

coho salmon exposed to longer periods of light grew about five times as fast in sea water as those exposed to a natural photoperiod. The use of continuous light or additional light once the fish were transferred to sea water increased the growth rate in underyearling salmon post-smolts (Duncan et al., 1999; Oppedal et al., 1999).

It took 60 days for the differences in growth and relative SGR to become significant, suggesting that acclimatization to the photoperiod required several weeks. This result agrees with other studies conducted in salmonids. Jørgensen et al. (1993) and Hatlen et al. (1997) reported that following the establishment of groups of Arctic charr (*Salvelinus alpinus*), two months or more may be required before the fish acclimatize. Similarly, Koskela et al. (1997) reported that Baltic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) require several weeks to become fully acclimatized to a new rearing environment.

A direct relationship between photoperiod and growth was found by Silva-Garcia (1996), who reported that the fish body proportion (weight/length ratio) increased with the number of light hours. The effect of photoperiod on rainbow trout growth could be explained by its direct impact on the brain-pituitary response, inducing production of growth hormone (Donaldson et al., 1979). During salmonid parr-smolt transformation, photoperiod manipulation triggered a change in plasma growth hormone and pituitary somatotrop activity (Bjornsson et al., 1989). This hormonal activity can modify fish appetite, food conversion and growth energy requirements (Phillips, 1969; Donaldson et al., 1979) and light/dark cycles can regulate feeding activity (Boujard and Leatherland, 1992b).

Gines et al. (1995), in an experiment with gilthead sea bream, found significant weight differences between fish held in a short photoperiod (6L/18D) and those held in the natural course from day 60, while between long photoperiods (16L/8D and 24L/0D) and the natural photoperiod, weight differences

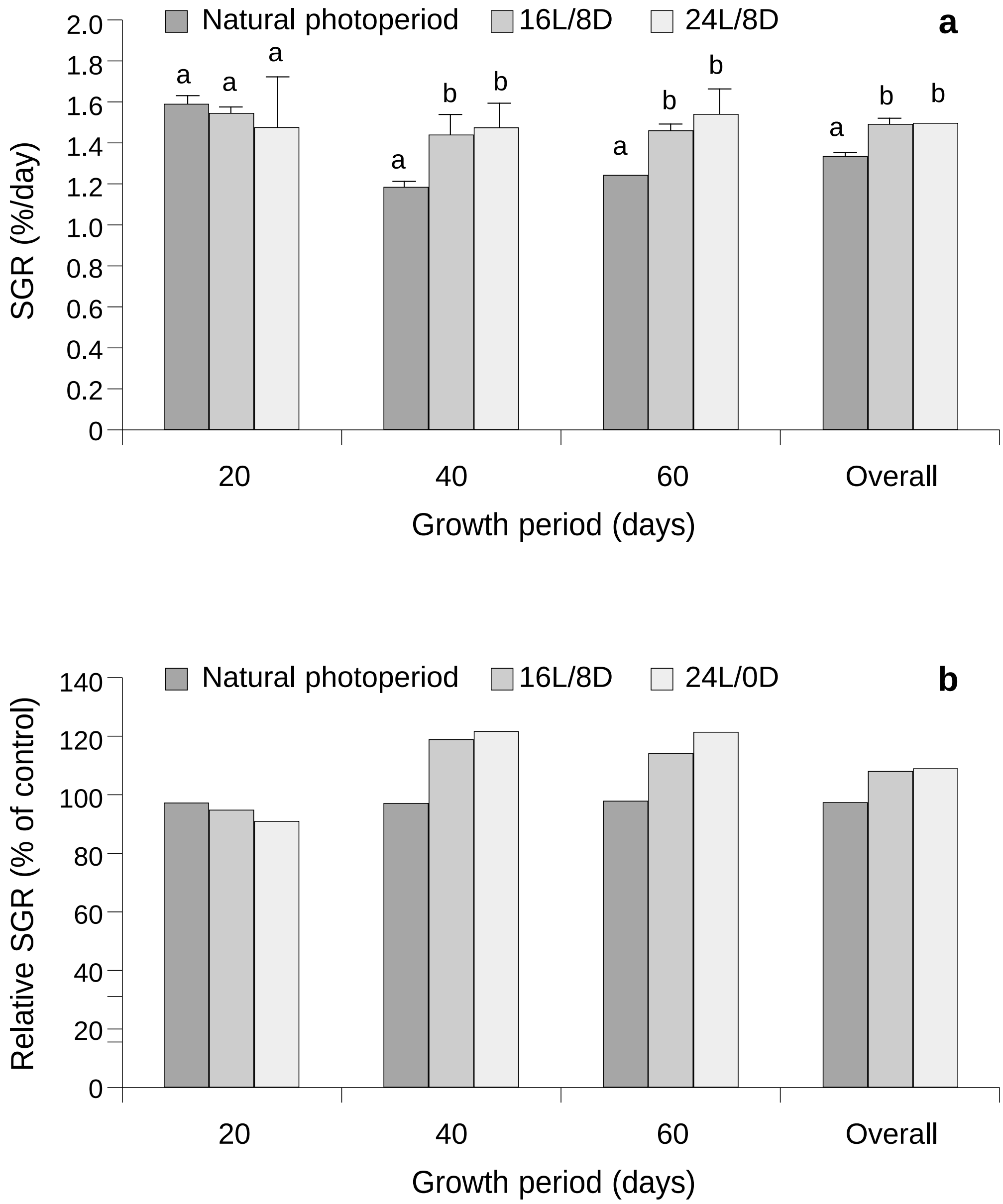

Fig. 2. Specific growth rate (a) and SGR relative to the natural photoperiod (b) of young rainbow trout exposed to a natural, long (16L/8D) or continuous (24L/0D) photoperiod. Data are means±SD. Bars with different letters are significantly different within groups ($p<0.05$). Specific growth rate was calculated as SGR = 100 x (ln final weight - ln initial weight)/days. Relative SGR was calculated as RSGR = SGR x 100/SGR of the control (natural photoperiod).

appeared at the end of the 150-day experiment. In gilthead sea bream, Silva-Garcia (1996) reported that growth differences between fish held in long (16L/8D, 24L/0D) and natural photoperiods appeared from day 145 of the experiment while in fish held in a short photoperiod (8L/16D), the difference in growth appeared by day 45. This might be directly related to hormone activity that regulates sex determination in sea bream (Monbrison et al., 1997; Kissil et al., 2001). It seems that long photoperiods have a positive long-term effect on the growth rate (Villareal et al., 1988; Boujard and Leatherland, 1992a). Future studies longer than 60 days are necessary to observe the effects of long and continuous photoperiods on the growth of young rainbow trout.

In conclusion, our results showed that the feed intake and growth of young rainbow trout are influenced by the photoperiod in which they are held. The results in the present study also suggest that a photoperiod of 16L/8D might be adequate for good growth of rainbow trout, as fish growth in this group was similar to fish growth in the group held at 24L/0D. Since photoperiod is an environmental factor that can easily be modified in intensive culture systems, simple photoperiod manipulation could be an easy way to increase rainbow trout growth and reduce the feed conversion rate.

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