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Effect of Photoperiod on Growth of Trout (*Oncorhynchus mykiss*) in Cold Ambient Sea Water

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Abstract

The effects of four photoperiod regimes on growth performance of the rainbow trout (*Oncorhynchus mykiss* W.) in cold ambient seawater conditions were compared in indoor seawater tanks (salinity 18 g/l; 6-8°C) in January-February. The photoperiods were the natural photoperiod (10 h light: 14 h dark), 20 h light:4 h dark, 16 h light:8 h dark, and 0 h light:24 h dark. Fish were fed a diet consisting of 47% protein, 20% fat, 11% ash, and 8.5% moisture. At the end of eight weeks, the relative growth rate and feed intake were significantly higher in fish exposed to 20L/4D than in other photoregimes. Total protein intake (g), protein retention (%), and N content in fish (%) significantly improved with the increase of light hours, indicating that optimal growth in the study conditions is obtained in extended light regimes (20L/4D or 16L/8D).

Introduction

The strongest 'zeitgeber' (time giver) for plants, land based animals, and fish is light. Other non-photic zeitgebers include water conditions, pharmacological manipulations, and feeding patterns. Light is very important for fish and larvae, depending on the developmental stage and species

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(Endal et al., 2000). Photoperiod manipulation has successfully improved the growth of some fish. Light-dark transitions are important in synchronizing locomotor activity rhythms in Atlantic salmon, *Salmo salar* (Richardson and McCleave, 1974). Diel rhythms of locomotor activity in the rainbow trout, *Oncorhynchus mykiss*, are influenced by a circadian time entrained to light-dark cycles (Iigo and Tabata, 1997). Light density is the main abiotic factor that influences growth, feed intake, immune system, and spawning in rainbow trout (Boujard et al., 1995; Leonardi and Klempau, 2003; Taylor et al., 2006).

The objectives of this study were to examine whether photoperiod manipulation can enhance the growth performance of rainbow trout cultured in sea water and whether culture can be sustained during the winter (5-10°C) or must be suspended. The growth rate and feed intake in rainbow trout cultured in extended photoperiods (20 h light/4 h dark or 16 h light/8 h dark) in the cold winter conditions of the Black Sea were examined.

Materials and Methods

Fish stock. Rainbow trout (*Oncorhynchus mykiss*) were supplied by a private trout farm in Bafra, Samsun (Turkey). Upon arrival at the Research Unit of the Faculty of Fisheries in the mid-Black Sea, they were acclimated to experimental conditions for ten days in tanks (30 x 55 x 40 cm).

Experimental design. After acclimation, the fish (avg 24.59±1.2 g) were divided into twelve groups of 15 fish each and stocked into 60-l plastic tanks supplied with running sea water (pH 8.2, 6-8°C, oxygen 8-10 mg/l, salinity 17-18 g/l). Three tanks were exposed to each of the four treatments: natural photoperiod (10 h light:14 h dark), 20 h light:4 h dark, 16 light and 8 dark, and 0 light and 24 dark. Light was supplied by one 24 W fluorescent tube at the water surface, controlled by electronic analogue timers. Dissolved oxygen, temperature, and pH were monitored throughout the study.

The fish were fed commercial extruded pellets (Ecobio Industry Co., Turkey, 0.4 cm diameter) to satiation twice daily (at 9:00 and 16:00). The diet contained 47% protein, 20% fat, 11% ash, and 8.5% moisture. The fish were fed manually with small amounts of feed. The appetite of the fish was observed to prevent feed loss. Uneaten feed was collected and weighed to estimate feed conversion ratio, feed efficiency, and other feed and growth parameters.

Five fish from each tank were weighed biweekly as well as at the end of the trial. All fish were returned to the tanks following weighing. Growth was measured as the percent weight gain. Feed conversion efficiency, protein efficiency ratio, and other feeding or growth indicators were calculated as described by Liu et al. (1998). The experiment lasted 56 days in January-February.

Chemical analysis. Eight fish at the beginning of the experiment plus three fish from each experimental tank at the end were randomly sampled and stored at -25°C for whole body composition analysis. For analysis, the diet and fish were dried in an oven at 105°C until a constant weight was obtained. Ash was weighed after incineration in a muffle furnace at 450°C for 16 h. Crude protein (N x 6.25) was determined by the Kjeldahl method using the Kjeltec system after acid digestion. Lipid content was determined by 40-60°C petroleum ether extraction in a Soxhlet apparatus.

Statistical analysis. Results were analyzed by one-way analysis of variance (ANOVA). When ANOVA identified differences among groups, multiple comparisons among means were made with Duncan's new multiple range test. Statistical significance was determined by setting the aggregate Type 1 error at 5% ($p<0.05$) for each set of comparisons.

Results

Survival was 100% for all treatments. Feed intake increased as the duration of light increased and there were significant differences among groups (Table 1). Growth, protein intake, protein retention, and energy intake were highest for trout exposed to 20 h light. Final body weight was also significantly higher in groups exposed to 20 h light than in other groups (Fig. 1). Fish exposed to 20 h light had significantly lower moisture content (Table 2).

Discussion

Extended light hours significantly improved the growth of the trout. Improved appetite, more feed intake, higher food conversion efficiency, and induction of growth hormone release are generally held responsible for faster growth in Atlantic salmon (Saunders and Harmon, 1990; Oppedal et al., 1997) and rainbow trout exposed to extended photoperiods (Boujard and Leatherland, 1992; Ergun et al. 2003, Taylor et al. 2005). Feeding activity is fundamental, as salmon eat very little

Table 1. Growth and feed performance of rainbow trout exposed to different photoperiods for eight weeks (averages of three replicates of 15 fish per tank).

	Photoperiod			
	Natural (10 h light:1 4 h dark)	*20 light: 4 dark*	*16 light: 8 dark*	*0 light: 24 dark*
Avg initial wt/fish (g)	24.82±0.22	24.74±0.32	24.07±0.39	24.74±0.37
Avg final wt/fish (g)	58.26±0.52^{a}	83.52±0.73^{c}	69.03±0.60^{b}	41.75±0.62^{d}
Daily growth/fish (%)[1]	1.44±0.01^{a}	1.94±0.01^{c}	1.72±0.03^{b}	0.91±0.02^{d}
Relative growth rate (%)[2]	134.69±4.11^{a}	237.59±6.48^{c}	186.82±5.51^{b}	68.74±4.84^{d}
Feed/tank (g)	550^{a}	972^{c}	765^{b}	270^{d}
Total protein intake (g)[3]	258.5±2.41^{a}	456.84±4.97^{c}	359.55±4.23^{b}	126.9±1.51^{d}
Protein retention/tank (%)[4]	33.54±0.3^{a}	37.93±0.23^{c}	36.28±0.26^{b}	31.50±0.36^{d}
Total N intake (mg/g)[5]	82.46±0.75^{b}	82.90±0.99^{b}	85.30±0.66^{c}	79.58±0.91^{a}
N content (%)[6]	2.62±0.03^{b}	2.94±0.42^{c}	2.86±0.04^{c}	2.46±0.48^{a}
Daily dry energy intake (Kcal/fish)	12.45±0.12^{a}	21.99±0.24^{c}	17.31±0.21^{b}	6.11±0.07^{d}

Values in a row with different superscripts significantly differ (p<0.05).
[1] Daily growth = $100(wt^2 - wt^1)/t(wt^2 + wt^1)/2$
[2] Relative growth rate = 100(final wt - initial wt)/(initial wt)
[3] Total protein intake = total feed intake x % protein in feed
[4] Protein retention = 100[(final wt x final protein in fish) - (initial wt x initial protein in fish)]/total protein intake
[5] N intake = total protein intake/no. of fish/6.25/total wt gain x 1000
[6] N content in fish = final protein in fish/6.25

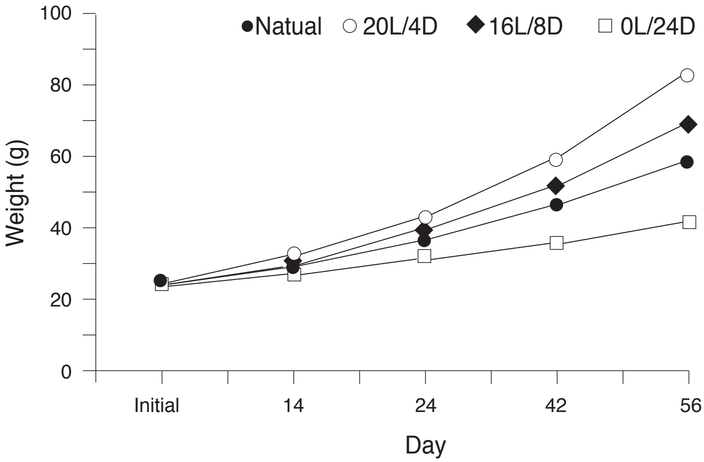

Fig. 1. Average weight (means±SD) of rainbow trout (*Oncorhnychus mykiss*) maintained on four different photoperiod regimes.

Table 2. Proximate composition (% wet weight) of rainbow trout grown in different photoperiods.

	Initial	*Photoperiod*			
		Natural (10 h light:) 14 h dark	*20 light: 4 dark*	*16 light: 8 dark*	*0 light: 24 dark*
Moisture	76.9±0.4	74.1±0.4^{a}	71.4±0.7^{c}	72.3±0.4^{b}	75.2±0.3^{d}
Crude protein	15.2±0.3	16.4±0.1^{a}	18.4±0.4^{b}	17.9±0.1^{b}	15.4±0.1^{c}
Crude lipid	5.8±0.2	6.8±0.5^{a}	7.8±0.4^{c}	7.4±0.4^{b}	6.1±0.3^{d}
Ash	1.5±0.03	2.2±0.1^{ab}	1.8±0.1^{a}	2.0±0.2^{ab}	2.5±0.3^{b}

Values in a row with different superscripts significantly differ (p<0.05).

or not at all during the night (Thorpe et al., 1989). On the other hand, growth in Atlantic salmon post-smolts, cultured in net pens, was enhanced when light hours were reduced (Huse et al., 1990) and the winter growth rate of seawater-reared rainbow trout was not affected by extended or constant light treatment (Solbakken et al., 1999). These differences in findings may be due to genetic differences or environmental conditions (Sumpter, 1992).

Fish growth, total feed intake, and total protein intake were closely related with each other and better in the prolonged light treatments. Growth of rainbow trout was better in covered tanks exposed to 1600 lx rather than 100 lx and, although the fish exposed to the higher intensity appeared more active with greater energy requirements, there were no differences in feed conversion (Cho, 1992). Long growth-stimulating photoperiods improve feed efficiency (Gines et al., 2004). The growth-promoting effect of the extended photoperiod can be attributed to the enhancement of parr-smolt transformation associated with growth, and increased levels of growth hormone. When the photoperiod rapidly increases, plasma growth hormone levels also increase (McCormick et al., 1995).

In conclusion, results indicate that an extended period of light (20L/4D) may improve the growth rate and feed utilization in juvenile rainbow trout grown in cold ambient seawater conditions.

References

Boujard T. and F. Leatherland, 1992. Demand-feeding behaviour and diel pattern of feeding activity in *Oncorhynchus mykiss* held under different photoperiod regimes. *J. Fish Biol.*, 40:535-544.

Boujard T., Gelineau A. and G. Corraze, 1995. Time of a single daily meal influences growth performance in rainbow trout *Oncorhynchus mykiss* (Walbaum). *Aquac. Res.*, 26:341-349.

Cho C.Y., 1992. Feeding systems for rainbow trout and other salmonids with reference to current estimates of energy and protein requirements. In: G.A.E. Gall (ed.). *The Rainbow Trout: Proc. 1st Aquaculture-Sponsored Symp. Aquaculture*, 100:107-123.

Endal H.P., Taranger G.L., Stefansson S.O. and T. Hansen, 2000. Effects of continuous additional light on growth and sexual maturity in Atlantic salmon *Salmo salar*, reared in sea cages. *Aquaculture*, 191:205-214.

Ergun S., Yigit M. and A. Turker, 2003. Growth and feed consumption of young rainbow trout (*Oncorhynchus mykiss*) exposed to different photoperiods. *Isr. J. Aquac. - Bamidgeh*, 55:132-138.

Gines R., Afonso J.M., Arguello A., Zamorano M.J. and J.L. Lopez, 2004. The effects of long-day photoperiod on growth, body composition and skin colour in immature gilthead sea bream (*Sparus aurata* L.). *Aquac. Res.*, 35:1207-1212.

Huse I., Bjordal A., Ferno A. and D. Furevik, 1990. The effect of shading in pen rearing of Atlantic salmon (*Salmo salar*). *Aquac. Eng.*, 9:235-244.

Iigo M. and M. Tabata, 1997. Circadian rhythms of locomotor activity in the rainbow trout *Oncorhynchus mykiss*. *Fish. Sci.*, 63:77-80.

Leonardi M.O. and A.E. Klempau, 2003. Artificial photoperiod influence on the immune system of juvenile rainbow trout (*Oncorhynchus mykiss*) in the southern hemisphere. *Aquaculture*, 221: 581-591.

Liu F.G., Yang S.D. and H.C. Chen, 1998. Effect of temperature on feed response, growth performance, and muscle proximate composition in juvenile hybrid striped bass (*Morone saxatilis* x *M. chrysops*). *Isr. J. Aquac. - Bamidgeh*, 50:184-194.

McCormick S.D., Bjornsson B.T., Sheridan M., Eilertson C., Carey J.B. and M. O'dea, 1995. Increased daylength stimulates plasma growth hormone and gill Na+, K+-ATPase in Atlantic salmon (*Salmo salar*). *J. Comp. Physiol.,* 165:245-254.

Oppedal F., Taranger G.L., Juell J.E., Fosseidengen J.E. and T. Hansen, 1997. Light intensity affects growth and sexual maturation of Atlantic salmon (*Salmo salar*) postsmolts in sea cages. *Aquat. Living Resour.*, 10:351-357.

Richardson N.E. and J.D. McCleave, 1974. Locomotor activity rhythms of juvenile Atlantic salmon (*Salmo salar*) in various light conditions. *Biol. Bull.*, 147:422-432.

Saunders R.L. and P.R. Harmon, 1990. Influence of photoperiod on growth of juvenile Atlantic salmon and development of salinity tolerance during winter-spring. *Trans. Am. Fish. Soc.*, 119: 689-697.

Solbakken V., Taranger G.L. and T. Hansen, 1999. Effects of photoperiod on somatic growth and sexual maturation in rainbow trout in sea cages. pp. 125-129. In: B. Norberg, O.S. Kjesbu, G.L. Taranger, E. Andersson, S.O. Stefansson (eds.). *Proc. 6th Int. Symp. Reproductive Physiology of Fish*. Bergen, Norway.

Sumpter J.P., 1992. Control of growth of rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, 100: 299-320.

Taylor J.F., Migaud H., Porter M.J.R. and N.R. Bromage, 2005. Photoperiod influences growth rate and insulin-like growth factor-I (IGF-I) levels in juvenile rainbow trout. *Gen. Comp. Endocrinol.*, 142:169-185.

Taylor J.F., North B.P., Porter M.J.R., Bromage N.R. and H. Migaud, 2006. Photoperiod can be used to enhance growth and improve feeding efficiency in farmed rainbow trout, *Oncorhynchus mykiss*. *Aquaculture*, 256:216-234.

Thorpe J.E., Adams C.E., Miles M.S. and D.S. Keay, 1989. Some influences of photoperiod and temperature on opportunity for growth in juvenile Atlantic salmon, *Salmo salar* L. *Aquaculture*, 82: 119-126.