www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 393-397 (2011) DOI: 10.4194/1303-2712-v11_3_08

Interrelationship of Photoperiod with Growth Performance and Feeding of Seawater Farmed Rainbow Trout, (*Oncorhynchus mykiss*)

Ali Türker[1,*], Önder Yıldırım[1]

[1] Mugla University, Fisheries Faculty, Department of Aquaculture, 48000 Kötekli, Mugla, Turkey.

* Corresponding Author: Tel.: +90.506 7519538; Fax: ;
E-mail: aliturker@mu.edu.tr

Received 5 May 2010
Accepted 15 February 2011

Abstract

Juvenile of rainbow trout (*Oncorhynchus mykiss,* weight 27.39±0.16 g) were reared under four photoperiods (Light/Dark hour) (11L:13D control group; 24L:0D continuous light group; 18L:6D extended light group and 6L:18D short light group) to examine their growth performance and some feeding parameters in sea water conditions. Fish were fed on a commercial diet until satiation for 8 weeks of the trial. Fish exposed to 24L:0D (continuous light group) had a significantly higher daily growth rate, relative growth rate and specific growth rates followed by 18L:6D, 11L:13D and 6L:18D photoperiods ($P<0.05$). The results demonstrated that the growth performance and feed utilization of rainbow trout can be stimulated clearly by using a continuous (24L:0D) or extended light (18L:6D) photoperiods in sea water.

Keywords: Rainbow Trout, *Oncorhynchus mykiss,* Juvenile, Photoperiod, Growth, Feeding, Sea Water.

Deniz Suyu Ortamında Yetiştirilen Yavru Gökkuşağı Alabalığının (*Oncorhynchus mykiss*) Büyüme Performansı ve Yem Değerlendirimi ile Fotoperiyod Ilişkisi

Özet

Bu çalışmada, deniz suyu koşullarında yavru gökkuşağı alabalığına (*Oncorhynchus mykiss,* ortalama ağırlık 27,39±0,16 g) uygulanan 4 farklı fotoperiyotun (Aydınlık/Karanlık saat) (11 saat aydınlık: 13 saat karanlık; Kontrol grubu; 24 saat aydınlık: 0 karanlık sürekli ışık grubu; 18 saat aydınlık: 6 saat karanlık; uzatılmış aydınlık grubu ve 6 saat aydınlık: 18 saat karanlık; kısaltılmış aydınlık grubu) balıkların büyüme performansı ve yem değerlendirmesi üzerine etkisi araştırılmıştır. Sekiz hafta süren denemede, balıklar ticari bir yemle doyuncaya kadar beslenmişlerdir. Sürekli ışığa tabi tutulan grupta günlük büyüme oranı, oransal büyüme oranı, spesifik büyüme oranı ve yem etkinliği daha iyi bulunmuştur ($P<0,05$). Bu grubu sırasıyla 18A:6K, 11A:13K ve 6A:18K grupları izlemiştir. Bu araştırmanın sonuçları, deniz suyu koşullarında yetiştirilecek olan gökkuşağı alabalığı yavrularına sürekli (24A:0K) yada uzatılmış (18A:6K) ışıklandırmanın, balıkların büyüme oranını ve yem değerlendirmesini olumlu yönde etkileyebileceğini göstermiştir.

Anahtar Kelimeler: Gökkuşağı alabalığı, *Oncorhynchus mykiss,* yavru, fotoperiyot, büyüme, yemleme, deniz suyu.

Introduction

Photoperiod manipulation has been used successfully to improve the growth of some juvenile fish species (Simensen *et al*., 2000; Biswas and Takeuchi, 2003; Valenzuela *et al*., 2006; Turker, 2009). Continuous additional light has also been used on the Atlantic salmon reared in the sea cages, especially during the spring and winter to enhance growth and delay sexual maturation rate (Taranger *et al*., 1995; Oppedal *et al*., 1997; Porter *et al*., 1999). Photoperiod manipulation applied in fish farming intends to increase the farming efficiency and get the fish to the commercial weight as soon as possible (Hansen *et al*., 1999). The effect of photoperiod on the growth performance of fish even varies depending on the developmental stages. On some occasions, on the photoperiod manipulation applied to give preference to rainbow trout spawning, the deterioration of egg quality, lower rate of survival and yolk-sac resoption besides higher rate of malformation percentage can appear (Bonnet *et al*., 2007). Leonardi and Klempau (2003) explained that artificial photoperiod significantly caused the effect of stress on rainbow trout. Boeuf and Le Bail (1999) clarified in their detailed gathering studies that the light has effects on the growth of fish. Oppedeal *et al.,* (1997) suggested that Atlantic salmon post-smolts in

Norway sea cages, grew significantly better under a high light intensity regime. Continuous additional light has a super imposing on salmons farmed in sea during winter and spring season (Endal *et al*., 2000). The aim of this paper is to determine the effects of different photoperiod regimes on the husbandry parameters of juvenile rainbow trout reared in sea water.

Materials and Methods

Samples and Rearing Conditions

This study investigated the effects of different photoperiod regimes 180 juvenile trout mean weight 27.31±0.16 g, obtained from a private commercial farm. Fish were stocked in 12 (filled with 60 L sea water) plastic tanks with 15 fish each. Three replicate tanks were randomly assigned for four photoperiod regimes.

Experimental Design

Fish were fed with commercial extruded pellets (Ecobio Industry Co. Turkey, 0.3 mm diameter; 47% protein, 20% fat, 11% ash and 8.5% moisture) and twice daily (at 09:00 and 16:00) until satiation for 60 days and similar diets. But since the fish were not fed on weighing days there were only 56 effective feeding days. The fish were exposed to four photoperiod regimes (light:dark, L:D) cycles 11L:13D control group; 24L:0D continuous light group; 18L:6D extended light group and 6L:18D short light group, with the use of 24 W fluorescent lamps. Photoperiods were controlled by a 24-h timer.

Environmental Conditions

During the experiment, water temperature fluctuated between 13-18°C, dissolved oxygen 9-10 mg L^{-1}, pH 7.8-8.4 and salinity 17-18 ppt. Dissolved oxygen (DO) concentrations and temperature were measured by using WTW multi DO meter. The water flow through each tank was approximately 18 L h^{-1} for the duration of the experiment.

Grow-Out Performance Analysis

All fish from each tank sampled every 2 weeks to measure their weight. All fish were harvested at the end of culture period, counted, and measured individually for weight. Growth parameters such as specific growth rate [($\ln W_F$-$\ln W_I$) x 100/days], feed efficiency (wet weight gain x 100/dry weight feed offered), weight gain (wet weight gain x 100/initial weight), total protein intake (feed intake × protein in feed) $(100)^{-1}$, apparent net protein retention; 100 [(final BW × final protein in fish) – (initial BW x initial protein in fish) (total feed intake n^{-1}) × (protein in feed)$^{-1}$] and survival were calculated (Yıldırım *et al*., 2009).

Diet Analysis

Ingredients and feed samples were analyzed by Standard methods for moisture (oven drying at 105°C for 24 h), crude protein (N-Kjeldahl x 6.25), Lipid content was determined by 40-60°C petroleum ether extraction in a Soxhlet apparatus.

Body Composition Analysis

Before the onset of the experiment, samples of 12 fish were taken randomly for analysis of initial whole body composition. At the end of the experiments, 3 fish were taken from each tank for final whole body composition analysis.

Statistical Analysis

One-way ANOVA and the Tukey Honest Significant Difference test (Winer, 1962) were used to compare differences among photoperiod groups. The statistically difference were indicated at $P<0.05$. Results were indicated as means±SD. All statistical analyses were carried out by using the statistical software package, MINITAB, version 13.

Results

Water Quality

During the experiment, water temperature, pH and dissolved oxygen (DO) and salinity were within 13-18°C; 8-8.4; 9-10 mg L^{-1}, 17-18 ppt. These values were suitable for tolerances of trout culture (Molony, 2001).

Growth, Feed Utilization and Biochemical Composition

The results of photoperiod trial applied to the juvenile rainbow trout reared in sea water indicated were significantly affected by the different photoperiod regimes (Table 1, Table 2). Survival in all tanks was 100%. Final body weight, daily growth rate, relative growth rate (RGR%) and specific growth rate (SGR%) were significantly greater in group 24L:0D than group exposed to 18L:6D, 11L:13D and 6L:18D photoperiod regimes ($P<0.05$) (Figure 1). The 24 and 18 light hours produced the best daily growth rate, 2.16% and 1.96% respectively as well as relative growth rate (306.4% and 244%), specific growth rate (2.5% and 2.21%). The feed efficiency of juvenile trout were significantly retarded by reducing light phase to 6L:18D ($P<0.05$).

There were significant differences in body moisture, crude protein, crude fat and ash contents

Table 1. Effect of different light regimes on growth performance of Rainbow trout for 8 weeks*

	Initial BW (g fish^{-1})	Final BW (g fish^{-1})	Daily growth rate (%)	Relative growth rate (%)	Specific growth rate (%)
13L:11D	27.50±0.17	88.13±0.67^{a}	1.87±0.18^{a}	220.48±2.76^{a}	2.08±0.1^{a}
24L:0D	27.21±0.36	110.60±1.45^{b}	2.16±0.3^{b}	306.4±4.83^{b}	2.5±0.2^{b}
18L:6D	27.31±0.24	93.94±0.82^{c}	1.96±0.2^{c}	244.43±3.8^{c}	2.21±0.2^{c}
6L:18D	27.57±0.41	69.8±1.04^{d}	1.55±0.13^{d}	153.16±4.13^{d}	1.66±0.1^{d}

*Values are mean of three groups of trout with 15 trout per group.
Within a column, values with different superscripts are significantly different (P<0.05)

Table 2. Effect of the different photoperiod regimes on feed intake, total protein intake, protein retention, total N intake, ANPR and daily dry energy intake during the experiment

Groups	Feed/tank (g)	Feed Efficiency (%)	Total protein intake (g)	Protein retention/tank (%)	Total N intake (mg g^{-1})	N content in fish (%)	ANPR (%)	Daily dry energy intake (Kcal fish^{-1})
11L:13D	1033.33±28.87^{a}	0.88±0.02^{a}	485.67±6.78^{a}	31.5±0.99^{a}	80.71±2.6^{a}	2.82±0.04^{a}	32.89±1.58^{a}	24.14±0.65^{a}
24L:0D	1268.33±2.89^{b}	0.99±0.01^{b}	596.12±8.36^{b}	39.33±0.53^{b}	69.78±0.95^{b}	2.91±0.02^{b}	39.37±0.24^{b}	28.70±0.06^{b}
18L:6D	1066±14.43^{c}	0.94±0.03^{c}	501.33±13.57^{c}	37.12±0,59^{c}	71.14±1.13^{b}	2.74±0.02^{c}	35.72±0.47^{c}	23.39±0.33^{c}
6L:18D	766.67±2.89^{d}	0.83±0.01^{d}	360.33±7.36^{d}	28.68±0.39^{d}	83.29±1.15^{a}	2.63±0.16^{d}	28.75±0.24^{d}	17.35±0.06^{d}

Values are means±S.D. of three group of trout with 15 trout per group. Within a column, values with different superscripts are significantly different (P<0.05).

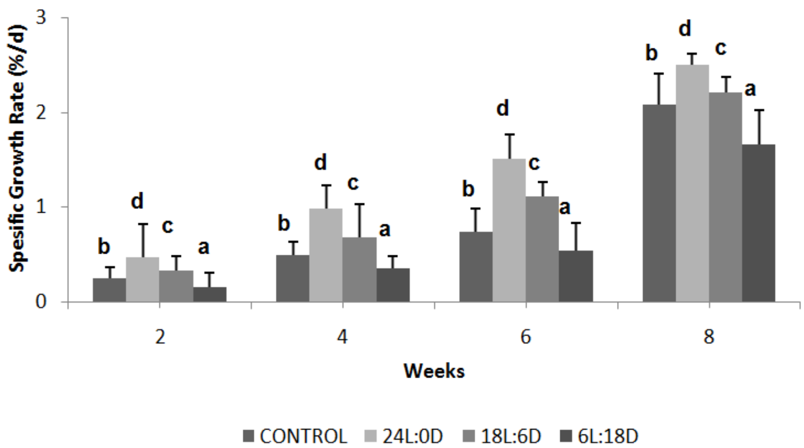

Figure 1. Specific growth rate (SGR) of juvenile rainbow trout exposed to Body weight of juvenile rainbow trout exposed to natural light (Control; 11L:13D), continuous light (24L:0D), extended light (18L:6D) and short light (6L:18D) during the experiment. Error bars represents SE. Different letters indicate groups that are significantly different within a sampling period.

among fish exposed to different photoperiod regimes (Table 3). Fish exposed to 24L:0D photoperiod regime had significantly lower moisture and ash than those of the other. Fish exposed to 6L:18D photoperiod regime had higher body ash but lower body protein and body fat compared to fish exposed to the 24L:0D and 6L:18D. According to the results, the levels of crude protein and fat were experienced as 18.2% and 8.8% in group 24L:0D while in other groups sequentially the results were obtained as 17.6% and 7.9% in group 18L: 6D, 17.1% and 7.24% in control group, and 16.4% and 7.3% in group 6L:18D (P<0.05).

The feed intake increased with extended of duration of light regime and significant differences (P<0.05) were found among groups. Final body weight, daily growth rate and relative growth rate of trout exposed different photoperiod regimes were presented in Table 1. Feed performance of rainbow trout exposed to different photoperiod regimes in the sea water were presented in Table 2. The total protein intake, protein retention and daily dry energy intake were the highest for trout exposed to 24:0D group than followed by 18L:6D group, control group and the lowest for trout exposed the 6L:18D.

Discussion

Juvenile rainbow trout subjected to the long light periods (24 and 18 h) had significantly better growth

Table 3. Effect of different light regime on the proximate composition (wet weight%) of Rainbow trout at the end of the photoperiod trial*. Each value is the mean (± s.d.) of three replicates

		Groups			
	Initial	11L:13D	24L:0D	18L:6D	6L:18D
Moisture	74.5±0.6	73±0.2^{b}	71±1.04^{a}	72.1±0.55^{ab}	73.1±0.4^{b}
Crude protein	16.53±0.4	17.1±0.1^{b}	18.2±0.1^{d}	17.6±0.24^{c}	16.4±0.1^{a}
Crude lipid	7.1±0.2	7.24±0.12^{a}	8.8±0.25^{c}	7.9±0.26^{b}	7.3±0.16^{a}
Ash	2.1±0.02	2.12±0.03^{c}	1.73±0.05^{a}	2.01±0.04^{b}	2.4±0.02^{d}

*

and feed utilization efficiency than those exposed to intermediate or short light periods (11 or 6 h). Similar results have been reported with several teleost fish, where the growth rates were improved with increasing light periods (Boeuf and Bail, 1999). The growth of seabream *Sparus aurata* (Tandler and Helps, 1985), salmonids (Endal *et al*., 2000; Porter *et al*., 1998) and rabbitfish *Siganus guttatus* (Duray and Kohno, 1988) were best under continuous light, while the growth of barramundi *Lates calcarifer* (Barlow *et al*., 1995) was better at 18 and 24 h light periods than at 12:12 h or shorter light periods.

It has been suggested that the continuous photoperiod improves growth only during the first three months after hatching on juvenile turbot, *Scophthalmus maximus* (Imsland *et al*., 1995). In another experiment took 18 months, it has been determined that turbot practiced extended photoperiod during the first winter pointed a more extended growth (Imsland *et al*., 1997). In another study produced for the purpose of encourage the growth of rainbow trout in sea water with extended photoperiod, it has been demonstrated that the trout 20L:4D showed a better growth performance and feed conversion rate (Turker, 2009). Our results showed a significant growth enhancing effect of exposure to 24L:0D and 18L:6D regimes in rainbow trout, *Oncorhynchus mykiss*. The data obtained from this experiment is consistent with that from other experiments on juvenile and adult salmons (Endal *et al*., 2000; Oppedal *et al*., 1997; Porter *et al*., 1999; Sigholt *et al*., 1997; Taranger *et al*., 1999).

It is presented that, significantly greater weight gains were observed for approximately 8 weeks after the onset of the experiment. These results suggest that growth is controlled by endogenous hormones (Taylor *et al*., 2005, 2006; Krakenes *et al*., 1991; Saunders and Harmon, 1988). As a result of photoperiod, the variable metabolic hormone activity of fish is one of the most important factors affect the growth performance of fish and feed intake (Taylor *et al*., 2001). Practices of short photoperiod on synchronizing an internal rhythm to the external environment for needing more energy, may lead to a drop of somatic fish growth (Biswas *et al*., 2002). If the fish is exposed to long photoperiod than short photoperiod cycles may provide higher energy conservation (Biswas *et al*., 2001)

In our results in the body weight of 24L:0D group being are significantly higher than other experimental groups. A similar overall increase in somatic growth has been seen in Atlantic salmon, *Salmo salar* (Porter *et al*., 1999). Exposure to long time photoperiods from the summer onwards has also been shown to enhance growth in salmon, *Salmo salar* (Saunders and Harmon, 1990). Continuous light treatment since the transfer to the seawater increases the growth rate of the underyearling salmons (Duncan *et al*., 1999; Oppedal *et al*., 1999). It has been found that 24L:0D light regime practiced during 8 weeks, encourage the growth rate on a sufficient level. In a similar way it has been seen that six week experiment of continuous light for delay rainbow trout spawning and mature time is adequate (Dustin and Bromage, 1998). Continuous light treatments for short terms are extremely important for energy productivity, both economic and practice (Endal *et al*., 2000).

Photoperiod cycles play in fish growth and metabolism. The present results revealed that photoperiods significantly affect the growth and feed intake of rainbow trout. In conclusion, a 24L:0D or 18L:6D regime is suggested for optimal growth performance and better feed efficiency of juvenile rainbow trout in sea water conditions.

References

Barlow, C.G., Pearce, M.G., Rodgers, L.J. and Clayton, P. 1995. Effects photoperiod on growth, survival and feeding periodicity of larval and juvenile barramundi *Lates calcarifer* (Bloch). Aquaculture, 138: 159-168.

Biswas, A.K., Endo, M. and Takeuchi, T. 2002. Effect of different photoperiod cycles on metabolic rate and energy loss of both fedand unfed young tilapia *Oreochromis niloticus*: Part I. Fish. Sci., 68:465–477.

Biswas, A.K. and Takeuchi, T. 2003. Effects of photoperiod and feeding interval on food intake and growth rate of Nile tilapia, *Oreochromis niloticus* L., Fish. Sci., 69: 1008–1014.

Biswas, A.K., Seoka, M., Tanaka, Y., Takii, K. and Kumai, H. 2006. Effect of photoperiod manipulation on the growth performance and stress response of juvenile red sea bream (*Pagrus major*). Aquaculture, 258: 350–356.

Boeuf, G. and Bail, P.Y. 1999. Does light have an influence on fish growth? Aquaculture, 177: 129-152.

Bonnet, E., Montfort, J., Eswuerre, D., Hogot, K., Fostier, A. and Bobe, J. 2007. Effect of photoperiod manipulation on rainbow trout (*Oncorhynchus mykiss*) egg quality: A genomic study. Aquaculture, 268: 13-22.

Duncan, N., Mitchell, D. and Bromage, N. 1999. Post-smolt growth and maturation of out-of-season 0+ Atlantic salmon (*Salmo salar*) reared under different photoperiods. Aquaculture, 177: 61-71.

Duray, M. and Kohno, H. 1988. Effects of continuous light on growth and survival of first-feeding larval rabbitfish, *Siganus guttatus*. Aquaculture, 72: 73-79.

Dustin, J. and Bromage, N. 1998. The entrainment role of photoperiod on hypoosmoregulatory and growth-related aspects of smolting in Atlantic salmon (*Salmo salar*). J. Comp. Physiol., 164: 259-268.

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

Hansen, T., Stefansson, S., Taranger, G.L., Norberg, B. 1999. Aquaculture in Norway. In: B. Norberg, O.S. Kjesbu, G.L. Taranger, E. Andersson and S.O. Stefansson, (Eds.), Proceedings of the 6th International Symposium on the Reproductive Physiology of Fish, 4-9 July 1999, University of Bergen, Bergen, Norway: 408-411.

Imsland, A.K., Folkvord, A.F. and Steffansson, S.O. 1995. Growth, oxygen consumption and activity of juvenile turbot (*Scophthalmus maximus* L.) reared under different temperatures and photoperiods. Neth. J. Sea Res., 34: 149-159.

Imsland, A.K, Folkvord, A.F., Jonsdottir, O.D.B. and Stefansson, S.O. 1997. Effects of exposure of extended photoperiods during the first winter on long-term growth and age at first maturity in turbot, (*Scophthalmus maximus*) (Rafinesque). Aquaculture, 178: 77–88.

Kråkenes, R., Hansen T., Stefansson S.O. and Taranger, G.L. 1991. Continuous light increases growth of Atlantic salmon (*Salmo salar*) postsmolts in seacages. Aquaculture, 95: 281–287.

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

Molony, B.W. 2001. Environmental requirements and tolerances of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) with special reference to Western Australia: a review. Department of Fisheries, Western Australia, Perth. Fish. Res. Rep., 130: 28 pp.

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

Oppedal, F., Taranger, G.L., Juell, J-E. and Hansen, T. 1999. Growth, osmoregulation and sexual maturation of underyearling Atlantic salmon smolt *Salmo salar* L. exposed to different intensities of continuous light in sea cages. Aquac. Res., 30(7): 491-499.

Porter, M.J.R., Randall, C.F., Bromage, N.R. and Thorpe, J.E. 1998. The role of melatonin and the pineal gland on the development and smoltification of Atlantic salmon (*Salmo salar*) parr. Aquaculture, 168: 139-155.

Porter, M.J.R., Duncan, N., Mitchell, D. and Bromage, N.R. 1999. The use of cage lighting to reduce plasma melatonin in Atlantic salmon (*Salmo salar*) and its effects on the inhibition of grilsing. Aquaculture, 176: 237-244

Porter, M.J.R., Duncan, N., Handeland, S.O., Stefansson, O. and Bromage, N.R. 2001. Temperature, light intensity and plasma melatonin levels in juvenile Atlantic salmon. J. Fish Biol., 58: 431-438.

Saunders, R.L. and Harmon, P.R. 1988. Extended day length increases postsmolt growth of Atlantic salmon. World Aquaculture, 19: 72-73.

Saunders, R.L. and Harmon, P.R. 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.

Sigholt, T., Erikson, U., Rustad, T., Johansen, S., Nordtvedt, T. and Seland, A. 1997. Handling stress and storage temperature affect meat quality of farmed-raised Atlantic salmon *Salmo salar*. Journal of Food Science, 62: 898-905

Simensen, L.M., Jonassen, T.M., Imsland, A.K. and Stefansson, S.O. 2000. Photoperiod regulation of growth of juvenile Atlantic halibut (*Hippoglossus hippoglossus* L.). Aquaculture, 190: 119-128.

Tandler, A. and Helps, S. 1985. The effects of photoperiod and water exchange rate on growth and survival of gilthead sea bream (*Sparus aurata*) from hatching to metamorphosis in mass rearing systems. Aquaculture, 48: 71-82.

Taranger, G.L., Daae, H., Jørgensen, K.O. and Hansen, T. 1995. Effects of continuous light on growth and sexual maturation in sea water reared Atlantic salmon, *Salmo salar* L. In: F.W. Goetz and P. Thomas, (Eds.), Proceedings of the 5th International Symposium on the Reproductive Physiology of Fish. Austin, TX. FishSymp 95, The University of Texas at Austin, Port Aransas, Texas, USA, 200 pp.

Taranger, G.L., Haux, C., Stefansson, S.O., Björnsson, W. and Hansen, T. 1998. Abrupt changes in photoperiod affect age at maturity, timing of ovulation and plasma testosterone and oestradiol 17β profiles in Atlantic salmon (*Salmo salar*). Aquaculture, 162: 85–98

Taranger, G.L., Haux, C., Hansen, T., Stefansson, S.O., Björnsson, W. and Kryvi, H. 1999. Mechanisms underlying photoperiod effects on age at sexual maturity in Atlantic salmon, *Salmo salar*. Aquaculture, 177: 47–60.

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

Turker, A. 2009. Effect of Photoperiod on growth of trout (*Oncorhynchus mykiss*) in cold ambient sea water. Bamidgeh, 61(1): 57-62.

Valenzuela, A.E., Silva, V.M. and Klempau, A.E. 2006. Qualitative and quantitative effects of constant light photoperiod on rainbow trout (*Oncorhynchus mykiss*) peripheral blood erythrocytes. Aquaculture, 251: 596-602.

Yıldırım, Ö., Ergün, S., Yaman, S. and Türker, A. 2009. Effects of two seaweeds (*Ulva lactuca* and *Enteromorpha linza*) as a feed additive in diets on growth performance, feed utilization, and body composition of rainbow trout (*Oncorhynchus mykiss*). Kafkas Univ. Vet. Fak. Derg., 15(3): 455-460.