EFFECTS OF PHOTOPERIODS ON THE GROWTH PERFORMANCE, FEED INTAKE AND FEED EFFICIENCY OF GILTHEAD SEA BREAM (*Sparus aurata*) JUVENILES

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ABSTRACT

In this study, gilthead sea bream (*Sparus aurata)* juveniles weighting 16.3 ± 0.3 g were reared at a density of 40 fish per 200-L fiberglass tanks for 42 days. The experimental treatments were four photoperiods (6L:6D, 12L:12D, 16L:8D and 24L:0D) with constant light intensity 1500 lx on the water surface. Growth performance, Feed intake, feed conversion efficiency (FCE) and survival rate were investigated. The fish were fed twice daily using a commercial diet containing 46% crude protein at a rate of 2.5 - 3% of body weight/day. The growth measurements were recorded at 15-day intervals during the experimental period. Significantly higher weight gain and specific growth rates were observed in fish exposed to a 24L:0D photoperiod followed by 16L:8D, 6L:6D and 12L:12D photoperiods ($P < 0.05$), respectively. Feed intake was significantly higher in fish exposed to 24L:0D followed by 16L:6D, 6L:8D and 12L:12D photoperiods ($P < 0.05$), respectively. The FCE was significantly higher for fish exposed to 24L:0D and 16L:8D than those exposed to 6L:6D and 12L:12D. The carcass contents of all treatments were unaffected ($P > 0.05$) by varying the photoperiod. These results demonstrated that growth performance, feed utilization and survival rate of gilthead sea bream (*Sparus aurata*) juveniles weighting 16.3 ±0.3 g can be stimulated significantly by using either a long (16L:8D) or continuous (24L:0D) photoperiod which could be carried out for rearing marine fish juveniles.

Keywords: Sea bream (Sparus aurata) – photoperiod – growth performance - Feed intake - feed efficiency.

INTRODUCTION

Determination of the optimal environmental conditions for larvae and juvenile fish is necessary to maximize the production in hatcheries (Hart *et al.*, 1996 and FAO, 2006). One of the most important physical parameters for the growth and survival of fish larvae is photoperiod (Chatain, 1994 and Battaglene, 1995). Many marine fish larvae are visual predators and therefore require light for efficient planktivory. However, optimal photoperiod for larval development, growth and survival may differ, and also change with larval ontogeny (Fielder *et al.,* 2002).

Fish growth is influenced by several biotic and abiotic factors. The photoperiod is classified as a directive factor (Ginés *et al.,* 2004) stimulating the endocrine system; for example, it is known to influence circulating growth hormone (McCormick *et al.*, 1995 and Björnsson, 1997). Photoperiod manipulation has been used successfully to improve the growth of juvenile and larval stages of a number of fish species. A long photoperiod can stimulate growth efficiency in different species (Silva-García, 1996; Boeuf and Le Bail, 1999; Kissil *et al.*, 2001; Ginés *et al.*, 2003; Trippel and Neil, 2003 and Biswas *et al.,* 2006). On the other hand, continuous light can enhance the juvenile growth of Black sea turbot (*Psetta maeotica*) (Turker *et al.*, 2005) and Tambaqui fish (Aride *et al.*, 2006). However, contradictory findings have been demonstrated in some species. In halibut *Hippoglossus hippoglossus*, Hallaråker *et al.* (1995) found no significant differences between the natural photoperiod and a continuous light regime, whereas Jonassen *et al.* (2000) and Simensen *et al.* (2000) observed that continuous light could be used to improve growth in juvenile halibut when reared from 30 to 170 g. Recently, Biswas *et al.* (2005 and 2006) demonstrated that growth performance can be enhanced in juvenile red sea bream reared from 20 to 100 g body weight. However, there is no information on the effect of photoperiod manipulation on the growth performance of juvenile red sea bream from 1 to 30 g. In order to establish a light regime giving optimal fish growth for a complete production cycle, the effect of photoperiod manipulation should be investigated on different sizes of fish.

Previous experiments on gilthead sea bream *Sparus aurata* L. have demonstrated the positive effects of photoperiod on cultivation of larvae by enhancing prey detection in this visual predator (Flos *et al.*, 2002 and Huidobro and Tejada, 2004). Therefore, the objectives of this study were to investigate the effect of photoperiod on the growth, feed intake, feed conversion efficiency and survival of gilthead sea bream juveniles reared in fiberglass tanks (200-L) for 42 days.

MATERIALS AND METHODS

Experimental fish: Gilthead sea bream (*Sparus aurata*) juveniles weighting 12-14 g were obtained from a local commercial farm (Al-Wafaa farm, Ismailia, Egypt) and transported to an indoor system at the same farm. Six hundred fish were randomly distributed into two cylindrical fiberglass tanks with a capacity of 300-L, and acclimated to the experimental conditions (for 2 weeks prior to the start of the study).

Water quality: The photoperiod in all tanks was set at 12 h light: 12 h dark (12L:12D) during the first week of acclimation. Each tank was continuously supplied with seawater filtered by 80 µm sand filter at a flow rate of approximately 4 L/ min (Biswas *et al.*, 2006). Throughout the 42-day experimental period, the rearing water in each tank was permanently saturated with oxygen by supplying air continuously through air-stones from an air-blower. The dissolved oxygen and pH were 6.2-7.3 mg/L and 6.5-8, respectively. Average water temperature ranged from 25°C to 27.5°C. Average salinity was 32 ppt.

Experimental diet: The fish were fed with a commercial diet of 46% crude protein (according to NRC, 1993), produced by the Sinai shrimps 21 Company, Port Said (Table1). The pellets (3mm) were offered by hand to fish twice daily at 9 am and 6 pm (Eroldogan *et al.*, 2008) at a rate of 2.5 - 3% BW/day (Sahin *et al.*, 1999).

The diet was stored at (4°C) during the experimental duration to avoid the nutrients deterioration.

The ingredients composition and proximate analysis of this feed are provided in Table (1).

Table (1): Ingredients composition and proximate analysis of the diet offered to gilthead sea bream in this experiment.

Ingredients	% dry weight
Fish meal[a]	59.9
Soluble fish protein concentrate[b]	1.0
Cod liver oil	5.8
Gelatinized starch[c]	29.8
Vitamin premix[d]	1.0
Mineral premix[e]	1.0
Choline chloride (50%)	0.5
Lignin sulphate	1.0
proximate analysis	
Dry matter	95.5
Crude protein	46
Crude fat	11.7
Crude fiber	4.3
Nitrogen free extract (NFE)	29.6
Crude Ash	8.4

a- Triple Nine, Denmark (CP: 78.6% DM; GL: 9.8% DM).
b- Sopropêche G, France (CP: 72.7% DM; GL: 18.0% DM).
c- C-Gel Instant-12016, Cerestar, Mechelen, Belgium.
d- Vitamins (mg kg−1 diet): retinol, 18,000 (IU kg−1 diet); calciferol, 2000 (IU kg−1 diet); alpha tocopherol, 35; menadion sodium bis., 10; thiamin, 15; riboflavin, 25; Ca pantothenate, 50; nicotinic acid, 200; pyridoxine, 5; folic acid, 10; cyanocobalamin, 0.02; biotin, 1.5; ascorbyl monophosphate, 50; inositol, 400 (Pfizer).
e- Minerals (mg kg−1 diet): cobalt sulphate, 1.91; copper sulphate, 19.6; iron sulphate, 200; sodium fluoride, 2.21; potassium iodide, 0.78; magnesium oxide, 830; manganese oxide, 26; sodium selenite, 0.66; zinc oxide, 37.5; potassium chloride, 1.15 (g kg−1 diet); sodium chloride, 0.40 (g kg−1 diet); dibasic calcium phosphate, 5.9 (g kg−1 diet) (Pfizer).

The photoperiod regime: The fish were exposed to the test photoperiods, where they were acclimated for another week before commencement of the rearing trial. Four different light regimes were established with three replicates for each treatment (light: dark, L:D): (6L: 6D followed by 6L: 6D, 12L: 12D, 16L: 8D and 24L: 0D), using fluorescent lamps. Photoperiods were controlled by a 24-h timer (Multi 9, Merlingerin, Germany) (El-Sayed and Kawann, 2004). Light intensity was kept constant at 1500 lx on the water surface throughout the study. After conditioning for three weeks, the fish were starved for 24 h and the body weight was measured. The stocking density was reduced to 40 fish per tank. The initial mean body weight was approximately 16.3±0.3g and the experimental period lasted 6 weeks (from 20th June 2008 to 2th August 2008). The growth measurements were recorded at 15-day intervals during the experimental period.

At the end of the experiment, twenty fish in each tank were sampled randomly and frozen at − 20° C for whole body proximate analysis.

Chemical analyses:

The diet and the fish in all treatments were analyzed for protein, fat, ash and moisture contents by standard methods (A.O.A.C., 1990).

Parameters used:

The parameters used were the weight gain (WG), specific growth rate (SGR), feed conversion efficiency (FCE) and survival rate using the following formulae:

Weight gain (g)

$WG = W1 - W0$

Specific growth rate (%/d)

SGR = 100 (lnW1 – lnW0) / t **(According to De- Silva and Anderson, 1995)**

Feed conversion efficiency (%)

FCE = 100 × [wet weight gain (g) / dry feed intake (g)]

(According to De- Silva and Anderson, 1995)

Survival rate (%)

= Ni × 100 / N0 **(According to Harrell *et al.*, 1990)**

Where:

W1= Final wet weight (g)
W0= Initial wet weight (g)
T = Time interval in days
Ni = Number of fish at the end
N0= Number of fish initially stocked

Statistical analysis:

The data obtained in this study were analyzed by one-way ANOVA procedure of statistical analysis system (SAS, 1988). Means were compared by Duncan's new multiple range test (Zar, 1996).

RESULTS AND DISCUSSION

The growth performance, Feed intake and feed conversion efficiency of gilthead sea bream are presented in Table 2. The final body weights showed significant ($P < 0.05$) differences among the treatments, where the highest values were (56.22± 1.8, 50.40± 2.1, 46.21± 1.9 and 42.66± 1.5) in fish exposed to 24L:0D followed by 16L:8D, 6L:6D and 12L:12D photoperiods, respectively. Similar trends were also observed in total weight gain and SGR among the treatments. The fish reared under a 24L:0D photoperiod showed the highest total weight gain and SGR followed by 16L:8D, 6L:6D and 12L:12D photoperiods (Table 2). In this study, the positive effect of long (16L:8D) and continuous (24L:0D) photoperiods on growth performances of gilthead sea bream is similar to the results observed on the same species, where long and constant photoperiods of both 16 hr of light (16L:8D) and continuous light (24L:0D) have improved growth (Kissil *et al.*, 2001 , Ginés *et al.*, 2004 and Biswas *et al.*, 2005). In young specimens (from 25 g to around 200 g) long and constant photoperiods have improved sea bream growth (Silva-Garcia, 1996 and Gines *et al.*, 2004).

From the data in Table (2), feed intake differed significantly among the treatments and the highest value was in fish at the 24L:0D group followed by

16L:8D, 6L:6D and 12L:12D photoperiods . During this experiment, the feed intake was greater under long (16L:8D) and continuous (24L:0D) photoperiods in comparison to those obtained in several fish studies such as red sea bream, *Pagrus major* (Biswas *et al.*, 2005 & 2006); largemouth bass, *Micropterus salmoides* (Petit *et al.*, 2003); Atlantic salmon, *S. salar* (Berrill *et al.*, 2003); halibut, *H. hippoglossus* (Jonassen *et al.*, 2000) and Snapper *Pagrus auratus* (Fielder *et al.*, 2002). The higher feed intake may be due to diurnal fishes are more active under long or continuous photoperiods, and having a greater foraging activity when Feed is delivered, or be related to hormonal stimulation of appetite under a long or continuous photoperiod. For example, growth hormone, known to have a positive effect on appetite, increased with increasing day length during smoltification in salmon (McCormick *et al.*, 1995 and Björnsson, 1997).

Table (2): Growth performance of juvenile gilthead sea bream *Sparus aurata* exposed to different photoperiods (mean ± s.d.)

Parameters	Photoperiods			
	6L:6D	12L:12D	16L:8D	24L:0D
Initial body weight (g)	16.3±0.1	16.2±0.4	16.0±0.2	16.1±0.3
Final body weight (g)	46.21±1.9^{c}	42.66±1.5^{d}	50.4±2.1^{b}	56.22±1.8^{a}
Weight gain (g)	29.9^{c}	26.2^{d}	34.4^{b}	40.1^{a}
SGR (%/d)	2.48±0.03^{c}	2.29±0.05^{d}	2.74±0.02^{b}	2.98±0.07^{a}
Total feed intake (g/fish)	31.8^{c}	28.6^{d}	36.2^{b}	42.3^{a}
FCE (%)	94.0±0.8^{b}	91.6±0.7^{b}	95.0±0.5^{a}	94.8±0.4^{a}
Survival rate (%)	97.5±1.5	95.5±1.4	100±0.0	100±0.0

Values in a row with different letters are significantly different ($P < 0.05$).

Survival rate (%) ranged between 100 and 95.5% for all treatments (Table 2). The average data indicated that the highest rate of survival was recorded with 24L : 0D and 16L : 8D photoperiods while the lowest was recorded with 12L :12D. However, there were differences in the rate of survival among treatments.

The data confirm that there was no significant difference in the FCE between fish exposed to 24L:0D and 16L:8D photoperiods (94.9± 0.4 and 95.1± 0.5). Also, the difference was not significant between fish exposed to 12L : 12D and 6L : 6D photoperiods. But the FCE of 24L: 0D and 16L: 8D was significantly higher than in the 12L: 12D and 6L: 6D photoperiods. The faster growth of red sea bream exposed to a long or continuous photoperiod was accompanied not only by greater feed intake but also by significantly higher FCE ($P < 0.05$) (Biswas *et al.*, 2005). The significantly higher feed intake and FCE in fish exposed to 16L:8D and 24L:0D photoperiods may be because the feeding strategy in fish exposed to these photoperiods reflected most closely the times of maximum appetite (Biswas *et al.*, 2005). The time of feeding has also been reported to affect feed intake and growth performance in sea bream (Ogata *et al.*, 2002; Ginés *et al.*, 2003 and Biswas *et al.*, 2006), goldfish (Trippel and Neil, 2003), rainbow trout (Boujard *et al.*, 1995), Atlantic salmon (Cook *et al.*, 2000) and tilapia (Biswas and Takeuchi, 2003 and El-Sayed and Kawanna, 2004). Silva-Garcia (1996) reported increased growth in immature gilthead sea bream (25-219 g) under long photoperiods. This author observed similar values between 16L:8D and 24L:0D treatments. Azzaydi *et al.* (1999) also demonstrated that improved growth and feed efficiency are achievable if the quantity of feed supplied is modulated in accordance with the time of maximum appetite. The finding that higher growth accompanied with both higher feed intake and FCE under long and continuous photoperiods parallels the findings in other fish studies, such as red sea bream, *Pagrus major* (Biswas *et al.*, 2005 & 2006); largemouth bass, *M. salmoides* (Petit *et al.*, 2003) and haddock, *Melanogrammus aeglefinus* (Trippel and Neil, 2003). On the other hand, Boeuf and Le Bail (1999) noted that growth might be influenced by light through better feed conversion efficiency and not just stimulated feed intake. However, the finding that higher growth accompanied with both higher feed intake and FCE contrasts the findings by Ogata *et al.* (2002).

Whole body composition data are presented in (Table 3), in general, the values were within the normal ranges of other studies on the same species. Similar results were obtained by Biswas *et al.* (2005). They stated that photoperiod has no significant effects on the protein and lipid contents in the meat of sea bream. In previous photoperiod experiments using gilthead sea bream, Eroldogan *et al.* (2008) did not find variation in body composition.

Table (3): Chemical composition of sea bream (*Sparus aurata*) exposed to different photoperiod regimes for 42 days (% dry matter basis).

Photoperiod	Dry matter	Crude protein	Ether extract	Crude ash
6L:6D	29.4	68.02	21.42	9.18
12L:12D	29.8	68.12	21.81	8.72
16L:8D	29.5	69.49	22.37	7.79
24L:0D	29.7	70.03	21.21	7.41

*Values reported are the mean of four replicates.

CONCLUSION

These results demonstrated that growth performance, feed utilization and survival rate of gilthead sea bream (Sparus aurata) juveniles weighting 16.3±0.3g can be stimulated significantly by using either a long (16L:8D) or continuous (24L:0D) photoperiod which could be carried out for rearing marine fish juveniles.

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تأثير فترات الإضاءة على أداء النمو و الغذاء المأكول و كفـــاءة تحويـــل الغـــذاء للطور اليافع لاسماك الدنيس٠

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فى هذه الدراسة - تم رعاية الأطوار اليافعة لأسماك الدنيس بمتوسط وزن١٦٫٣ ±٣٫جم فى تنكات من الفيبرجلاس (٢٠٠ لتر ماء) بكثافة تخزينية ٤٠ سمكة لكل تنك لمدة ٤٢ يوم على أربع فترات إضاءة مختلفة (٦ ساعات اضاءة: ٦ ساعات اظلام وتكرر ٦ ساعات إضاءة : ٦ ساعات إظلام، ١٢ ساعه اضاءة: ١٢ ساعه إظلام، ١٦ ساعة إضاءة: ٨ ساعات إظلام و٢٤ ساعه اضاءة: عدم وجود اظلام) ٠ وكانت كثافة الضوء ثابتة (١٥٠٠ لوكس) على سطح الماء وذلك لتقدير أداء النمو، الغذاء المأكول، كفاءة تحويل الغذاء ومعدل البقاء٠ تم تغذية الأسماك مرتين يوميا على عليقة تجارية تحتوى على ٤٦٪ بروتين وبمعدل ٢٫٥ - ٣ ٪ من وزن الجسم يوميا٠ تم تقدير قياسات النمو المختلفة كل ١٥ يوم خلال فترة التجربة ٠ لوضحت النتائج وجود اختلافات معنوية عالية لكل من الوزن المكتسب ومعدل النمو النوعى فى الأسماك المعرضة ل ٢٤ ساعة اضاءة ، ثم ١٦ ساعة إضاءة، ثم يليها ٦ ساعات إضاءة، ثم ١٢ساعة إضاءة ($P < 0.05$)٠لوحظ اختلافات معنوية عالية للغذاء المأكول فى الاسماك المعرضة ل ٢٤ ساعة اضاءة ثم ١٦ ساعة إضاءة يليها ٦ ساعات إضاءة ثم ١٢ ساعة إضاءة ($P < 0.05$)٠ كانت كفاءة تحويل الغذاء أعلى معنويا للأسماك المعرضة ل٢٤ ساعة ضوء والمعرضة ل ١٦ ساعة ضوء مقارنة بالأسماك المعرضة ل ١٢ ساعة ضوء والمعرضة ل ٦ ساعات ضوء٠ كانت مكونات الجسم لكل المعاملات لم تتغير أو تتأثر معنويا بتغيير فترة الاضاءة.

وقد خلصت النتائج إلى ان أفضل أداء لنمو الطور اليافع لأسماك الدنيس يكون تحت نظام ٢٤ ساعه اضاءة :عدم وجود إظلام وأيضا ١٦ ساعة اضاءة : ٨ ساعات إظلام، وهذا يرجع الى تحسن فى الغذاء المأكول، ارتفاع كفاءة تحويل الغذاء ومعدل البقاء - لهذا يوصى بتطبيق ذلك لرعاية الطور اليافع لأسماك المياه المالحة٠