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Effect of photoperiod manipulation on the growth performance and stress response of juvenile red sea bream (*Pagrus major*)

Amal K. Biswas [a,*], Manabu Seoka [a], Yoshimasa Tanaka [b], Kenji Takii [a], Hidemi Kumai [a]

[a] *Fisheries Laboratory, Kinki University, Uragami, Nachikatsuura, Wakayama 649-5145, Japan*
[b] *Kansai Electric Power Co. Inc., Nakanoshima 3-6-16, Kita-ku, Osaka 530-8270, Japan*

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Abstract

Juvenile of red sea bream (*Pagrus major*, body weight 1~30 g) were reared under four photoperiods (6L:6D, 12L:12D, 16L:8D and 24L:0D) with constant light intensity 1500 lx on the water surface to investigate their growth performance and stress response. Fish were fed a commercial diet to apparent satiation for 8 weeks of the experiment. Significantly higher weight gain and specific growth rates (SGR) were observed in fish exposed to a 24L:0D photoperiod followed by 16L:8D, 6L:6D and 12L:12D photoperiods ($P<0.05$). Food intake was significantly higher in fish exposed to 24L:0D followed by 6L:6D, 16L:8D and 12L:12D photoperiods ($P<0.05$). There was no significant difference in the feed conversion efficiency (FCE) between fish exposed to 24L:0D and 16L:8D photoperiods, but the FCE in both photoperiods was significantly higher than that of 6L:6D and 12L:12D photoperiods. There were no significant differences in hematocrit levels and plasma levels of cortisol and glucose among the treatments at the end of experiment. The results demonstrated that the growth performance of juvenile red sea bream reared from 1 to 30 g can be stimulated significantly by using a continuous (24L:0D) photoperiod without any measurable significant stress response in fish.

Keywords: Photoperiod; Juvenile *Pagrus major*; Growth; Food intake; Feed conversion efficiency; Stress response

1. Introduction

Photoperiod manipulation has been used successfully to improve the juvenile growth of some finfish species (Kadmon et al., 1985; Saunders et al., 1985; Folkvord and Otterå, 1993; Barlow et al., 1995; Imsland et al., 1995; Silva-García, 1996; Simensen et al., 2000; Petit et al., 2003; Biswas and Takeuchi, 2003); however, for other species, juvenile growth was not enhanced by photoperiod manipulation (Fuchs, 1978; Purchase et al., 2000). The effect of photoperiod manipulation on the growth performance even varies depending on the developmental stages of fish. In halibut *Hippoglossus hippoglossus*, Hallaråker et al. (1995) found no effect of photoperiod manipulation when rearing fish from 5 to 20 g, whereas 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) demonstrated that growth performance can be enhanced in juvenile red sea bream reared

* Corresponding author. Tel.: +81 735 58 0116; fax: +81 735 58 1246.
E-mail address: ns_akb@nara.kindai.ac.jp (A.K. Biswas).

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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 in different sized fish.

Environmental disturbances are generally regarded as potential sources of stress (Donaldson, 1981; Barton, 1997). Although photoperiod changes reportedly influence steroids and corticosteroids hormone levels and diel activity, stress (any threat to or disturbance of homeostasis) is not an apparent consequence (Pickering and Pottinger, 1983; Audet et al., 1986; Biswas et al., 2004). Leonardi and Klempau (2003), however, demonstrated that artificial photoperiod induced a significant stress response in rainbow trout *Oncorhynchus mykiss* (Walbaum) with plasma cortisol levels remaining high for at least 2 months after terminating the photoperiod regime; however, in red sea bream reared from 20 to 100 g, Biswas et al. (2006) demonstrated that photoperiod manipulation did not cause significant acute or chronic stress response. There is no information on the stress responses in juvenile red sea bream reared from 1 to 30 g exposed to different photoperiods.

Therefore, the objectives of this study were i) to investigate whether photoperiod manipulation can be used to enhance the growth performance in juvenile red sea bream reared from 1 to 30 g and ii) to investigate whether, or which, artificial photoperiod cause stress response in juvenile red sea bream. This paper is one of a series of studies to establish a light regime giving optimal fish growth for a complete production cycle of red sea bream *Pagrus major*, which is one of the most important fish in Japan because of its multipurpose uses as 'sashimi', 'sushi' or presented in ceremonies such as weddings, where it is seasoned with salt and grilled.

2. Materials and Methods

2.1. Experimental design

Juvenile red sea bream (body weight 0.2–0.5 g) of the selected strain (Murata et al., 1996) were obtained from the Fish Nursery Center of Kinki University, Uragami, Japan. Six hundred fish were randomly distributed into two 300-l tanks and acclimated to the new rearing environment. The photoperiod in all tanks was set at 12 h light:12 h dark (12L:12D) during the acclimation period. The tanks were supplied with filtered seawater and the rearing tank was aerated to maintain the oxygen level near 100% saturation. The water flow was 4 L min^{-1} and the temperature was maintained at 21 ± 1 °C throughout the study. Fish were fed to apparent satiation with a commercial diet (protein 47.7%, lipid 10.7%, Marubeni Nisshin Feed Co. Ltd., Tokyo, Japan), twice daily during the light phase.

After conditioning for three weeks, fish were starved for 24 h and their standard body length and total body weight was measured. The fish were then exposed to the test photoperiods at a density of forty fish in each of three replicates (200 L) for each treatment. The initial mean body weight was approximately 1.4 g. The water flow, temperature and dissolve oxygen levels were maintained as were in conditioning period. Four different light regimes were established: i) 6 h light:6 h dark (6L:6D), ii) 12L:12D, iii) 16 h light:8 h dark (16L:8D), and iv) continuous light (24L:0D). A 12-h cycle (6L:6D) was selected because higher growth performance was observed in other species (Biswas and Takeuchi, 2003). A programmed time controller (Matsushita Electric Works Ltd., Osaka, Japan) was used to maintain the periods of light and dark, including dimming over 30 min periods. The three tanks in each treatment were illuminated with one 40 W fluorescent tube suspended 45 cm above the water surface. Light intensity was maintained at 1500 lx on the water surface during light phase and 0 lx during dark phase throughout the experiment. Each set of three replicates was isolated from the other set and from stray light by shielding with an opaque partition. Sixty fish were stored at −80 °C as an initial sample for proximate analysis. Fish were fed a commercial diet to apparent satiation according to the feeding schedule given elsewhere (Biswas et al., 2005) for 8 weeks. Individual body length and weight were taken at the start, at the 3rd and 6th week, and at the end of the trial. Fish were deprived of food for 24 h before each weighing and anesthetized with 100 ppm 2-phenoxyethanol (Wako Pure Chemical Industries Ltd. Osaka, Japan). All possible care was taken to ensure that the fish in each treatment had equal starvation periods before weighing. After length–weight measurement at the end of the experiment, twenty fish were sampled randomly from each tank and frozen at −80 °C for whole body proximate analysis. Five fish from each of the three replicate tanks for all treatments were dissected to measure the wet weight of visceral organs and associated fat tissue, and wet weight of liver.

An initial blood sample could not be collected as the fish were too small. At the end, approximately 1 ml of blood was collected from the caudal vein of each fish using a heparinized syringe equipped with a 25 G needle. The blood was put in 1 ml tube and maintained on ice until centrifugation. This protocol was repeated