Continuous photoperiod can be used to get higher growth performance in juvenile red sea bream (*Pagrus major*)

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This report is one of a series of articles devoted to establishing a light regime that will promote optimal growth for a complete production cycle of red sea bream, *Pagrus major* (Figure 1). This 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. There is a growing concern as to how the production of this commercially important fish can be enhanced. Photoperiod manipulation has proven to be a more economic way of stimulating growth performance in this species without adverse affecting its physiology when reared from 1 to 30 g (Biswas *et al*. 2006a,b; Biswas *et al*. in press), and has also been effective when used with other species (Boeuf and Le Bail 1999). This article shows a positive effect of photoperiod manipulation on the growth performance of red sea bream without a stress response when reared from 20 to 100g.

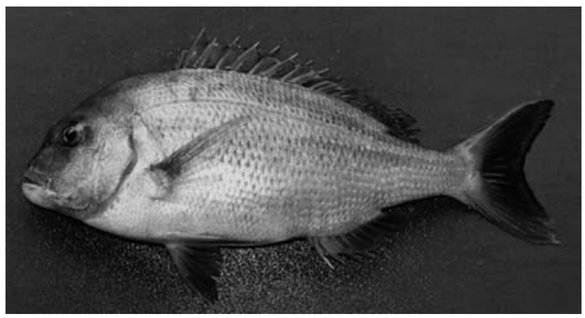

*Fig. 1. Red sea bream (*Pagrus major*)*

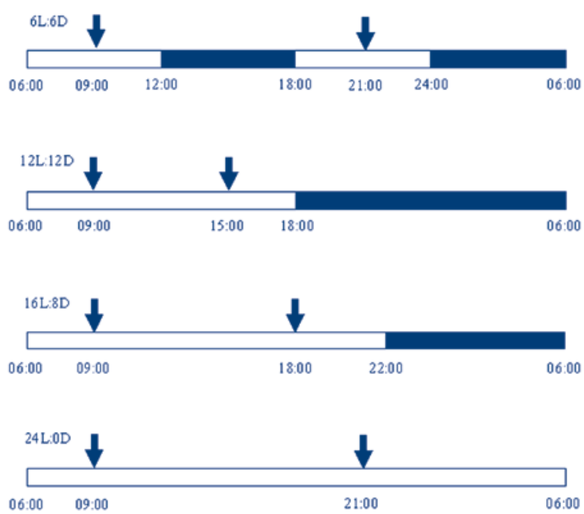

Fig. 2. Feeding schedule in different photoperiods. Arrow indicates the time of feeding and the black bar shows the dark phase of the photoperiod.

Photoperiod Design

Four different light regimes were established (Figure): 6 h light:6 h dark (6L:6D), 12 h light:12 h dark (12L:12D), 16 h light:8 h dark (16L:8D) and continuous light (24L:0D).

A programmed time controller[3] was used to maintain the periods of light and dark, including dimming over 30 minute periods. 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 lux on the water surface throughout the experiment. Each set of three replicates was isolated from the other set and from stray light by shielding with an opaque partition.

Fish and Experimental Design

Juvenile red sea bream (body weight 10-30 g) of the Kinki University strain (Taniguchi *et al.* 1995, Murata *et al.* 1996) were obtained from the Fish Nursery Center of Kinki University, Uragami, Japan and acclimated to the new rearing environment. During the acclimation period, photoperiod in all tanks was set at 12L:12D. The tanks were supplied with filtered seawater and aerated to maintain the oxygen level near saturation. The water flow was 5 L/min and the temperature was maintained at 21±1°C throughout the rearing period. After conditioning for one week the fish were exposed to the test photoperiods at a density of 32 fish in each of three replicates (200 L) for each treatment. The initial mean body weight was approximately 20 g. Fish were fed a commercial diet to apparent satiation for eight weeks according to the feeding schedule presented in Figure 2. Individual body length and weight were taken at the end of the trial to calculate the growth performance. Blood samples were also taken to investigate the levels of stress indicators in the plasma.

To investigate the effect of photoperiod manipulation on the digestive performance of red sea bream, fish were reared for another three weeks and fed a diet containing 0.5 pecent chromic oxide (Cr_2O_3) using to the feeding schedule in Figure 2.

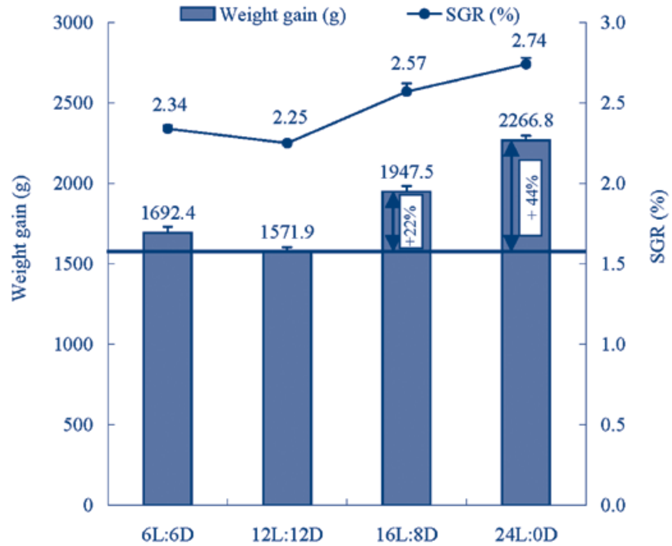

Fig. 3. Variation in weight gain and specific growth rate (SGR) among photoperiods. [SGR (percent) = 100 × (lnW_2-lnW_1)/time (days), where, W_1 and W_2 indicate the initial and final weight (g), respectively].

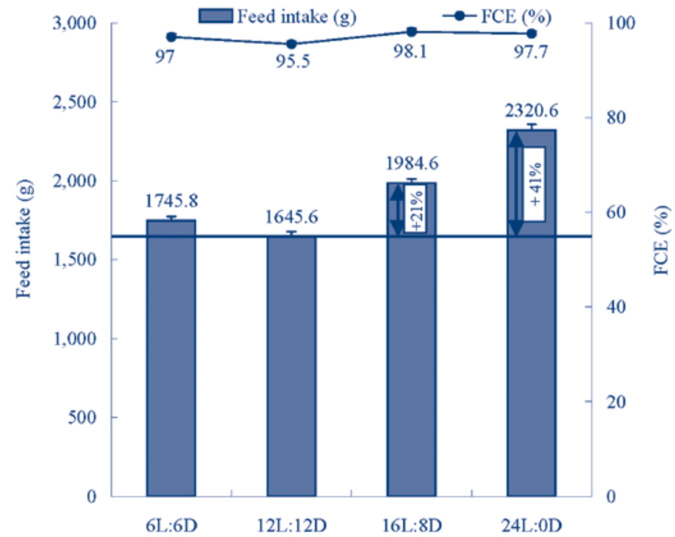

Fig. 4. Variation in feed intake and feed conversion efficiency (FCE) among photoperiods. [FCE (percent) = 100 × {wet weight gain (g) / dry feed intake (g)}].

Before fecal collection, all possible care was taken during feeding so that no uneaten feed settled to the tank bottom. The fecal collectors were removed from the tanks and the tanks were thoroughly cleaned 30 min after feeding. After collection, fecal samples were freeze-dried and analyzed to estimate the digestibility of protein, lipid and energy.

Table 1. Apparent digestibility coefficient (ADC) of protein, lipid and energy in fish exposed to different photoperiods.

ADC (%)[1]	6L:6D	12L:12D	16L:8D	24L:8D
Protein	94.6	94.4	96.2	95.4
Lipid	91.5	91.5	93.6	93.5
Energy	87.2	86.3	87.1	88.2

[1]ADC of nutrients or energy (%) = 100 × [1 – {(dietary Cr_2O_3 / fecal Cr_2O_3) × (fecal nutrient or energy / dietary nutrient or energy)}]

Results and Discussion

Red sea bream exposed to a 24L:0D photoperiod showed the highest total weight gain and specific growth rate [SGR (percent) = 100 × (lnW_2-lnW_1)/time (days), where, W_1 and W_2 indicate the initial and final weight (g)] compared with fish exposed to other photoperiods (Figure 3). Weight gain in fish exposed to 24L:0D was 44.4 percent higher than that of fish exposed to 12L:12D. Similarly, feed intake in fish reared under 24L:0D photoperiod was 41.0 percent higher than those reared under 12L:12D (Figure 4). Feed conversion efficiency [FCE (percent) = 100 × {wet weight gain (g) / dry feed intake (g)], was higher in fish exposed to 24L:0D and 16L:8D (Figure 4). The higher food intake in continuous photoperiod is a result of diurnal fishes being more active under continuous photoperiods and having greater foraging activity when food is delivered. It is also related to a positive effect of growth hormone on appetite (Johnsson and Björnsson 1994). Feeding time is also one of the important factors causing variation in feed intake among the treatments.

It is generally assumed that the fish take more feed when the feeding time coincides with the time of maximum appetite. Therefore, the remarkable higher food intake and FCE in 24L:0D suggested that the feeding strategy in fish exposed to that photoperiod reflected most closely the times of maximum appetite.

The digestibility of protein, lipid and energy was higher in fish exposed to 16L:8D and 24L:0D (Table 1). This was the result of a longer time interval between feeding times in fish exposed to 16L:8D and 24L:0D that have allowed the most efficient digestive process. This might have improved digestion and retention efficiency in both treatments. This resulted in a significantly higher FCE in fish exposed to 16L:8D and 24L:0D.

These results suggest that growth was influenced by photoperiod through better food conversion efficiency and not just through stimulated food intake (Boeuf and LeBail 1999). The lower growth performance in 6L:6D, in spite of a longer time interval between feeding times, may be attributed to the dissipation of energy for other purposes.

In the aquaculture industry, fish stress, which is simply defined as any threat to or disturbance of homeostasis, is a growing concern inasmuch as it has caused reduced growth rate, disease resistance and food intake and increased mortality. Therefore, although higher growth performance was observed in fish reared under 24L:0D photoperiod, it would be premature to propose that photoperiod as optimal for rearing fish without careful analysis of how it photoperiod affects stress level. To clarify whether or not 24L:0D caused

Table 2. Comparison of different stress indicators in fish exposed to different photoperiods with levels observed in stressed fish

Parameters	Control values	Stressed values[1]	Values from different photoperiods 6L:6D	12L:12D	16L:8D	24L:0D
Cortisol (ng/mL)	6.7	190.1	7.7	7.1	7.4	7.7
Glucose (mg/100 mL)	69.2	109.5	76.4	73.6	70.8	72.9
Protein (g/100 mL)	3.8	3.0	4.8	4.3	4.6	4.3
Cholesterol (mg/100 mL)	237	180	246	244	238	248

[1]*Biswas et al. (2006a)*

stress, a number of stress indicators were investigated. The results are summarized in Table 2, where the values of different stress indicators observed in this study are compared with stress-induced levels (Biswas *et al.* 2006a).

The results demonstrate that the levels of different stress indicators in fish exposed to the 24L:0D were far lower than the stress-induced levels. Although stress has been demonstrated to reduce food intake and growth rate in different fish, red sea bream exposed to 24L:0D showed neither a decreased growth rate nor reduced food intake compared to those exposed to 12L:12D. Therefore, photoperiod manipulation did not cause a noticeable stress response in red sea bream when reared under different artificial photoperiods.

In growout farms, photoperiod manipulation can be used to hasten growth rate and has been practiced in many countries in recent years. The main concern is how the different photoperiods could be controlled in outdoor farms. Some possible ways were discussed by Bromage *et al.* (2001). Generally, this involved the installation of light-proof covers over culture units and the provision of artificial lighting controlled by automatic time clocks. The heavy-duty polythene or butyl linings are suspended over a simple metal, plastic pipe or wooden framework providing a cheap and effective method of blacking-out the desired areas. Tungsten or fluorescent sources of illumination can be used, preferably with a spectrum as close as possible to that of natural light. The lights should provide intensities of at least 100 lux at the water surface in all areas of the enclosures. Intensities less than 20 lux should be avoided inasmuch as they may lead to inconsistent results. To reduce stress from abrupt changes in light at the switch-on and switch-off times, fluorescent lights may require a second system of less bright lights to be installed, which are switched on shortly before and after the main system and, hence, provide the necessary twilight periods.

In conclusion, the growth performance of juvenile red sea bream reared from 20 to 100 g can be stimulated remarkably by using a continuous (24L:0D) photoperiod without any adverse effect on physiology. Biswas *et al*. (2006b) demonstrated that the growth performance of red sea bream, when reared from 1 to 30 g, can also be stimulated. These results together help to establish a light regime giving optimal fish growth for a complete production cycle of red sea bream. It is assumed that more attention will be given to indoor and outdoor culture in the near future. Photoperiod manipulation will definitely be the option of choice to get higher output from those types of systems.

Notes

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