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Photoperiod Manipulation Stimulated Growth Performance in Young Striped Knifejaw, *Oplegnathus fasciatus*

Amal K. Biswas [1], Manabu Seoka [1], Kazushige Inoue[2], Kenji Takii [1], Hidemi Kumai [1]

This study was aimed to investigate whether photoperiod manipulation can be used to stimulate the growth performance without stress response in striped knifejaw Oplegnathus fasciatus with 280-350g body weight. Fish were fed a commercial diet to apparent satiation, two times a day for 9 weeks. Blood was also collected from the initial fish. Although there was no major variation in weight gain, specific growth rate, feed intake and feed conversion efficiency between 16L:8D and 24L:0D photoperiods, all parameters in these photoperiods were remarkable higher than those of 12L:12D photoperiod. There was no major difference in final whole body proximate composition among the treatments; however, retentions efficiencies of protein and energy, HSI and VSI in fish under 16L:8D photoperiod were remarkable higher than those of 12L:12D photoperiod. At the end, the plasma levels of cortisol, glucose and total protein in fish under the artificial photoperiods were similar to those of initial levels. The results demonstrated that the artificial photoperiod 16L:8D can be used to enhance the growth performance of *O. fasciatus* without causing significant stress response.

Key words: photoperiod; *Oplegnathus fasciatus*; growth performance; stress response

A series of experiments have been going on in our laboratory to investigate whether photoperiod manipulation can stimulate the growth performance of commercial important fishes in Japan. Previous studies revealed that photoperiod manipulation can be used successfully to enhance the growth performance of red sea bream, *Pagrus major* (Biswas et al., 2005, 2006b, 2008a). Photoperiod manipulation has also been used successfully to improve the growth performance of other species at larval, juvenile and adult stages (Saunders et al., 1985; Tandler and Helps, 1985; Duray and Kohno, 1988; Barlow et al., 1995; Imsland et al., 1995; Hart et al., 1996; Silva-García, 1996; Simensen et al., 2000; Biswas and Takeuchi, 2003; Petit et al., 2003). In contrary, photoperiod manipulation could not stimulate the growth performance in other species (Fuchs, 1978; Hallaråker et al., 1995; Purchase et al., 2000).

Striped knifejaw, *Oplegnathus fasciatus* has attracted great interest from Japanese fish farmers due to its high market value and consumer demand. Our previous study demonstrated that photoperiod manipulation can also be used to stimulate the growth performance of striped knifejaw when reared from 130 to 290g body size (Biswas et al., 2008b). However, there is no information on the effect of photoperiod manipulation on growth performance of other sizes. Therefore, it is necessary to investigate the influence

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

of photoperiod manipulation on the growth performance at other sizes of striped knifejaw, as it has demonstrated that the effect of photoperiod manipulation even varies depending on the developmental stages of fish (Hallaråker et al., 1995; Simensen et al., 2000).

There is controversy on the effect of photoperiod manipulation on stress response in fish. In rainbow trout, Leonardi and Klempau (2003) demonstrated that the artificial photoperiod induced a significant stress (any threat to or disturbance of homeostasis) response with plasma cortisol levels remaining high for at least 2 months after terminating the photoperiod regime. In other species, however, stress is not an apparent consequence due to photoperiod manipulation (Pickering and Pottinger, 1983; Audet et al., 1986; Biswas et al., 2004, 2006 a, b, 2008a). In striped knifejaw, artificial photoperiods did not cause stress when reared from 130 to 290g body size (Biswas et al., 2008b). However, there is no information on how photoperiod manipulation affects the stress response in striped knifejaw of other sizes and this area also needs to be clarified.

The objectives of this study were i) to investigate whether photoperiod manipulation could stimulate the growth performance and ii) to investigate whether artificial photoperiods cause stress response in striped knifejaw with 280-350g body weight.

Materials and Methods

Experimental design

Three hundreds striped knifejaw with 250-300g body weight were obtained from the Fish Nursery Center of Kinki University, Uragami, Japan and were randomly distributed among six 3 m^3 tanks at a density of 50 fish per tank to acclimate to the new rearing environment for 2 weeks at 12 h light : 12 h dark (12L:12D) photoperiod. The tanks were supplied with filtered seawater at 7 L/min and aerated to maintain the oxygen level near 100% saturation. Fish were fed to apparent satiation with a commercial diet (protein 46%, lipid 11%, Marubeni Nisshin Feed Co. Ltd., Tokyo, Japan), twice daily at 09:00 and 15:00 h during the light phase.

After conditioning, the fish were starved for one day, anesthetized with 200 ppm 2-phenoxyethanol (Wako Pure Chemical Industries Ltd. Osaka, Japan), and body length and weight were measured. Fish in each tank were selected to minimize variation in initial weights among treatments and the stocking density was reduced to 35 fish with a mean body weight of 284 g per tank. At the beginning, a pooled sample of 10 fish was stored in a freezer for whole body proximate analyses, and blood was collected from another four fish. Water temperature was 24±1°C during the course of rearing trial. Three photoperiods were adopted: i) 12L:12D, ii) 16L:8D, and iii) continuous light, 24L:0D. Different photoperiods were controlled using a programmed time controller (Matsushita Electric Works Ltd., Osaka, Japan), including dimming over 30 minute periods. The experiment was designed in duplicate and each tank was partitioned with black polyvinyl sheet to avoid light penetration. Each tank was illuminated with one 40 W fluorescent tube with light intensity at 1500 lx on the water surface. It provided 0 lx inside the frame at dark phase. Fish under 12L:12D, 16L:8D and 24L:0D were fed a commercial diet to apparent satiation at 09:00 and 15:00, 09:00

and 18:00, and 09:00 and 21:00, respectively. Individual body length and weight were taken at the start, at the 3rd and 6th week, and at the end of the trial. Four fish were sacrificed from each tank when sampled at the 3rd and 6th weeks and at the end of the experiment to take blood. At the end, another five fish were sampled randomly and frozen at -20°C for whole body proximate analysis and were dissected to measure the wet weight of visceral organs, associated fat tissue and liver.

At the end of the experiment, the growth performance among treatments was compared in terms of weight gain, specific growth rate (SGR), feed conversion efficiency (FCE), condition factor (CF), protein retention efficiency (PRE), energy retention efficiency (ERE), and viscerosomatic (VSI) and hepatosomatic index (HSI). Stress response was investigated by plasma levels of cortisol, glucose and total protein.

Analytical procedures

Diets and fish were analyzed for proximate composition except crude lipid using standard methods (AOAC, 1995). Crude lipid was determined using a chloroform-methanol extraction procedure (Folch et al., 1957).

Plasma cortisol levels were determined by ELISA according to the manufacturer's instructions (Product code: EA65, Cortisol EIA kit, Oxford Biomedical Research, Inc., U.S.A.). In brief, cortisol was extracted from 100 μl of plasma with ethyl ether. After separation, the organic phase was evaporated with a stream of N2. The residue was then dissolved in 100 μL of diluted extraction buffer and subsequently diluted the extract 100 fold by adding 10 μL of the above extract into 990 μL of diluted extraction buffer. Fifty microliters of sample or standard solution was first added to the micro-plate in duplicates and incubated at room temperature for 1 h by adding the diluted enzyme conjugate. The plate was then washed and quantitative test results were obtained with a microplate reader at 650 nm. Plasma levels of glucose (Wako Pure Chemical Ind. Ltd., Osaka, Japan) and total protein (Wako Pure Chemical Ind. Ltd., Osaka, Japan) were also measured using analytical kits.

Statistical analyses

All statistical analyses wherever possible were carried out using the SPSS program for Windows (v. 10.0). Data were expressed as the mean ± SE. The means within each treatment and among treatments were compared using Tukey's test of multiple comparison with a 95% significance level.

Results

Almost all fish from a tank of 12L:12D photoperiod was died because of an accident. Therefore, the results for growth performance of 12L:12D photoperiod are represented from a single tank which could not provide us the opportunity to compare growth data statistically among the treatments. The mean initial and final body weight of fish exposed to different photoperiods are given in Fig. 1. Although final body weight in fish under 16L:8D and 24L:0D was similar, both photoperiods showed remarkable higher than that of 12L:12D photoperiod. Similar results were observed in weight gain and SGR (Fig. 2), and feed intake and FCE (Fig. 3). There was no mortality in fish under 16L:8D and 24L:0D of this study.

There was no major variation in final whole body proximate composition among the treatments (Table 1). Although the variation is not remarkable, retention efficiencies of protein and energy, HSI and VSI in fish under 16L:8D was higher than those of 12L:12D photoperiod (Table 1). The plasma levels of cortisol, glucose and total protein at the beginning and at the end of this study are presented in Table 2. There was no major variation in those stress indicators observed at the end of the experiment compare to the initial levels.

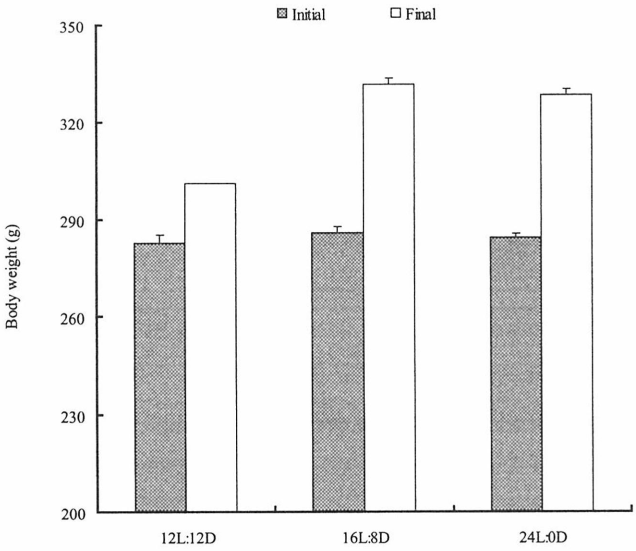

Fig. 1. Mean initial and final body weight in fish exposed to different photoperiods.

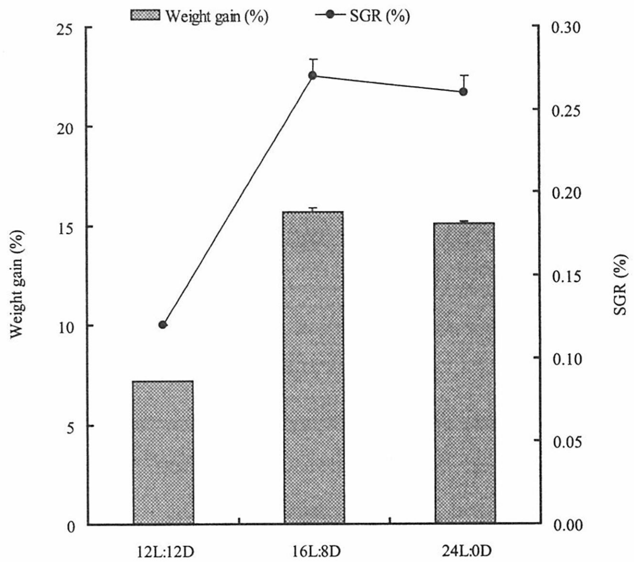

Fig. 2. Weight gain (%) and SGR (%) in fish reared under different photoperiods. Weight gain (%) = 1000 × (average weight gain / average initial body weight), where average weight gain = {(final total weight + sampled fish weight) – initial total weight}/average of initial and final number of fish. SGR (%) = 100 × (ln final weight – ln initial weight) / rearing period (days).

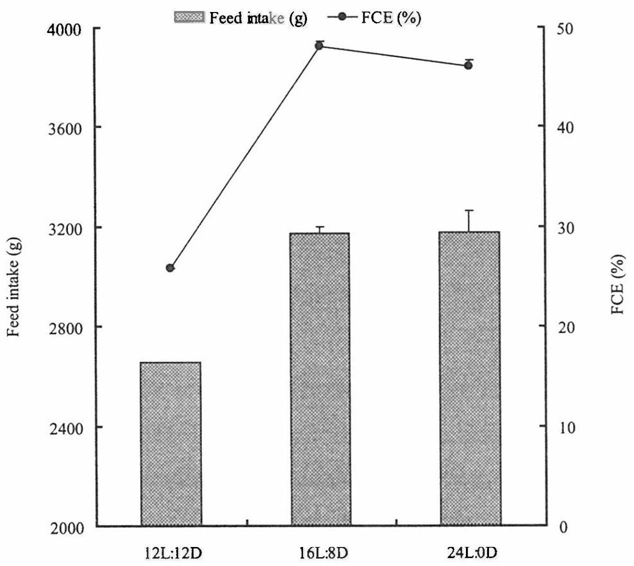

Fig. 3. Variation in feed intake and FCE (%) in fish reared under different photoperiods. FCE (%) = 100 × (weight gain / feed intake).

Table 1. Proximate compostion, retention efficiency and relative organ weight in fish exposed to different photoperiods

Parameters	Photoperiods		
	12L:12D	16L:8D	24L:0D
Proximate composition (%)			
Moisture (%)	67.5±1.9	65.8±1.8	64.9±1.5
Crude protein (%)	16.9±0.1	17.5±0.3	17.2±0.3
Crude lipid (%)	12.8±0.1	11.8±0.2	13.2±0.6
Crude ash (%)	3.2±0.2	4.0±0.4	3.8±0.3
Retention efficiency (%)			
PRE (%)	21.9	24.8±3.1	23.8±0.8
ERE (%)	37.7	40.4±1.7	38.3±3.3
Relative organ weight (%)			
HSI (%)	2.7±0.2	3.2±0.4	2.8±0.3
VSI (%)	9.8±0.8	11.6±0.9	10.8±1.0

Values are mean ± SEM (n=2) except retention efficiency of 12L:12D photoperioc

Discussion

The results revealed that the artificial photoperiods can be used to stimulate the growth performance of striped knifejaw without causing significant stress response when reared from 280 to 350g body weight. Both 16L:8D and 24L:0D photoperiods showed remarkable higher weight gain, SGR, feed intake and FCE than those of 12L:12D photoperiod, which parallel the findings in the same species when reared from 130 to 290g body size (Biswas et al., 2008b). This result is also consistent with the findings in other species where 16L:8D and 24L:0D photoperiods stimulated the growth performance (Saunders et al., 1985; Tandler and Helps, 1985; Thorpe et al., 1988; Barlow et al., 1995; Jonassen et al., 2000; Kissil et al., 2001; Biswas and Takeuchi, 2003; Petit et al., 2003; Ginés et al., 2004; Biswas et al., 2005, 2006b, 2008a). The higher growth performance in both photoperiods is due to fish being more active under such conditions and having a greater foraging activity when food is delivered, or be related to hormonal stimulation of appetite (Johnsson and Björnsson, 1994; Björnsson, 1997; Petit et al., 2003). The time of feeding may also have influenced the growth performance in fish exposed to these photoperiods by increasing feed intake and FCE, as reported in other studies (Noeske-Hallin et al., 1985; Azzaydi et al., 1999; Biswas and Takeuchi, 2003; Biswas et al., 2005, 2006b, 2008a). The higher feed intake in fish under the manipulated photoperiods may be because the feeding strategy in fish under these photoperiods reflected most closely the times of maximum appetite (Azzaydi et al., 1999; Biswas et al., 2006b, 2008a). As discussed by Biswas et al. (2005, 2006b, 2008a), the longer time interval between feeding times in fish exposed to 16L:8D and 24L:0D photoperiods may allow a slower and more efficient digestive process, which might improve digestion and retention efficiency in those photoperiods. These results therefore suggested that growth performance might be influenced by light through better food conversion efficiency and not just stimulated food intake (Boeuf and LeBail, 1999). In this study, there was no major variation in the growth performance of striped knifejaw between 16L:8D and 24L:0D photoperiods; however, the 24L:0D photoperiod demonstrated significantly higher growth performance than 16L:8D photoperiod in red sea bream, Pagrus major (Biswas et al., 2005, 2006b, 2008a). This may be due to the species-specific variation.

As different stress indicators in fish exposed to 16L:8D and 24L:0D photoperiods were far from the acute stress-induced levels observed elsewhere in the same species but different body sizes (Biswas et al., 2008b), the results demonstrated that both photoperiods did not cause a significant stress response in striped knifejaw. This result is agreed with the findings in other species where artificial photoperiod did not cause significant stress response (Pickering and Pottinger, 1983; Audet et al., 1986; Biswas et al., 2004, 2006 a, b).

In conclusion, the results demonstrated that the growth performance of striped knifejaw can also be enhanced by both 16L:8D and 24L:0D photoperiods when reared from 280 to 350g body size. However, the 16L:8D photoperiod should be given priority for rearing striped knifejaw because of the higher electricity cost for 24L:0D photoperiod. In addition, the artificial photoperiods did not cause significant stress response.

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