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# Light Intensity Requirements for Feeding Behaviour by the Brown-marbled Grouper, *Epinephelus fuscoguttatus*

(Keperluan Keamatan Cahaya untuk Perlakuan Pemakanan Ikan Kerapu Harimau, *Epinephelus fuscoguttatus)*

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ABSTRACT

*In this study, we investigated the feeding behavior of the brown-marbled grouper,* Epinephelus fuscoguttatus *with light intensities ranging over eight orders of magnitude from 0 – 1000 lx to estimate the optimum light intensity for larval rearing.* Artemia *ingestion rates of* E. fuscoguttatus *of 36 days and 42 days old larvae were measured in feeding behavior experiments and they were significantly higher with light intensities ≥10 lx compared with feeding rates at ≤ 1 lx.* E. fuscoguttatus *larvae also exhibited* Artemia *ingestion rates in the dark or in dim lighting (0 – 1 lx) that were about 20% of the ingestion rates with ≥ 10 lx.*

*Keywords: Brown-marbled grouper,* Epinephelus fuscoguttatus*; feeding behavior; ingestion rates; visual thresholds*

ABSTRAK

*Dalam kajian ini kami telah menyelidik tabiat pemakanan ikan kerapu harimau,* Epinephelus fuscoguttatus *dengan keamatan cahaya berjulat lebih daripada lapan tingkat magnitud daripada 0 – 1000 lx bagi menentukan keamatan cahaya yang optimum untuk ternakan larva ikan. Kadar pengambilan* Artemia *oleh larva* E. fuscoguttatus *pada umur 36 hari dan 42 hari diukur dalam uji kaji tabiat pemakanan dan didapati tinggi bersignifikan dengan keamatan cahaya ≥ 10 lx jika dibandingkan dengan kadar pemakanan pada ≤ 1 lx. Sebaliknya, larva ikan memperlihatkan kadar pengambilan* Artemia *dalam keadaan gelap atau cahaya samar (0 – 1 lx) sebanyak 20% daripada kadar pengambilan dengan ≥ 10 lx.*

*Kata kunci:* Epinephelus fuscoguttatus*; kadar pengambilan; kerapu harimau; tabiat permakanan; tahap penglihatan*

## INTRODUCTION

The brown-marbled grouper *Epinephelus fuscoguttatus* (Forsskal) is widely distributed in the Indo-Pacific region and the Red Sea (Heemstra & Randall 1993). Together with other groupers, it is considered a threatened species because groupers are heavily fished for the live fish trade (Cornish 2004). Aquaculture of *E. fuscoguttatus* began about 20 years ago in Southeast Asia (Lim et al. 1990), but several problems remain such as the low survival rate at the larval stage. There are little data available on the conditions that are required for larval rearing. Thus, there is an absence of guidelines on the optimum light conditions for *E. fuscoguttatus*.

Mukai et al. (2012) examined the retinomotor response of *E. fuscoguttatus* larvae. The retinomotor response was observed between 0.1 and 10 lx with dark adaptation at 0.1 lx, an intermediate situation at 1 lx, and light adaptation at 10 lx. A light intensity ≥10 lx is sensed by cone vision in *E. fuscoguttatus* larvae.

The appropriate illumination for larval rearing tanks should be based on the visual sensitivity of the species being reared. Numerous studies have investigated the retinomotor responses and visual sensitivity of fish larvae (Blaxter & Jones 1967; Blaxter & Stains 1970; Kawamura 1979; Masuma et al. 2001; Neave 1984) and their feeding behavior with different light intensities (Blaxter 1968a, 1968b; Mukai 2011; Mukai et al. 2010), but there have been no such investigations on *E. fuscoguttatus*. Boeuf & Bail (1999) described the effects of light intensity on the growth of many fish species, where larvae require lighter than older stages for feeding and predator avoidance, but too intense light is stressful and even lethal. Hence, there is still no data what light intensity is optimum for *E. fuscoguttatus* larvae.

In general, the larval rearing tanks in hatcheries are not illuminated at night, so larval rearing tanks have dark or dim light conditions. There is no study whether *E. fuscoguttatus* larvae can get their food during the night.

This study addressed several questions. A previous study (Mukai et al. 2012) found that six weeks old larvae displayed clearer retinomotor responses when compared with four weeks old larvae. Thus, in this study we investigated larvae aged 36 days and 42 days to compare them with the feeding behavior observed at a similar age (six weeks) in our previous study.

## Materials and Methods

*Epinephelus fuscoguttatus* larvae were brought from the Tanjung Badak Marine Fisheries Centre in Sabah, Malaysia to a laboratory at the Borneo Marine Research Institute in Universiti Malaysia Sabah. Larvae were reared in the laboratory and used for experiments within one week of transfer. Larvae were kept in a 1 $m^3$ tank with the microalgae *Nannochloropsis* sp. was added to maintain a density of $2 \times 10^6$ cells $mL^{-1}$. Larvae were fed with *Artemia nauplii* enhanced nutrition by omega-3 and powdered formulated feed (Otohime, Marubeni Nissin Feed Co. Ltd. Japan) according to their growth.

Fluorescent lamps (Power-Glo, 20 w Hagen Inc. Canada) and neutral density filters (HOYA, NDx8) were used to provide eight different orders of magnitude of light intensity in the dark room, 0 lx, 0.001 lx, 0.01 lx, 0.1 lx, 1 lx, 10 lx, 100 lx and 1000 lx. The fish were starved for 12 h before tests. For each age group and light intensity, 10 larvae were placed individually in 10 beakers (500 mL) and allowed 90 min to recover from handling. Thirty *Artemia nauplii* were then added to each beaker and feeding was allowed for 20 min. Then, 200 ppm MS-222 was added to each beaker and the anesthetized fish were removed and the remaining *Artemia* in each beaker was counted to determine the percentage (%) of *Artemia* eaten by each fish in 20 min.

Feeding experiments were conducted at approximately 36 days and 42 days (Figure 1). The 36 days fish had complete notochord flexion. The spine and fin ray number had not yet reached the constant number. The body had no strong pigment, so the body was still transparent. At this stage, fish exhibited pelagic swimming in the middle layer of the tank. These fish were still at the larval stage. The 42 days fish were just before settled down to the bottom of the tank. The pigmentation on the body surface had increased and the fish had the constant number of fin rays and spines. Therefore, these fish were the juvenile stage. Feeding experiments for each group of fish were conducted in triplicate. The data were analyzed using a one-way ANOVA and Tukey's multiple comparison test (SPSS v.17).

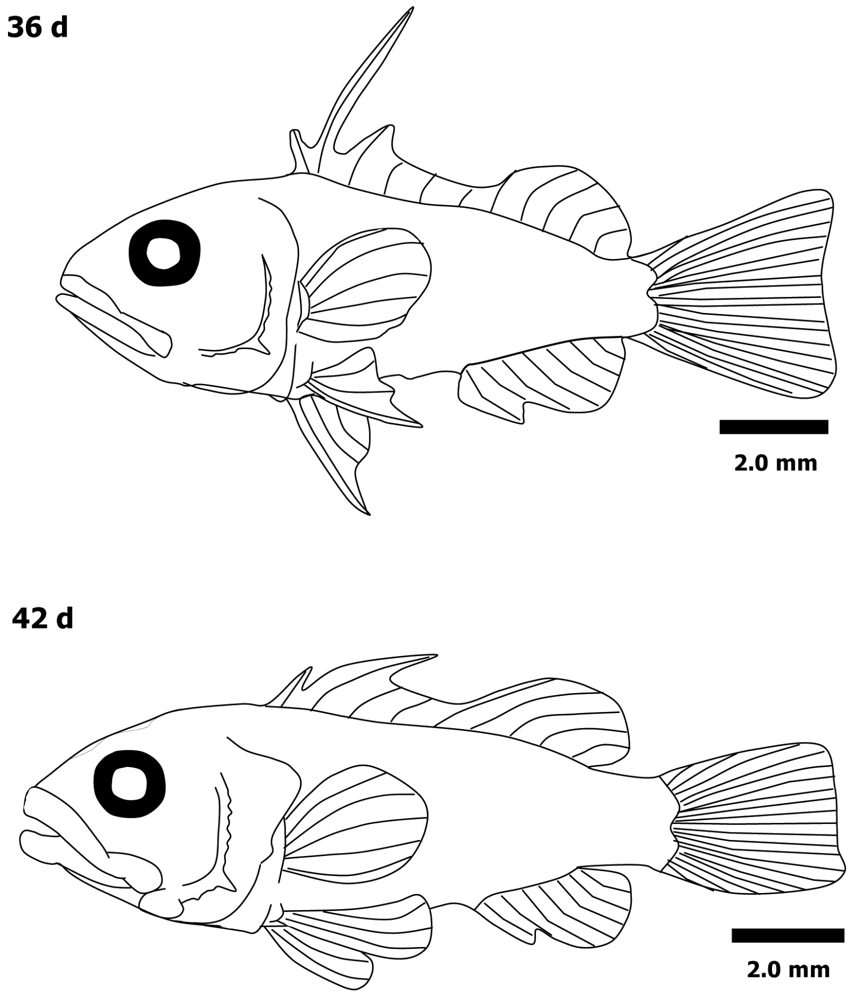


FIGURE 1. 36 days old larva and 42 days old juvenile of *Epinephelus fuscoguttatus*. The 36 days fish had complete notochord flexion. The spine and fin ray number had not yet reached the constant number. The fish were still at the larval stage. The 42 days fish were just before settled down to the bottom of the tank. The fish had the constant number of fin rays and spines. The fish were at the juvenile stage

## RESULTS & DISCUSSION

The *Artemia* ingestion rates of 36 days and 42 days *E. fuscoguttatus* were significantly higher at light intensities ≥10 lx compared with ≤1 lx (Figure 2). Fish would detect *Artemia* using cone cells at ≥10 lx. In contrast, *Artemia* ingestion rates in dark and dim lighting conditions (0–1 lx) were about 20% of those observed in bright conditions.

*Epinephelus fuscoguttatus* 36 days and 42 days fish ingested most *Artemia* (almost >80%) at ≥10 lx. This result agreed with a previous study on retinomotor responses (Mukai et al. 2012) that determined dark adaptation at 0.1 lx, an intermediate situation at 1 lx, and light adaptation at 10 lx. The larvae had the cone vision at ≥10 lx, and the high ingestion rates must have been dependent on cone vision.

Yoseda et al. (2008) suggested that 1000–3000 lx at the water surface are required for grouper larvae rearing in 60 $m^3$ tanks. There is a large difference between the visual threshold determined in the physiological study and the light intensity used in the hatchery.

The larvae still ingested *Artemia* under dark and dim lighting conditions. Other fish species, such as the willow shiner *Gnathopogon elongatus* (Mukai 2006) and Asian seabass *Lates calcarifer* (Mukai & Lim 2012) also ingested *Artemia* under dark conditions. Fish larvae must use sensory organs other than the eyes in dark conditions. Brown-marbled groupers have a full complement of free neuromasts on their head and trunk that can receive stimuli from various directions (Mukai & Lim 2012). These neuromasts probably detect the vibrations produced by *Artemia* and these would allow groupers to ingest in the dark. The willow shiner (Mukai et al. 1994; Mukai 2006) and Asian seabass (Mukai & Lim 2012) also exhibit similar feeding behaviors under dark conditions.

The actual fish production sites need sufficient ingesting zooplankton to improve survival and growth rates. However, there has been little consideration of nighttime feeding. Asian seabass and willow shiner larvae display a clear feeding ability in dark conditions (Mukai et al. 1994; Mukai 2006: Mukai & Lim 2012). Further study is required; however the current study suggested that the larvae of brown-marbled grouper were able to catch zooplankton during the nighttime. The possibility of larval feeding behavior during the nighttime should be considered and utilized to improve the seed production of *E. fuscoguttatus*.

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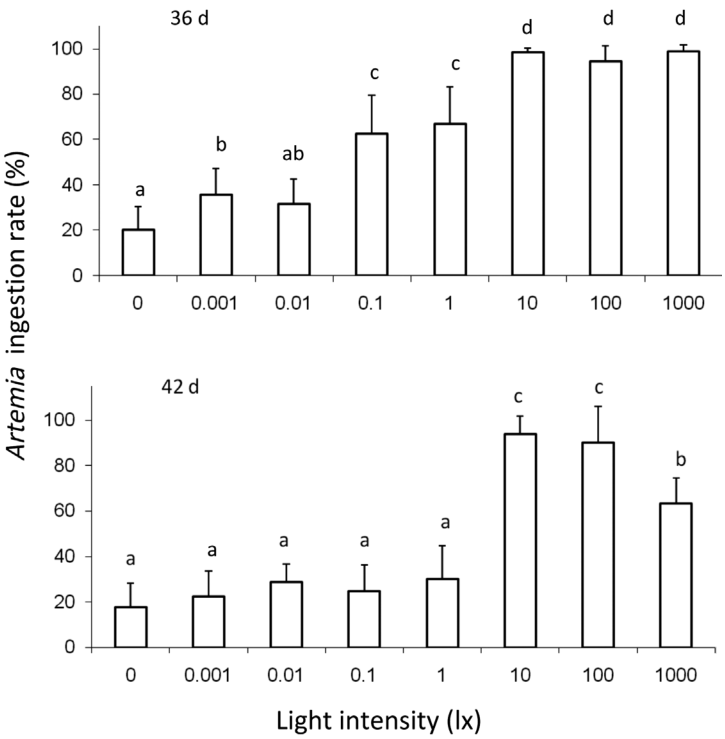


FIGURE 2. *Artemia* ingestion rates of *Epinephelus fuscoguttatus* in different light intensity at the ages of 36 days and 42 days. Different letters indicate significant differences ($p$<0.05)

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