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Effect of light intensity on first feeding of the chub mackerel *Scomber japonicus* larvae

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This study investigated the effect of different light intensities on first feeding of chub mackerel *Scomber japonicus* larvae. Fertilized eggs, obtained from LHRHa-induced spawning of captive broodstock, were stocked (60 larvae/l) into twelve 30-l aquaria under light intensities of 0, 100, 200, 500 and 1000 lx, with three replicate aquaria per treatment. Temperature was maintained at 20°C and salinity was 35 psu. Larvae were fed the rotifer *Brachionus rotundiformis* at a density of five rotifers/ml. Feeding incidence was measured as the percentage of larvae with prey in the digestive tract. Feeding intensity was evaluated as the number of prey in the digestive tract of the larvae. Larvae fed in darkness (0 lx) had significantly lower ($P < 0.05$) feeding incidence ($13 \pm 0.05\%$ larvae with prey) and feeding intensity (1.00 ± 0.05 rotifers per larva) than those larvae fed at 100 ($30 \pm 0.07\%$, 1.17 ± 0.09 rotifers per larva), 200 ($43 \pm 0.08\%$, 1.24 ± 0.11 rotifers larvae^{-1}), 500 ($53 \pm 0.08\%$, 1.48 ± 0.14 rotifers per larva) and 1000 lx ($60 \pm 0.08\%$, 1.38 ± 0.13 rotifers per larva). The feeding incidence of *S. japonicus* larvae increased with light intensity while feeding intensity showed no significant difference ($P > 0.05$) between light treatments.

Keywords: chub mackerel; *Scomber japonicus*; light intensity; first feeding; feeding incidence; rotifer

Introduction

Chub mackerel (*Scomber japonicus* Houttuyn, 1782) is a cosmopolitan middle-sized pelagic species with a very wide distribution over the continental shelf of tropical and subtropical regions of the Atlantic, Indian and Pacific Oceans as well as the adjacent seas (Bayhan 2007). It is primarily a coastal species, found down to 300 m depth (Collette and Nauen 1983). The larvae were transformed into juveniles at a mean size of 15 mm standard length (SL) in 16–24 days post-hatching according to adult fin ray counts (Hunter and Kimbrell 1980), and completed the ossification process at sizes between 18.9 and 24.6 mm SL (Kramer 1960). The juveniles have been known to move into the inshore nursery ground (Watanabe 1970). There have been few reports on the early growth of mackerel (Hwang and Lee 2005).

Incidences of mortality have been reported in several fish species especially during the initial feeding stage rather than other growing phases (Gisbert and Williot 1997; Mookerji and Rao 1999; Dou et al. 2005). First feeding of fish larvae from endogenous reserves to exogenous feeding is very crucial for their subsequent growth and survival. Failure to initiate successful first feeding soon after mouth opening will eventually lead to deformed growth and the inability to swim and predate on preferred prey (Houde 1974; Dou et al. 2002; Kailasam et al. 2007). Various factors contribute to feeding success, such as the concentration and type of food (Hunter 1981), turbulence (MacKenzie et al. 1994; Dower et al. 1997), temperature (Paul 1983) and light conditions (Blaxter 1986).

Although larvae of some fish species have non-visual senses for feeding (Blaxter 1969; Batty and Hoyt 1995), most marine fish larvae are visual predators (Blaxter 1986; Batty 1987; Porter and Theilacker 1999) and thus environmental light conditions represent a key factor in their feeding success (Sabates et al. 2003). A number of studies have been carried out on the light requirements of different fish larvae. These studies have shown that larval response to a particular characteristic of light is species-specific. Downing and Litvak (1999) reported that haddock larvae performed better in first feeding at higher light intensities. Puvanendran and Brown (2002) showed that overall growth and survival rates in Atlantic cod larvae reared under high light intensities was higher than larvae reared under lower light intensities. Although detailed light intensity information on a number of marine fish species is available (Chesney 1989; Huse 1994; Monk et al. 2006), information on mackerels remains scarce (Macy et al. 1998).

The objective of this study was to determine the effect of light intensity on first feeding in order to improve rearing conditions during larval culture of chub mackerel larvae.

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Materials and methods

Experimental design

Fertilized eggs were obtained following volitional spawning of captive broodstock induced with pelleted LHRH-a at 20°C and 35 psu in sand-filtered seawater (Watanabe et al. 2003). Twelve 30-l aquaria were used to test four different light intensities (0, 100, 200, 500, and 1000 lx). Three replicate aquaria were maintained per treatment. Lighting was provided by two 55-W full-spectrum fluorescent lamps (Doo Young, E55EX, Korea). The light intensity was controlled by placing the aquaria at different distances from the light source, and use of a shade cloth. Light intensity was measured using a light meter (T-10 M, Minolta, Japan).

Sampling and parameters estimation

First feeding larvae were stocked in the aquaria at a density of 60 larvae/l. After 3 hours of acclimation (Yoseda et al. 2008), the larvae were fed with the rotifer *Brachionus rotundiformis* at a density of five rotifers/ml. One hour after feeding, samples of 20 larvae were collected from each aquarium and anaesthetized with MS-222. Feeding incidence was measured as the number of sampled larvae with rotifers in the digestive organ. Feeding intensity was evaluated by counting the number of rotifers in the digestive organ of the larvae using a microscope.

Statistical analysis

Statistical analyses were performed to examine differences in feeding incidence and feeding intensity among the experimental treatments. Parameters in each experiment were examined by one-way ANOVA, and Tukey's test was carried out if statistical significance ($P < 0.05$) was detected. Data are reported as mean values $\pm$ SEM.

Results

Feeding incidence

At first feeding, feeding incidence and intensity for chub mackerel larvae are affected by light intensity. The number of larvae showing food in the digestive tract increased with light intensity. Larvae fed at 1000 lx showed significantly higher ($P < 0.05$) feeding incidence ($60 \pm 0.08\%$ larvae with prey) than larvae fed at 100 ($30 \pm 0.07\%$ larvae with prey) and 200 ($43 \pm 0.08\%$ larvae with prey) lx. No significant difference ($P > 0.05$) was observed in the feeding incidence of larvae fed at 500 ($53 \pm 0.08\%$ larvae with prey) and 1000 ($60 \pm 0.08\%$ larvae with prey) lx (Figure 1).

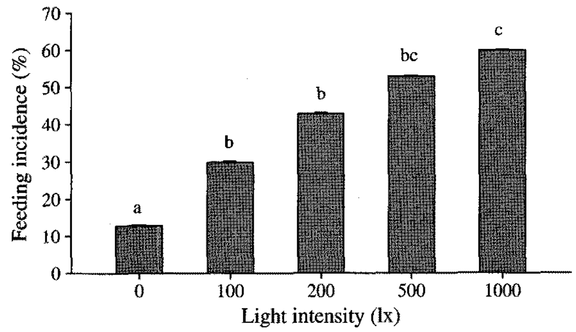

Figure 1. Feeding incidence (%) of chub mackerel larvae at first feeding for different light intensities. Different letters represent statistical significance ($P < 0.05$).

Feeding intensity

The number of prey ingested by larvae fed at 100 (1.17 ± 0.09 rotifers per larva), 200 (1.24 ± 0.11 rotifers per larva), 500 (1.48 ± 0.14 rotifers per larva) and 1000 (1.38 ± 0.13 rotifers per larva) lx showed no significant differences ($P > 0.05$) (Figure 2). Ingested prey were detected in larvae fed in darkness. However, feeding incidence ($13 \pm 0.05\%$ larvae with prey) and feeding intensity (1.00 ± 0.05 rotifers per larva) were significantly lower ($P < 0.05$) than larvae fed in all light treatments.

Discussion

Light intensity has a significant effect on the feeding incidence of chub mackerel larvae. Most marine fish larvae are primarily visual feeders (Blaxter 1986), and thus the light regime of their environment is critical for optimal feeding. Previous studies have also shown that most marine fish larvae are visual feeders in the daytime (Blaxter and Staines 1970; Hunter 1981; Blaxter 1986; MacKenzie et al. 1999; Sawada et al. 2000) and first-feeding larval fish require a threshold

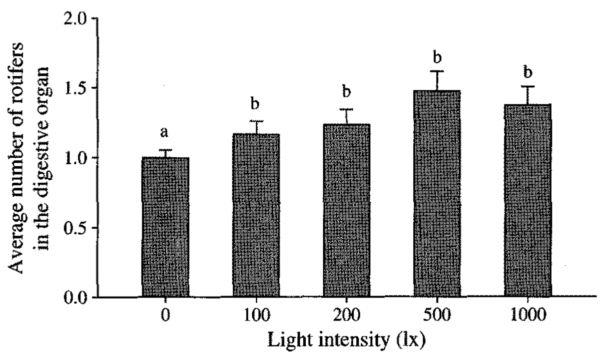

Figure 2. Feeding intensity (prey per larva) of chub mackerel larvae at first feeding for different light intensities. Different letters represent statistical significance ($P < 0.05$).

light intensity (at 0.1 lx) to initiate feeding (Blaxter 1986).

In this study, feeding intensity showed no significant difference among light treatments. Larvae were found to also consume prey in the dark, albeit infrequently and with lower prey numbers. Although unlikely, this may have been a consequence of accidental ingestion during osmoregulatory drinking (Huse 1994). More plausible is prey detection by sensory modalities other than vision (e.g. chemosense, free neuromasts or lateral line system) (Downing and Litvak 2001). Also, high food abundance may increase the probability of chance encounters between larva and prey (Connaughton et al. 1994). The prey concentration in this study (five rotifers/ml) is often used by culturists and, although on the high end, is feasible as a natural prey density, particularly for contagiously distributed plankton (Laurence 1974).

Based on the results of this study, the appropriate light intensity for chub mackerel larvae first feeding is concluded to be between 500 and 1000 lx. Further studies with light intensities of less than 200 and more than 1000 lx are necessary to better optimize rearing conditions for chub mackerel larvae.

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