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Effects of different light sources and illumination methods on growth and body color of shrimp *Litopenaeus vannamei*

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Abstract

Shrimps *Litopenaeus vannamei* with initial body weight of 2.108 ± 0.036 g were sampled for specific growth rates (SGR) and body color measurements for 50 days under different light sources (incandescent lamp, IL; cool-white fluorescent lamp, FL; metal halide lamp, MHL; and control without lamp) and different illumination methods (illumination only in day, IOD, and illumination day and night, IDN). Body color of *L. vannamei* was measured according to the free astaxanthin concentration (FAC) of shrimp. The SGR, food intake (FI), feed conversion efficiency (FCE) and FAC of shrimps showed significant differences among the experimental treatment groups ($P<0.05$). Maximum and minimum SGR occurred under IOD by MHL and IDN by FL, respectively (difference 56.34%). The FI of shrimp for the control group did not rank lowest among treatments, confirming that shrimp primarily use scent, not vision, to search for food. FI and FCE of shrimps were both the lowest among treatment groups under IDN by FL and growth was slow, thus FL is not a preferred light source for shrimp culture. Under IOD by MHL, shrimps had the highest FCE and the third highest FI among treatment groups ensuring rapid growth. FAC of shrimp were about 3.31 ± 0.20 mg/kg. When under IOD by MHL and IDN by FL, FAC was significantly higher than the other treatments ($P<0.05$). To summarize, when illuminated by MHL, *L. vannamei* had not only vivid body color due to high astaxanthin concentration but also rapid growth. Therefore, MHL is an appropriate indoor light source for shrimp super-intensive culture. SGR of shrimp was in significantly negative correlation to FAC of shrimp ($P<0.05$). Thus, when FAC increased, SGR did not always follow, suggesting that the purpose of astaxanthin accumulation was not for growth promotion but for protection against intense light.

Keywords: *Litopenaeus vannamei*; Light source; Illumination method; Growth; Body color

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1. Introduction

As light is an important environmental factor for animals living in water, many studies have been undertaken on its effect. Significant differences in behavior, food intake and growth of aquatic animals appeared under different light conditions (Blaxter, 1968; Gehrke, 1994; Giri et al., 2002). Light also impacted on ovarian maturation, reproduction and juvenile growth of some aquatic animals (Kelemec and Simth, 1980; Wallace, 1988; Hillier, 1984; Fanjul-Moles and Fuentes-Pardo, 1988; Fanjul-Moles et al., 1992; Primavera and Caballero, 1992; Wang et al., 2003a,b). Fluorescent lamp (FL) has been used as the main light source for trials involving shrimps (Wang et al., 2003a,b) and there are few studies on the effect of different light sources on shrimp.

Body color is one of the major factors determining quality and price of shrimp (Chien and Jeng, 1992; Boonyaratpalin et al., 2001). Concentration of astaxanthin is the main factor controlling shrimp body color (Crozier, 1967; Howell and Matthews, 1991; Menasveta et al., 1993; Pangantihon-Kühlmann et al., 1998; Nègre-Sadargues et al., 2000; Stepnowski et al., 2004a). In this study, free astaxanthin concentration (FAC) in shrimp was chosen as the indicator of shrimp body color. Astaxanthin is also a powerful antioxidant; indeed its antioxidant ability is much stronger than that of β-carotene, vitamin E or C. Animals are unable to synthesize these pigments, therefore they must accumulate these pigments through the diet (Shahidi et al., 1994; Nègre-Sadargues et al., 2000; Velu et al., 2003). Astaxanthin can also act to enhance the immune system of aquatic animals, prevent disease, increase survival rate and improve growth (Chien and Jeng, 1992; Coral-Hinostroza and Bjerkeng, 2002; Stepnowski et al., 2004b; Velu et al., 2003). However, the mechanism of astaxanthin accumulation is less studied. It has been observed that the body color of *Penaeus monodon* becomes faint when cultured indoors (Tseng et al., 1998). Therefore there may be some relationship between astaxanthin accumulation of shrimp and light condition.

In this paper, different types of lighting (incandescent lamp, IL; fluorescent lamp, FL; metal halide lamp, MHL; and control without lamp) were chosen to investigate the effect of light conditions on growth and body color of *Litopenaeus vannamei* and the influence of light on astaxanthin accumulation was also investigated.

2. Material and methods

2.1. Source and acclimation of shrimp

The experiment was conducted from July 7 to August 25, 2003 at the Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. Shrimp *L. vannamei* used in the experiment was collected from a coastal shrimp farm in Qingdao, Shandong Province, China. Before starting the experiment, all shrimp selected were healthy and had been acclimated for 15 days in a 10 m^3 concrete tank with specific experimental sea water (see in the next part) under natural light. During both the acclimation and experimental period shrimps were fed with a formulated diet ($44.39 \pm 0.27\%$ crude protein, $8.74 \pm 0.32\%$ fat, $10.91 \pm 0.06\%$ ash, and $9.41 \pm 0.07\%$ moisture, bought from Haiyue Feed Stuffs Company, Qingdao) at satiation level twice daily (at about 6:00 and 18:00 hours).

2.2. Rearing condition

The shrimp were maintained in glass aquaria ($45 \times 35 \times 25$ cm, water volume of 35 l). Each rearing unit contained six shrimps. Different lighting treatments (shaded from each other) were conducted in well-ventilated separate wooden boxes ($150 \times 135 \times 50$ cm). Water exchange was conducted in all treatments simultaneously from an identical water source filtered by a common water filter tower filled with fine-grained sand. Aeration was provided continuously and 90% of water volume in the aquaria was replaced every other day in order to maintain water quality. Dissolved oxygen was maintained above 6.0 mg/l, pH was approximately 8.0; concentration of ammonia was under 0.24 mg/l, salinity was between 28 to 32, and water temperature varied from 23~30 °C according to air temperature.