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Short communication

Effect of temperature on survival and developmental period of coconut crab (*Birgus latro*) larvae reared in the laboratory

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ABSTRACT

Populations of the coconut crab, *Birgus latro*, have been severely depleted on most inhabited islands throughout Indo-Pacific regions because of overharvesting and environmental degradation. To assist in the development of artificial propagation technologies for restocking/stock enhancement of this species, this study was designed to elucidate the effect of rearing temperature on survival and developmental period of zoeae through a laboratory experiment testing six constant temperatures levels (18.9, 21.3, 24.6, 27.0, 29.8, and 32.4 °C). Mortality of all first stage zoeae occurred at 18.9 °C. In contrast, the survival rate to the megalopal stage was significantly higher (85.6 and 82.2%) at 27.0 and 29.8 °C, respectively, than all other treatments. Temperature also had marked effects on larval developmental periods. The number of days from hatching required to reach each larval stage (D) significantly decreased with increasing temperature (T). The mean duration from hatching to the megalopal stage ranged between ~19 and 23 days at appropriate temperatures for larval survival (27.0 and 29.8 °C).

1. Introduction

The coconut crab, *Birgus latro*, is a land-dwelling hermit crab species that can reach 4 kg in weight and is widely distributed on isolated coral islands throughout Indo-Pacific regions (Brown and Fielder, 1991; Lavery et al., 1995). This terrestrial crab needs the sea to complete its life cycle; females hatch their eggs in the coastal sea and the planktonic larvae pass through zoeal stages in the ocean before they metamorphose to benthic megalopae and then finally acquire a gastropod shell and migrate onto the shoreline (Reese, 1968; Reese and Kinzie, 1968; Brown and Fielder, 1991). They give up the shell-carrying habit of their hermit crab ancestors at ~8 mm thoracic length (TL) (Kadiri-Jan and Chauvet, 1998).

Coconut crab populations have been severely depleted on most inhabited islands because of overharvesting for commercial consumption and environmental degradation. This species is particularly impacted because of its biological and ecological characteristics, such as low growth rate and longevity of more than 40 years (Amesbury, 1980; Wells et al., 1983; Fletcher et al., 1990; Brown and Fielder, 1991). Restocking/stock enhancement is one of the measures being used to conserve and enhance the depleted wild populations, via reintroduction of captive-bred individuals into the wild (Bell et al., 2005).

Successful restocking/stock enhancement programs will require the development of artificial propagation technologies to produce juveniles for release into the wild. Furthermore, producing juveniles will enable researchers to explore the potential of aquaculture of coconut crab, which is another conservation measure that might help the depleted wild populations. To date, a few attempts to culture coconut crab larvae have been made and complete larval development and growth to the megalopal stage have been reported (Reese and Kinzie, 1968; Wang et al., 2007). However, artificial propagation technologies have not been studied thoroughly for this species. Therefore, we initiated studies to develop technology for rearing coconut crab larvae.

Temperature is one of the most important environmental factors known to affect the survival and development of decapod crustacean larvae under culture conditions as well as larval dynamics in the field (e.g., Anger, 2001; Hamasaki, 2003; Anger et al., 2004; Gardner et al., 2004; Bryars and Havenhand, 2006; Bermudes and Ritar, 2008). The aim of this study was to elucidate the effect of rearing temperature on survival and developmental period of coconut crab zoeae through a laboratory experiment testing six constant temperatures levels.

2. Materials and methods

2.1. Broodstock and larvae

A female of 33.9 mm TL bearing eggs in the early embryonic stage (Schiller et al., 1991) was caught on June 22, 2005 on Ishigaki Island (24°27′N, 124°07′E), Okinawa Prefecture, Japan. It was transferred to the Yaeyama Station of the National Center for Stock Enhancement, Fisheries Research Agency, on Ishigaki Island and was held in an indoor

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Table 1
Survival rates to each larval stage of coconut crab, *Birgus latro*, reared at six different temperatures.

Water temperature (°C)	Survival rate (%) to each larval stage				
	Z2	Z3	Z4	Z5	MG
18.9	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0^{a}	0.0 ± 0.0	0.0 ± 0.0^{a}
21.3	88.9 ± 1.9^{b}	56.7 ± 18.6^{b}	24.4 ± 25.2^{a}	1.1 ± 1.9	1.1 ± 1.9^{a}
24.6	98.9 ± 1.9^{c}	95.6 ± 3.8^{c}	94.4 ± 1.9^{b}	2.2 ± 1.9	56.7 ± 0.0^{b}
27.0	98.9 ± 1.9^{c}	97.8 ± 1.9^{c}	93.3 ± 3.3^{b}	–	85.6 ± 6.9^{c}
29.8	100.0 ± 0.0^{c}	94.4 ± 1.9^{c}	93.3 ± 0.0^{b}	–	82.2 ± 3.8^{c}
32.4	98.9 ± 1.9^{c}	97.8 ± 3.8^{c}	83.3 ± 14.5^{b}	–	55.6 ± 10.7^{b}

Larval stage: Z2–Z5, second to fifth zoeal stage; MG, megalopal stage. Each value is mean ± SD of three replicates (one replicate = survival rate of one beaker). Significant differences were found between groups with different superscripts in the same column (pairwise *t*-test, $P<0.05$).

rectangular polyethylene tank (58.7 cm in height, 79.2 cm in length, and 50.0 cm in width) at ambient room temperature and humidity. The mean ± standard deviation (SD) values for room temperature and humidity measured each hour using a thermo-hygrometer during the rearing period were 29.2 ± 2.3 °C and 83.5 ± 9.1%, respectively. Half of the tank bottom was covered with a plastic plate to simulate land, and a small plastic container contained fresh water for drinking and a vertically half-cut vinyl chloride pipe (20 cm in diameter and 20 cm in length) provided shelter. Ambient seawater, filtered with sand and irradiated with ultraviolet lights, was supplied to the tank in a flow-through system. The female was not fed during the egg incubation period to prevent eggs from being contaminated with foods and/or female's faeces. Hatching of eggs occurred around 8 p.m. on July 20, 2005 (water temperature, 24.8 °C; salinity, 34‰). After hatching, the female was released into the natural habitat from which it had been collected.

2.2. Larval rearing

One hour after hatching, first stage zoeae were stocked in 1 L plastic beakers filled with sand-filtered and ultraviolet irradiated seawater (temperature, 24.8 °C; salinity, 34‰). Each beaker contained 30 zoeae. The beakers were then placed in temperature-controlled baths at six different temperatures (mean ± SD, recorded every 30 min with data

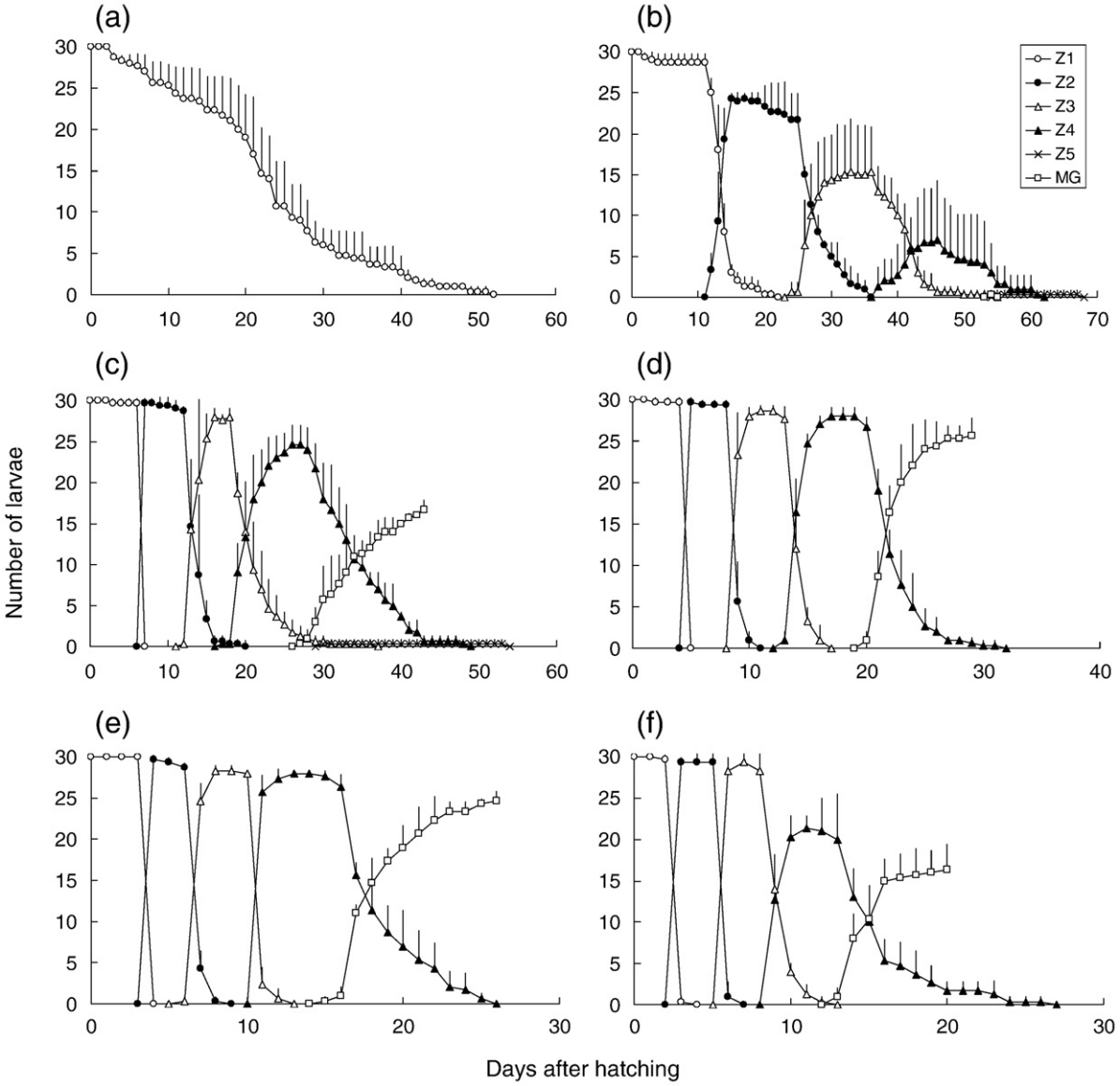

Fig. 1. Changes in the number of larvae (mean ± SD) in relation to days after hatching for different stages of coconut crab, *Birgus latro*, larvae reared at six constant temperatures levels ($N=3$). Mean temperature was 18.9 °C (a), 21.3 °C (b), 24.6 °C (c), 27.0 °C (d), 29.8 °C (e), and 32.4 °C (f). Z1–Z5 refer to the first to fifth zoeal stages; MG means megalopal stage. Vertical bars indicate the standard deviations.