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DESCRIPTION OF THE PARALARVAE OF *WUNDERPUS PHOTOGENICUS* HOCHBERG, NORMAN & FINN, 2006 (CEPHALOPODA: OCTOPODIDAE)

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ABSTRACT. **–** Recruitment studies of wild animals rely heavily on a means to identify early life history stages. Among shallow-water octopodids (Cephalopoda: Octopodidae), founder chromatophore patterns are used to identify paralarvae (planktonic hatchlings) to the species level. Here we describe the founder chromatophore patterns and external morphology of paralarval *Wunderpus photogenicus*, an octopus that is commercially important but remains unmonitored in the wild. Within the brood of a single female *Wunderpus photogenicus*, we observed variation in key characteristics used to identify cephalopod paralarvae to species: the number of chromatophores on the ventral mantle and funnel of hatchlings. Chromatophores preserved in various states of relaxation and contraction could generate these different variations of the baseline pattern, even when all chromatophores are anatomically present.

KEYWORDS. **–** Life history, larvae, octopus, marine ornamentals, plankton, Indo-West Pacific.

INTRODUCTION

Wunderpus photogenicus Hochberg, Norman & Finn, 2006 is a charismatic tropical octopus distributed from the Philippines to Vanuatu (Norman, 2000; Hochberg et al., 2006). Its distinct deimatic display, possible mimicry behavior, and apparent rarity help make it an expensive marine ornamental that is also popular among underwater photographers and videographers (Hochberg et al., 2006). Despite the commercial value of these animals, life history and population status of wild stocks remain entirely unstudied. Photoidentification offers a means to estimate the density and home ranges of individual adults (Huffard et al., 2008). However tools for identifying and monitoring their planktonic hatchlings from larval stocks are not currently available.

Traditionally, species-specific founder chromatophore patterns are used to identify cephalopod paralarvae, a process that can be verified by collecting hatchlings from confidently-identified brooding females. Founder chromatophores are conspicuous dark pigment sacs that appear early in the development of cephalopod skin patterns (Packard, 1985). We have limited knowledge of the chromatophore patterns of tropical octopodid paralarvae, especially those from regions of extreme biodiversity with pressing marine management needs, such as Indonesia. For example of the more than ten octopodids that inhabit North Sulawesi, Indonesia (distributions in Norman, 2000), hatchlings have been illustrated or photographed for only *Hapalochlaena lunulata* Quoy & Gaimard, 1832, *Octopus cyanea* Gray, 1849, and *Abdopus aculeatus* (d'Orbigny, 1834) (Overath & Boletzky, 1974; Young et al., 1989; Huffard, 2007). Here we describe the founder chromatophore patterns and other morphological characteristics of *W. photogenicus* hatchlings offering a means to identify them from zooplankton samples.

MATERIALS AND METHODS

A mature female *Wunderpus photogenicus* (20 mm mantle length post-spawning) was purchased from a live reef fish store by DWG (Dallas North Aquarium, Dallas Texas) on 4

Sep.2006. The female was reported to have been collected from Bali, Indonesia on either 28 or 29 Aug.2006, and autotomized one arm in transit from Los Angeles, California to Dallas, Texas within the United States. Beginning 13 September 2006 she was maintained at 21–25°C in a 100 L BioCube™ with sand and live rock substrate. She fed on three to four reef crabs [*Varuna litterata* (Fabricius, 1798)], carapace width approximately 19–32 mm) every three to four days by web-casting and immobilizing prey. The lighting schedule was initially 13:11 hr daylight and darkness respectively, until 30 Sep.2006 when a lighting system was installed to produce 8 hrs of daylight, preceded and followed by one hour of dawn and dusk, with a 14 hr period of blue 'night' light. Lighting was provided by 40.6 cm 36 W Compact Flourescent 10 K Daylight, 40.6 cm Actinic 03 Phospor and Lunar Blue- Moon-Glow LED bulbs.

Brooding was monitored from four days after the eggs were laid until hatching. Paralarvae (n = 46, all preserved at hatching on day 37) and unhatched eggs (n = 35 preserved on day 35; n = 5 preserved on day 37) were preserved in 10% buffered formaldehyde for approximately four weeks and then transferred to 95% isopropyl alcohol. Paralarvae in good condition (n = 22) were measured and drawn under a compound microscope with the aid of a camera lucida. Descriptions of paralarvae follow Hochberg et al. (1992).

RESULTS

On approximately 22 Sep.2006 the female *Wunderpus photogenicus* stopped eating, hid in live rock, and was believed to have laid eggs. Brooding was considered to

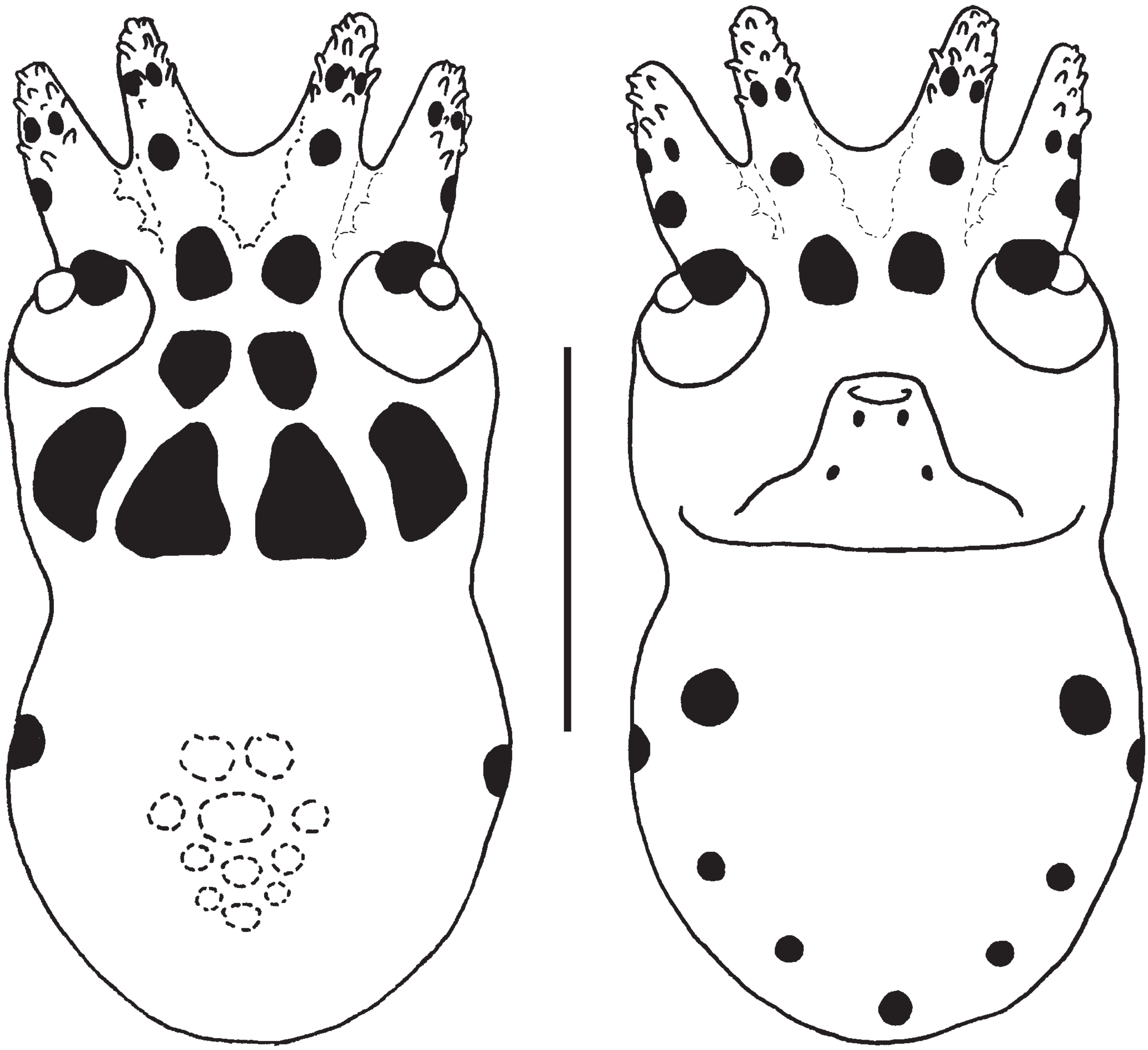

Fig. 1. Hatchlings of *Wunderpus photogenicus*. (left) Dorsal view. Chromatophores with dashed outlines are situated on the digestive gland. (right) Ventral view. Scale bar = 1 mm.

have started on this date. The eggs were held in the oral web, near the mouth as described by Miske & Kirchhauser (2006). For an unknown reason, on occasion the female dropped small egg strands while crawling along the bottom, a behavior reported previously for *Hapalochlaena* sp. by Tranter & Augustine (1973). These eggs were transferred to a mesh net basket within the aquarium. By day 33 after spawning the female had crawled into a pump chamber (opening 1.5 mm diameter) and abandoned the remaining eggs. Hatching took place on day 37. Hatchlings swam in the water column rather than crawling on the bottom, and likely adopt a planktonic lifestyle. The female died on day 38, after more than a month without feeding.

The female *Wunderpus photogenicus* laid 86 fertile eggs. We do not know if additional eggs were laid and either degraded, eaten, or hatched earlier and lost in the tank. At death the female's ovary measured approximately 4 mm in diameter and contained immature oocytes.

Hatchlings measured 1.35 mm ML ± 0.03 S.E. (n = 22; Fig. 1) and exhibited the following morphological characteristics: arms short, subequal, and with four suckers each, extending approximately two thirds of proximal arm length, distal third of the arms without suckers; approximately 20–50 small finger-like projections scattered on the distal third of aboral surfaces of all arms; webs subequal, extending down approximately half of arm length; arms with 4 dark brown chromatophores (1 arm base chromatophore plus longitudinal row of 1 + 2 chromatophores running from proximal to distal tip); funnel with 2 + 2 chromatophores, two specimens with 1 + 2 + 2 configuration (2 on funnel base, line of 3 on distal funnel); dorsal head with 6 chromatophores (2 + 4); one chromatophore on each side of mantle; ventral mantle with 5–7 chromatophores along the lateral and posterior margin; visceral mass with 8–13 chromatophores scattered evenly over surface. Fig. 1 illustrates maximum number of chromatophores. Chromatophores were missing from this baseline pattern in variable forms.

DISCUSSION

The hatchlings of *Wunderpus photogenicus* can be identified by both their unique founder chromatophore patterns and tiny finger-like projections on the arm tips. We could find no reference to arm-tip projections or similar chromatophore patterns in previously described octopodid paralarvae. However similar finger-like arm-base projections have been described previously for paralarvae of the undescribed 'crescent' octopus from Hawaii (Young et al., 1989). We do not know the degree to which these paralarval characteristics may reflect evolutionary relationships. Because the identity of the 'crescent' octopus remains unclear, we are not able to compare similarities in adult forms.

Within the brood of a single female *Wunderpus photogenicus*, we observed variation in key characteristics used to identify cephalopod paralarvae to species: the number of chromatophores on the ventral mantle and funnel of hatchlings. Some hatchlings did not bear all of the chromatophores in the baseline pattern (Fig. 1). Similar variation has been documented previously for a number of other octopodid populations (Hochberg et al., 1992). In a Loliginid squid, differences in embryonic temperatures are correlated with certain founder chromatophores being missing from the baseline pattern typical of that species (Gowland et al., 2003). It may be possible that eggs in the single brood of *W. photogenicus* observed here experienced slightly different temperature regimes, but not nearly to the degree needed to produce such changes in squid. Thus, another mechanism likely led to variation observed in these preserved specimens. In live octopodid hatchlings (such as in the planktonic paralarvae of *Octopus bocki* Adam 1941, CLH pers. obs.) founder chromatophores may not be visible if radial chromatophore muscles are relaxed and the elastic pigment sac is contracted. Chromatophores preserved in various states of relaxation and contraction could generate different variations of a baseline pattern, even when all chromatophores are anatomically present. Thus workers aiming to identify early stages of *W. photogenicus* should consider all variations observed here, particularly if using preserved material for which the arms are degraded.

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