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Description of the first zoëal stage of *Geograpsus crinipes* (Dana, 1851) (Decapoda: Brachyura: Grapsidae) from the Red Sea

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ABSTRACT

Ovigerous females of the species *Geograpsus crinipes* (Dana, 1851) were collected from the Rabigh coast of the Red Sea. The morphology of the first zoëal stage is illustrated and described in detail from laboratory-hatched material. The characteristic features of this stage are compared with those of the closely related first zoëal stage larva of *G. lividus* (H. Milne Edwards, 1837) from the Pacific coast of Panama, the Gulf of Mexico and Jamaica. Morphological differences with respect to the larvae of *G. lividus* populations are discussed.

KEY WORDS: Decapoda, Brachyura, Grapsidae, *Geograpsus*, *Geograpsus crinipes*, *Geograpsus lividus*, crab, larva, zoëa, Red Sea.

INTRODUCTION

The study of crustacean systematics and phylogeny has from the very earliest times involved the recording of larval characters; and details of larval morphology reveal phylogenetic relationships among different brachyurans (Martin & Davis 2001). Consideration given to larval characters solves many of the existing problems of brachyuran taxonomy. Brachyuran larval culture and subsequent description will lead to correct identification of planktonic zoëae obtained from marine samples. Data on larval development and growth are poor for some brachyuran groups, and most larval descriptions deal only with the first zoëal stages because of the difficulties encountered in appropriately feeding the small late larval stages (Ingle 1987; Cuesta & Rodríguez 2000).

The family Grapsidae MacLeay, 1838, currently includes 40 species assigned to eight genera (Ng *et al.* 2008). The genus *Geograpsus* Stimpson, 1858, includes five species (Ng *et al.* 2008) and only one species, *Geograpsus crinipes* (Dana, 1851), is known from the Red Sea (Holthuis 1977). This species is widely distributed throughout the Indo-Pacific regions (Sakai 1976). The first grapsid zoëae can be distinguished from other grapsid larvae by the reduction of the antennal exopod to a small seta (Fransozo *et al.* 1998; Landeira & Cuesta 2012). At present, there are three descriptions of the larval stages of a species of *Geograpsus*, namely *G. lividus* (A. Milne Edwards, 1837). The first zoëal stage of this species was described from Panamanian waters (Cuesta & Schubart 1999) and the western Atlantic (Guerao *et al*. 2001). More recently, details of the complete larval development of *G. lividus* from Jamaican waters were published by Cuesta *et al.* (2011).

In the present study, larvae of *G. crinipes* were reared in the laboratory; and no larval stages could be obtained beyond the first zoëal stage. This is described and illustrated, and compared with the larvae of *G. lividus*.

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MATERIAL AND METHODS

Ovigerous *Geograpsus crinipes* crabs were collected by hand from the rocky shore of Rabigh (22°79'N 39°03'E) on 12 July 2010. The females were held in aquaria (50× 20×25 cm), provided with a gravel base and rocky refuge, and fed fragments of fresh fish.

The seawater was changed every day until hatching took place. The eggs hatched on 15 July 2010. Approximately 250 larvae survived for four days. Soon after hatching, the healthy and actively swimming larvae were removed and separated in individual (each larva in 80 ml of filtered seawater) and mass bowls (20 larvae in 800 ml of filtered seawater). The temperature was kept constant at 27°C, salinity at 37‰ and photoperiod at 12 h light and 12 h dark (Al-Aidaroos 2005; Cuesta *et al*. 2011). The larvae were fed the rotifer *Brachionus* sp., together with algae.

Larval specimens were dissected in polyvinyl lactophenol using a stereomicroscope and allowed to clear for 24 h. Coverslips were sealed with clear nail varnish. Appendages were drawn using an Olympus BH-2 microscope equipped with differential interference contrast (DIC) and which had a camera lucida. At least five replicates of each appendage were drawn in order to detect any variations (Clark & Al-Aidaroos 1996).

The first-stage zoëa is described and fully illustrated. The sequence of the zoëal description is based on the malacostracan somite plan and described from anterior to posterior. Setal armature of appendages is described from proximal to distal segments and in order of endopod to exopod (Clark *et al*. 1998). The long antennular aesthetascs and the long plumose natatory setae of the first and second maxillipeds have been drawn truncated. Figures were drawn to scale with the aid of a camera lucida (Clark & Paula 2003).

Measurements are given to the nearest 0.01 mm and are based on a total of five larvae. A micrometer was used for measuring zoëal rostrodorsal length (RDL) from the tip of the rostral spine to the tip of the dorsal spine; carapace length (CL) from the base of the rostral spine to the posteriormost carapace margin; and carapace width (CW) as the maximum width of the carapace or the distance between the tips of the minute lateral spines. The pleon length (ABL) was measured from the first pleonite anterior margin to the posterior furca of the telson (Cuesta *et al*. 2011). Furcal length (fl) was deduced from an imaginary line across the base of the outer seta at the posterior margin of the telson to the furcal tip; and the basal telson length (bt) from a line across the anterior margin of the telson to the posterior margin (base of the outer seta) (Cuesta *et al*. 2011; Landeira & Cuesta 2012).

Specimens of *Geograpsus crinipes* have been deposited at the Senckenberg Natural History Museum in Frankfurt, catalogue number SMF 43574.

RESULTS

Family Grapsidae MacLeay, 1838
Genus *Geograpsus* Stimpson, 1858
Geograpsus crinipes Dana, 1851

Figs 1–3

First zoëa.

Size (mm): RDL = 0.89 ± 0.01, CW = 0.52 ± 0.02, CL = 0.43 ± 0.07, ABL = 0.84 ± 0.02.

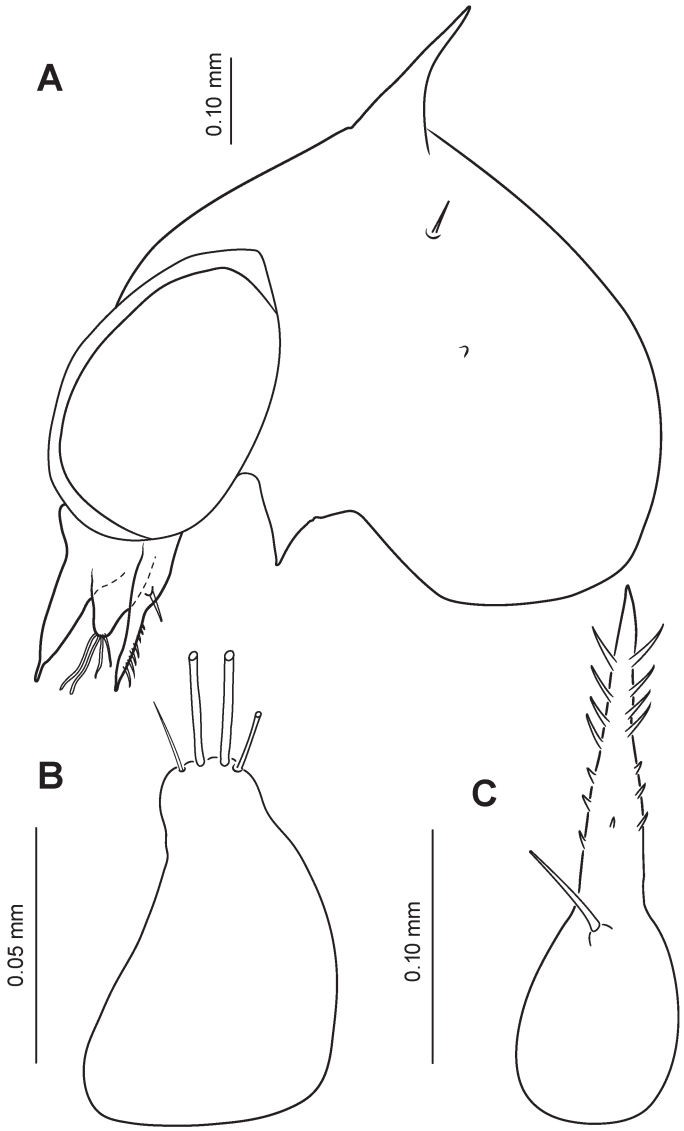

Fig. 1. *Geograpsus crinipes* (Dana, 1851), first zoëa: (A) lateral view of carapace; (B) antennule; (C) antenna.

Carapace (Fig. 1A): Globose. Dorsal spine short and without setae. Rostral spine straight, shorter than dorsal spine. Lateral spine reduced to minute spine. There is a pair of dorsolateral setae. Anterodorsal, posterior and ventral margins without setae. *Eyes*: sessile.

Antennule (Fig. 1B): Uniramous. Endopod absent. Exopod unsegmented, with 2 long and 1 shorter unequal terminal aesthetascs, and 1 simple seta.

Antenna (Fig. 1C): Well-developed protopod process, longer than rostral spine, with 2 rows of 7 spinules of increasing size distally towards the tip. Endopod absent. Exopod reduced to a small bud with a simple terminal seta.

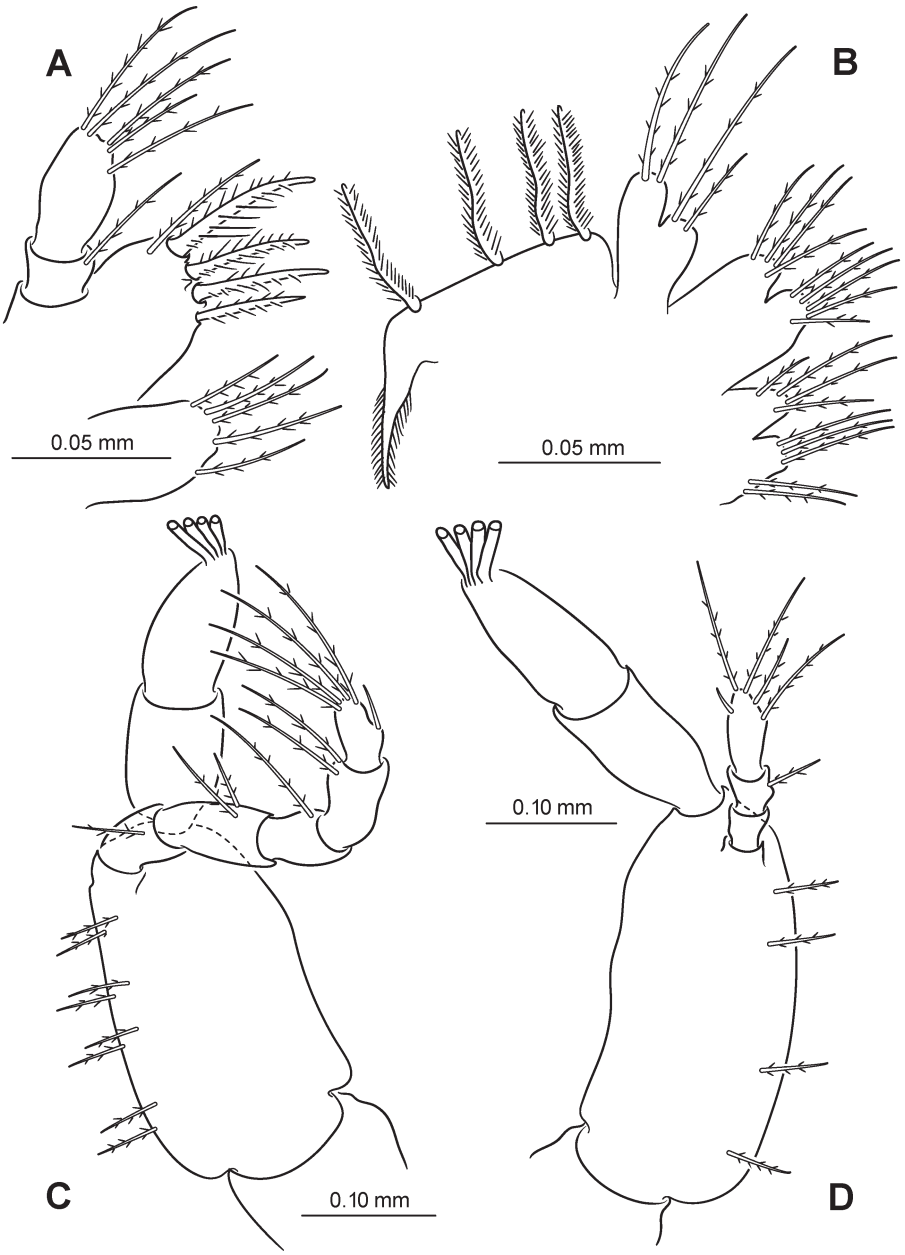

Fig. 2. *Geograpsus crinipes* (Dana, 1851), first zoëa: (A) maxillule; (B) maxilla; (C) first maxilliped; (D) second maxilliped.

Mandible: Palp absent.

Maxillule (Fig. 2A): Coxal endite with 5 plumodenticulate setae. Basal endite with 5 setae and 2 minute spines. Endopod 2-segmented, proximal segment with 1 distal seta; distal segment with 1 subterminal and 4 terminal setae. Exopod setae absent.

Maxilla (Fig. 2B): Coxal endite bilobed, with 5+4 setae. Basal endite bilobed, with 5+4 setae. Endopod bilobed, with 4 (2 subterminal + 2 terminal) setae. Exopod (scaphognathite) margin with 4 plumose setae and a setose posterior stout process.
First maxilliped (Fig. 2C): Coxa without setae. Basis with 8 setae arranged 2+2+2+2. Endopod 5-segmented, with 1, 2, 1, 2 and 5 (1 subterminal + 4 terminal) setae. Exopod 2-segmented, distal segment with 4 terminal plumose natatory setae.
Second maxilliped (Fig. 2D): Coxa without setae. Basis with 4 setae arranged 1+1+1+1. Endopod 3-segmented, with 0, 1 and 5 (2 subterminal, denticulate + 3 terminal) setae, respectively. Exopod 2-segmented, distal segment with 4 terminal natatory setae.
Third maxilliped: Absent.
Pereiopods: Absent.
Pleon (Figs 3A, B): Five somites, somite 2 with 1 pair of dorsolateral processes directed anteriorly. Somites 3–5 with 1 pair of dorsolateral processes directed ventrally, somites 2–5 with 1 pair of posterodorsal setae, also with posterolateral processes, these especially well-developed in somites 3–4. Pleopods absent.
Telson (Figs 3A, B): Forks short, slightly divergent; with a minute spine at base of each furcal arm, and lateral margins without spines. Posterior margin with 3 pairs of stout spinulate setae, medial setae shorter than the proximal ones; bt / fl > 1.

DISCUSSION

In many cases, only the first zoëal stage had been described for species in the family Grapsidae because of the difficulties in culturing larvae using techniques commonly employed in the laboratory for the later larval stages of various species of Brachyura (Guerao *et al.* 1999). Larval morphology is poorly documented in the Grapsidae, with the exception of the genus *Metopograpsus* (Cuesta *et al*. 2011, Table 2).

The morphological features of the first zoëal stages of *Geograpsus lividus* and *G. crinipes* correspond to those that define the zoëae of Grapsidae according to Fransozo *et al.* (1998), Cuesta *et al*. (1997), Cuesta and Schubart (1999) and Landeira and Cuesta (2012). Fransozo *et al.* (1998) distinguished zoëae of *G. lividus* on the Brazilian coast from other grapsid species on the basis of three characteristics: (a) telson furca with minute outer seta-like spines (type A); (b) fourth abdominal segment with minute medio-lateral process; and (c) fourth abdominal segment not laterally expanded. In the present study, *G. crinipes* was found to have somewhat similar characters to *G. lividus*. Only one important character is different and it can be used to distinguish between these species: lateral spines are not present on the telson of *G. crinipes* (there are 2–3 spines in *G. lividus*) (Table 1).

Consistent morphological differences could also be observed between the first zoëal stages of the two populations of *G. lividus*. The abdomen of the larvae from the Atlantic coast of Mexico has dorsolateral processes on somite 5, which are absent in the Pacific population (Cuesta & Schubart 1999). However, according to Schubart (2011), *G. lividus* from the Pacific could be *G. occidentalis*, based on mtDNA data. The same processes on somite 4 are more developed in Atlantic specimens than in their Pacific and Jamaican counterparts (Guerao *et al.* 2001). This variation may follow a temperature gradient rather than necessarily being indicative of geographic separation (Cuesta *et al*. 2011).

When these zoëae with are compared with those from Jamaica, differences in size are seen to be a prominent feature, with the Jamaican larvae being the smallest and those

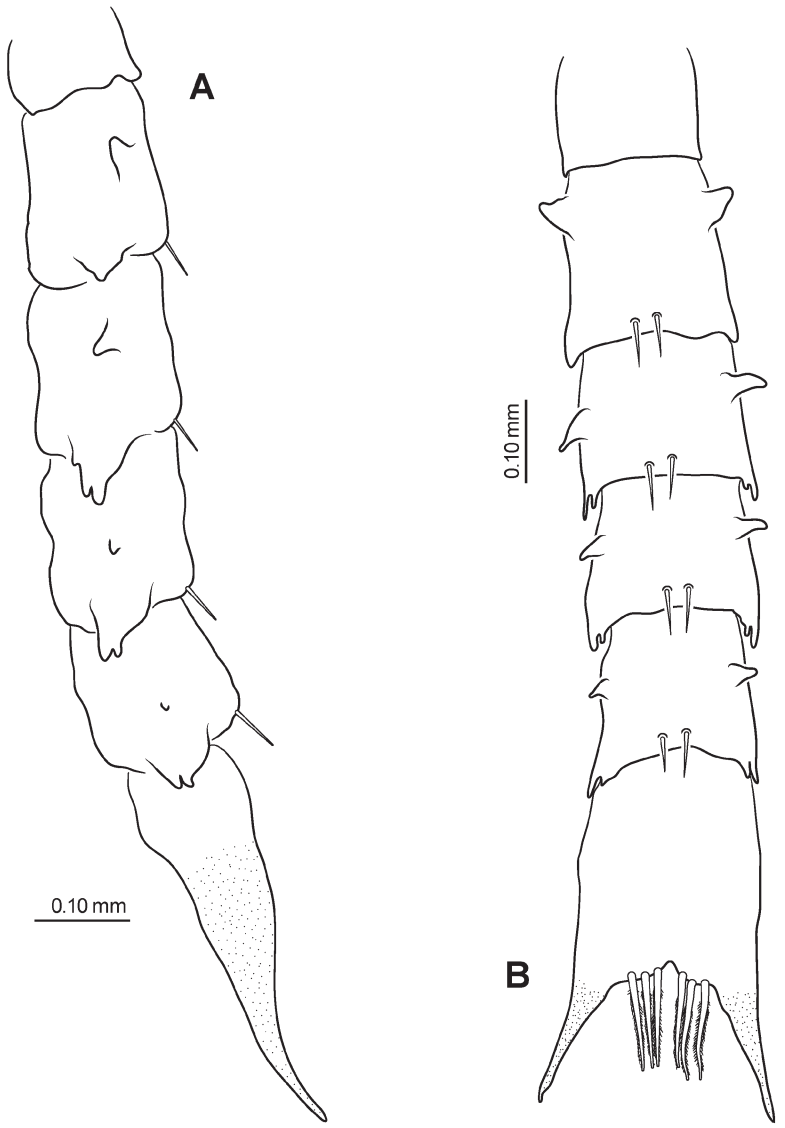

Fig. 3. *Geograpsus crinipes* (Dana, 1851), first zoëa: (A) lateral view and (B) dorsal view of abdomen and telson.

from the Gulf of Mexico the largest. According Guerao *et al.* (2001), Atlantic zoëae of *G. lividus* have three minute outer spines on the furcal arms of the telson, while there are only two in the Pacific population. The zoëal stage of *G. lividus* of the Pacific coast of Panama and that from the Gulf of Mexico could be distinguished from each other by the morphological features of the antennae, furcal arms of the telson, and abdomen (Cuesta *et al*. 2011).

As in the case of *G. lividus*, geographical differences may exist between the larvae of *G. crinipes*, also due to the temperature gradient and other factors. Therefore, further

TABLE 1

Morphological differences among first zoëas of the genus *Geograpsus*. Abbreviations: A–aesthetascs, CL–carapace length, CW–carapace width; nd–no data, P–pleonites, RDL–rostradorsal lengh, S–setae.

		G. lividus			***G. crinipes***
References		Cuesta & Shubart (1999)	Guerao *et al.* (2001)	Cuesta *et al*. (2011)	Present study
Carapace	**RDL (mm)**	0.75±0.03	0.81±0.02	0.67±0.02	0.89±0.01
	CW (mm)	0.32±0.01	0.34±0.01	0.36±0.03	0.52±0.02
	CL (mm)	0.42±0.02	0.45±0.01	0.50±0.02	0.43±0.07
Antennule		2A, 1S	3A, 1S	3A, 1S	3A, 1S
Antenna	**Small spines in protopod**	6–7	5–6	5–6	7
Maxilliped 1	**Coxa (S)**	nd	1	1	0
Telson	**Outer spines**	3	2	2	0
Pleon	**Dorsolateral processes (P)**	2–4	2–5	2–4	2–5

research is required on the larval stages of *G. crinipes* from different regions in order to understand geographical variation as well as to enable keys to the zoëae of this species to be formulated confidently. This, in turn, will facilitate accurate plankton identification from marine collections.

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