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DESCRIPTION OF THE FIRST JUVENILE STAGE OF THE FIDDLER CRAB *MINUCA MORDAX* (SMITH, 1870) (CRUSTACEA, DECAPODA, OCYPODIDAE)

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ABSTRACT

The first stage of the fiddler crab Minuca mordax *is described here. Zoea larvae obtained from four ovigerous female were reared in the laboratory until the development of the first crab stage. The development from zoea I to the first juvenile instar lasted 35 days after hatching. The first crab stage of* Minuca mordax *can be morphologically distinguished from those of* Minuca burgersi *and* Leptuca cumulanta *by a 2-segmented antennule endopod (3-segmented in* M. burgersi, *unsegmented in* L. cumulanta*), an unsegmented maxillule endopod (2-segmented in* M. burgersi *and* L. cumulanta*), and a 4-segmented first and second maxilliped endopod (respectively unsegmented and 5-segmented in* M. burgersi *and* L. cumulanta*). The three species have the following characters in common: segmented peduncle of antennule 2; endopod of antennule unsegmented; presence of aesthetascs on the antennule; peduncle of antenna 3-segmented; flagellum of antenna 6-segmented; mandible 3-segmented; maxilla with coxal and basal endite bilobed; first, second and third maxillae with exopod 2-segmented and abdomen with six somites that are wider than long.*

KEY-WORDS: Juvenile morphology; Development; Mangrove; Guaratuba Bay.

INTRODUCTION

The former fiddler crab genus *Uca* Leach, 1814 was composed of approximately 104 species, with 12 recognised subgenera (Beinlich & Von Hagen, 2006; Landstorfer & Schubart, 2010; Naderloo *et al.,* 2010; Shih *et al.,* 2010, 2013). Recently, Shih *et al.* (2016) reviewed the taxonomy of the genus and recognized all subgenera of *Uca* as full genera based on molecular evidence. Ten species are found in Brazil, including *Minuca mordax* (Smith, 1870). This species is distributed in the Western Atlantic Ocean, from the Gulf of Mexico to the Rio Grande do Sul state, southern Brazil (Bezerra, 2012). It is found in the upstream of estuaries, where water is almost freshwater (Crane, 1975). In Guaratuba Bay, PR, Brazil, the distribution of *M. mordax* is limited to the oligohaline and freshwater region inside estuaries, with high densities (15 individuals per m²) along the banks of the rivers that discharge into the bay (Masunari, 2006).

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Studies on *M. mordax* have been carried out on various aspects: description of the developmental stages; density; relative growth; population dynamics and intraspecific variation (Rieger, 1997; Masunari & Dissenha, 2005; Masunari, 2006; Fransozo *et al.,* 2009; Thurman *et al.,* 2013; Hampton *et al.,* 2014). However, no study on the morphology of the juvenile phase of this species has been previously undertaken.

Little is known about the juvenile phase of the ten fiddler crabs species occuring in Brazil, probably due to the difficulty in rearing specimens to this stage in development. The first juvenile stage has only been morphologically described in detail for *Minuca burgersi* Holthuis (1967) and *Leptuca cumulanta* Crane (1943) (Hirose *et al.,* 2010; Vieira *et al.,* 2010).

According to O'Connor (1990), the difficulty in identifying juveniles of fiddler crabs to species hampers investigations on ecological roles and functions within estuaries. Therefore, morphological descriptions of different developmental stages constitute fundamental knowledge required for ecological and systematic studies. Furthermore, the study of early stages of crabs can help in developing phylogenetic hypotheses for brachyurans (Martin *et al.,* 1984).

This article describes the first crab stage of *M. mordax* reared under laboratory conditions, and is aimed to facilitate the identification of fiddler crab species as juveniles.

MATERIAL AND METHODS

Four ovigerous females of *M. mordax* were captured along the banks of the São João River in Guaratuba Bay, Paraná, in November 2012. In the laboratory, they were kept in an aquarium (18 × 18 cm) containing a small amount of water from the collection site (salinity = 0), with continuous aeration, temperature of 25°C and a photoperiod of 12:12 hours (light: dark), until the hatching of larvae. The red alga *Catenella caespitosa* that was growing in the collection site was offered as food.

After hatching, the larvae (zoea I) were attracted by a light source, removed from hatching aquariums using a pipette and acclimated to a salinity of 20‰ via transfer to a series of polyethylene containers in a progression of 5‰ salinity increases. Larvae remained for one hour in each salinity exposure. The various salinity solutions were obtained by dissolving refined sea salt without artificial iodine in deionized water, in proportion to the desired salinity, determined with the aid of a precision scale and an optical refractometer. The larvae acclimated to a 20‰ salinity were reared in 1L polyethylene containers with 500 ml of water and kept in a common incubator for BOD (biochemical oxygen demand) with the same photoperiod and temperature as the adult females.

Zoea I to zoea III larvae were fed daily with the vagile microalga *Nannochloropsis oculata* and the rotifer *Brachionus plicatilis* Müller, 1786. From zoea III onwards, specimens were feed with newly hatched nauplii of *Artemia* sp. (according to the protocol used by Rieger, 1997) until the juvenile stage. The water was changed and new food was offered daily. The first crab stage appeared 35 days after zoea hatching.

The first juveniles of *M. mordax* were dissected and the structures mounted on semi permanent slides. All appendages were figured with the aid of camera lucida. The variability of morphological structures was examined based on six dissected juveniles.

RESULTS

Carapace (Fig. 1a, CL = 1.0 mm): dorsally convex, approximately pentagonal, width equal length, no visible separation of carapace regions, covered with scarce and short plumose setae; front broad, anterior margin with weak notch medially; 1 tooth at the antero-lateral corner, followed posteriorly by another smaller tooth on the antero-lateral margin. Eyes stalked, bearing 6 setae dorsally.

Antennule (Fig. 1c): basal segment well developed, with 3 plumose and 14 simple setae. Peduncle 2-segmented, each with 1 plumose seta. Endopod unsegmented, bearing single terminal plumose seta. Exopod 2-segmented, with 8 aesthetascs on the proximal segment and single aesthetasc on the distal segment.

Antenna (Fig. 1d): peduncle 3-segmented, with 1, 1, 0 plumose and 5, 1, 3 simple setae, respectively. Flagellum 6-segmented, with 1, 0, 5, 0, 2, 2 simple setae, respectively; 1 long (about 3 times length of segment) and 1 short plumose seta (about half length of segment) on fifth segment.

Cheliped (Fig. 1e): chelae symmetrical, with sparse simple and plumose setae. Propodus and dactylus with 3 small teeth on each along the cutting surface.

Pereiopods 2-5 (Fig. 1f-i): second, third, fourth, and fifth pereopods morphologically very similar, fully articulated, bearing simple and plumose setae on the surface and a dark spine on the distal end of the dactyl.

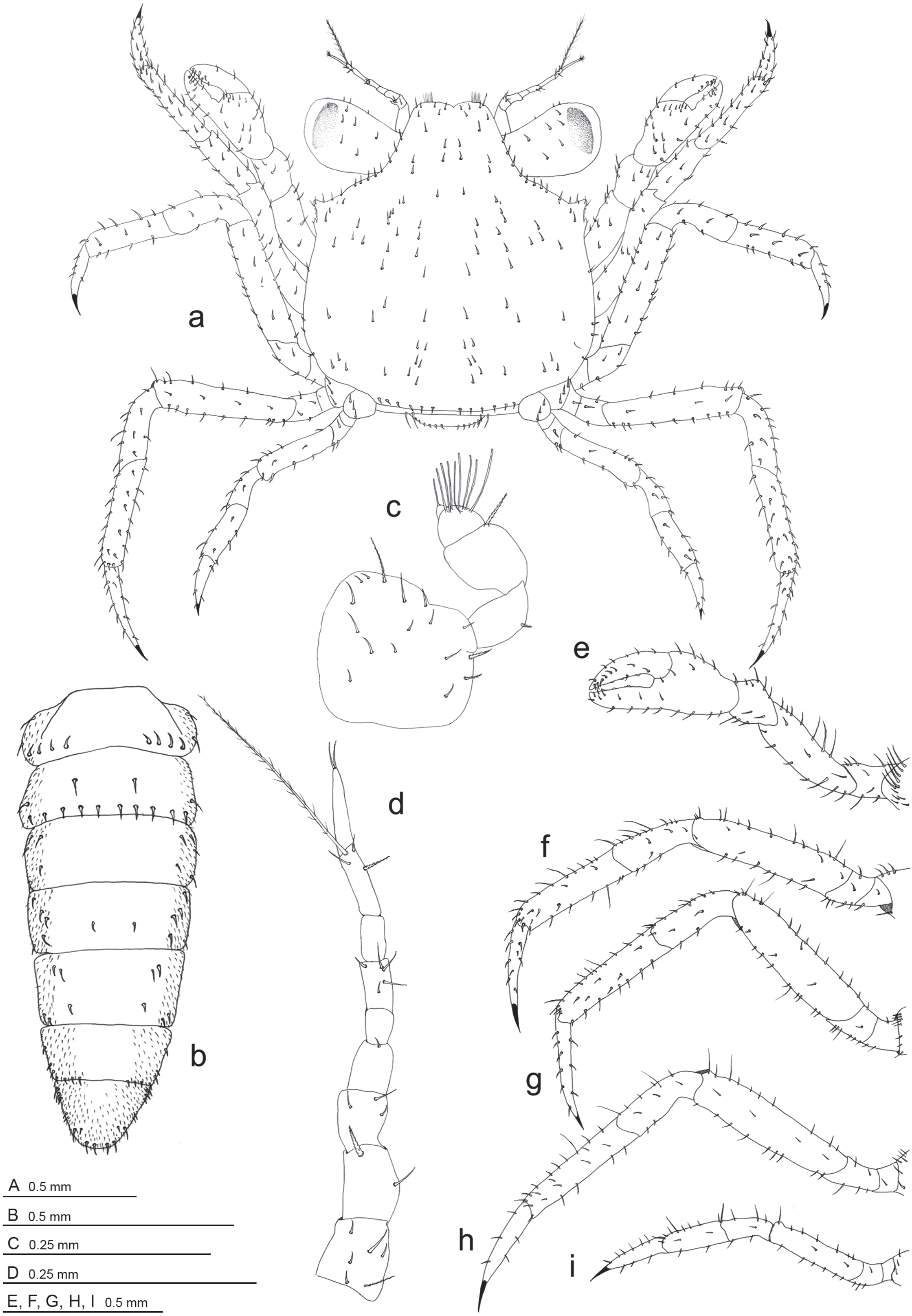

FIGURE 1: *Minuca mordax.* First crab instar. a = dorsal view, b = dorsal view of abdomen, c = antennule, d = antenna, e-i = first to fifth pereopod.

Mandible (Fig. 2a): with strongly chitinous and sharp blade; palp 3-segmented with, with 1, 1, 11 plumose setae (3 long, 8 short).

Maxillule (Fig. 2b): coxal endite with 14 plumose and 12 simple setae. Basal endite with 5 plumose and 15 cuspidate setae. Endopod unsegmented, with 2 plumose setae and 1 simple seta. Protopod with 2 long plumose setae marginally.

Maxilla (Fig. 2c): coxal endite bilobed, with 10-11 plumose and 5 simple setae on proximal lobe; 5 plumose setae and 1 simple seta on distal lobe. Basal endite bilobed, with 1 plumose and 11 simple setae on proximal lobe, 13 plumose and 1 small simple seta on distal lobe. Endopod unsegmented, with 1 plumose seta on its basal margin. Scaphognathite with 38 plumose marginal setae and 4 setae on blade surface.

FIGURE 2: *Minuca mordax.* First crab instar. a = mandible, b = maxillule, c = maxilla, d = first maxilliped, e = second maxilliped, f = third maxilliped.

First Maxilliped (Fig. 2d): coxal endite with 20 simple setae. Basal endite with 36 simple setae. Endopodite 4-segmented, with 3, 5, 0, 9 plumose and 3, 1, 9, 0 simple setae. Exopodite 2-segmented, with 2, 0 plumose and 1, 4 simple setae. Epipodite with 2 plumose and 11 simple setae.

Second Maxilliped (Fig. 2e): Endopodite 4-segmented, with 4, 19, 1, 3 plumose and 0, 0, 2, 13 simple setae. Exopodite 2-segmented, with 8 plumose setae on proximal segment; 3 plumose and 1 simple setae on distal segment. Basis of exopodite with a branchial bud.

Third Maxilliped (Fig. 2f): endopodite 5-segmented, with 23, 10, 8, 5, 2 plumose and 12, 4, 0, 0, 2 simple setae. Exopodite 2-segmented with 11, 0 plumose and 0, 4 simple setae. Epipodite 3-segmented with 18, 12, 0 plumose and 10, 1, 19 simple setae.

Abdomen (Fig. 1b): elongate, with six completely separated somites and telson; somites wider than long, with 12, 14, 10, 12, 10, 14 and 18 simple setae, respectively, and several microtrichia on the outer surface.

DISCUSSION

Due to the limited knowledge of the first juvenile stage of fiddler crab, a morphological comparison until known was limited to *Minuca burgersi* and *Leptuca cumulanta* described by Hirose *et al.* (2010) and Vieira *et al.* (2010), respectively.

According to Rieger & Beltrão (2000), it is possible to identify juvenile crabs of various species based primarily on the number of segments and setae in each appendage. Indeed, the characters that distinguished the first crab stage of *M. mordax* from those of *M. burgersi* and *L. cumulanta* were of that nature: exopod of antennule 2-segmented; endopod of maxillule unsegmented; endopod of the first and second maxilliped 4-segmented (Table 1). In contrast *M. burgersi* has a 3-segmented antennule exopod, 2-segmented maxillule endopod, unsegmented first maxilliped endopod and 5-segmented second maxilliped endopod, while *L. cumulanta* has an unsegmented antennule exopod, 2-segmented maxillule endopod, unsegmented first maxilliped endopod, and 5-segmented second maxilliped endopod (Hirose *et al.,* 2010; Vieira *et al.,* 2010) (see Table 1 for a detailed comparison of all appendages).

Other visible differences are related to the number of setae on the following structures or appendages: antennule, antenna, mandible, maxillule, maxilla, first, second and third maxillipeds. *Minuca mordax* has the lowest total number of setae on these structures or appendages (≅ 505 setae), followed by *M. burgersi* (≅ 523) (Vieira *et al.,* 2010) and *L. cumulanta* (≅ 616) (Hirose *et al.,* 2010) (Table 1).

The brushlike appearance and arrangement of the numerous setae on the maxillule and maxilla of *M. mordax* juveniles are similar to *L. cumulanta* described by Hirose *et al.* (2010). This arrangement of setae may be related to detritivorous feeding habit of these species, with these setae used in the segregation of food particles from the sediment (Crane, 1975).

According to Margalef (1974) these differences in the number of setae can be related to environmental, seasonal and food variations, but the genetic constituent seems to be equaly important.

Although the three species mentioned species belonging to different genera, they share the following morphological characters: peduncle of the antennule 2-segmented; endopod of the antennule unsegmented; presence of aesthetascs in the exopod of the antennule; peduncle of the antenna 3-segmented; flagellum of the antenna 6-segmented; palp 3-segmented; maxilla with coxal and basal endites bilobed; first, second and third maxilliped with exopod 2-segmented and abdomen with six somites that are wider than long (Table 1).

A morphological comparison between juveniles and respective adults reveals that juveniles are more similar to each other than to their respective adults. The antero-lateral carapace spine remains in the adults of the three species but is not as conspicuous as in juveniles (see Vieira *et al.,* 2010 for *M. burgersi* and Hirose *et al.,* 2010 for *L. cumulanta*). Additionally, juveniles of *M. burgersi* and *M. mordax* have a bilobed front, whereas adults have lost this feature. However, in *L. cumulanta* juveniles and adults, this bilobed front is absent.

When comparing the shape of the abdomen of the three species as juveniles, *L. cumulanta* and *M. mordax* showed the highest similarities, while *M. burgersi* was the most distinct. The first abdominal segment in *M. burgersi* is about seven times wider than long, while in *M. mordax* it is only about three times and in *L. cumulanta,* 5.4 times wider than long.

The juvenile fiddler crabs are morphologically similar to adults, with morphological differences likely mainly related to habitat occupation and feeding biology, allowing the occupation of different niches, and thus avoiding intraspecific competition. For example, it was observed that the abundance of juveniles of *M. mordax* was higher among entangled

TABLE 1: Morphological comparison of the first juvenile stage among Gelasiminae. Setal types: I = simple, II = plumose, III = serrate, IV = plumodenticulate, V = serrulate, VI = cuspidate, VII = aesthetascs.

Segment		Setae		
		Minuca burgersi Vieira *et al.* (2010)	*Leptuca cumulanta* Hirose *et al.* (2010)	*Minuca mordax* Present study
Antennule	peduncle	2-segmented; 2 II	2-segmented; 2 I	2-segmented; 2 II
	endopod	unsegmented; 2 I	unsegmented; I	unsegmented; 1 II
	exopod*	3-segmented; 1 I, 9 VII	unsegmented; 1 I, 7 VII	2-segmented; 9 VII
	exopod	4 VII	7 VII	9 VII
Antenna	peduncle	3-segmented; 7 II	3-segmented; 4 I, 3 II	3-segmented; 9 I, 2 II
	flagellum	6-segmented; 12 II	6-segmented; 9 I	6-segmented; 10 I, 1 II
Mandible	palp	3-segmented; 12 II	3-segmented; 11 II	3-segmented; 13 II
Maxillule	endopod*	2-segmented; 2 I	2-segmented; 2 I, 1 II	unsegmented; 1 I, 2 II
Maxilla	coxal endite	bilobed; 20 II	bilobed; 3 I, 3 III, 21 V	bilobed; 6 I, 16 II
	basal endite	bilobed; 29 II	bilobed; 22 I, 11 II, 2 III	bilobed; 12 I, 14 II
First Maxilliped	exopod	2-segmented; 9 II	2-segmented; 8 II	2-segmented; 5 I, 2 II
	endopod*	unsegmented; 24 II	unsegmented; 5 I, 27 II, 3 III	4-segmented; 13 I, 17 II
Second Maxilliped	exopod	2-segmented; 18 II	2-segmented; 3 I, 12 II, 1 VI	2-segmented; 1 I, 11 II
	endopod*	5-segmented; 42 II	5-segmented; 10 I, 22 II, 11 III, 7 IV	4-segmented; 15 I, 27 II
Third Maxilliped	exopod	2-segmented; 18 II	2-segmented; 19 II	2-segmented; 4 I, 11 II
Abdomen	6-somites (wider than long)	I, II	I	72 I
	telson		I, II	18 I

* The characters that differentiate *M. mordax* from the *M. burgersi* and *L. cumulanta.*

thallus of the red algae *Catenella caespitosa* and *Herposiphonia secunda* than inside muddy substrates (Martins, 2014). A similar pattern was observed in *Minuca pugnax* (Smith, 1870), juveniles preferring a substrate covered by *Spartina alterniflora* (Behum *et al.,* 2005), indicating that juveniles may prefer areas with higher organic-matter content more than adults, including habitats that may provide greater protection against desiccation and predation (Levinton, 1982; Flores & Negreiros-Fransozo, 1999; Litulo, 2005; Hirose *et al.,* 2010).

Due to the limited number of studies on the morphology of juveniles of other species of Gelasiminae occurring in Brazil, it remains unclear how the particuliar characters of *M. mordax* identified here hold up against other congenerics. Studies on the early stages of other Gelasiminae species are highly desirable not only from that regard, but also in order to contribute to a better understanding of taxonomic classification, ontogenetic development and ecological partitioning.

RESUMO

O primeiro estágio juvenil do caranguejo chama-maré Minuca mordax *foi descrito. Larvas zoea foram obtidas de fêmeas ovígeras e cultivadas em laboratório até atingir o primeiro estágio juvenil. O desenvolvimento de zoea I até o primeiro estágio juvenil teve duração de 35 dias após a eclosão. O cultivo foi mantido em um aquário com salinidade 20‰, sob fotoperíodo (claro: escuro/12:12) e temperatura (25°C) constante. Os juvenis foram dissecados e os apêndices desenhados e descritos. O primeiro estágio juvenil de* M. mordax *pode ser morfologicamente distinto do mesmo estágio de* M. burgersi *and* L. cumulanta *por apresentar antênula com endopodito bisegmentado (3-segmentos em* M. burgersi, *não segmentado em* L. cumulanta*), maxílula com endopodito não segmentado (2-segmentos em* M. burgersi *e* L. cumulanta*), e primeiro e segundo maxilípodo com endopodito 4-segmentado (respectivamente não segmentado e 5-segmentos em* M. burgersi *e* L. cumulanta*). Os seguintes caracteres são comuns a estas três espécies: pedúnculo da antênula bissegmentado; antênula com endopodito não segmentado; presença de estetascos na antênula; pedúnculo da antena trisegmentado; flagelo da antena 6-segmentado; mandíbula trisegmentada; maxila com coxal e basal endito bilobado; primeira, segunda e terceira maxila com exopodito bissegmentado e abdômen com seis somitos que são mais largos do que longos.*

Palavras-Chave: Morfologia do juvenil; Desenvolvimento ontogenético; Manguezal; Baía de Guaratuba.

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