INTRODUCTION


The study of juvenile phase of Brachyura are very important for identification purposes, as most of the characters used in the identification of brachyrurans are based upon descriptions of mature adults, whether either a juvenile or immature is caught, identification might be somewhat difficult, or even impossible, in the absence of appropriate morphological descriptions of these stages. The study of early crab stages also may help to establish phylogenies within Brachyura (Martin et al. 1984).

However, the descriptions of juvenile stages are only available for few crabs species, less than 10% in the case of ocypodids. Regarding to the genus *Uca*, Hyman (1920) described the juvenile stages of *Uca pugilator* (Bosc, 1802) (as *Gelasimus pugilator* Bosc, 1802) until 4 mm of carapace width; gross morphology of first and second stages of *Uca panacea* Novak & Salmon (1974) was described by Novak & Salmon (1974); Muraoka (1976) described the first juvenile stage of *Uca lactea* (de Haan, 1835) and O’Connor (1990) described the morphological differentiation of juveniles stages based on number of spoon-tipped setae on the meropodite of the second maxilliped of *Uca pugilator* and *Uca pugnax* (Smith, 1870).
Uca (Minuca) burgersi Holthuis, 1967 is widely distributed over the eastern American Coast, as it is found in Florida, Gulf of Mexico, Antillas, Venezuela and Brazil (from Maranhão to São Paulo). It inhabits estuarine beaches, usually near to mangrove trees, living in burrows constructed in the intertidal zone (Melo 1996).

This paper describes the first crab juvenile stages of Uca burgersi reared under laboratory conditions and some alterations on the morphology of the nine subsequent juvenile stages. A comparison of juvenile morphology is given for the juvenile of other species already studied and than occur in the Brazilian coast.

MATERIAL AND METHODS

Uca burgersi ovigerous females were collected handly at Praia Dura (Ubatuba, São Paulo - Brazil). In the laboratory, the females were isolated in tanks with 10 L of filtered seawater, with salinity at 34‰ and continuous aeration until larval hatching. Tanks were kept in a BOD-eletrolab climatic chamber with controlled temperature (25 ±1 ºC) and a photoperiod of 12 h of light and 12 h of dark. Females were not fed during this period.

Rearing method of larvae and description of larval development has been described by Rieger (1998). Each juvenile, 10 in total, was placed in an individual 50 mL acrylic jar with 20 mL of seawater at salinity 34‰. Afterwards, jars were transferred to the climatic chamber with the same temperature and photoperiod settings stated earlier. Juveniles were monitored daily to register mortality and verify the occurrence of ecdysis. Dead juveniles and exuviae were fixed in 96% alcohol and glycerin mixture at ratio of 1:1 (vol:vol). Jars were washed daily with freshwater. Juveniles were fed ad libitum with Artemia sp.

Carapace maximum length and width were recorded at each juvenile stage. Drawings and measurements were done in juveniles and exuviae using an Olympus BX-40 microscope equipped with camera lucida. The descriptions of appendages were based on Clark et al. (1998). Throughout the text, the following nomenclature was adopted: J-I, first stage juvenile; J-II, second stage juvenile; J-III, third juvenile stage, successively. Numbers presented in brackets means variation in the number of setae.

RESULTS

The first juvenile crab appeared 43 days after hatching. Only one individual reached the 10th juvenile stage (174 days after hatching). The maximum, minimum and average duration of each stage of the juvenile phase is presented in Table I.

Table I – Uca burgersi Holthuis, 1967. Duration and survival of the juvenile stages starting from the hatching. $\bar{x}$, accumulated average (in days); D, minimum duration; D', maximum duration; n, number of alive individuals; †, number of dead individuals and S%, survival percentage.

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Description of the first juvenile stage

Carapace (Figure 1a) dorsally convex, with sparsely distributed simple, small, and plumose setae.

Gastric, cardiac, intestinal and branchial regions not evident. Antero-lateral edges with minute teeth.
Figure 1 – *Uca burgersi* Holthuis, 1967. First juvenile stage, (a) dorsal view; (b) abdomen, dorsal view; (c) cheliped (Q) and pereopods (P<sub>2</sub>-P<sub>5</sub>). Scale bars = 0.5mm.

**Antennule** (Figure 2a) basal segment well developed with 17(13, 15) plumose setae. Peduncle 2-segmented with 2(3) plumose setae on proximal segment; distal segment without setae. Endopod (ventral flagellum) unsegmented with 2 terminal simple setae. Exopod (dorsal flagellum) 3-segmented: proximal segment without setae; median segment with 1(2-3) simple setae, 5(6) aesthetascs; distal segment with 4(5) aesthetascs and without setae.
Figure 2 – *Uca burgersi* Holthuis, 1967. First juvenile stage, (a) antennule; (b) antenna; (c) mandible; (d) maxillule; (e) maxilla. Scale bar = 0.1mm.

Antenna (Figure 2b) peduncle 3-segmented with 4, 2(1), 1(2) plumose setae. Flagellum 6-segmented with 0, 0, 3, 0, 5, 1 subterminal and (3)3 terminal plumose setae.

Mandible (Figure 2c) palp 3-segmented with 0, 4, 8 plumose setae.

Maxillule (Figure 2d) coxal endite with 28(23-30) plumose setae. Basal endite with 22(20-23) plumose setae. Endopod 2-segmented with 1 simple seta in each segment. Protopod with 3(2) plumose setae.

Maxilla (Figure 2e) coxal endite bilobed with 14(15-17) plumose setae on proximal lobe; 6(7-8) plumose setae on distal lobe. Basal endite bilobed with 13(11-14) plumose setae on proximal lobe, and 16(14-15) plumose setae on distal lobe. Endopod unsegmented and without setae. Exopod (scaphognathite) with 51(46-50) marginal plumose setae and 8(9, 10) simple setae on median surface.

First Maxilliped (Figure 3a) coxal endite with 21(20, 22-25) plumose setae. Basal endite with 34(35-42) plumose setae. Endopod unsegmented with 24(20-23) plumose setae. Exopod 2-segmented with 5(6-7) plumose setae on proximal segment and 4 plumose setae on distal segment. Epipod triangular shaped, is well-developed, with 2 basal simple setae and 5(4) terminal simple setae.
Second Maxilliped (Figure 3b) endopod 5-segmented with 4, 18(16-19), 2, 9(10-11), 9(7-10) plumose setae. Exopod 2-segmented with 14(13) plumose setae on proximal segment; 4(3) plumose setae on distal segment. Epipod with 3 simple setae. Basis of epipod with a podobranchial bud.

Third Maxilliped (Figure 3c) endopod 5-segmented with 33(34-40), 18(14-20), 9(10), 6(5-8), 6(7) plumose setae. Exopod 2-segmented with 14(13-19) plumose setae on proximal segment; 4 plumose setae on distal segment. Protopod with 27(22-29) simple setae. Protopod with one posterior arthrobranchial and a podobranchial buds. Epipod with 16(17) basal simple setae, 19(15-18) terminal simple setae, one of them having anchors.

Abdomen (Figure 1b) with six somites and telson folded under carapace; somites wider than longer, with small, simple and plumose setae dorsally. Abdominal somites, from second to fifth, with four pairs of pleopods (Figure 6 J-I) without setae; uropods absent.

Chelipeds (Figure 1c-Q) symmetrical with sparse and plumose setae; two arthrobranchiae at the basis. Propodus with two small teeth, dactylus with one small tooth. Other pereopods (Figure 1c-P2-P5) morphologically very similar. The third is the largest, the fifth is the shortest. All pereopods have sparsely distributed simple and plumose setae.

Figure 3 – Uca burgesi Holthuis, 1967. First juvenile stage, (a) first maxilliped; (b) second maxilliped; (c) third maxilliped. Scale bar = 0.1mm.
General comments on different aspects observed in further stages

From the first stage of the juvenile phase, in addition to the increase in size, important modifications occur on the carapace, abdomen, pleopods and chelipeds. There were no changes in shape of the cephalic and thoracic appendages, but an increase in the number of aesthetascs and setae occurred on each article. Branchial ontogeny was complete after the second juvenile stage: 1 pair of arthrobranchia and 1 pair of podobranchia in the second maxilliped; 2 pairs of arthrobranchiae and 1 pair of podobranchia in the third maxilliped; 2 pairs of arthrobranchiae and 1 pair of pleurobranchia in the first pereopod.

From the second stage of the juvenile phase, the carapace (Figure 4) has no lateral teeth and it becomes progressively wider than longer with stage changing (Table II). In the 9th juvenile stage, carapace is very similar to the adult carapace.

Figure 4 – Uca burgersi Holthuis, 1967. (a) carapace from second juvenile to ninth juvenile stage. Scale bar = 0.5mm.
Table II – *Uca burgersi* Holthuis, 1967. Measurements in millimeters, of mean (\(\bar{x}\)) carapace length (CL) and carapace width (CW). Variation expressed as standard deviation (sd); number of observed crabs (N) and carapace width/length ratio (CW/CL).

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Abdominal sexual dimorphism cannot be observed until the 5\(^{th}\) juvenile stage. From the 6\(^{th}\) stage, gender differences in abdominal morphology can be observed, as males have a smaller abdomen than the females (Figure 5 J-VI). Dimorphism of the abdomen is clear-cut from the 7\(^{th}\) juvenile stage (Figure 5 J-VII - J-IX).

Figure 5 – *Uca burgersi* Holthuis, 1967. Abdomen from sixth juvenile stage to ninth juvenile stage (J-VI – J-IX). Scale bar = 0.5mm.
After the first juvenile stage until the 3rd juvenile stage all pleopods decrease in size (Figure 6 J-II – J-III). In the 4th stage (Figure 6 J-IV) males have two pairs of pleopods, one pair in the first and one pair in the second abdominal somite. Females have four pairs of pleopods (Figure 6 J-IV), one pair in each abdominal somite (from the second to the fifth). From the 4th juvenile stage, all pleopods increase in size (Figure 6 J-IV – J-VII and Figure 7 J-VIII – J-IX). In J-V, first and second pairs of pleopods (Figure 6 PL2 and PL3) in females (3 in total) are biramous. All pleopods of females are biramous in sixth juvenile stage (Figure 6 J-VI – J-IX), with endopod longer than exopod. There are 3 males and 3 females in J-VIII and the first pleopods (Figure 7-PL1) of males with 3(4-5) simple setae, second pleopod without setae (Figure 7-PL2); in females endopods are 2-segmented, first pleopod without setae; second with 2(3-5) simple setae on proximal segment and 1(2) simple setae on distal segment of endopod; third and fourth pleopod without setae. In the J-IX (Figure 7 PL1-PL2), first pleopod (PL1) of males has eight simple setae, second without setae (PL2); females (Figure 7 PL2-PL5) have simple setae on all exopod and endopod of pleopod.
Figure 6 – *Uca burgersi* Holthuis, 1967. Pleopods from first juvenile to seventh juvenile stage (J-I – J-VII). Scale bars = 0.1mm.

A significant characteristic of the genus *Uca*, which can even be seen in the juvenile stages, is the asymmetry of the chelipeds of males. Until the 6th juvenile stage (Figure 8 J-VI) no dimorphism of chelipeds is found. In 7th stage (Figure 8 J-VII), chelipeds of males start to be slightly larger than chelipeds of females; however no asymmetry between male chelipeds is noticed. In 8th stage (Figure 8 J-VIII), a slight difference between right and left cheliped of males is noticed, as the right cheliped tends to have a slightly bulkier propod than the left cheliped.

Figure 7 – *Uca burgersi* Holthuis, 1967. Pleopods from eight juvenile to ninth juvenile stage (J-VIII - J-IX). Scale bars = 0.1mm.
Figure 8. – *Uca burgersi* Holthuis, 1967. Chelipeds from sixth juvenile stage to eight juvenile stage (J-VI – J-VIII). Scale bars = 0.5mm.

**DISCUSSION**

One of the most striking morphological changes in juvenile stages of Brachyura is a marked change of the abdomen of females, which forms an incubating chamber in which the eggs will develop. Abdominal dimorphism of females, in *Uca burgersi* has been observed from the 6th juvenile stage onwards, as in *Pilumnus vestitus* Haswell, 1882 (Pilumnidae) (Hale 1931). In *Inachus dorsetensis* (Pennant, 1777) (Inachidae) described by Ingle (1977) and *Pyromaia tuberculata* (Lockington, 1877) (Inachoididae) described by Flores et al. (2002) differentiation occurs in the 3rd stage and in *Pachygrapsus transversus* (Gibbes, 1850) (Grapsidae) in the 7th stage (Flores et al. 1998). In *Panopeus austrobesus* Williams, 1984 as *Panopeus herbstii* H. Milne-Edwards, 1834 (Panopeidae) (Hebling et al. 1982) and in *Callinectes sapidus* Rathbun, 1896 (Portunidae) (Barutot et al. 2001), no abdominal dimorphism occurs until the 8th and 11th juvenile stages.

Sexual differentiation is the main event in the juvenile phase of crabs and it can occur in many different stages, depending on the species. In Grapsoidea there is no pattern. For instance, in *P. transversus*, *Neohelice granulata* (Dana, 1851), *Cyrtojapsus angulatus* Dana, 1851 and *Sesarma rectum* Randall, 1840 differentiation occurs in the 2nd, 3rd, 4th and 12th juvenile stage, respectively (Flores et al. 1998, Rieger & Nakagawa 1995, Rieger & Beltrão
2000, Fransozo 1986/1987). In Xanthoidea such as Panopeus austrobesus, Eriphia gonagra (Fabricius, 1781), Eurypanopeus abbreviatus (Stimpson, 1860), Menippe nodirrons Stimpson, 1859 and Hexapaneus caribaeus, differentiation always occurs in the fourth stage (Hebling et al. 1982, Fransozo & Negreiros-Fransozo 1987, Fransozo et al. 1988, Vieira 2000). Similar finding is reported for the Portunidae Callinectes sapidus studied by Barutot et al. (2001). In Uca pugilator the differentiation occurs when the carapace of juvenile reaches 3 mm of wider (Hyman 1920), while in U. burgessi, it occurs in the 4th juvenile stage (2.31 mm of carapace width).

Sexual dimorphism in the size of the cheliped is reported to be the origin of the secondary sexual organ, which is important in the definition of territory as well as combat, display, courtship and mating (Hartnoll 1988). Until sexual differentiation in Uca, chelipeds are symmetrical in both sexes. When sexual differentiation takes place, at around 3 mm width of carapace in U. pugilator, at approximately 1.7 mm width of carapace in Uca cumulanta Crane 1943 (Hyman 1920, Ahmed 1978) and in the seventh juvenile stage (3.11 mm carapace width) in U. burgessi, either right or left cheliped of males becomes slightly larger than the counter side. Unfortunately, few individuals were obtained in order to establish in which side heterochely predominates during the development of U. burgessi. Nevertheless, while left heterochely was reported in adult populations of U. burgessi by Crane (1975), right heterochely in cogenetic species [U. vocans (Linnaeus 1758) and in U. tetragonon (Herbst 1790)] was reported by Barnwell (1982).

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FRANSOZO, A. 1986/87. Desenvolvimento dos estágios juvenis de Sesarma (Holometopus) rectum Randall, 1840 (Decapoda, Portunidae) reared in the laboratory. Zoologia da Universidade de São Paulo) for confirmation of species identification. We thank to Dr. Maria Lucia Negreiros-Fransozo (Departamento de Zoologia, IBB - UNESP Campus de Botucatu, SP) and Dr. Duane Baros Fonseca for valuable comments on the manuscript.


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