Development and functional morphology of the foregut of larvae and postlarva of *Ucides cordatus* (Decapoda, Ocypodidae).

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Abstract

Important studies on the ecology of the mangrove crab *Ucides cordatus* are available in the literature. However, the biological aspects of the morphology during the larval development of this species were little reported, mainly those related to functional importance of the features of digestive system. The gross morphology and fine structures of the foregut of the first and last larval stages and first juvenile of *U. cordatus* were described in details and compared in relation to the functional morphology. The first larva shows a small foregut and a filter press incompletely developed, but apparently functional. However, these structures became more complex during the larval development. Increasing in number of setae and specialisation of the filter press is observed in the last zoeal stage. A drastic changing in the foregut occurs after metamorphose to megalopa and first juvenile. Investigations on the function of the digestive system may aid in the solution of problems in crustacean culture by an adequate choice of food, improving larval survival rate.

Key words: foregut, larvae, first juvenile, crab, morphology.

Introduction

The mangrove crab *Ucides cordatus* (Linnaeus, 1763) is one of the most appreciated crustaceans in Brazil, mainly in the northeast region. Researches have been carried out in the wild related to the bioecological aspects (Alcantara-Filho, 1978; Ivo and Gesteira, 1999; Ivo and Dias, 1999; Botelho *et al.*, 1999; Vasconcelos *et al.*, 1999). In early studies, the complete larval development of this species was described in detail by Rodrigues and Hebling (1989). More recently, it was investigated the necessary requirement of food for first larvae of *U. cordatus* by Abrunhosa *et al.* (2002).

Studies on the functional importance of the feeding apparatus, especially the mouthparts and structures of foreguts of the larval and postlarval stages of *U. cordatus* are not reported in the scientific literature. Such aspects are considered relevant to improve a rational crab culture, establishing an adequate diet for a large-scale production of postlarvae (Abrunhosa and Melo, 2002). These studies are also important for identification of a suitable feed at each larval stage in order to develop feeding strategies in the culture system.

The atrophy or whole absence of setation in the appendages of the mouthparts and lateral teeth in the foregut have showed evidences of non-feeding behaviour for pueluri of spiny lobsters (Nishida *et al.*, 1990; Wolfe and Felgenhauer, 1991; Lemmens and Knott, 1994) and glaucothoes of anomurans (Abrunhosa and Kittaka, 1997a,b). These results indicate that food is not required in water culture during all stage of metamorphosis keeping in good conditions the water quality.

The present work aims to examine in detail the foregut of the *U. cordatus*, tracing its development from first larval stage through metamorphosis and to the first juvenile. The functional significance and morphological changes occurred in the foregut is also discussed.

Material and Methods

Samples of zoeae in the I and VI stages (last zoeal stage), megalopae and first juveniles of *U. cordatus* were obtained from larval rearing of a large-scale experiments. Egg-bearing females were collected in the estuary of Ceará River, northeastern Brazil. The larvae and postlarvae were fixed in 10% formalin. Later, 10 individuals of each stage were immersed in 20ml of 5% aqueous solution of KOH heated to 80° C for about, 30 minutes for the zoeae and megalopae and 12 h for the first juveniles. Then, the samples were washed and stained with 0.1% methylene blue. The foreguts were dissected with fine needles under a compound microscope. The illustrations were made using a lucida camera.

The terminology used in the description followed Meiss and Norman (1977), Nishida *et al.* (1990) and Abrunhosa and Kittaka (1997a).

Abbreviations utilized in the descriptions: amp = anterior mesopyloric ossicle, ap = pleuropyloric ossicle, appc = prepectinal accessory, c = cardiac chamber, cf = cardiac, floor, cpv = cardiopyloric valve, dt = dorsal teeth, exp = exopyloric ossicle, fp = filter press, ir = interampullary ridge, lt = lateral teeth, mp = median pleuropyloric ossicle, msc = mesocardiac ossicle, oes = oesophagus, ov = oesophageal valve, p = pyloric chamber, pop = pospectinal ossicle, pp = posterior pleuropyloric ossicle, ppc = prepectinal ossicle, prp = propyloric ossicle, ptc = pterocardiac ossicle, py = pyloric ossicle, sd = subdentate ossicle, up = uropyloric ossicle, urc = urocardiac ossicle, zyc = zygocardiac ossicle.

Results

Morphology of the foreguts

1. First larval stage (Figure 01A)

The foregut is small, simple and chitinous, lacking gastric mill and lateral teeth.

Cardiac chamber: Flattened laterally, much more narrow in relation to pyloric chamber; base of cardiac floor with numerous fine setae; cardiac wall lacking setae; cardiopyloric valve enlarged and robust, bent to the pyloric chamber and armed with long setae on posterior portion.

Pyloric chamber: Large, showing fine setae on the pyloric roof; filter press large filling all inferior portion but incompletely developed; median and elongate setae in the interampullary ridge (dorsal brush)

2. Last larval stage (Stage VI) (Figure 01B)

The foregut is more complex then that of first stage: lacking gastric mill and lateral teeth.

Cardiac chamber: About 2 times longer than pyloric chamber; cardiac floor with numerous elongated setae; cardiac wall showing setae on the anterior portion; cardiopyloric valve enlarged with elongated setae.

Pyloric chamber: Elongated setae on the posterior portion of the pyloric roof; the pyloric wall with many setae along the chamber; filter press enlarged and visually specialized; interampullary ridge with numerous setae; ampullary setal screen very complex and functional

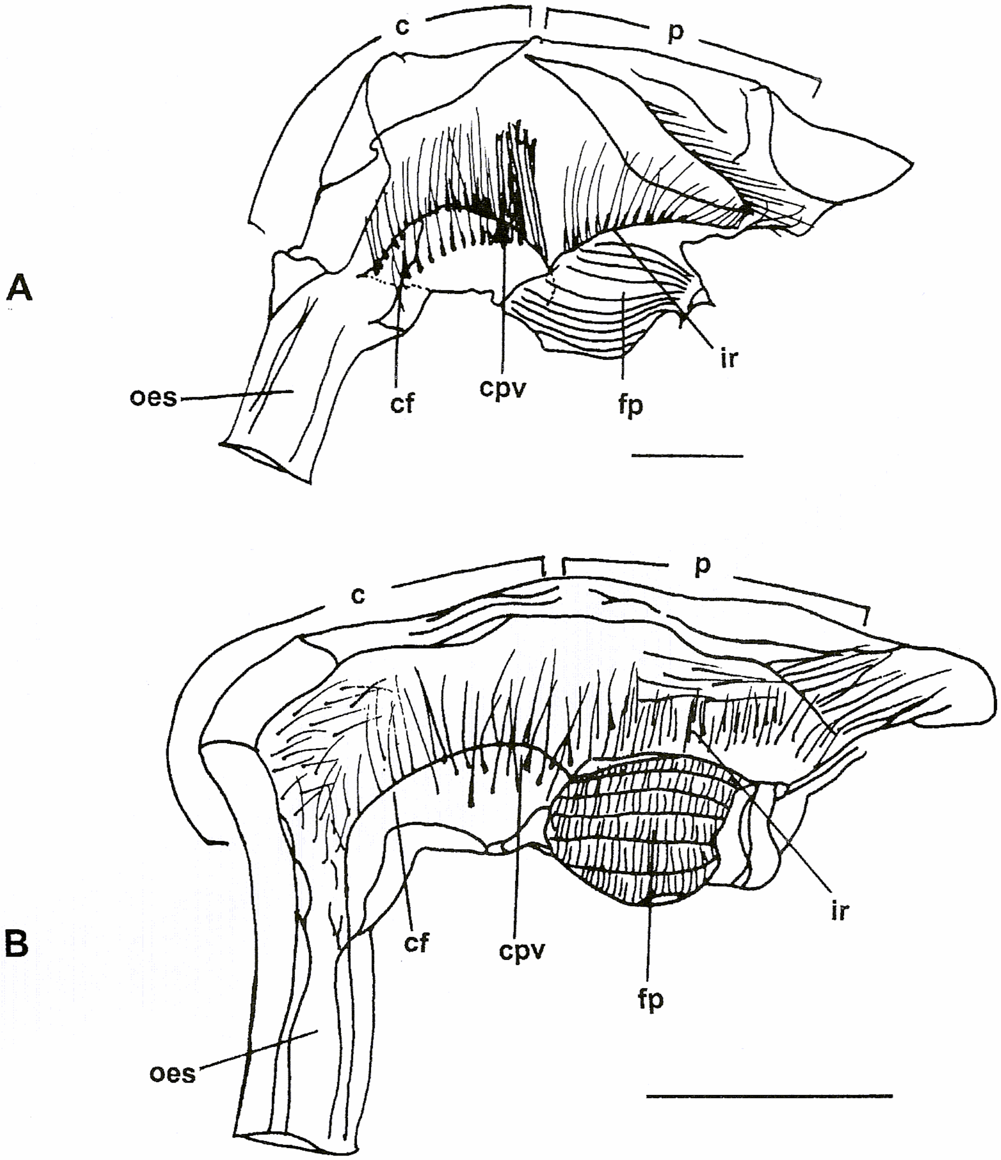

Figure 1: *Ucides cordatus*, foregut of the zoeae, lateral view (right): A, stage I; B, stage VI (last zoeal stage). Scale, A= 0.04 mm and B= 0.20 mm.

3. Megalopa (Figure 02)

Drastic morphological changes occur at the megalopa foregut compared to the zoeal stages. Main changes are observed in general form and size of the abdomen and appearance of the gastric mill and lateral teeth. Besides, the oesophageal valve bears many long setae.

Cardiac chamber: Enlarged dosolaterally (about 2 times larger than the pyloric chamber) by the solidly ossicles, but seeming to be little calcified; the cardiac floor lies vertically; the cardiac wall has few setae; the mainly ossicles are present as: zygocardiac (bearing the lateral teeth) and the urocardiac (bearing a strong dorsal) tooth; the cardiopyloric valve is strong and specialized having many short setae on the superior portion.

Pyloric chamber: Setae filing the anterior and posterior portions of the pyloric roof; pyloric wall showing minute setae; filter press more specialized by the size and increment of setae; interampullary ridge with long setae.

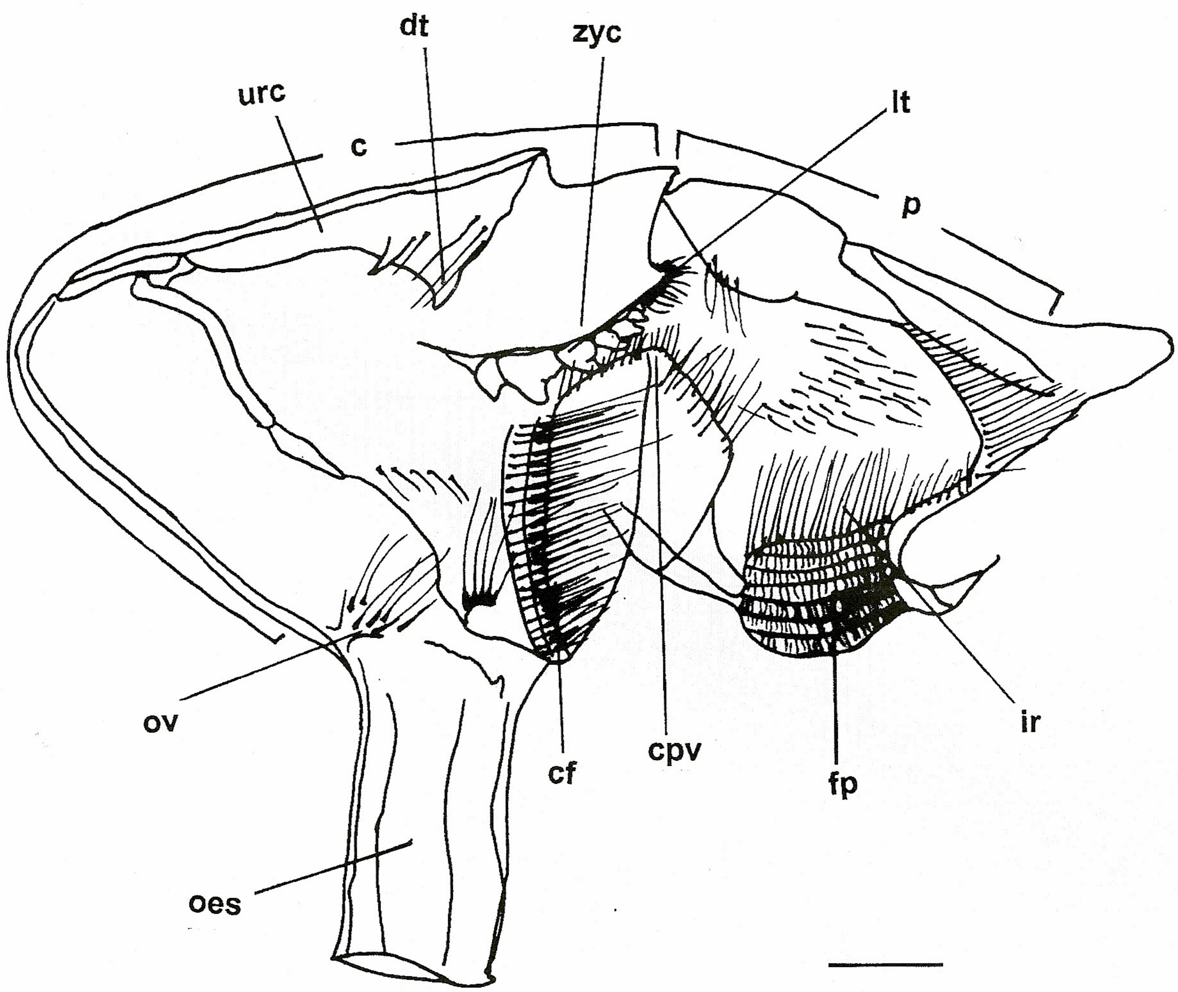

Figure 2: *Ucides cordatus*, foregut of the megalopa in lateral view (right).
Scale = 0.08 mm.

4. Juvenile I (Figure 03A)

More ossicles are well visible in the foregut compared with previous stage (megalopa) and more specialized; oesophageal valve with medium setae.

Cardiac chamber: Similar shape compared with previous stage (megalopa); gastric mill well defined having the following articulates ossicles: subdentate, postpectinal, prepectinal, postpecnial, pterocardiac, mesocardiac, urocardiac (bearing a prominent dorsal tooth, Figure 03B), zygocardiac (bearing the lateral teeth, Figure 03C), propyloric and exopyloric; the cardiac floor lies vertically; cardiac wall lacks setae; cardiopyloric valve more robust and specialized with short and strong setae on the superior portion.

Pyloric chamber: specialized, having the ossicles: anterior pleuropyloric, anterior mesopyloric, median pleuropyloric, posterior pleuropyloric, uropyloric and pyloric; filter press complex and functional.

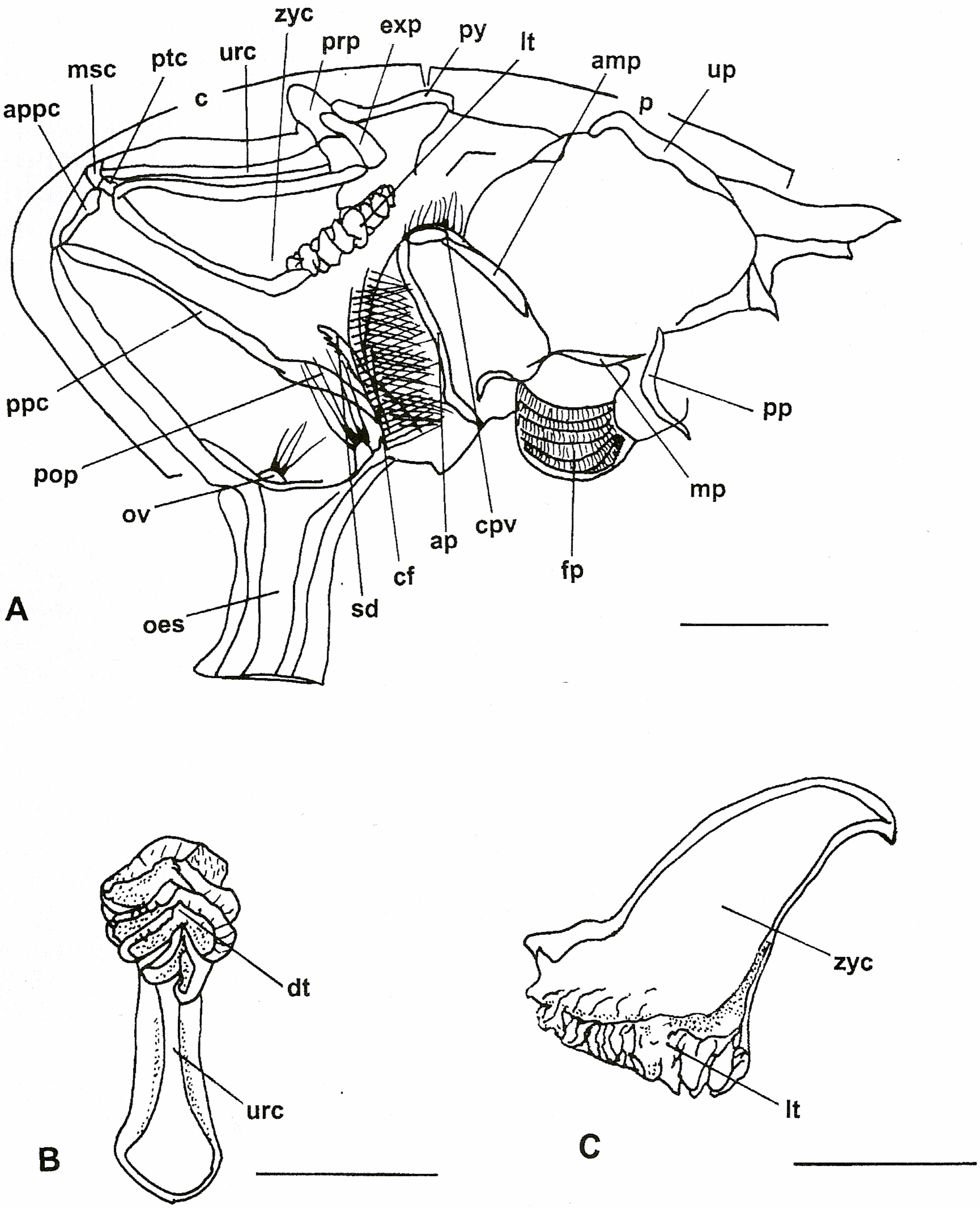

Figure 3: *Ucides cordatus*, foregut of the juvenile in lateral view (right) and details of urocardiac and zygocardiac ossicles: A, Juvenile I; B, detail of the urocardiac ossicle (inferior view); C, detail of the zycocardiac ossicle and lateral tooth (lateral left view).
Scale, A, B and C = 0.16 mm

Discussion

Several works dealt morphological and functional aspects of the foregut in decapods. However, majority of these studies is concentrated to adult of decapods. Information on structure and function of foregut are considered important role for understanding the digestive process of larvae and postlarvae at different stages.

The larvae of *U. cordatus* appear to be able to feed in the first stage despite of a reduced number of setae and to present of an incompletely developed filter press. However, researches have demonstrated that first larvae of *U. cordatus*, submitted to a food experiment, were able to molt to second stage without feed, probably because the nutritional reserve, even having a low survival rate. Those treatments where the larvae were submitted with adequate feeding they molted at elevate percentage (Abrunhosa *et al.* 2002).

The numerous setae present in the cardiac and pyloric chambers, observed during the larval development, indicate that improvement in capture the prey occurs at zoeal foregut. Besides, the absence of a complex gastric mill, dorsal lateral teeth are absent, but the presence of a complex fitter press in the pyloric foregut, strongly suggests that the zoeal foregut has not function of grinding, as adults, but mixing food function, and it is well adapted for processing soft food. Similar observations were reported for king crab zoeae *Paralithodes* species and Phyllosoma of spiny lobsters (Factor, 1989; Nishida *et al.*, 1990; Abrunhosa and Kittaka, 1997 a,b).

The foregut of megalopa of the *U. cordatus* is drastically changed after the metamorphosis (Figure 02). The megalopa foregut has a complex gastric mill and the medial and lateral teeth. The presence of these structures indicates that they can feed of hard particles of food. Similar observations were reported by Factor (1982). Based on the postlarval characteristics of foreguts in which showed presence of the teeth of the gastric mill the author concluded megalopae of the stone crab, *Menippe mercenaria*, are feeding animals.

On the other hand, evidences of non-feeding larvae have been reported in the transitory stages of other decapods. Pueluli of spiny lobsters of the genera *Panulirus* and *Jasus* and glaucothoes of king crabs *P. ca.. tschaticus*, *P. brevipes* and *P. platypus* show a reduced and uncalcified mandibles, reduction in number of setae in the mouthpart appendages and poorly developed foregut (Kittaka, 1988; Lemmens and Knot, 1994; Nishida *et al.*, 1990, 1995; Abrunhosa and Kittaka, 1997 a,b). These morphological characteristics strongly suggested the absence of feeding behaviour of these metamorphosed stages, and such information have influenced in their larval culture.

The change of feeding to a non-feeding habits will make possible to organize a no feeding schedule and consequently to improve the larval culture, because food such as *Artemia* nauplii and others may induces water quality deterioration.

Remarkable changes of morphology in the foregut take place during the transition from megalopa of *U. cordatus* to first juvenile. The foregut of the newly moulted juvenile is highly complex with well-developed and calcified gastric mil, which is similar to that of adults of other decapods described in the literature (Meiss and Norman, 1977; Kunze and Anderson, 1979; Suthers and Anderson, 1981). The molting of the megalopa to the first juvenile brings changes in the foregut necessary to process a large quantity of soft and solid food, which they encounter in the benthic environment.

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