Revista Ciência Agronômica, v.36, n.3, p. 290-294, 2005
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br ISSN 0045-6888

# Development and functional morphology of the foregut of larvae and postlarvae of *Petrolisthes armatus* (Gibbes) (Decapoda, Porcellanidae)[1]

## Desenvolvimento e morfologia funcional do estômago de larvas e pós-larvas de *Petrolisthes armatus* (Gibbes) (Decapoda, Porcellanidae)

**Jô de Farias Lima[2], Fernando Abrunhosa[3] e Marlon Aguiar Melo[4]**

**Abstract -** Previous studies on foreguts of the transitional stages have revealed complete absence of ossicles of the gastric mill in anomuran crabs, suggesting non-feeding behavior in this stage. In order to verify non-feeding behavior might occur in other anomuran species, the present work gives a detailed description of the foregut during the development of the porcellanid *P. armatus*. The foregut of the zoea I and II are structurally similar. They are morphologically simple, chitinous and lacking hard structures, but apparently functional. However, a significant change is observed in the foregut after metamorphosis into megalopal stage. In this change, the cardiac chamber shows a complex gastric mill supporting two lateral teeth and the pyloric chamber has a filter press relatively small, but specialized. These structures become more complex and calcified in the juvenile I. Comparisons between these characteristics and functionality of the *P. armatus* foreguts with other anomuran species, previously reported, are discussed.

***Index terms*:** foregut, larva, post-larva, anomura crab.

**Resumo** - Estudos anteriores sobre estômago de estágios transitórios revelaram completa ausência de ossículos do moinho gástrico em caranguejos anomuras, sugerindo que este estágio não se alimenta. A fim de verificar se o comportamento não alimentar pode ocorrer em outras espécies anomuras, o presente trabalho fornece a descrição morfológica detalhada do estômago dos estágios zoea I e II (último estágio), megalopa e juvenil I do porcelanídeo *Petrolisthes armatus*. Os estômagos dos zoea I e II são estruturalmente similares. Eles se apresentam morfologicamente simples, quitinosos e com ausência de estruturas rígidas, porém aparentemente funcionais. Entretanto, uma drástica mudança é observada no estômago dos megalopas, nos quais apresentam na câmara cardíaca um complexo moinho gástrico suportando dois dentes laterais bem desenvolvidos. A câmara pilórica apresenta um filtro pilórico relativamente simples, mas especializado. Essas estruturas tornam-se mais complexas e calcificadas no juvenil I. As características e a funcionalidade dos estômagos de *P. armatus*, em cada estágio larval e pós-larval, são comparadas e discutidas com as de outras espécies de anomuras descritas em trabalhos anteriores.

***Termos para indexação***: estômago, larva, pós-larva, caranguejo anomura.

---

[1] Recebido para publicação em 06/07/2004; aprovado em: 12/05/2005
[2] Biólogo, Mestrando do Grupo de Estudos Costeiros, UFPA, PA, jodeflima@yahoo.com.br.
[3] Eng. de Pesca, Ph. D., Prof. do Núcleo de Estudos Costeiros, Campus de Bragança, UFPA, Alameda Leandro Ribeiro s/n, Aldeia, 68.600-000 Bragança, PA, Brasil, faraujo@ufpa.br.
[4] Eng. de Pesca, Mestrando em Engenharia de Pesca, CCA/UFC,CE, aguiarmarlon@yahoo.com

## Introduction

*Petrolisthes armatus* Gibbes is a shallow-water porcelanid crab widely distributed in the tropical waters. This species lives in intertidal areas to a depth of 60m, under stone, corals, mussel banks, in sponges and shellfishes (Melo, 1999).

Information on the complete larval development of *P. armatus* was published by Gore (1970, 1972). This author concentrated only in the descriptions of the general external structures, and no functional importance of the feeding apparatus was considered.

Observations on the functionality of the mouthparts and foregut have elucidated problems concerned to the feeding behavior of larvae of the decapod species, mainly those utilized in the aquaculture (Nishida et al., 1990; Nishida et al., 1995; Abrunhosa and Kittaka, 1997a,b; Abrunhosa and Melo, 2002; Abrunhosa et al., 2003). The result of these studies have contributed to increase survival rate of some species and consequently, incremented the productivity of the crustacean culture (Abrunhosa and Kittaka, 1997a,b).

Investigations on foreguts of the transitional stages of the anomuran crabs, *Paralithodes camtschaticus*, *P. brevipes* and *P. platypus*, revealed complete absence of ossicles of the gastric mill and few setae present (Abrunhosa and Kittaka, 1997a,b). Thus, these authors strongly suggested evidence of non-feeding behavior during the glaucothoe stage and this characteristic might occur in other anomuran crabs.

In order to verify if non-feeding behavior occurs in other anomuran species, the present work provides a detailed description of the foregut of the porcellanid *P. armatus* during development from larval to postlarval stages. The functional significance of the foregut is also discussed and briefly compared with others decapods.

## Material and Method

In January 2003, six ovigerous females of *P. armatus* were collected in the estuarine area of Canela Island, northeastern of the state of Pará, Brazil, and transported to the laboratory. They were placed in recipient (capacity 10l) containing seawater at 27ºC and salinity 35‰.

The zoeae were transferred to small recipients (capacity 150ml) with density of 30 larvae/recipient. They were fed with *Artemia* sp. nauplii. The water was changed every three days and microalga *Dunaliella viridis* was added to the culture.

Exuviae, larvae and postlarvae were fixed in 10% formalin. Later on, 10 individuals of each stage were immersed into 20ml of 5% aqueous solution of KOH heated to 80°C for about 30 minutes for the zoeae and megalopae and 45 minutes for the juvenile. Then, the samples were washed and immersed in glycerol + ethyl alcohol 70% (1:1). The foreguts were dissected with fine needles (BD Ultra-Fine®, 12.7 x 0.33mm) under optic microscope and stained with 1% methylene blue. The terminology used in the description followed Meiss and Norman (1977), Nishida et al. (1990) and Abrunhosa and Kittaka (1997a).

## Results and Discussion

*Foregut of the zoea I* (Figure 1A)

The foregut of this stage is simple, chitinous and unprovided of hard structures.

Cardiac chamber: flattened laterally, longer and narrower that pyloric chamber; base of the cardiac floor with numerous fine setae; cardiac wall with many medium setae; cardio-pyloric valve not prominent and armed with long and wide setae on posterior portion.

Pyloric chamber: with reduced fine setae along of the pyloric wall and many long setae on posterior portion of the roof; filter press completely developed and occupying all inferior portion of the chamber; numerous median setae present in the interampullary ridge (dorsal brush).

*Foregut of the zoea II* (Figure 1B)

Morphologically similar to stage I.

Cardiac chamber: as long as the pyloric chamber; similar disposition of setae in relation to the previous stage; cardio-pyloric valve with increment of distinct setae on posterior portion.

Pyloric chamber: similar to previous stage in the general disposition of setae; filter press enlarged and visually specialized. Interampullary ridge with numerous setae and ampullary net complex and functional.

*Foregut of the megalopa* (Figure 2A)

A remarkablele change occurs in the megalopa foregut. Ossicles of the gastric mill are present enlarging the foregut dorsolaterally. A pair of lateral teeth is present and they are the most proeminent acessory part of the gastric mill. However, some ossicles appear to be not completely formed.

Cardiac chamber: enlarged dorsolaterally (about twice wider than the pyloric chamber) and almost inclined vertically; cardio-pyloric valve prominent, with numerous short setae in the posterior portion. Ossicles of the gastric mill present as follow: zygocardiac supporting posteriorly the lateral teeth; urocardiac supporting a medial tooth; others ossicles as pectinal, prepectinal and pterocardiac also present.

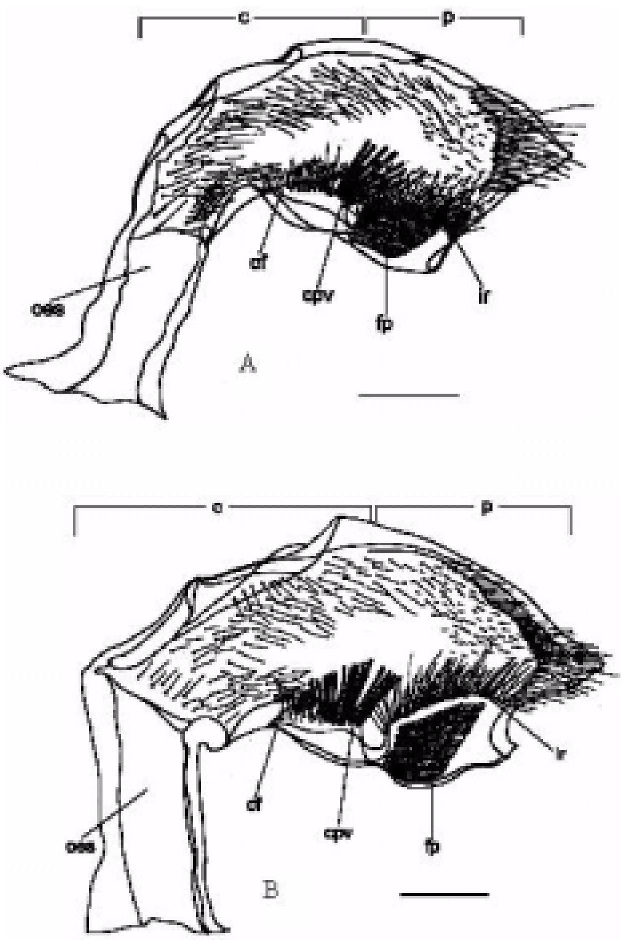


**Figure 1** - *Petrolisthes armatus*, foregut of the zoeae, lateral view (right): A, zoea I; B, zoea II. (c, cardiac chamber; cf, cardiac floor; cpv, cardio-pyloric valve; fp, filter press; ir, interampullary ridge; oes, oesophagus; and p, pyloric chamber). Scale bars = 0,05mm.

Pyloric chamber: fine and short setae filling the pyloric roof; pyloric wall lacking setae laterally; filter press being more specialized when compared to zoeal stages; interampullary ridge bearing numerous short setae.

*Foregut of the first juvenile* (Figure 2B)

In this stage the foregut is similar to the megalopa stage, bearing the ossicles of the gastric mill entirely formed, more distinct and clearly calcified.

Cardiac chamber: enlarged dorsolaterally (about twice wider than the pyloric chamber). Cardio-pyloric valve similar in shape to previous stage, with numerous short setae in the posterior portion. Gastric mill present, showing solid and calcified ossicles; cardiac floor almost inclined vertically; cardiac wall with few setae. Main ossicles of the gastric mill present as follow: zygocardiac, supporting the lateral teeth; and urocardiac, supporting a medial tooth; other ossicles such as prepectinal, pectinal, pterocardiac present.

Pyloric chamber: with fine and short setae filling the posterior portion; main ossicles present as follow: anterior pleuropyloric ossicle, mesopyloric, posterior supra-ampullary and uropyloric ossicle; filter press similar to that of the megalopa stage.

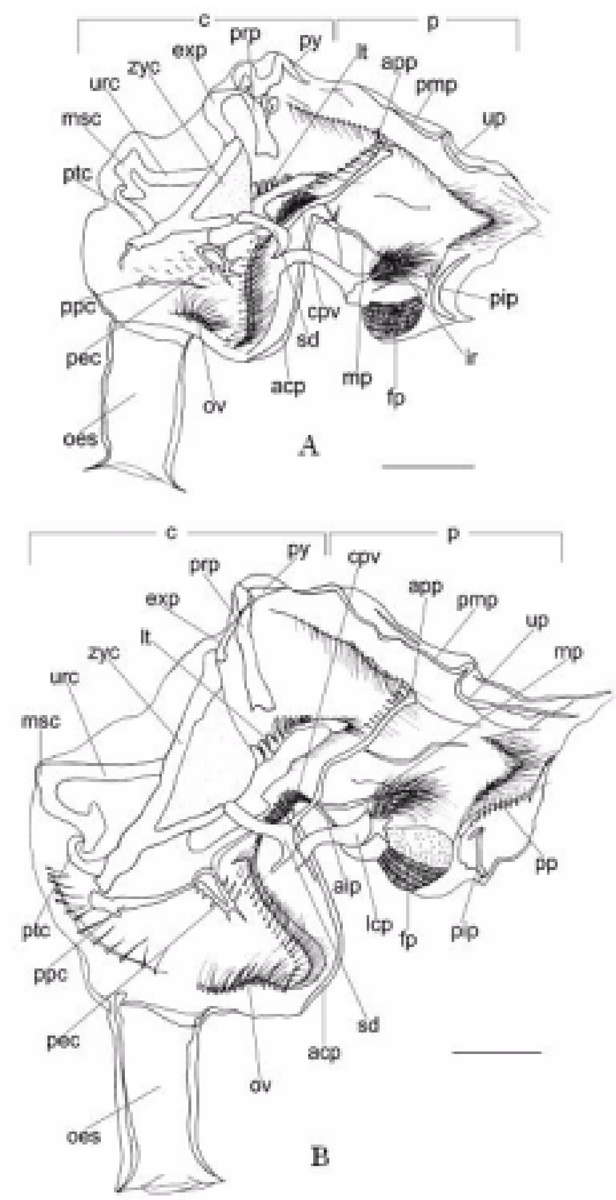


**Figure 2** - *Petrolisthes armatus*, foregut of the transitional and juvenile stages, lateral view (right): A, megalopa; B, first juvenile. (acp, anterior ossicle of the cardio-pyloric valve; aip, anterior inferior pyloric ossicle; app, anterior pleuropyloric ossicle; c, cardiac chamber; cpv, cardio-pyloric valve; exp, exopyloric ossicle; fp, filter press; ir, interampullary ridge; lcp, lateral cardio-pyloric ossicle; lt, lateral teeth; mp, middle pleuropyloric ossicle; msc, mesocardiac ossicle; oes, oesophagus; ov, oesophageal valve; p, pyloric chamber; pec, pectinal ossicle; pip, posterior inferior pyloric ossicle; pmp, posterior mesopyloric 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; and zyc, zygocardiac ossicle). Scale bars = 0,05mm.

The absence of rigid structures of the gastric mill suggested that the foreguts of the larvae of decapods crustaceans mix soft and fine particles with digestive enzymes (Nishida et al., 1990). The foregut of many crustacean species undergoes few changes along their zoeal development. However, the functionally of this structure is indicated by the presence and disposition of the setae and complexity of the filter press (Factor, 1989; Nishida et al., 1990; Mikami and Takashima, 1993, 1994; Abrunhosa and Kittaka, 1997a,b; Abrunhosa and Melo, 2002, Abrunhosa et al., 2003). These characteristics are observed in the foreguts of the zoeae stages of *P. armatus* (Figure 1).

Gore (1970, 1972) reported that the feeding appendages of the larvae of *P. armatus* have numerous setae. These features and those showed in the present work strongly suggest that larvae of *P. armatus* are well adapted to eat small and soft food particles such as freshly hatched *Artemia* nauplii, rotifers or microalgae. The addition of hard particles of food in the culture tanks is not appropriated for larvae.

After metamorphosis into megalopa stage, a drastic change occurs in the morphology of the foregut, that is, the ossicles of the gastric mill appear (Figure 02a). This stage has also well-developed external feeding appendages (Gore, 1970, 1972). The presence of these structures indicates that the megalopa stage of *P. armatus* may eat hard particles of food. Similar observation was reported for brachyuran crabs (Factor, 1982; Minagawa and Takashima, 1994; Abrunhosa et al., 2003).

In culture experiments have demonstrated the individuals show cannibalistic behavior during early megalopa. All these results have appointed that megalopa stage of *P. armatus* is a feeding stage. Thus, large quantities of food are appropriate for this transitional stage.

On the other hand, evidences of non-feeding stage have been reported in the transitional glaucothoe of the anomuran king crabs genus *Paralithodes* (Abrunhosa and Kittaka, 1997a,b), when showed a reduced and uncalcified mandibles, reduction in number of setae in the mouthpart appendages and poorly developed foregut (without ossicles of the gastric mill). These morphological characteristics strongly suggest the absence of feeding behavior for metamorphosed stage of *Paralithodes*. This fact was confirmed in larval culture experiments (Abrunhosa and Kittaka, 1997a,b).

These results clearly show that non-feeding behavior may be associated to life strategies of some transitional stages among different groups or species of decapods. Unfortunately, accurate information on feeding habits of crustacean larvae is little known and more studies on functional morphology of these animals is needed.

The foregut of the first juvenile stage of *P. armatus* (Figure 02b) is heavily calcified and specialized, with gastric mill still more complex that the previous stage. The cardiac chamber of the foregut becomes broadly stretched and the pyloric chamber bears diverse ossicles showing close similarity with adult foregut of other decapods described in the literature (Meiss and Norman, 1977; Kunze and Anderson, 1979; Suthers and Anderson, 1981; Mikami and Takashima, 1994; Brösing et al., 2002). Thus, it is suggested that the first juveniles of *P. armatus* are able to process a large quantity of soft and solid food, which they encounter in the benthic environment.

# Conclusions

The morphology observed at foregut of the zoea I of *P. armatus* is simple, but provided of specific setae and still filter press showing apparently functional. This suggests the first larva is adapted to eat short and soft food particles such as freshly hatched *Artemia* nauplii, rotifers or microalgae.

The grinding structure of the gastric mill is not present in the zoea II (last stage). Thus, strongly suggests that the zoeal foregut has only mixing food function. After metamorphosis to the megalopa stage, considerable changes occur in the morphology of the foregut, for appearance of ossicles of the gastric mill and well-developed lateral and medial tooth. The presence of these structures indicates that the megalopa stage may eat hard particles of food.

The foregut of the first juvenile stage of *P. armatus* showed calcified and specialized, with gastric mill still more complex that the previous stage. Thus, suggests that the first juveniles of *P. armatus* are able to process a large quantity of soft and solid food.

# Bibliographic References

ABRUNHOSA, F. A.; KITTAKA, J. Functional morphology of mouthparts and foregut of the last zoea, glaucothoe and first juvenile of the king crabs Paralithodes camtschaticus, *P. brevipes* and *P. platypus*. **Fisheries Science**, v. 63, n. 6, p. 923-930, 1997a.

ABRUNHOSA, F. A.; KITTAKA, J. Morphological changes in the midgut, midgut gland and hindgut during the larval and postlarval development of the red king crab *Paralithodes camtschaticus*. **Fisheries Science**, v. 65, n. 5, p. 746-754, 1997b.

ABRUNHOSA, F. A.; MELO, M. A. Morfologia comparativa do primeiro e último estágios zoea e juvenil de *Macrobrachium rosenbergii* (De Man, 1879) (Decapoda: Palaemonidae). **Revista Ciência Agronômica**, v. 33, n. 2, p. 65-68, 2002.

ABRUNHOSA, F. A.; MELO, M. A.; ABRUNHOSA, J. P. Development and functional morphology of the foregut of larvae and postlarva of *Ucides cordatus* (Decapoda, Ocypodidae). **Nauplius**, v. 11, n. 1, p. 37-43, 2003.

BRÖSING, A.; RICHTER, S.; SCHOLTZ, G. The foregut-ossicle system of *Dromia wilsoni*, *Dromia personata* and *Lauridromia intermedia* (Decapoda, Brachyura, Dromiidae), studied with a new staining method. **Arthropod Structure & Development**, v. 30, p. 329-338, 2002.

FACTOR, J. R. Development and metamorphosis of the feeding apparatus of the stone crab, *Menippe mercenaria* (Brachyura, Xanthidae). **Journal of Morphology**, v. 172, p. 299-312, 1982.

FACTOR, J. R. Development of the feeding apparatus in decapod crustaceans. In: FELGENHAUER, B. E.; WATLING, L.; THISTLE, A. B. (Ed.). **Crustacean issues**. Rotterdam: Balkema, v. 6, p. 185-203, 1989.

GORE, R. H. *Petrolisthes armatus*: A redescription of larval development under laboratory conditions. (Decapoda, Porcellanidae). **Crustaceana**, v. 18, n. 1, p. 75 – 89, 1970.

GORE, R. H. *Petrolisthes armatus* (Gibbes, 1850): The development under laboratory conditions of larvae from a Pacific specimen (Decapoda, Porcelanidae). **Crustaceana**, v. 22, p. 67 – 83, 1972.

KUNZE, J.; ANDERSON, D. T. Functional morphology of the mouthparts and gastric mill in the hermit crabs *Clibanarius taeniatus* (Milne Edwards), *Clibanarius virescens* (Krauss), *Paguristes squamosus* McCulloch and *Dardanus setifer* (Milne Edwards) (Anomura: Paguridae). **Australian Journal of Marine Freshwater Research**, v. 30, n. 5, p. 683-722, 1979.

MEISS, D. E.; NORMAN, R. S. Comparative study of stomatogastric system of several decapod Crustacea. I. Skeleton. **Journal of Morphology**, v. 152, n. 1, p. 21-53, 1977.

MIKAMI, S.; TAKASHIMA, F. Development of the proventriculus in larvae of slipper lobster, *Ibacus ciliatus* (Decapoda: Scyllaridae). **Aquaculture**, v. 116, p. 199-217, 1993.

MIKAMI, S.; TAKASHIMA, F. Functional morphology of the digestive system. In: PHILLIPS, B. F.; COBB, J. S.; KITTAKA, J. **Spiny lobster management**. Oxford: Ed. Fishing News Books, p. 473-482, 1994.

MELO, G. A. S. **Manual de identificação dos Crustacea Decapoda do litoral brasileiro**: Anomura, Thalassinidea, Palinuridea, Astacidea. São Paulo: Plêiade, 551p., 1999.

MINAGAWA, M.; TAKASHIMA, F. Developmental changes in larval mouthparts and foregut in the red frog crab, *Ranina ranina* (Decapoda: Raninidae). **Aquaculture**, v. 126, p. 61-71, 1994.

NISHIDA, S.; QUIGLEY, B. D.; BOOTH, J. D.; NEMOTO, T.; KITTAKA, J. Comparative morphology of the mouthparts and foregut of the final-stage phyllosoma, puerulus, and postpuerulus of the rock lobster Jasus edwardsii (Decapoda: Palinuridae). **Journal of Crustacean Biology**, v. 10, n. 2, p. 293-305, 1990.

NISHIDA, S.; TAKAHASHI, Y.; KITTAKA, J. Structural changes in the hepatopancreas of the rock lobster *Jasus edwardsii* (Crustacea: Palinuridae) during development from the puerulus to post-puerulus. **Marine Biology**, v. 123, n. 4, p. 837-844, 1995.

SUTHERS, I. M.; ANDERSON, D. T. Functional morphology of mouthparts and gastric mill of *Ibacus peronii* (Leach) (Palinura: Scyllaridae). **Australian Journal of Marine Freshwater Research**, v. 32, p. 931-944, 1981.