Nauplius
THE JOURNAL OF THE BRAZILIAN CRUSTACEAN SOCIETY

e-ISSN 2358-2936
www.scielo.br/nau
www.crustacea.org.br

Predatory behavior of the paguroid *Dardanus venosus* (H. Milne–Edwards, 1848) (Anomura: Diogenidae) on the snail *Aurantilaria aurantiaca* (Lamarck, 1816) (Gastropoda: Fasciolariidae)

Felipe Bezerra Ribeiro[1], Helena Matthews-Cascon[2] and Luis Ernesto Arruda Bezerra[3]

[1] Programa de Pós-graduação em Biologia Animal, Departamento de Zoologia (Laboratório de Carcinologia), Instituto de Biociências, Universidade Federal do Rio Grande do Sul. Av. Bento Gonçalves, 9500, pr. 43435. 91501-970 Porto Alegre, Rio Grande do Sul, Brazil.

[2] Laboratório de Invertebrados Marinhos do Ceará, Departamento de Biologia, Centro de Ciências, Universidade Federal do Ceará. Av. Mister Hull, s/n, Campus do Pici, Fortaleza, Ceará, Brazil.

[3] Instituto de Ciências do Mar, Universidade Federal do Ceará. Av. da Abolição, 3207. 60165-081 Fortaleza, Ceará, Brazil.

ZOOBANK http://zoobank.org/urn:lsid:zoobank.org:pub:BCD8F669-F1FC-4FCC-939C-FA9A45E6F20E

ABSTRACT

Paguroids are usually detritivorous organisms and the occurrence of predation on mollusks is very unusual. This contribution reports the occurrence of a predatory behavior of the paguroid *Dardanus venosus* (H. Milne Edwards, 1848) on the snail *Aurantilaria aurantiaca* (Lamarck, 1816). Single specimen of paguroid was found attacking the snail in a sea grass meadow dominated by *Halodule wrightii* Ascherson on the coast of Ceará, northeastern Brazil. The paguroid and gastropod specimens were brought to the laboratory and placed in an aquarium and the behavior was recorded by photos. Paguroid behavior was characterized by sequencial movements of chelipeds in the attack to the snail when the snail was hold by paguroid ambulatory legs. External lip of shell aperture, operculum and foot of the gastropod were severely damaged.

KEY WORDS

Hermit crab, behavior, gastropod, predation, feeding, Brazil.

CORRESPONDING AUTHOR
Felipe Bezerra Ribeiro
fbribeiro.ufc@gmail.com

SUBMITTED 14 June 2016
ACCEPTED 2 December 2016
PUBLISHED 2 March 2017

DOI 10.1590/2358-2936e2017001

Paguroids comprise dense populations in intertidal environments. They use empty gastropod shells to protect themselves against predators, desiccation, and other environmental stresses (Reese, 1969; Bertness, 1981; Hazlett, 1981). In spite of the extensive literature on their behavior, most studies focus on how paguroids use their shelter, namely shell selection and assessment (Reese, 1963; Hazlett, 1966; Elwood and Neil, 1992; Mesce, 1993; Garcia and Mantelatto, 2001; Dominciano and Mantelatto, 2004; Turra and Leite, 2004; Biagi *et al.*, 2006; Mantelatto *et al.*, 2007; Meireles *et al.*, 2008), shell fighting (Hazlett, 1981; Briffa *et al.*, 1998), reproductive behavior (Hazlett, 1966; 1968a; 1972; 1986; Turra, 2005), and clustering behavior (Turra and Leite, 2000a).

However, other aspects of paguroid biology, such as feeding behavior, have not been addressed. Most of paguroid species are defined as generalist in diet and opportunistic in their feeding habits, with an omnivore-detritivore feeding style (Orton, 1927; Roberts, 1968; Caine, 1975, 1976; Hazlett, 1981; Benvenuto *et al.*, 2003). The available data indicate that paguroids have a wide range of feeding strategies (Schembri, 1982a). They can be classified as detritivores (Orton, 1927; Roberts, 1968; Greenwood, 1972; Caine, 1975; 1976); mesograzers (Ruesink, 2000); microphagous, scavengers and predators (Kunze and Anderson, 1979; Hazlett, 1981a). Moreover, a single species is able to feed in different ways according to the food available at the time (Kunze and Anderson, 1979; Schembri, 1982a). Paguroids diet can change seasonally and include other marine invertebrates such as ophiuroids, bivalves, amphipods, shrimps, and small hermit crabs (Hunt, 1925).

Dardanus venosus (H. Milne Edwards, 1848) is a colorful paguroid species that typically occurs in the intertidal zone up to a depth of 100 m, and is commonly found among rocks, shells, coralline algae (Rieger, 1997; Melo, 1999) or even in sea grass meadows constituted by species *Thalassia testudinum* Banks *ex* König and *Syringodium filiforme* Kuetz (Bauer, 1985). This paguroid species is distributed in the western Atlantic, from Florida to Brazil (from the state of Pará to state of São Paulo, including the Rocas atoll and the Fernando de Noronha archipelago) (Mantelatto *et al.*, 2001).

Gastropods are also widely distributed and abundant in intertidal environments (Veras *et al.*, 2013) and have different feeding habits. The feeding habits of gastropods are extremely varied and include herbivory, detritivory, suspensivory, carnivory and parasitism (Taylor *et al.*, 1980; Hughes, 1986; Meirelles and Matthews-Cascon, 2003). Predatory gastropods are represented by species with tremendous adaptive success. Species of the family Fasciolariidae Gray, 1853 are usually predators of other gastropods and bivalves (Matthews-Cascon *et al.*, 1989). This group preys on shell chipping that it uses to reach the soft parts of the prey (Hughes, 1986). *Aurantilaria aurantiaca* (Lamarck, 1816) is commonly found on the bottoms with calcareous algae and corals at shallow waters of the northeastern Brazil. The reproductive period of this species in that region is from August to December, and the egg masses are found under the rocks (Meirelles and Matthews-Cascon, 2005).

Paguroids have not been recognized as important predators in the intertidal environments, and they often obtain empty shells from the environment without killing gastropods. Therefore, the aim of this paper is to report for the first time a predatory behavior of the paguroid *D. venosus* on the snail *A. aurantiaca*.

A sample represented by one single specimen of *D. venosus* and one of *A. aurantiaca* was collected on the bottom covered by sea grass meadows mainly dominated by the species *Halodule wrightii* Ascherson at the coastal waters of the municipality of Icapuí, state of Ceará, northeastern Brazil (04°41'00"S 37°21'00"W) (Fig. 1). The sampling area is part of the Barra Grande estuarine system and covers approximately 540 ha; its bottom structure consists mostly of extensive sand/mud banks (Carlos *et al.*, 2010). The paguroid was found showing aggressive behavior, moving chelipeds into the shell aperture. For this reason, the sample was brought to the laboratory and placed in an aquarium containing 10 L of seawater from the collection site and maintained under constant aeration for three days. Subsequently, the sample was cryo-anesthetized and fixed.

The gastropod shells of the snail and that occupied by the paguroid were identified based on Rios (2009) and measured for aperture length (SAL) and width (SAW). The hermit crab was identified according to Melo (1999) and sexed by the presence of genital

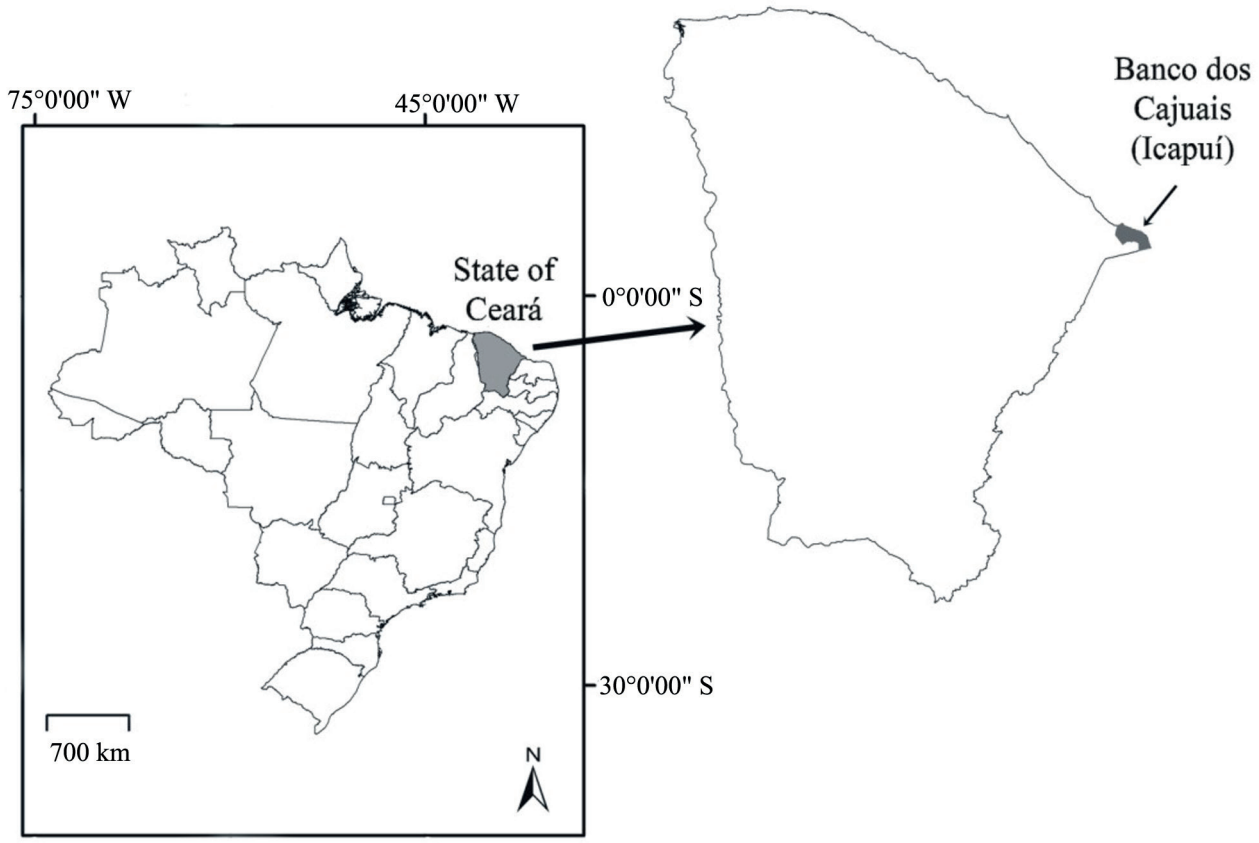

Figure 1. Location of the sea grass meadow (Banco dos Cajuais), on the east coast of the state of Ceará, northeastern Brazil.

pores (on the basis of third pereiopods in females and of the fifth in males). The paguroid was then measured to establish shield length (SL), which is the distance from the edge of the rostrum to the V-shaped groove in the posterior margin. All measurements were made using a vernier caliper (0.01 mm accuracy).

The specimen of *D. venosus* was deposited in the Carcinological Collection of the Departamento de Zoologia, Universidade Federal do Rio Grande do Sul (catalogue number: UFRGS 5912), and the specimen of *A. aurantiaca* was deposited in the Coleção Malacológica Professor Henry Ramos Matthews série B (catalogue number: CMPHRM B 4082). The aggressive behavior of *D. venosus* on *P. aurantiaca* was observed during three days (3h/day: one hour during the morning, one in afternoon and one in the night). On the fourth day, the paguroid died, possibly because of the stress. Main aspects of this behavior were recorded by photos using a Sony WX30 digital camera.

The paguroid was a male of *D. venosus* (SL = 11.16 mm), occupying a shell of *Voluta ebraea* Linnaeus, 1758 (SAL = 63.53 mm; SAW = 15.47 mm) in good conditions (without severe cracks or perforations) but covered by some ectosymbiont groups: bryozoans, barnacles, calcareous algae, calyptraeid gastropods and polychaete worm tubes. The individual of *A. aurantiaca* (SAL = 56.02 mm; SAW = 14.40) had a shell in very good conditions (without cracks, perforations and ectosymbionts).

The paguroid reestablishes its aggression immediately after it was placed in the aquarium with the snail and stayed all the time attacking the mollusk during the observation time. Predatory behavior was characterized by the use of pereiopods and mouth parts. The second and third pairs of pereiopods (ambulatory legs) were used to hold laterally the shell in the spire region and in the siphonal chanel of the gastropod (Fig. 2A, B). The first pair of pereiopods (chelipeds) was projected into the shell aperture and moved alternately to hit the gastropod hard structures. The left cheliped (major chela) was used mainly to break the shell and the operculum of *A. aurantiaca* and the right cheliped (minor chela) to tear apart pieces of snail flesh (Fig. 2 A–C). When enough material was accumulated in the fingers, this was brought to the third pair of maxillipeds that were used to manipulate and select the pieces,

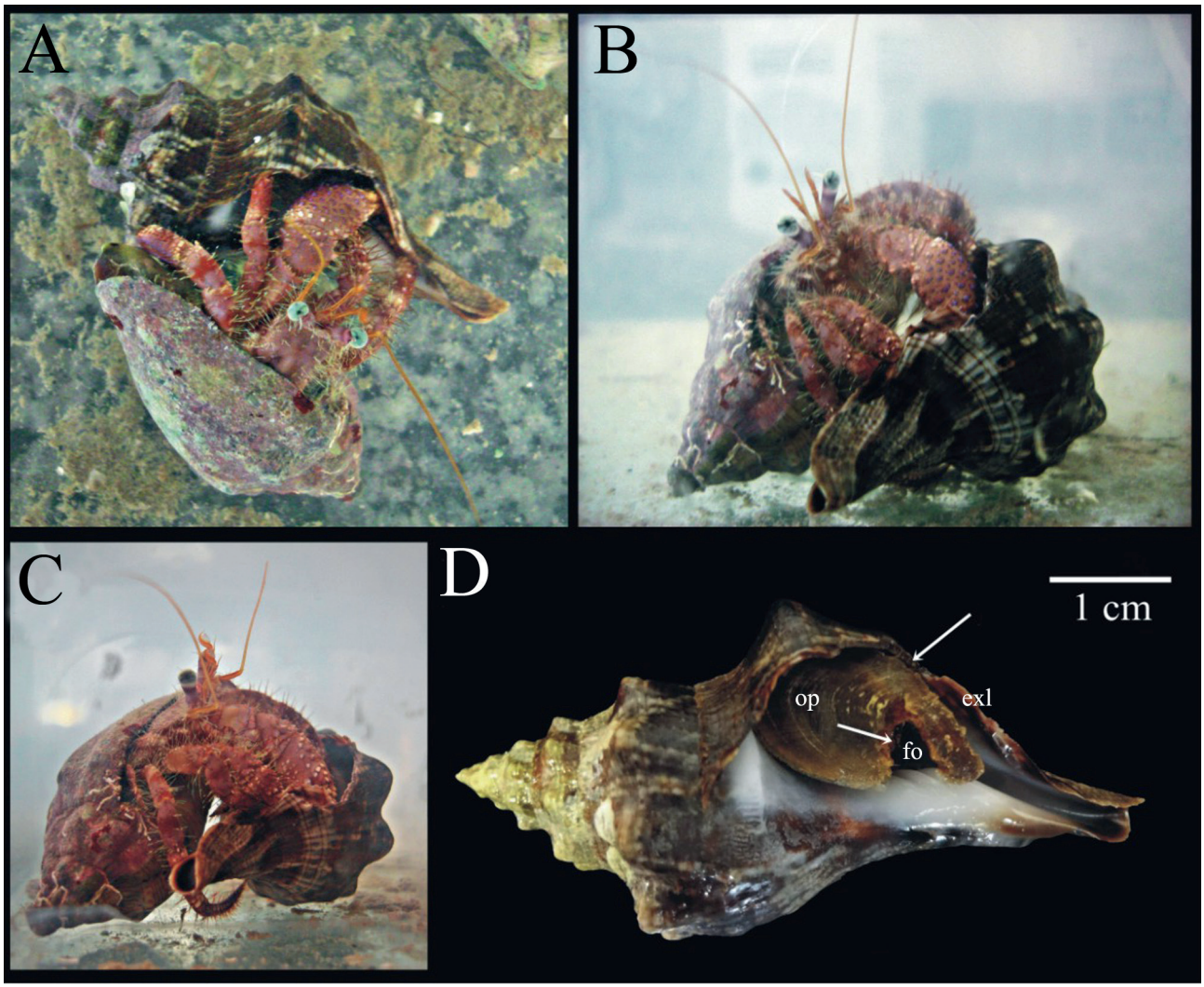

Figure 2. A–C, Sequence of attacks of *Dardanus venosus* on *Aurantilaria aurantiaca*; D, damages in *A. aurantiaca* after the attack. White arrows indicates the damages in the operculum (op), foot (fo) and external lip (exl).

and push them towards the mandible. In addition, the right cheliped of *D. venosus* is covered by long setae and it helped the paguroid to obtain small pieces of snail flesh occasionally trapped in the setae and then, these pieces were moved to the mouthparts. All pieces of snail flesh were chopped by the mandibles and then ingested with the aid of the mandibular palps. Part of the external lip of shell aperture was broken and the operculum and foot of the gastropod were severely damaged (Fig. 2D).

This report is an important record of the uncommon feeding behavior of hermit crabs since they are mainly omnivorous detritivores (Caine, 1975; 1976) and rarely show predatory behavior. Paguroids usually acquire gastropod shells without killing, being attracted to sites where gastropods are sick or dying (Pezzuti *et al.*, 2002). Predatory behavior in paguroids has been recorded in *Pagurus traversi* (Filhol, 1885), *Diacanthurus rubricatus* (Henderson, 1888), *Pylopagurus* sp. A. Milne-Edwards & Bouvier, 1893 and *Sympagurus dimorphus* (Studer, 1883) (Schembri, 1982a; 1982b). These paguroid species usually capture small gastropods and can break shells using the teeth of the cutting edge of the major chela. Paguroids have more success when the prey is small (Schembri, 1982b). The cheliped structure in paguroids may be useful to indicate if one species is feeding on large pieces of food or entire animals. Among paguroids that display predatory behavior, the cutting edges of the fingers are usually sharp and one of chelipeds is larger (Caine, 1975), as found in *D. venosus*. Sharp fingers can also be used to cut and reduce the size of food (Caine, 1975). The morphology

of chelipeds and fingers of *D. venosus* together with the damages found in the shell indicate that this paguroid was, in fact, trying to predate the snail.

Paguroids usually do not attack and kill healthy gastropods (Lancaster, 1988), but there are records of hermit crabs attacking sick or injured snails (Scully, 1983). In this contribution, the snail specimen was apparently healthy and there was no evidence of past injury or sickness. Even in hermit crabs that filter feed on suspended matter, as *Diogenes brevirostris* Stimpson, 1858, *Diogenes pugilator* (Roux, 1829) and *Paguristes hummi* Wass, 1955, can feed on macroscopic pieces of dead or wounded organisms when available (Hazlett, 1968b). Predatory habits in paguroids may have evolved from casual feeding on small invertebrates, which they disturb while foraging amongst algae (Schembri, 1982b).

Aurantilaria aurantiaca is classified as a generalist predator in intertidal environments and may compete with hermit crabs to obtain food. These generalist predators play an important role in the community structure. *Aurantilaria aurantiaca* can be classified as a key predator in marine intertidal environments. It preys on several other gastropods, such as *Pisania pusio* (Linnaeus, 1758), *Tegula viridula* (Gmelin, 1791), and *Stramonita brasiliensis* Claremont & Reid, 2011 in the intertidal zone (Meirelles and Matthews-Cascon, in prep.).

Finally, we consider that there are few studies concerning the feeding habits of hermit crabs in Brazil and this report brings relevant new information of one record of predation of a hermit crab on a gastropod that plays an important role in the intertidal food chain. We think that the studies to be carried out in the future on the feeding behavior of paguroids can help determine all aspects of food obtainment by predatory action.

Acknowledgements

The authors would like to thank the undergraduate Biology student Victor M. Azevedo for his help during sampling, Cipriana Leme for correcting the English text and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for grant a Master of Science Scholarship to FBR (Ciências do Mar – Processo 0532/2010) and support for sampling (Ciências do Mar II – Processo 2005/2014 – 23038.004308/2014–14).

References

Bauer, R.T. 1985. Hermit crab fauna from sea grass meadows in Puerto Rico: species composition, diel and seasonal variation in abundance. *Journal of Crustacean Biology*, 5: 249–257.

Benvenuto, C.; Sartoni, G. and Gherardi, F. 2003. Foraging behavior of the hermit crab *Clibanarius erythropus* in a Mediterranean shore. *Journal of Marine Biological Association of the United Kingdom*, 83: 457–461.

Bertness, M.D. 1981. Competitive dynamics of a tropical hermit crab assemblage. *Ecology*, 62: 751–761.

Biagi, R.; Meireles A.L.; Scelzo M.A. and Mantelatto F.L. 2006. Comparative study of shell choice by the hermit crab *Loxopagurus loxochelis* from Brazil and Argentina. *Revista chilena de historia natural*, 79: 481–487.

Biffar, T.A. and Provenzano Jr., A.J. 1972. A reexamination of *Dardanus venosus* (H. Milne Edwards) and *D. imperator* (Miers), with a description of a new species of *Dardanus* from the western Atlantic (Crustacea, Decapoda, Diogenidae). *Bulletin of Marine Science*, 22: 777–805.

Briffa, M.; Elwood R.W. and Dick, J.T.A. 1998. Analysis of repeated signals during shell fights in the hermit crab *Pagurus bernhadus*. *Proceedings of the Royal Society of London* – Biological Sciences, 265: 1467–1474.

Caine, E.A. 1975. Feeding and masticatory structures of selected Anomura (Crustacea). *Journal of Experimental Marine Biology and Ecology*, 18: 277–301.

Caine, E.A. 1976. Relationship between diet and the gland filter of the gastric mill in hermit crabs (Decapoda, Paguridea). *Crustaceana*, 31: 312–313.

Carlos, C.J.; Fedrizzi, C.E.; Campos, A.A.; Matthews-Cascon, H.; Barroso, C.X.; Rabay, S.G.; Bezerra, L.E.A.; Meirelles, C.A.O.; Meireles, J. and Thiers, P.R.L. 2010. Migratory Shorebird Conservation and Shrimp Farming in NE Brazil - Final Report. 162 pp.

Dominciano, L.C.C. and Mantelatto, F.L.M. 2004. The influence of shell species and size in the shell selection pattern of *Paguristes tortugae* (Decapoda, Diogenidae) from Anchieta Island (Ubatuba, Brazil). *Iheringia*, 94: 425–428.

Elwood, R.W. and Neil, S.J. 1992. Assessments and decisions. A Study of information gathering by hermit crabs. Chapman & Hall. London, xi+192p.

Garcia, R.B. and Mantelatto, F.L. 2001. Population dynamics of the hermit crab *Paguristes erythrops* (Diogenidae) from Anchieta Island, Southern Brazil. *Journal of the Marine Biological Association of the United Kingdom*, 81: 955–960.

Greenwood, J.G. 1972. The mouthparts and feeding behavior of two species of hermit crabs. *Journal of Natural History*, 6: 325–337.

Hazlett, B.A. 1966. Social behavior of the Paguridae and Diogenidae of Curacao. *Studies on the fauna of Curacao and other Caribbean Islands*, 23: 1–143.

Hazlett, B.A. 1968a. The sexual behavior of some European hermit crabs. *Pubblicazione della Stazione zoologica di Napoli*, 36: 238–252.

Hazlett, B.A. 1968b. Stimuli involved in the feeding behavior of the hermit crab *Clibanarius vittatus* (Decapoda, Paguridea). *Crustaceana*, 15: 305–311.

Hazlett, B.A. 1972. Shell fighting and sexual behavior in the hermit crab genera *Paguristes* and *Calcinus* with comments on *Pagurus*. *Bulletin of Marine Science*, 22: 806–823.

Hazlett, B.A. 1981. The behavioral ecology of hermit crabs. *Annual Review of Ecology, Evolution and Systematics*, 12: 1–22.

Hazlett, B.A. 1986. Sexual behavior of the hermit crab *Pagurus traversi* (Filhol) (Decapoda, Paguridea). *Crustaceana*, 51: 107–108.

Hughes, R.N. 1986. A functional biology of marine gastropod. London, Croom Helm, 245p.

Hunt, O.D. 1925. The food of the bottom fauna of the Phymouth fishing grounds. *Journal of the Marine Biological Association of the United Kingdom*, 13: 560–599.

Kunze, J. and Anderson, D.T. 1979. Functional morphology of the mouthparts and gastric mill in the hermit *Clibanarius taeniatus* (Milne Edwards), *Clibanarius virescens* (Krauss), *Paguristes squamosus* McCulloch and *Dardanus setifer* (Milne–Edwards) (Anomura: Paguridea). *Australian Journal of Marine Freshwater Research*, 30: 683–722.

Lancaster, I. 1988. *Pagurus bernhardus* (L.)—An introduction to the natural history of hermit crabs. *Field Studies*, 7: 189–238.

Mantelatto, F.L.; Garcia, R.B.; Martinelli, J.M. and Hebling, N.J. 2001. On a record of *Dardanus venosus* (H. Milne Edwards) (Crustacea, Anomura) from the São Paulo State, Brazil. *Revista brasileira de Zoologia*, 18: 71–73.

Mantelatto, F.L.; Biagi, R.; Meireles, A.L. and Scelzo, M.A. 2007. Shell preference of the hermit crab *Pagurus exilis* (Anomura: Paguridae) from Brazil and Argentina: a comparative study. *Revista de Biología Tropical*, 55(Suppl. 1): 153–161.

Matthews-Cascon, H.; Matthews, H.R. and Kotzian, K.B. 1989. Os gêneros *Fasciolaria* Lamarck, 1799 e *Leucozonia* Gray, 1847 no Nordeste Brasileiro (Mollusca: Gastropoda: Fasciolariidae). *Memórias do Instituto Oswaldo Cruz*, 84: 357–364.

Meireles, A.L.; Biagi, R. and Mantelatto, F.L. 2008. Influence of prior existence on shell selection by the white spotwrist hermit crab *Pagurus criniticornis* (Crustacea: Paguridea). *Hydrobiologia*, 605: 259–263.

Meirelles, C.A.O and Matthews-Cascon, H. 2003. Relations between shell size and radula size in marine prosobranchs (Mollusca: Gastropoda). *Thalassas*, 19: 45–53.

Meirelles, C.A.O and Matthews-Cascon, H. 2005. Spawn and larval development of *Pleuroploca aurantiaca* (Lamarck, 1816) (Gastropoda: Fasciolariidae) from northeast Brazil. *Scientia Marina*, 69: 199–204.

Melo, G.A.S. 1999. Manual de Identificação dos Crustacea Decapoda do litoral brasileiro: Anomura, Thalassinida, Palinuroidea e Astacidea. São Paulo, Ed. Plêiade, 551p.

Mesce, K.A. 1993. The shell selection behavior of two closely related hermit crabs. *Animal Behaviour*, 45: 659–671.

Orton, J.H. 1927. On the mode of feeding of the hermit crab *Eupagurus bernhardus* and some other decapods. *Journal of Marine Biological Association of the United Kingdom*, 14: 909–921.

Pezzuti, J.C.B.; Turra, A. and Leite, F.P.P. 2002. Hermit crab (Decapoda, Anomura) attraction to dead gastropod baits in an infralittoral algae bank. *Brazilian Archives of Biology and Technology*, 45: 245–250.

Reese, E.S. 1963. The behavioral mechanisms underlying shell selection by hermit crabs. *Behavior*, 21: 78–126.

Reese, E.S. 1969. Behavioral adaptations of intertidal hermit crabs. *American Zoologist*, 9: 343–355.

Rieger, P.J. 1997. Os "ermitões" (Crustacea, Decapoda, Parapaguridae, Diogenidae e Paguridae) do litoral do Brasil. *Nauplius*, 5: 99–124.

Rios, E. 2009. Compendium of Brazilian Sea Shells. Rio Grande, Ed. Evangraf, 668p.

Roberts, M.H. 1968. Functional morphology of mouth parts of the hermit crabs, *Pagurus longicarpus* and *Pagurus pollicaris*. *Chesapeake Science*, 9: 9–20.

Ruesink, J.L. 2000. Intertidal mesograzers in field microcosms: linking laboratory feeding rates to community dynamics. *Journal of Experimental Marine Biology and Ecology*, 248: 163–176.

Schembri, P.J. 1982a. Functional morphology of the mouthparts and associated structures of *Pagurus rubricatus* (Crustacea: Decapoda: Anomura) with special reference to feeding and grooming. *Zoomorphology*, 101: 17–38.

Schembri, P.J. 1982b. Feeding behavior of fifteen species of hermit crabs (Crustacea: Decapoda: Anomura) from the Otago region, southeastern New Zealand. *Journal of Natural History*, 16: 859–878.

Scully, E.P. 1983. The behavioral ecology of competition and resource utilization among hermit crabs. In: S. Rebach and D.W. Dunham (eds), Studies in adaptation: the behavior of higher Crustacea. New York, John Wiley& Sons, xvii+282p.

Taylor, J.D.; Morris, N.J. and Taylor, C.N. 1980. Food specialization and the evolution of predatory prosobranch gastropods. *Palaeontology*, 23: 375–409.

Turra, A. 2005. Reproductive behavior of intertidal hermit crabs (Decapoda, Anomura) in southeastern Brazil. *Revista brasileira de Zoologia*, 22: 313–319.

Turra, A. and Leite, F.P.P. 2000. Clustering behavior of hermit crabs (Decapoda, Anomura) in an intertidal rocky shore at São Sebastião, Southeastern Brazil. *Revista Brasileira de Biologia*, 60: 39–44.

Turra, A. and Leite, F.P.P. 2004. Shell-size selection by the intertidal sympatric hermit crabs. *Marine Biology*, 145: 251–257.

Veras, D.R.A.; Martins, I.X. and Matthews-Cascon, H. 2013. Mollusks: how are they arranged in the rocky intertidal zone? *Iheringia*, 103: 97–103.