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ORIGINAL ARTICLE

Sabellariid (Polychaeta: Annelida) reefs as nursery ground for the hermit crab *Clibanarius symmetricus* (Randall, 1840) on the Amazonian coast of Brazil

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ABSTRACT
The present study investigated the structure of the crab *Clibanarius symmetricus* (Randall, 1840) population found in a biogenic reef formed by the polychaete *Sabellaria wilsoni* Lana & Gruet, 1989 on the Amazonian coast. The population was sampled over a one-year cycle on a reef located in the mesolittoral zone of a sandy beach. The mean and maximum size of the crabs collected on the reef were smaller than those recorded in other tropical and subtropical coastal habitats, given that most of the specimens collected were immature (undetermined sex juveniles and sexually immature adults). *Thaisella coronata* (Lamarck, 1816) was the gastropod species whose shells were most occupied by the hermit crabs (70% of the specimens), although the smallest juveniles have used more the shells of other species. The results of the study suggest that *C. symmetricus* uses the reef as a nursery habitat, with bimonthly peaks in density that reflect recruitment periods. The sexually mature adults appear to use the reef only as a foraging area and, occasionally, as a refuge. The results demonstrated the importance these reefs on the population biology of this species and supports the need for more detailed monitoring studies and conservation actions for these habitats.

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Introduction

Hermit crabs are decapod crustaceans (Superfamily Paguroidea) most of which have noncalcified abdomen and for their protection typically use gastropod shells (Williams and McDermott 2004). This behaviour allows the hermit crabs to occupy a range of different marine environments and is one of the principal factors determining the evolutionary success of the paguroids (McLaughlin 1983; Williams and McDermott 2004). Hermit crabs play an extremely important ecological role, as both scavenging omnivores that contribute to the decomposition of organic matter, and a source of prey for many marine species, including seabirds and commercially-important fishes (Fransozo et al. 2008; Laidre and Greggor 2015).

Clibanarius symmetricus (Randall, 1840) is a hermit crab endemic to the western Atlantic Ocean, being found in the waters of Caribbean Sea and off eastern South America, between Venezuela and Brazil (Negri et al. 2014). The Brazilian populations of *C. symmetricus*, which had long been misidentified as *Clibanarius vittatus* (Bosc, 1802) (see Negri et al. 2014), are found in rocky and sandy-muddy habitats, as well as biogenic substrates, that includes mangrove areas and polychaete reefs (Fransozo et al. 2008; Mantelatto et al. 2010; Negri et al. 2014; Aviz et al. 2019). The data available on the ecology of this species are derived primarily from studies conducted on rocky substrates in subtropical waters, and the vast majority of them identified as *C. vittatus*. The available studies have focused on the spatiotemporal distribution of the species (Turra and Denadai 2003; Sampaio et al. 2009), its population parameters (Turra and Leite 2000; Sant'Anna et al. 2008; Mantelatto et al. 2010), behaviour (Turra and Denadai 2003; Turra 2005), growth patterns (Turra and Leite 2000; Sant'Anna et al. 2008), and occupation of shells (Turra and Leite 2001; Rodrigues and Martinelli-Lemos 2016). Ecological data from tropical regions are scarce, and are lacking, in particular, for the region of the Amazon coast (Rodrigues and Martinelli-Lemos 2016; Rodrigues and Martinelli-Lemos 2019; Danin et al. 2020).

Although hermit crabs are a prominent feature of reefs formed by sabellariid worms (Polychaeta: Sabellariidae), including species of the genera *Clibanarius*, *Calcinus*, *Diogenes*, *Pagurus*, *Paguristes*, and *Petrochirus* (Gherardi and Cassidy 1994; Eeo et al. 2017; Velasquez et al. 2017; Jones et al. 2018; Aviz et al. 2019), the role

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of these reefs in the life history of the crabs is still poorly understood. This is due, in particular, to the fact that most research has focused on documenting the biodiversity of these substrates. Population data can provide important insights into the biology and ecology of an organism (Brey 2001; White et al. 2007), and in the context of the present study, the characteristics of the relationship between the crab species and this type of biogenic substrate.

Extensive reefs formed by *Sabellaria wilsoni* Lana & Gruet, 1989 have recently been identified on Algodoal-Maiandeua Island, on the Amazon coast of northern Brazil (Aviz et al. 2016). The bioconstructions formed by this polychaete species provide a substrate for a variety of benthic organisms, including the paguroid *C. symmetricus (*Aviz et al. 2019*)*. To date, the studies carried on *S. wilsoni* reefs have evaluated effects of these bioconstructions on the biodiversity of meiofauna (Ataide et al. 2014) and macrofauna (Aviz et al. 2019) assemblages, being that, structure and dynamics data of the resident populations have not been evaluated.

The present study investigated features of the structure (temporal variation in density, sex ratio, and the size and species of occupied shells) of the *C. symmetricus* population found on a *S. wilsoni* reef. The life history traits of the crab in this biogenic substrate were compared with those recorded previously in other tropical coastal habitats.

Material and methods

Study area

Algodoal-Maiandeua Island is located on the Brazilian Amazon coast (00°36′ S, 47°34′ W), and is surrounded on three sides by rivers and estuarine channels, with only its northern margin being exposed to the Atlantic Ocean (Figure 1). The local climate is humid tropical with a mean annual temperature around 26°C (Barbosa et al. 2015) and a mean annual precipitation (30-year record) of 2000–2800 mm (Moraes et al. 2005). Precipitation varies considerably over the course of the year, with a well-marked rainy season from January to July (total rainfall of approximately 1700 mm), and a dry season from August to December, with total rainfall of around 500 mm (Moraes et al. 2005). The region is dominated by semidiurnal macrotides with amplitudes of 4–6 m (Pereira et al. 2012). The island's beaches are characterized by their fine sand and wide midlittoral zone, of 200–400 m (Rosa Filho et al. 2011), with rocky outcrops (lateritized sandstone) which are often colonized by *S. wilsoni*.

Sampling

Samples were collected on a monthly basis between May 2008 and April 2009 on Caixa D'Água Beach, a semi-exposed, low tide sand flat (Rosa Filho et al. 2011). The study reef (Figure 1C) is located on a large rocky outcrop, and is composed of a cohesive cluster of hummocks (area ≈ 1000 m^2), surrounded by sandy substrates. Sampling occurred during a spring low tide period, always in the morning. Two profiles, perpendicular to the coastal line, were determined to ensure the sampling of the full extension of the reef (see Ataide et al. 2014). Along each profile, two sampling blocks were delimited: one at the low tide line, and the other 50 m from the first, in the intertidal zone (see Ataide et al. 2014). In each month, four samples were collected randomly in each block by inserting a metallic sampler (10 cm diameter) into the top of the reef as far as the underlying rocky

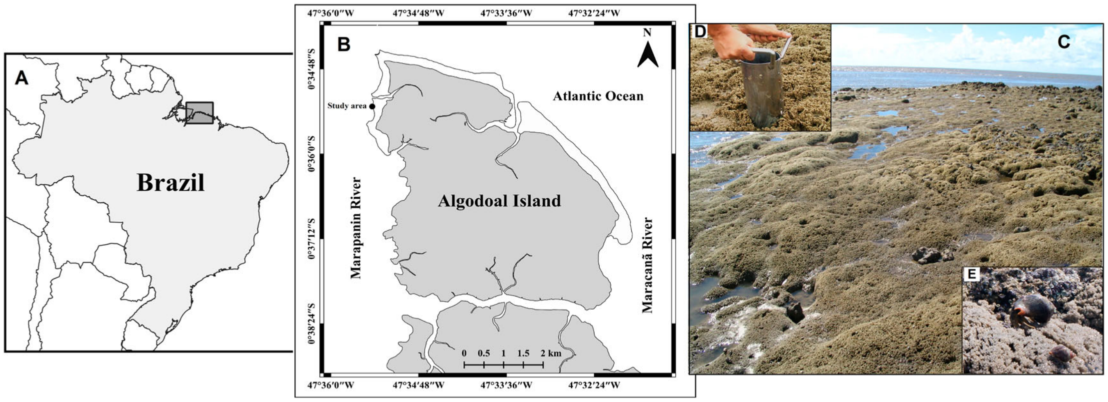

Figure 1. The location of Algodoal-Maiandeua Island on the Amazon coast of northern Brazil (A, B), and the general characteristics of the *Sabellaria wilsoni* reef monitored in the present study (C). In detail: (D) use of metallic sampler into the top of the reef; (E) a specimen of *Clibanarius symmetricus*.

substrate (adapted from Dubois et al. 2002). Given the irregular topology of the bioconstruction, the volume of the samples was determined by liquid displacement in a graduated beaker (adapted from Ribeiro et al. 2003). Each sample was then fixed in 4% saline formalin, buffered with sodium tetraborate, and stored in a labelled plastic bag. The salinity of the water was measured simultaneously, at the low tide line. Data on rainfall and air temperatures were collected online at the INMET portal (Instituto Nacional de Meteorologia – http://www.inmet.gov.br).

In the laboratory, the reef fragments were disaggregated over a sieve (0.3 mm mesh) and the organisms found in the substrate were separated individually, and counted. The hermit crabs were extracted from their shells for analysis. Hermits were removed from the shells with the aid of forceps and, when necessary, was used a bench vise to break the shells. The gastropod species to which the shell belonged were identified. The sex/development stage of each crab (indeterminate juvenile, male, female, or intersex) was also identified and its Cephalothorax Shield Length (CSL) was measured with a digital caliper (0.01 mm precision). The sex of the specimens was checked based on the position of the gonopores. In the male, the gonopores are located on the coxae of the fifth pair of pereiopods, whereas in the female, they are found on the coxae of the third pair. Intersex individuals had gonopores at the base of both the third and the fifth pereiopods (Turra 2004). Specimens whose sex could not be confirmed were assigned to the 'indeterminate sex' category. Specimens with a CSL of less than 3.60 mm [minimum size at first sexual maturity estimated for the species in coastal areas of the Amazon, see Rodrigues and Martinelli-Lemos (2019)] were classified as immature. Voucher specimens were deposited in the carcinological collection of the Goeldi Museum in Belém, Brazil (catalog numbers: MPEG 003179–003183).

Statistical analysis

The density of organisms was calculated as the number of individuals per volume of the sample (ind. L^{-1}). For density and statistical analysis, the blocks (combination of four samples) were considered as sample units, to increase the sampling area (≈300 cm^2), reduce the number of sample units with no organisms, and normalize the data. A two-way analysis of variance (ANOVA) was used to compare densities between sampling seasons (dry and rainy) and among months (nested in seasons), with *a posteriori* comparison being based on the Student–Newman–Keuls (SNK) test. Prior to applying the ANOVA, the data were evaluated for normality (Shapiro–Wilk test) and homoscedasticity of variance (Levene's test). The sex ratio was analysed using χ^2 for the study period as a whole and for each month. Regression analyses were applied to determine the degree of relationship between the size of the hermit crab (CSL) and shell parameters (TSL = Total Shell Length; SAL = Shell Aperture Length; SAW = Shell Aperture Width), as well as between the salinity of the water and the abundance of crabs. All analyses considered a $p = 0.05$ significance level.

Results

A total of 510 hermit crabs were collected during the present study (CSL: 0.20–7.01 mm), of which, 44% were male (CSL: 0.20–7.01 mm), 42% were female (CSL: 0.3–5.40 mm), 1% were intersex (CSL: 2.19–3.01 mm), and 12% were juveniles of indeterminate sex, with CSLs of 0.2–0.6 mm (Figure 2). Around 2% of the females were ovigerous (CSL = 3.7–3.9 mm), and these were recorded only during the dry season, that is, in July and August (Figure 2). Based on the body-size criterion, 79% of the crabs captured at the reef were immature (Figure 2). The overall sex ratio was 1.1♂:1♀, and did not deviate significantly ($\chi^2 < 3.84$; $p > 0.05$) from 1:1 for study period and each month. However, the males (mean CLS = 2.78 ± 0.25 mm) were significantly larger ($F_{1,1} = 1.98$; $p < 0.05$) than the females (CLS mean = 2.1 ± 0.24 mm), and predominated significantly in the highest size class (CLS>4.6mm).

The density of the crabs did not vary significantly between seasons, although mean density was higher in the dry season (mean density = 1.7 ± 0.2 ind. L^{-1}) than in the rainy season (mean density = 1.1 ± 0.1 ind. L^{-1}), and significantly higher densities were recorded in July, August and November than in most other study months (Figure 3). The study period was marked by clear bimonthly peaks in density (Figure 3), although no *C. symmetricus* individuals were collected during two rainy season months, February and June.

Temperature was almost constant throughout the study period (26.3–29.6°C), with mean of 26.6°C in the rainy season, and 28.7°C in the dry season (Figure 4). The precipitation and salinity of the study area presented a clear seasonal pattern (Figure 4). Precipitation was lowest during the dry season months, when the highest salinity (27–35 per mille) was recorded, whereas the salinity was lowest (7–24) during the rainy season. However, while *C. symmetricus* was more abundant during the dry season months, no significant relationship ($r^2 < 0.2$; $p < 0.05$) was found

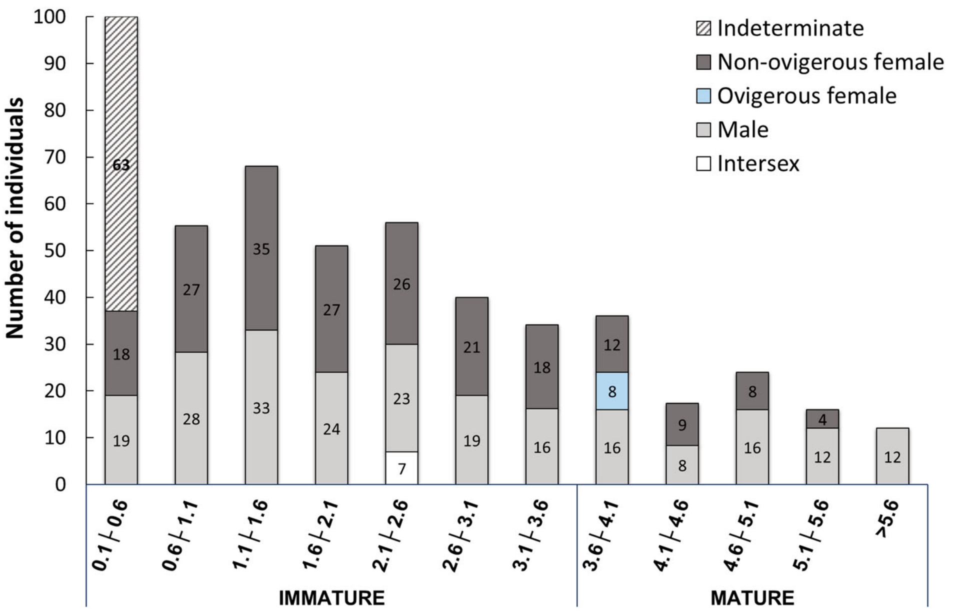

Figure 2. Frequency distribution of cephalothoracic shield lengths (CSL) in the different sex/life stages of the *Clibanarius symmetricus* specimens sampled on Algodoal-Maiandeua Island on the Amazonian coast. Immature = specimens with CSL < 3.60 mm; Mature = specimens with CSL ≥ 3.60 mm. The asterisks indicate a significant deviation from a ratio of 1:1. The numbers on the bars represent the number of individuals for each class.

between precipitation/salinity/temperature and the density of crabs in any of the categories, i.e. total, indeterminate juveniles, mature, and immature.

Thaisella coronata (Lamarck, 1816) was the gastropod species whose shells were most used by the *C. symmetricus* specimens collected during the present study, with 70% of the crabs being found in shells of this species (crab CSL: 1.52–7.01 mm). The shells of three other species were also used by the hermit crabs: *Parvanachis obesa* (C. B. Adams, 1845) shells were occupied by 17% of the crabs (CSL: 0.20–0.40 mm), with a further 7% being recorded in *Natica*

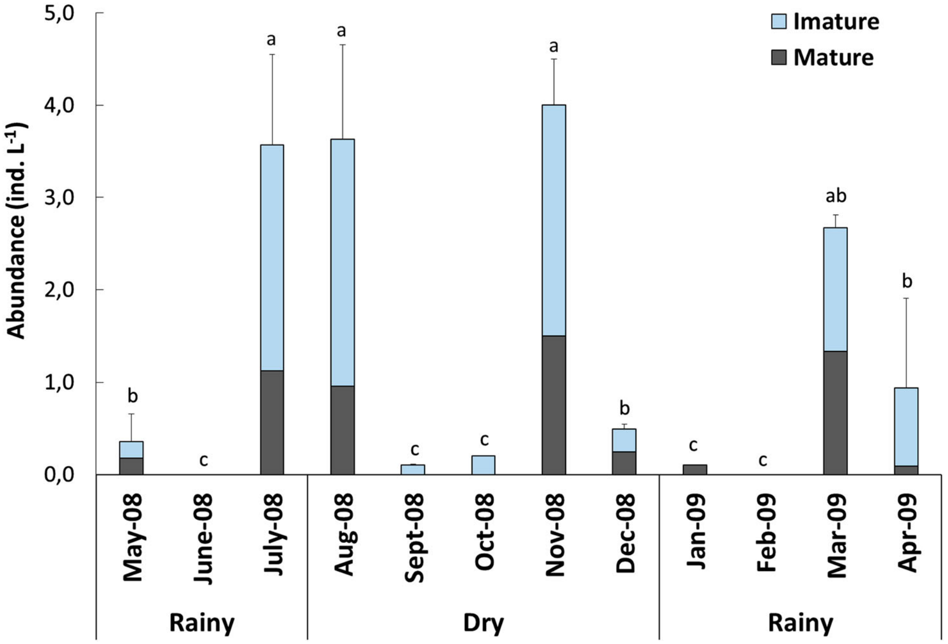

Figure 3. Monthly mean abundance of Clibanarius symmetricus in the study area on Algodoal-Maiandeua Island on the Amazonian coast. The vertical lines are the standard error and different letters indicate significantly different results in the post-hoc SNK. Immature = specimens with CSL < 3.60 mm; Mature = adult (female and male) with CSL ≥ 3.60 mm.

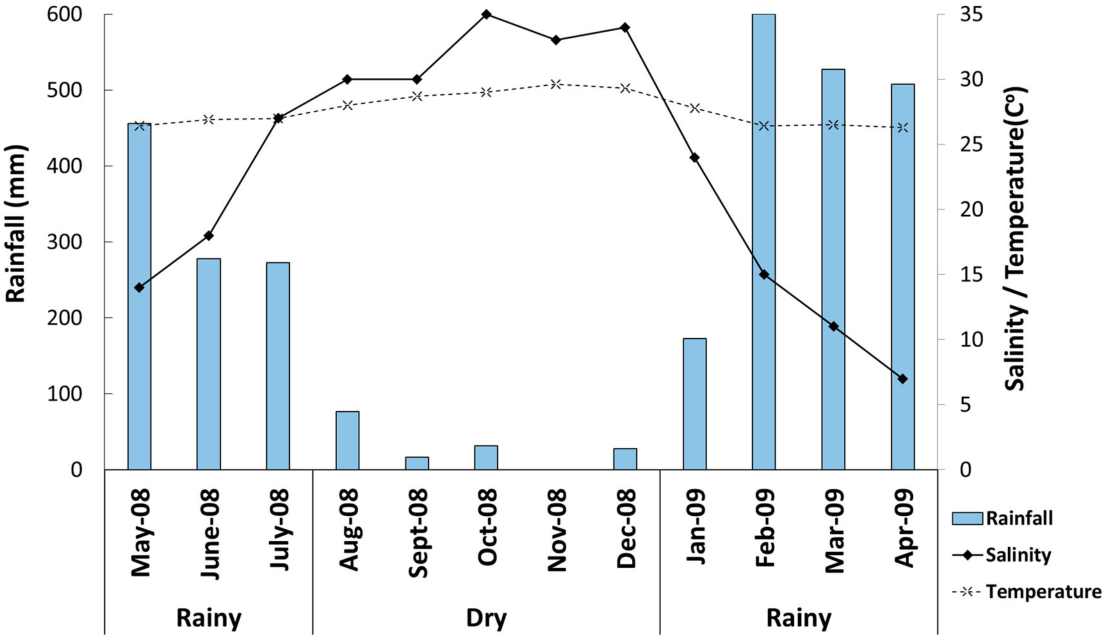

Figure 4. The variation in salinity, precipitation (cumulative total rainfall), and mean air temperature in the study area on Algodoal-Maiandeua Island on the Amazonian coast.

marochiensis (Gmelin, 1791) shells (CSL: 1.39–2.81 mm), and 6% in *Phrontis vibex* (Say, 1822) shells (CSL: 1.28–3.01 mm). The shells of *T. coronata* were the only ones occupied by mature males and females, whereas specimens of indeterminate sex were found primarily in *P. obesa* shells (Figure 5).

Significant regressions were found between the dimensions of the gastropod shells and the size (cephalothoracic shield length) of the resident hermit crab (Table I). The highest correlation coefficients were obtained for the models of total shell length occupied by crabs in the immature category (Table I).

Discussion

The results of the present study indicate that *Sabellaria wilsoni* reefs are commonly used by *Clibanarius symmetricus*, and suggests that this habitat is especially used during the initial phases of the life cycle of this species. The percentage (79%) of crabs of indeterminate sex,

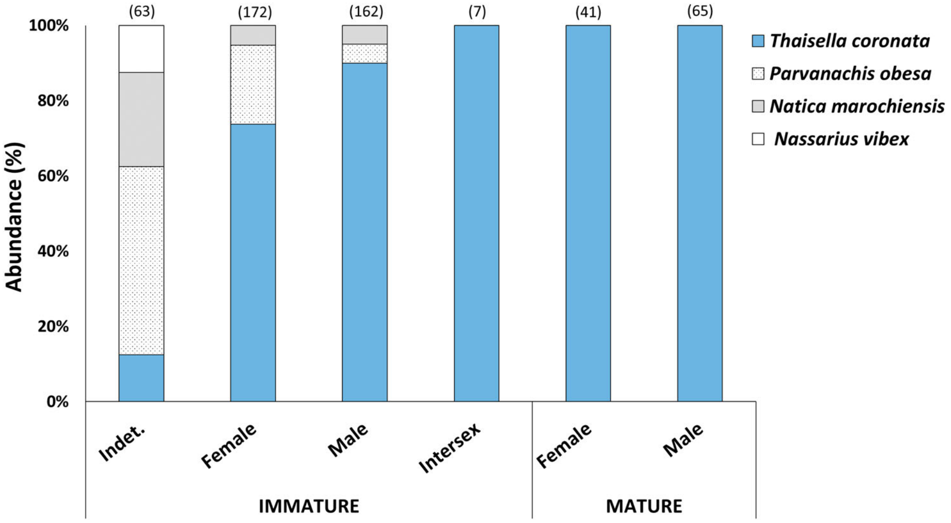

Figure 5. Frequency distribution of the shell species occupied by hermit crabs in the *Clibanarius symmetricus* population. Indet. = indeterminate sex; Immature = specimens with CSL < 3.60 mm; Mature = specimens with CSL ≥ 3.60 mm. The numbers on the bars represent the number of individuals for each class.

Table I. Regression equations with the highest correlation coefficients (r^2) recorded between the crab cephalothoracic shield length (CSL) and different shell parameters (TSL = Total Shell Length; SAL = Shell Aperture Length; SAW = Shell Aperture Width) in the *Clibanarius symmetricus* population sampled on a *Sabellaria wilsoni* reef on Algodoal-Maiandeua Island on the Amazonian coast of northern Brazil. Juvenile = indeterminate sex, Immature = *C. symmetricus* specimens with CSL < 3.60 mm; Mature = *C. symmetricus* specimens with CSL $\geq$ 3.60 mm. * = significant correlation ($p < 0.05$)

Relationship	Class	Linear equation	r^2
CSL vs. TSL	Juvenile	$y = 1.56x + 0.66$	0.59*
	Immature	$y = 3.27x + 1.53$	0.70*
	Mature	$y = 3.27x + 1.53$	0.61*
	All classes	$y = 3.96x + 0.28$	0.66*
CSL vs. SAL	Juvenile	$y = 3.70x + 0.66$	0.48*
	Immature	$y = 5.14x + 3.42$	0.59*
	Mature	$y = 6.36x + 0.90$	0.54*
	All classes	$y = 5.15x + 3.53$	0.55*
CSL vs. SAW	Juvenile	$y = 2.74x + 1.37$	0.45*
	Immature	$y = 3.13x + 0.51$	0.58*
	Mature	$y = 3.08x + 0.75$	0.48*
	All classes	$y = 2.63x + 1.70$	0.54*

Table II. Characteristics of the *Clibanarius symmetricus* populations studied to date in intertidal habitats on the coast of Brazil. CSL = Cephalothoracic Shield Length; Max. = maximum size. *as *Clibanarius vittatus*.

Locality	Habitat	CSL (mm) Mean (±SE)	Max.	Reference
Algodoal Island, Pará (00°36′S)	Sabellariid reef	2.77 ± 0.20	7.01	Present study
Farol Beach, Pará (00°35′S)	Rocky outcrops	3.20 ± 0.80	12.0	Danin et al. (2020)
Marapanim Estuary, Pará (00°38′S)	Rocky outcrops	3.44 ± 1.60	8.91	Rodrigues and Martinelli-Lemos (2019)
Coqueiro Beach, Piauí (02°05′S)	Rock shelf	8.47 ± 2.49	13.90	Mantelatto et al. (2010)*
Mangrove of Araçá (23° 48′S)	Rocks, mud and mangrove roots	7.60 ± 1.17	10.20	Mantelatto et al. (2010)*
São Sebastião, São Paulo (23° 49′S)	Mud, boulders and rocky shore	6.98 ± 1.04	≈11.25	Turra and Leite (2000)*
Pescadores Beach, São Paulo (23° 58′S)	Sandy beach	7.32 ± 1.74	13.80	Sant'Anna et al. (2009)*
Baixio Mirim, Paraná (25° 52′S)	Tideflat, muddy sand	5.86 ± 1.32	11.56	Sampaio et al. (2009)*

probably sexually immature, recorded here was considerably higher than the rates recorded in previous studies of *C. symmetricus* (Rodrigues and Martinelli-Lemos 2019; Danin et al. 2020). The occupation of the *S. wilsoni* reef by this portion of the population was reflected in mean (2.77 ± 0.20 mm) and maximum (7.01 mm) CLS values much lower than those recorded previously in other intertidal habitats, including some on the Amazon coast (Table II). For example, mean CSL values of 5.86 ± 1.32 mm and 7.60 ± 1.17 mm have been recorded in south-eastern Brazil, with a maximum value of 13.8 mm (Table II). In rocky outcrops on the Amazon coast adjacent to Algodoal-Maiandeua Island, mean CSL values in *C. symmetricus* ranged between 3.20 ± 0.80 mm and 3.44 ± 1.60 mm, reaching a maximum of 12.0 mm (Rodrigues and Martinelli-Lemos 2019; Danin et al. 2020).

The reefs formed by *S. wilsoni* on the sandy beaches of the Amazon coast represent a heterogeneous environment with a variety of microhabitats that are relatively well-protected from severe abiotic (e.g. winds, currents, high temperatures, and desiccation) and biotic factors (Aviz et al. 2019). Juvenile *C. symmetricus*, which are probably more vulnerable to environmental pressures and predation than the adults, may be more dependent on the protection offered by the reefs. Biogenic substrates, such as colonies of bryozoans (Alves et al. 2013) and sponges (Caruso et al. 2005; Wulff 2006), and seaweed beds (Zieman and Zieman 1989; McDevitt-Irwin et al. 2016) often provide nursery grounds for many marine intertidal invertebrates. *C. symmetricus* juveniles were collected primarily within the reef, whereas the adults were generally epibenthic. The internal space of the *S. wilsoni* reef studied here may be relatively unsuitable, in general, for larger crabs, and it seems likely that, as the specimens grow, they will tend to occupy alternative environments within the intertidal zone, visiting the sabellariid reefs mainly to forage, and occasionally, when seeking refuge. Hermit crabs tend to be distributed heterogeneously in the environment, and will often shift among habitats according to the prevailing environmental conditions or the needs of the different life phases, that demand different resources (shells) (Lancaster 1988; Turra and Leite 2000; Turra and Denadai 2003).

The well-marked bimonthly peaks in density observed over the course of the year may represent the periods during which *C. symmetricus* is recruited in the study area. This species may breed continuously in tropical and subtropical regions, where reproductive peaks may be recorded at different times of the year (Mantelatto et al. 2010; Rodrigues and Martinelli-Lemos 2019; Danin et al. 2020). On the Amazon coast, these peaks typically occur during both rainy and dry seasons (Rodrigues and Martinelli-Lemos 2019; Danin et al. 2020). Salinity has often been related to temporal fluctuations in abundance of the *C. symmetricus* populations. For example, migration of ovigerous females toward areas of higher salinity, resulting in the absence or reduced abundance of the ovigerous females in areas of low salinity (Sant'Anna et al. 2008; Rodrigues and Martinelli-Lemos 2019). This assumption is supported by the data on the development of the eggs and larvae of the congeneric *C. vittatus*, for which optimal conditions appear to be found in salinities of 25–35 per mille (Fotheringham and Bagnall 1976; Young and Hazlett 1978; Kelly and Turner 2011). In fact, studies on ionic modulation of gills (Na^+, K^+)-ATPase in *C. symmetricus*, revealed a modest hyperosmoregulation and enzymatic activity levels comparable to those of exclusively marine decapods, indicating that the species is susceptible to variations in salinity (see Gonçalves et al. 2006).

The high densities of juveniles of *C. symmetricus* and the presence of ovigerous females exclusively in the dry season may indicate that this period has more favourable conditions (higher salinity and more nutrients input) for spawning and larval development. In addition to greater salinity, studies have recorded greater phytoplankton densities in the dry season, when compared to the rainy season, due to the decreased turbidity and increased sunlight penetration, which stimulates the development of microalgae (Paiva et al. 2006; Matos et al. 2016).

In the study area, the male *C. symmetricus* were larger than the females, as reported previously in other populations of this species (e.g. Sant'Anna et al. 2009; Mantelatto et al. 2010; Rodrigues and Martinelli-Lemos 2019). The sexual dimorphism found in hermit crabs is well stablished and has been attributed to either (i) sexual selection (Harvey 1990), in which larger males are able to compete more successfully for access to breeding partners (Abrams 1988) or (ii) differences in the energy available for growth, with males investing more in somatic growth in comparison with females, which dedicate more energy to the production of eggs (Bertness 1981; Rodrigues and Martinelli-Lemos 2019; Rodrigues and Martinelli-Lemos 2019; Rodrigues and Martinelli-Lemos 2019). In the sabellariid reef, however, no deviation was found in the total sex ratio, which contrasts with the results of previous studies, outside biogenic habitats, which have found male-biased (Sampaio et al. 2009; Mantelatto et al. 2010; Rodrigues and Martinelli-Lemos 2019) or female-biased ratios (Turra and Leite 2000; Sant'Anna et al. 2008; Mantelatto et al. 2010; Danin et al. 2020). This finding may have been influenced by the predominance of immature crabs in the sample, given that a biased sex ratio may result from differential survival rates and life expectancy of the two sexes, as well as sex reversal in the adults (Wenner 1972; Mantelatto et al. 2010).

The *C. symmetricus* specimens collected from the *S. wilsoni* reef in the present study occupied gastropods shells of four different species, with those of the muricid *T. coronata* being occupied by 70% of the specimens. A predominance of the occupation of *T. coronata* shells has also been recorded in previous studies on the Amazon coast, and is probably related to the abundance of this gastropod on the local rocky outcrops (Rodrigues and Martinelli-Lemos 2016; Danin et al. 2020) and *S. wilsoni* reefs (Aviz et al. 2019). Hermit crabs typically occupy shells of the most abundant gastropod in a given area (Reese 1969; Bertness 1982; Turra and Leite 2001). The architecture of the *T. coronata* shell also appears to be especially appropriate for the insertion of the adult crabs and their protection (Rodrigues and Martinelli-Lemos 2016; Danin et al. 2020), which may also contribute to the selection of shells by the crabs (Emmerson and Alexander 1986; Turra and Leite 2001).

In general, *T. coronata* shells were occupied mainly by adult hermit crabs, whereas the juveniles used shells of a variety of species, as observed in previous studies of *C. symmetricus (*Turra and Leite 2001*;* Rodrigues and Martinelli-Lemos 2016*;* Danin 2017*)*. A reduction in the diversity of the shell species occupied by the hermit crabs as they increase in size is a pattern observed in other hermit crabs (Turra and Leite 2001; Mantelatto and Dominciano 2002; Carranza et al. 2008), and may reflect either a shift in preference during the growth and development of the individual (Straughan and Gosselin 2014; Rodrigues and Martinelli-Lemos 2016) or a greater taxonomical diversity of smaller-sized shells (Turra and Leite 2001).

In the present study, the size of the crab and the morphometric parameters of the shell it occupied were well correlated, especially in the immature specimens (Table I). This correlation is more typical of areas where gastropod shells are relatively abundant in the environment (Mantelatto and Dominciano 2002; Biagi et al. 2006). The *S. wilsoni* reefs found on Algodoal-Maiandeua Island are known to be occupied by at least 26 species of gastropod (Silva 2015; Aviz et al. 2019), and the shells of eight of these species are used by *C. symmetricus (*Rodrigues and Martinelli-Lemos 2016*;* Danin 2017*)*, which was the only hermit crab recorded in this habitat. However, only ten of these species are probably an abundant resource (relatively more abundant and frequent throughout the year) in *S. wilsoni* reefs, including *T. coronata, Costoanachis sparsa* (Reeve, 1859), *P. obesa,* and *Epitonium albidum* (d'Orbigny, 1842), which have their shells used by *C. symmetricus*. Species of other shells used by the hermit, such as *N. marochiensis, Littoraria flava* (P. P. King, 1832), *Olivella minuta* (Link, 1807), and *P. vibex*, are a less abundant resource in this habitat (Silva 2015; Aviz et al. 2019).

Most (20 species) of the gastropods recorded on the *S. wilsoni* reefs (Silva 2015; Aviz et al. 2019) are small, with a mean shell length of less than 20 mm (Warmke and Abbott 1975; Rios 2009). In a study of the *C. symmetricus* population found on rocky outcrops of the Amazon coast (Danin 2017; Danin et al. 2020), more than 80% of the crabs occupied shells that were more than 20 mm long, including shells of *T. coronata, Marsupina bufo* (Bruguière, 1792) and *Pugilina tupiniquim* Abbate & Simone, 2015, the latter two species were not recorded in the *S. wilsoni* reef on the Amazon coast (Silva 2015; Aviz et al. 2019). This suggests that the reduced availability of shells of large size may be one factor determining the reduced abundance of adult *C. symmetricus* on the *S. wilsoni* reefs. A number of studies have shown that population dynamics and residence times in different habitats are influenced by the availability of suitable empty gastropod shells and that hermit crab migrations should be considered to be a resource-dependent phenomenon (Lancaster 1988; Gherardi et al. 1990; Turra and Leite 2000). However, more detailed studies, including behaviour and dispersal patterns, will be required to provide more conclusive insights into the influence of spatial constraints and the availability of shells in sabellariid reefs on the distribution of *C. symmetricus*.

The results of the present study indicate that *C. symmetricus* uses the *S. wilsoni* reef as a nursery ground, and that the alternating bimonthly peaks of high and low density may reflect recruitment in the region. Previous studies on the ecological role of polychaete reefs have tended to emphasize their influence as modifiers of the physical environment and local biodiversity patterns. However, some studies, including the present one, have demonstrated that the presence of these reefs may have a considerable impact on the population biology of a range of different species (Luppi and Bas 2002; Rabaut et al. 2010; Bruschetti 2019), which supports the need for the further, more detailed monitoring and conservation of these habitats.

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Disclosure statement

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