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Population features of the pea crab *Dissodactylus crinitichelis* Moreira, 1901 (Decapoda, Brachyura, Pinoteridade) associated with the sand-dollar *Encope emarginata* (Echinodermata, Echinoidea) in the southeastern Brazilian coast

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ABSTRACT

Crabs of the *Dissodactylus* genus are commonly found in symbiosis with other marine invertebrate organisms. This study describes the structure of the population of the Pinnotheridae crab *Dissodactylus crinitichelis* living in symbiosis with the sand dollar *Encope emarginata* on a temporal scale and over the size class distribution, sex-ratio, recruitment defined as the specimens of the two first size classes, and breeding period. Specimens were collected in sand bottoms at the infralittoral zone at Flamengo Beach in Ubatuba, in the northeastern coast of São Paulo state, using free diving performed by one diver from August 2017 to July 2018, for 30 minutes per month. 337 juvenile, 51 adult females, and 38 adult males were analyzed, comprising 12 ovigerous females. There was registered recruitment, in almost all months. The sex ratio was 1:1.3, with more females than males in the population. In March, there was a significant recruitment period with 337 juveniles in one sample. The maximum carapace width was 6.6mm in males and 7.65mm in females. The representative number of specimens in the first size class may provide information that *D. crinitichelis* presents some levels of spatial segregation in the population in this area and should be monitored for preservation.

Keywords: crustacea, ecology, Flamengo beach, symbiosis, Ubatuba.

Parâmetros populacionais do caranguejo-pêra *Dissodactylus crinitichelis* Moreira, 1901 (Decapoda, Brachyura, Pinoteridade) associado com a bolacha-do-mar *Encope emarginata* (Echinodermada, Echinoidea) no litoral sudeste brasileiro

RESUMO

Caranguejos do gênero *Dissodactylus* são frequentemente reconhecidos associados a alguma relação simbionte. O objetivo aqui é apresentar algumas características populacionais

do caranguejo pinoterídeo *Dissodactylus crinitichelis*, em associação à bolacha-da-praia Encope emarginata, em escala temporal, destacando a distribuição em classes de tamanho, proporção sexual, recrutamento e período reprodutivo. Os caranguejos foram amostrados mensalmente, no infralitoral não consolidado, na Praia do Flamengo, Ubatuba, litoral norte paulista, junto às bolachas-da-praia, durante sessões de mergulho livre, mensalmente de agosto/2017 a julho/2018, com esforço amostral de aproximadamente 30 minutos/mês, por um coletor. Foram obtidos 426 caranguejos, dos quais 337 indivíduos jovens e 89 adultos sendo 51 fêmeas e 38 machos, incluindo 12 fêmeas ovígeras. O recrutamento foi registrado em praticamente todo o período amostrado, com pico de frequência em março, com 71 jovens. A proporção sexual verificada foi 1:1.3, desviada para as fêmeas. A maior da largura da carapaça para machos e fêmeas de *D. crinitichelis* foi de 6,6 e 7,65 mm, respectivamente. O principal caráter da população amostrada foi a presença dominante de jovens, o que sugere a existência de segregação espacial da população amostrada em simbiose à bolacha-da-praia, o que parece estabelecer regiões preferenciais de recrutamento nessa praia, o que torna a região de grande importância para a conservação dessa espécie de caranguejo

Palavras-chave: crustacea, ecologia, praia do Flamengo, simbiose, Ubatuba.

1. INTRODUCTION

Pinnotherid crabs are commonly associated with a large variety of hosts, such as mollusks, ascidians, polychaetes, and especially echinoderms (Bell, 1984). They show a large diversity of lifestyles, such as commensalism, parasitism (Baeza and Thiel, 2000; De Bruyn *et al.*, 2011), and endosymbiosis or ectosymbiosis, involving solitary or communal distribution on the host, where they live during their life cycle, though free-living stages can be observed (Bell, 1984).

The genera *Dissodactylus* Smith, 1870, and *Clyperasterophilus* Campos and Griffith, 1990, belong to the *Dissodactylus* complex that includes 13 species (Campos and Griffith, 1990; Martin and Davis, 2001). These species present an Amphi-American geographic distribution, occurring in the Atlantic and Pacific oceans. On the Brazilian coast, these crabs are recorded from Pará to Rio Grande do Sul states, extending to Argentina. They are commonly found on sandy bottoms and coral reefs and are associated with irregular echinoids (Melo, 1996).

The tiny crab *Dissodactylus crinitichelis* Moreira, 1901 (informally named pea crabs), is commonly found living in the dense coat of spines on the oral side of several species of sand dollars, such as *Encope michelini* L. Agassiz, 1841 (Schmitt *et al.* 1973), and was most recently found hosted in *Leodia sexiesperforata* (Leske, 1778), in the coast of Salvador, Bahia state, northeastern Brazil (Queiroz *et al.*, 2011). According to Melo (1996), this species has a large distribution ranging from North Carolina (USA) to Argentina. Some biological aspects of *D. crinitichelis* are available, such as its phylogenetic relationships (Griffith, 1987; Marques and Pohle, 1995; Pohle and Marques, 1998), growth rate (Fumis *et al.*, 2006), host descriptions (Queiroz *et al.*, 2011; Lima *et al.*, 2014), host selection/host-use pattern (Martinelli Filho *et al.*, 2014) and mating system (Alves *et al.*, 2017).

Crustaceans constitute a highly diversified group with various morphologies and behaviors and occupy a wide variety of aquatic and terrestrial habitats. In addition, several crustacean clades have independently evolved symbiotic relationships with other macro-invertebrates (Thiel and Baeza, 2001).

Many different host-symbiont associations have been described for several crustacean species; however, little is known about crab population biology and the nature of the symbiotic relationship. In this sense, host exploitation will depend not only on the symbionts' mating or social systems but also on the nature of the symbiotic relationship (see Thiel 2000, De Bruyn

et al., 2009). In this respect, the association of pea-crabs and their hosts could be commensalism or parasitism, providing advantages only to the crab, because of their small size and inconspicuous nature; it is unlikely the crabs provide some benefit to the echinoderms, such as protection (Reeves, 2000; Lima *et al.*, 2014). In addition, under laboratory conditions, some *Dissodactylus* species seem to prefer to inhabit living sand dollars or bury themselves in the sand (Bell, 1984).

In addition to the special population conditions of the symbiotic population, Begon *et al.* (1996), suggests that changes in population characteristics in space and time, even in simple communities, have the potential to be, and indeed often are, very complex and pose a wealth of ecological questions.

This study provides information regarding some features of the population structure, as size, frequency distribution, sex-ratio and recruitment of the pea crab *D. crinitichelis* associated with the sand-dollar *Encope emarginata* (Leske, 1778) on a sandy beach on the southeastern Brazilian coast.

2. MATERIAL AND METHODS

2.1. Sampling procedures

The crabs were sampled on the sand dollars on the sand bottom of the Flamengo Beach, Ubatuba municipality, on the northeastern coast of São Paulo state (23°30'46.5" S 45°06'38.4" W) (Figure 1). Collections were carried out by free dive sessions monthly, from August/2017 to July/2018, with 30 minutes catch effort performed by one person. Sand dollars were bagged immediately after being captured to avoid crab loss.

Figure 1. Map of the study area, Flamengo Beach, in Ubatuba municipality, northeastern São Paulo state coast (Modified from Google Earth, 2022).

The sand dollars were carefully examined to find the crabs with the help of a hand magnifying glass. After field procedures, all sand dollars were returned to the sea. The obtained crabs were stored in identified jars filled with ethanol 70% and transferred to the Laboratory of Zoology of the University of Taubaté - UNITAU.

2.2. Laboratory procedures

Crabs were measured to the largest Carapace Width (CW) using a vernier caliper or an optical stereo microscope, equipped with ocular micrometric, grouped in demographic classes: Male (M), Female (F), Ovigerous Female (OF) and Juvenile (J), and sorted into 14 size classes, ranging from 1.0 to 8.0 mm CW, with intervals of 0.5 mm, according to Rios (2002)

2.3. Analysis procedures

Monthly frequency histograms were plotted, and sex ratio analyses were also calculated monthly and tested by Chi-square (χ^2) ($\alpha = 0.05$) (Zar, 1996). The normality of the size distribution frequency was evaluated by the Kolmogorov-Smirnov test (Zar, 1966). The breeding period was verified by the monthly frequency of the ovigerous female. The recruitment was defined as the frequency of the individuals in the two first-size classes.

During the sampled period, the mean water temperature was 23.7±2.4ºC, ranging from 21 to 27ºC. Mean salinity was 22±16.5 UPS, ranging from 26 to 39 UPS. There was no significant association between environmental parameters and crab frequency.

3. RESULTS

A total of 426 crabs were obtained, distributed as 51 adult females, 12 ovigerous females, 38 adult males and 337 juveniles, in 568 sand-dollar individuals captured, with a mean density of 0.57 crabs/sand-dollar, ranging from zero to six crabs/sand-dollar.

The mean CW size of the sampled population was 4.05±1.5mmCW, ranging from 1.2 to 7.65mmCW. Males' and females' mean sizes were 4.20±1.5mmCW, ranging from 1.2 to 6.6mmCW, and 5.38±1.11 mm, ranging from 3.5 to 7.65 mm, respectively.

An abundance peak of crabs was recorded in March/2018, with 81 individuals, while the sand-dollar frequency remains virtually constant during the studied period (Figure 2).

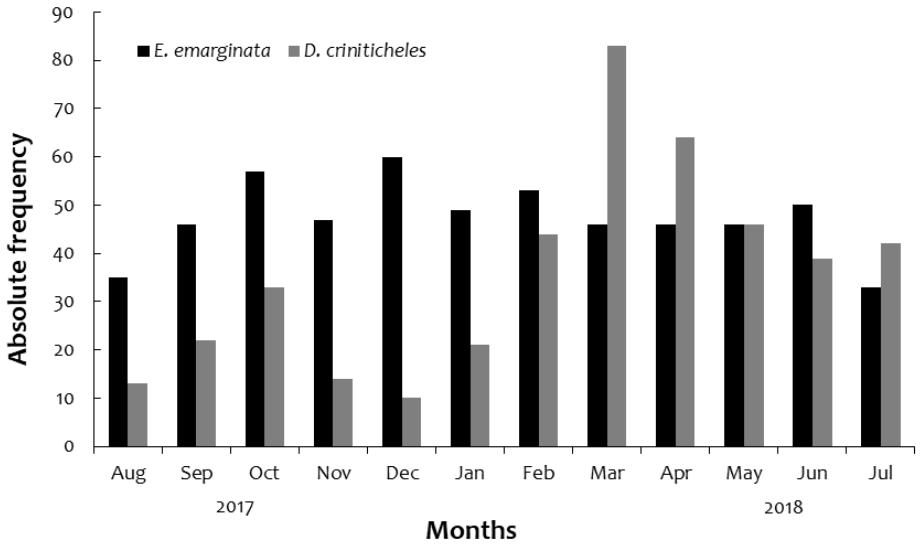

Figure 2. Monthly frequency distribution of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state.

A non-normal size-frequency distribution was registered (Kolmorov-Smirnov-KS= 0.1259; $p < 0.01$), unimodal, with the 4—| 4.5mmCW as the modal class (Figure 3). Monthly size-frequency distribution histograms show recruitment pulses, with the absence of recruits during August, September, November, December/2017, and January/2018 (Figures 4 A and B).

The overall sex-ratio of 1:1.3 male/female was recorded, significantly biased to females

(Chi-square χ^2 = -24.110; p>0.05), fitting in the "reversal" pattern (Wenner, 1972), showing deviations for both males and females over the temporal scale, as well as for the size classes, represented in Figures 5 and 6 by the male´s frequency. Ovigerous females were regularly recorded from August to December 2017, and only one individual in February, March and May 2018 (Figure 7).

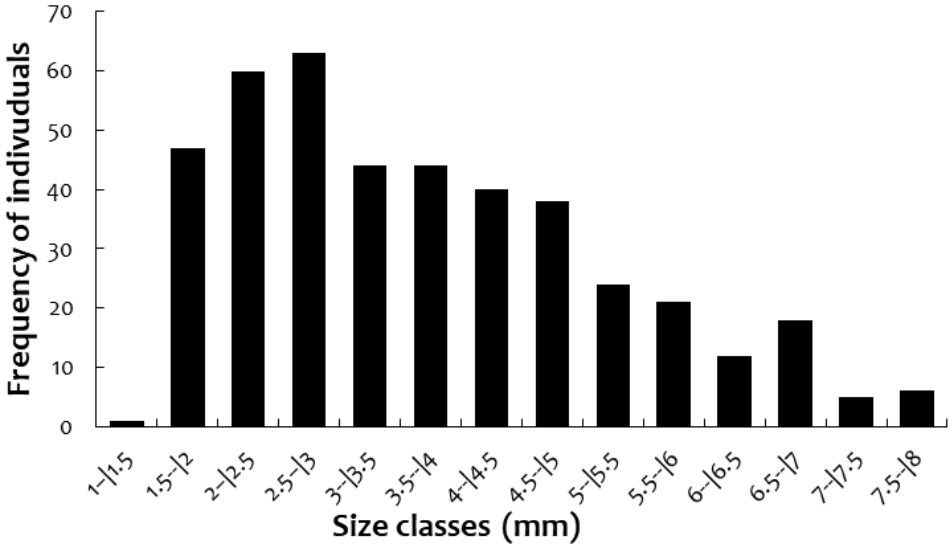

Figure 3. Size frequency distribution of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state.

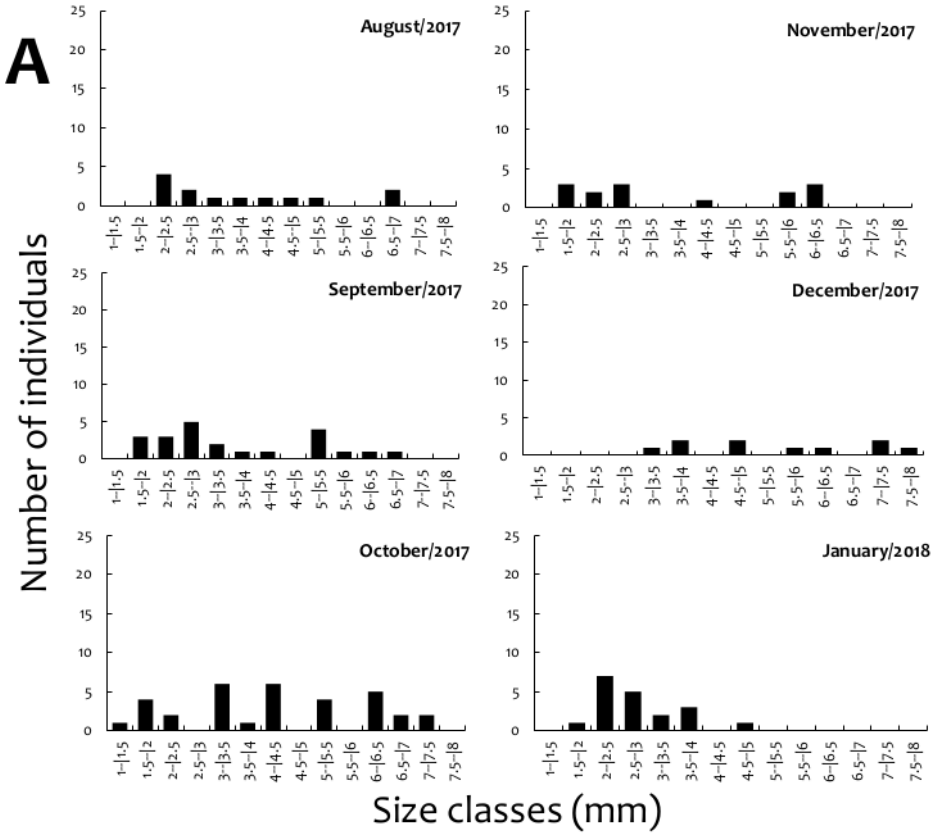

Figure 4A. Monthly size frequency distribution histograms of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state, from August 2017 to January 2018.

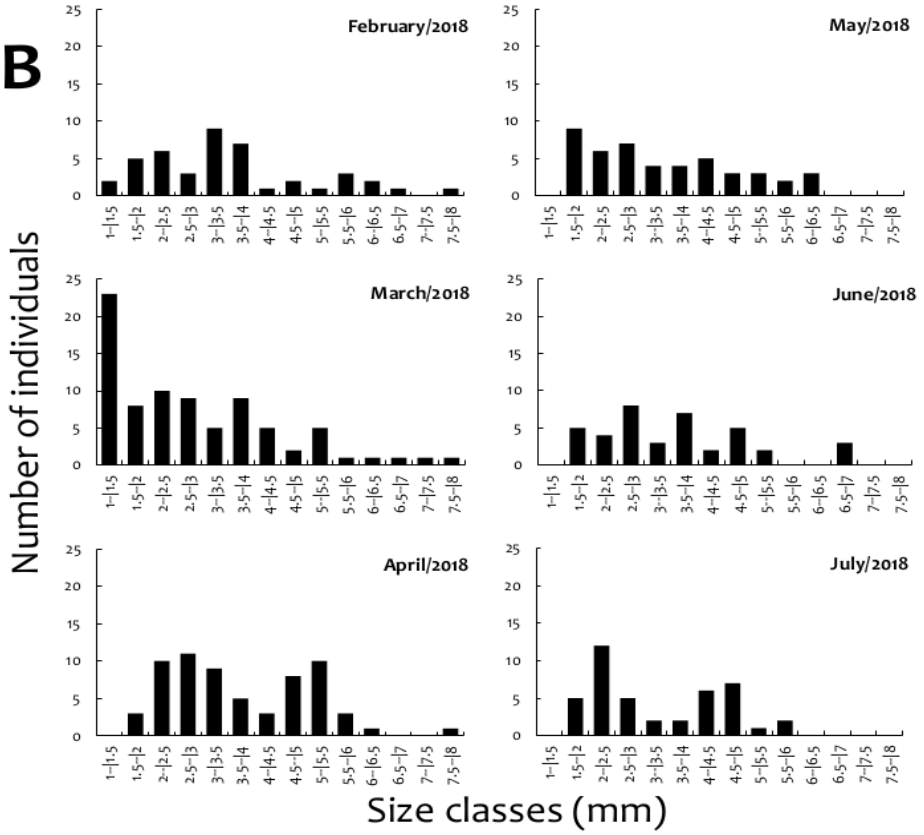

Figure 4B. Monthly size frequency distribution histograms of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state, from February 2018 to July 2018.

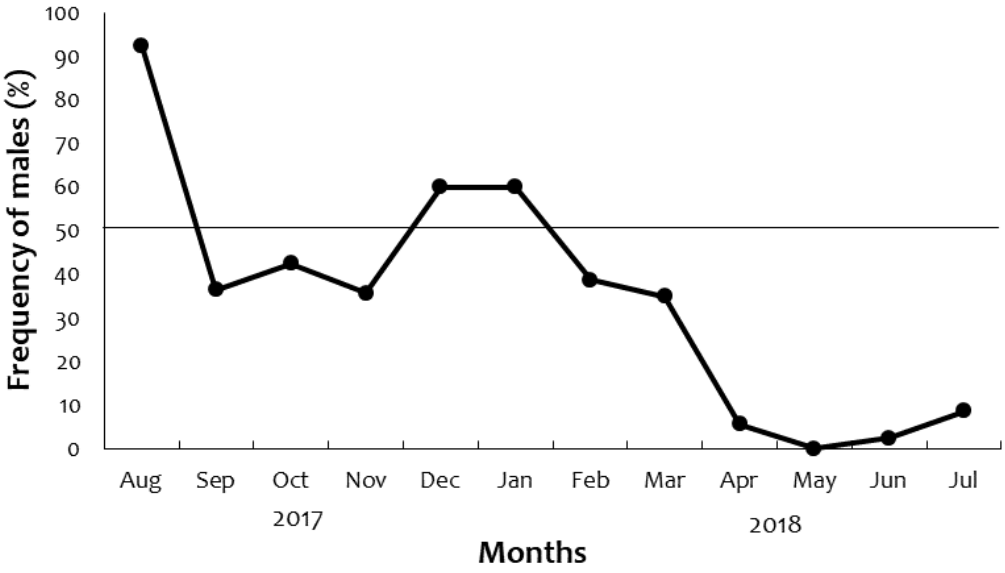

Figure 5. Male monthly frequency of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state.

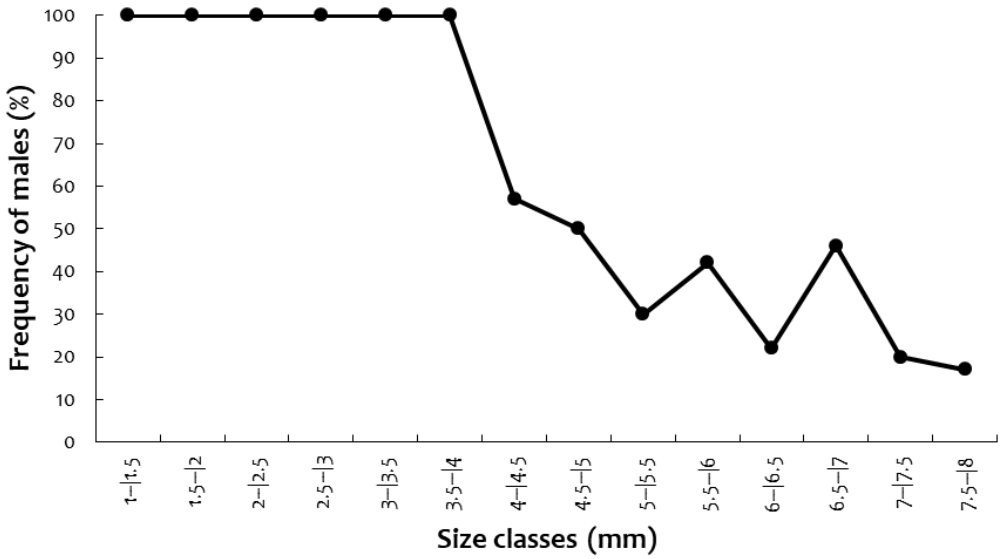

Figure 6. Male size frequency distribution of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state.

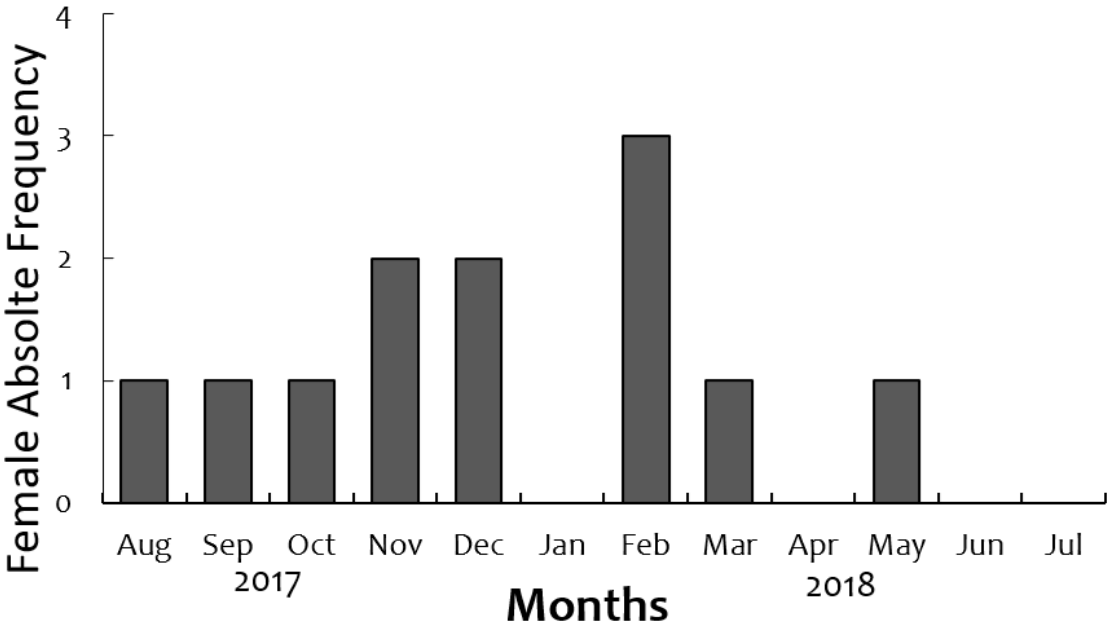

Figure 7. Monthly frequency of the ovigerous females of *Dissodactylus crinitichelis* in the Flamengo Beach, northeastern coast of the São Paulo state.

4. DISCUSSION

There are many examples of symbiosis among sea animals in that smaller symbionts are looking for larger hosts, presumably because suitable refuge is limited and competition for space is high (Reeves, 2000).

However, the costs and benefits of symbiosis are not always clear and fluctuate along a continuum that is influenced by environmental and biological factors (Leung and Poulin, 2008). According to Telford (1978), because of their small size and inconspicuous nature, it is unlikely the crabs provide benefits such as protection to the echinoderms. For this reason, they are generally regarded as commensals or parasites (see De Bruyn *et al.* 2009 for revision).

In this investigation, densities, as registered for *D. crinitichelis*, suggest an irregular host occupation, associated with the large availability of hosts, as previously reported for *Clypeasterophilus stebbingi* (Rathbun, 1918), also hosted in *E. emarginata* (Rios, 2002).

Besides this similarity, *D. crinitichelis* is larger than *C. stebbingi*, in terms of mean size of the carapace. In addition, the females of *D. crinitichelis* were larger than male, in contrast to *C. stebbingi* that presents slightly larger males (Rios, 2002).

Both Rios (2002) and this investigation indicate high recruitment in the studied area for both crab species, represented by a large number of individuals in the two first size classes, suggesting possible demographic segregation in the population, with exclusive areas for recruits and adults; however, this assumption requires further investigations.

The females were more frequent on the sand dollar most of the time, except in August, December 2017, and January 2018, when a larger proportion of males was recorded, contrasting to the registered for *C. stebbingi* (Rios, 2002), and even for *D. crinitichelis* in Pernambuco state coast (Cunha, 2015), suggesting that the sex-ratio is likely not be constrained to this relationship.

Asymmetric size distributions have been commonly recorded for brachyuran crabs in the tropical Atlantic, as reported for *Sesarma rectum* (Randall, 1840) (De Arruda Leme, 2002) and *Neohelice granulata* (Dana, 1851) (Gregati and Negreiros-Fransozo, 2009), both in São Paulo state coast, southeast of Brazil; they are skewed for the right, indicating scarcity of juveniles. On the other hand, asymmetrical frequency size distributions, as verified in this study for *D. crinitichelis,* are unexpected and could suggest a kind of spatial segregation or an exclusive recruitment area.

The normal size distribution usually recorded in populations of brachyuran crabs in the tropical Atlantic reflects the balance of natality and mortality and emigration and immigration rates that are characteristics of stable populations (Diaz and Conde, 1989), as reported for *Mithraculus forceps* A. Milne Edwards, 1875 (Cobo, 2006), in the Couves Island, northeastern São Paulo state coast. However, the studied population of *D. crinitichelis* showed a non-normal size distribution within a juvenile dominance, reinforcing the spatial segregation hypothesis in the hosts at the sampled site. The same pattern was found for *C. stebbingi* (Rios, 2002), suggesting some influence of the symbiotic relationship.

Despite the irregular presence of the ovigerous females, during the monthly collections, the recruitment was continuous, as reported for the most tropical and subtropical brachyuran crabs (see Cobo, 2006; Barros-Alves *et al.*, 2013; Cunha, 2015; Camargo *et al.*, 2017), which reinforces the suggestion of the spatial segregation for this population at this beach.

The "reversal" pattern of sex-ratio observed for *D. crinitichelis* is unexpected for this species once this pattern is usually associated with the functional hermaphroditism (Wenner, 1972). This situation may also suggest the formation of areas of demographic segregation, considering that *D. crinitichelis* is a gonochoric species, and the "anomalous" pattern is the most commonly registered for tropical and subtropical crab species (Cobo, 2006). In addition, Cunha (2015) found some contrasting results for the *D. crinitichelis* sex ratio, on the northeastern Brazilian coast, with little deviation for males over the period, while in this study, a significant deviation was verified for females.

The presence of ovigerous females was unregular, concentrated in the first half of the year, which added to the presence of juveniles in most of the sampled months, may suggest a continuous breeding period, which is reported as a pattern for brachyuran crabs (see Hernández Reyes *et al.*, 2001).

The months without ovigerous females are likely a sample failure caused by bad weather conditions during the dive sessions.

In short, considering the size-frequency distribution, sex ratio, recruitment, and breeding season characteristics, *D. crinitichelis* are constraints on the expected population of crabs from tropical and subtropical regions, characterized by the normal size-frequency distribution and dominated by adults. According to Hernández Reyes *et al.* (2001), these differences may be originated from the ectosymbiosis with the san-dollar, reinforcing the premise that the host

presence must shape the population characteristics of the guest (Furlan, 2010; Gómez Lemos, 2010; Cunha, 2015). Alternatively, these results could be constrained by the segregation of the population that could account for the absence of ovigerous females during some months of the year and even the low presence of adults compared with the juveniles.

Moreover, these results are relevant from a conservation perspective, as they can offer information about recruitment seasons and breeding periods of crab species, to contribute to site conservation efforts, which can guarantee the maintenance of both host and guest in symbiosis.

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