Population structure and breeding period of *Pachycheles monilifer* (Dana) (Anomura, Porcellanidae) inhabiting sabellariid sand reefs from the littoral coast of São Paulo State, Brazil

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ABSTRACT. The purpose of the present study is to examine the population structure and the breeding period of *Pachycheles monilifer* (Dana, 1852) inhabiting sabellariid worm reefs in the littoral of São Paulo State coast. The specimens were obtained at 2-month intervals from September/94 to July/95. The study sites were located at the rocky shores of Tenório and Paranapuã Beaches. Individuals sampled showed a total averaged 4.4 ± 1.4 mm carapace length. Ovigerous females were more frequent in September. Despite clear differences regarding the arrangement of these sabellariid colonies, they are extremely important to the establishment and maintenance of *P. monilifer*.

KEY WORDS. Porcellanidae, *Pachycheles monilifer*, sabellariid worm reefs, biology

According to MELO (1999), porcelain crabs enclose 27 genera and about 230 species, among which 21 are found in Brazil and 13 along São Paulo State coast. Porcelain crabs are much alike true (brachyuran) crabs, but they possess uropods and their reduced last walking legs are dorsally directed. The Porcellanidae are mainly represented by littoral species, excepting rare accounts in the deep sea. They are known to occupy a variety of habitats, including hard substrata such as crevice systems, under boulders or in bottoms covered by calcareous algae (VELOSO & MELO 1993).

In general, sabellariid polychaetes build up conspicuous masses of sand-compacted tubes, forming extensive colonies composed by thousands of individuals (AMARAL 1987).

These reefs supply a hard substratum, shelter and food for several decapod species allowing them to exploit the surf zone; an area probably inaccessible otherwise (GORE *et al.* 1978). Some studies had focused the composition, biology and the interaction among decapod crustaceans associated to sabellariid worm reefs (*e.g* FAUSTO-FILHO & FURTADO 1970; GORE *et al.* 1978; ALMAÇA 1990; PINHEIRO *et al.* 1997; NEGREIROS-FRANSOZO *et al.* 1998; MICHELETTI-FLORES & NEGREIROS-FRANSOZO 1999). Other studies had emphasized the population structure and reproductive biology of porcelain crabs (SAMUELSEN 1970; SMALDON 1972; AHMED & MUSTAQUIM 1974; BREMEC & CAZZANIGA 1984; SCELZO 1985; STEVCIC 1985; OLIVEIRA & MASUNARI 1995).

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The porcelain crab *Pachycheles monilifer* (Dana, 1852) is distributed along the Western Atlantic coast from Eastern coast of Florida (USA) to Brazil (from Rio Grande do Norte to Santa Catarina), including Gulf of Mexico and Venezuela. It was also found in Eastern Pacific (Equador) by VELOSO & MELO (1993).

The purpose of the present study is to examine the population structure and the reproductive period of *P. monilifer* inhabiting sabellariid worm reefs from littoral of São Paulo State coast.

MATERIAL AND METHODS

The individuals of *P. monilifer* were obtained at 2-month intervals from September/1994 to July/1995 in Tenório Beach, Ubatuba (23°28'S and 45°03'W) and Paranapuã Beach, Santos (23°59'S and 46°23'W).

The sample size was determined by a performance curve (BROWER & ZAR 1977) and the mean size of each sample for each beach was approximately 50 kg.

At the laboratory, porcelain crabs were sorted and fixed in 10% formaline. They were sexed and their carapace length (CL) measured with the aid of a microscope provided with a camera lucida. Females present gonopores in the coxa of the third pair of pereopods and three pleopod pairs located at the 3^{rd}, 4^{th} and 5^{th} abdominal somites. Males are characterized by lacking pleopods. Individuals smaller than 2.5 mm of CL were classified as "non-sexable" specimens (ns).

In size frequency distribution individuals were separated in four categories: males, adult non-ovigerous females, ovigerous females and non-sexable individuals. Performing 95 % confidence intervals tested differences of crab size between populations and sexes.

RESULTS

During the sampling period, 157 *P. monilifer* specimens were obtained at Tenório and Paranapuã Beaches. Table I shows the number total of individuals of each category obtained during this study.

Table I. *Pachycheles monilifer*. Total number of individuals obtained at each month during the sampling period (September/94 to July/95).

Months	ns	Males	Non-ovigerous females	Ovigerous females	Total of individuals	Total (%)
September	–	4	2	8	14	8.9
November	3	–	2	–	5	3.2
January	–	–	–	–	–	–
March	1	16	6	5	28	17.8
May	–	3	3	5	11	7.0
July	8	44	28	19	99	63.1
Total	12	67	41	37	157	100.0

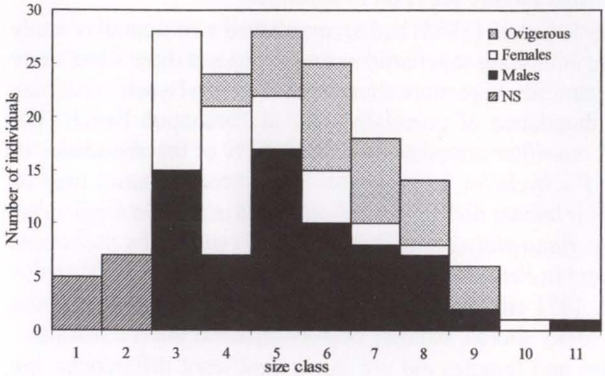
Amplitudes and mean values are shown in table II for each category. No significant difference was found between size of individuals in both populations and between sex ($p > 0.05$).

A total of 11 size classes starting at 1.1 mm CL with an interval of 0.7mm were used. Non-sexable crabs were distributed in the first two size-classes, while juveniles with already noticeable secondary sexual characters fell in the third one. In the case of ovigerous females, size-range was restricted from the 4th to the 9th size classes (Fig. 1).

Ovigery proportion from potential breeding females varied along the sampling period with a highest number of ovigerous females were obtained in September. In November and January no ovigerous females were recorded (Fig. 2).

Table II. *Pachycheles monilifer*. Descriptive statistics of carapace length (mm) in each category.

Sex	N	Mean ± sd	Minimum	Maximum
Non-sexable	12	2.0 ± 0.3	1.6	2.5
Males	67	4.6 ± 1.3	2.6	8.5
Non-ovigerous females	41	3.9 ± 1.1	2.6	7.6
Ovigerous females	37	5.3 ± 1.0	3.3	7.3



Size Classes	CL (mm)
1	1.1 –] 1.8
2	1.8 –] 2.5
3	2.5 –] 3.2
4	3.2 –] 3.9
5	3.9 –] 4.6
6	4.6 –] 5.3
7	5.3 –] 6.0
8	6.0 –] 6.7
9	6.7 –] 7.4
10	7.4 –] 8.1
11	8.1 –] 8.8

Fig. 1. *Pachycheles monilifer*. Size-frequency distributions for crabs sampled.

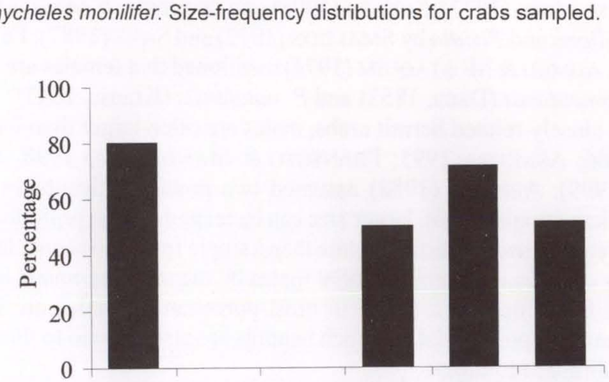


Fig. 2. *Pachycheles monilifer*. Percentage of ovigerous females of all potential breeding individuals.

DISCUSSION

The Paranapuã Beach is a much more sheltered environment than Tenório Beach, besides the former is more exposed to a high concentration of pollutants that may probably contribute to the development of *Phragmatopoma lapidosa* Kinberg, 1867 colonies. This fact benefits several other species that depend on this sabellariid polychaet at least during a certain life-phase.

Besides clear differences regarding the arrangement of these sabellariid colonies, they are extremely important to the establishment and maintenance of *P. monilifer* at both sites. According to GORE *et al.* (1978), the porcelain crab *P. monilifer* feeds on suspension organic matter and seeks for shelter in these sand reefs to avoid predators. Therefore, its trophic level is similar to its host's, only differing in the size of ingested particles. The authors also stated that a variety of crab species inhabiting these colonies are predators, as is the case of *Menippe nodifrons* Stimpson, 1859 that largely preys on *P. monilifer*.

NEGREIROS-FRANSOZO *et al.* (1998) had accomplished a comparative study of the decapod assemblage inhabiting sabellariid worm colonies at these same study sites. They observed that xanthids were more abundant at Tenório Beach, what may also explain the higher abundance of porcelain crabs at Paranapuã Beach. The authors had found that *P. monilifer* abundance was about 1% of the abundance of the co-existing congener *Pachycheles laevidactylus*. Such predominance may be related to differences in their habitat distribution, as observed in *Pisidia longicornis* (Linnaeus, 1766) and *Porcellana platycheles* (Pennant, 1777) studied by SMALDOM (1972) and SANZ (1987) and in *Petrolisthes cinctipes* (Randall, 1861) and *Petrolisthes eriomerus* Stimpson, 1871 studied by JENSEN & ARMSTRONG (1991). Those sympatric species live in rocky shores, but they occupy different intertidal zones.

Mean size of males and females did not show significant differences, but males attained a larger size. Similar results were reported for the porcellanid genera *Petrolisthes* by JONES (1977), SCELZO (1985) and OLIVEIRA & MASUNARI (1995), and for *Porcellana* and *Pisidia* by SMALDON (1972) and SANZ (1987). For the genus *Pachycheles*, AHMED & MUSTAQUIM (1974) mentioned that females are larger than males in *P. tomentosus* (Dana, 1852) and *P. natalensis* (Krauss, 1843).

In the closely related hermit crabs, males are often larger than females (*e.g.* HAZLETT 1966; ASAKURA 1995; FRANSOZO & MANTELATTO 1998; BERTINI & FRANSOZO 1999). ABRAMS (1988) assumed two possible advantages for males being larger than females. First, larger size can be related to high reproductive effort in males, which can thereby fertilize more than a single female. Second, larger males increase their chances to obtain potential mates by means of agonistic interactions with conspecific competitors. Since in most porcellanids, males are larger than females, it can be hypothesized that such benefits are also applied to this anomuran family, including *P. monilifer*.

The breeding season in crustaceans can be determined as the year-period when ovigerous females are present in the population. Together with other related topics such as fecundity, larval dynamics and juvenile-megalopal recruitment, information on the breeding patterns of dominant species is of most importance towards a better understanding of their reproductive biology (EMMERSON 1994).

As can been seen in table III porcellanids already studied had shown a great variability of reproductive patterns. Ovigerous females of *P. monilifer* were not recorded in the population only during summer, indicating that this species have a wide reproductive period.

Table III. Breeding period in some porcellanid species.

Species	Breeding period	Geographic location	Reference
Petrolisthes politus (Gray, 1831)	Year-round	Isla Cubagua, Venezuela (10°N)	SCELZO (1985)
Petrolisthes boscii (Audovim, 1826)	Feb – Oct	Manora Island, Karachi, Pakistan (24°N)	AHMED & MUSTAQUIM (1974)
Petrolisthes cinctipes (Randall, 1839)	Year-round	Monterey Bay, California, USA (36°N)	BOOLOOTIAN et al. (1959)
Petrolisthes rufescens (Heller, 1861)	Jan – Nov	Manora Island, Karachi, Pakistan (24°N)	AHMED & MUSTAQUIM (1974)
Petrolisthes armatus (Gibbes, 1850)	Year-round	Ilha do Farol, Paraná, Brazil (25°S)	OLIVEIRA & MASUNARI (1995)
Petrolisthes elongatus (H. Milne Edwards, 1837)	Year-round	Hauraki Gulf, New Zeland (37°S)	GREENWOOD (1965)
Petrolisthes elongatus (H. Milne Edwards, 1837)	Jul – Mar	Wellington Harbour, New Zeland (41°S)	WEAR (1965)
Petrolisthes elongatus (H. Milne Edwards, 1837)	Oct – Mar	Kaikoura Peninsula, New Zeland (42°S)	JONES (1977)
Petrolisthes novazelandiae (Haig, 1981)	Year-round	Wellington Harbour, New Zeland (41°S)	WEAR (1964)
Petrolisthes eriomerus Haig, 1956	8 months	Puget Sound, Washington, USA (49°N)	KNUDSEN (1964)
Petrolisthes vanderhorsti Haig, 1956	Apr –May	Barbados, West India (13°N)	LEWIS (1960)
Pisidia longicornis (Linnaeus, 1766)	May-Oct	Gower Peninsula, South Wales, UK (51°N)	SMALDON (1972)
Pisidia longicornis (Linnaeus, 1766)	May-Oct	Raunefjorden, Western Norway (60°N)	SAMUELSEN (1970)
Porcellana platycheles (Pennant, 1777)	Mar-Aug	Gower Peninsula, South Wales, UK (51°N)	SMALDON (1972)
Porcellana platycheles (Pennant, 1777)	Feb-Jun	Ruja Bay, Northern Adriatic, Croatia (45°N)	STEVCIC (1985)
Porcellana platycheles (Pennant, 1777)	Jan-Aug	Ericeira, Lisboa, Portugal (39°N)	ALMAÇA (1990)
Pachycheles tomentosus (Dana, 1852)	Year-round	Manora Island, Karachi, Pakistan (24°N)	AHMED & MUSTAQUIM (1974)
Pachycheles natalensis (Krauss, 1843)	Year-round	Manora Island, Karachi, Pakistan (24°N)	AHMED & MUSTAQUIM (1974)
Pachycheles monilifer (Dana, 1852)	Mar-Sept	Paranapuã and Tenório, São Paulo, Brazil (23°S)	Present Study

There are many opinions about the factors that regulate the reproductive period of marine crustaceans. AMEYAW-AKUMFI (1975) drew attention to the possibility of competition as a factor involved in the breeding of tropical hermit crabs. For SASTRY (1983) the breeding period seems to be closely related to temperature, food availability for larvae, and latitude where a given population is located. SCELZO (1985) suggested that the variation in the reproductive period is related to better temperatures for the species or periods of higher primary and/or secondary production providing higher availability of food to the planctonic larvae and to the deposit-feeders organisms.

Sabellariid worm reefs play a key role during the ontogeny of *P. monilifer*. The biologic processes of this species largely depend on an adequate development of the intertidal sabellariid biotope.

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