Cnidarians of Saint Peter and St. Paul Archipelago, Northeast Brazil

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Abstract This study gives information about the cnidarian fauna of Saint Peter and St. Paul Archipelago, a remote group of rocks lying just north of the equator (0º56'N; 29º22'W), 960 km off the Brazilian coast. Most collections were made by scuba but snorkeling was also used. Specimens were collected during five main Expeditions: August 1998, June, August and September 1999, and August 2000, from depths between 0 and 60 m, by hand or using chisels and hammers. A total of 19 species of cnidarians were recorded: three species of hydroids (*Halopteris alternata*, *Aglaophenia rhyncocharpa* and *Sertularella* sp.); four species of scleractinian corals (*Scolymia wellsi*, *Madracis decactis*, *Astrangia braziliensis* and *Polycyathus* sp.*)*; six species of anemones (*Actinia bermudensis*, *Aiptasia pallida*, *Anemonia sargassensis*, *Bunodosoma caissarum*, *B. cangicum* and *Telmatactis roseni*); four species of zoanthids *(Zoanthus sociatus*, *Z. nymphaeus*, *Palythoa caribaeorum* and *Parazoanthus* sp.); one species of octocoral (*Carijoa* sp.); and one species of black coral (*Antipathes* sp.). Eleven new occurrences were recorded. St. Peter and St. Paul Archipelago has a lower richness of cnidarians when compared to the nearest area of Fernando de Noronha Archipelago.

Keywords Cnidaria, Saint Peter and St. Paul Archipelago, Scleractinia.

Introduction

St. Peter and St. Paul Archipelago is a remote group of rocks lying just north of the equator on the mid-Atlantic ridge (0^0 55'N; 29^0 22'W), approximately 960 km off the northeast coast of Brazil (Figs. 1 and 2). These rocks are probably one of the smallest isolated oceanic islands in the world. It is unique among oceanic islands in being non-volcanic and is of particular interest because of its intermediate position between the West African and Brazilian fauna (Edwards and Lubbock 1983). It consists of 10 small and 5 larger islets covering an area of 15000 m^2. The larger islets are arranged in the shape of a horseshoe and are separated by narrow canals (Fig. 2). The largest islet of all, Belmonte, is approximately 150 m long and 50 m wide. It is 23 m above sea level, which makes it the highest point of the archipelago (Lima 1999; Hudson 2000).

The rocks of Saint Peter and St. Paul Archipelago have characteristics that are anomalous in relation to the rocks of other Atlantic Ocean islands. They are not volcanic but plutonic rocks and represent the ocean's superior mantle that came to the surface due to tectonic forces (Campos et al. 2001).

The sea surface is influenced by the South Equatorial Current (SEC) from east to west, with an average velocity of 20 cm/s. At 50-100 m depth, the archipelago is influenced by the Equatorial Undercurrent (EUC) from west to east, with an average velocity of 100 cm/s (Travassos et al. 1999).

According to Macêdo et al. (1999), during 1997 the mean surface temperature was 27.51^{o}C, the mean salinity was 35.62, the pH remained always alkaline, and the values of dissolved oxygen was close to the level of saturation and in equilibrium with the atmosphere until the beginning of the thermocline (starting between 60 and 90 m and ending between 220 and 300 m). The dissolved nutrients were in low concentrations indicating a nutrient deficiency in the photic layer, but a greater availability of nutrients in the aphotic layer was observed, which characterized the

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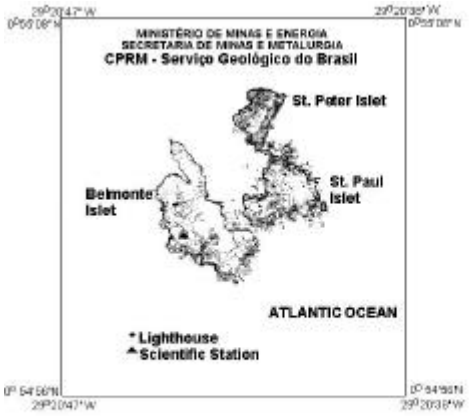
region as an oligotrophic area (Macêdo et al. 1999).

Few data are available on the cnidarians of St. Peter and St. Paul Archipelago owing to its difficult accessibility (Edwards and Lubbock 1983). According to Edwards and Lubbock (1983) and Maida and Ferreira (1997), there are few studies about St. Peter and St. Paul Archipelago. Only one expedition was previously made in 1979, by the University of Cambridge (Edwards and Lubbock 1983). In that study, the ecology of the islands was described and some cnidarian species identified and deposited in the Natural History Museum (London) including: the zooxanthellate corals *Madracis decactis* and *Scolymia wellsi;* the azooxanthellate corals *Polycyathus* sp., *Caryophyllia* sp., and *Astrangia* sp.; the zoanthids *Zoanthus sociatus* and *Palythoa caribaeorum*; the black corals *Antipathes thamnea* and *A. hirta*; the anemones *Actinia infecunda*, *Phymactis sanctaehelenae*, and *Telmatactis americana*; and the octocoral *Carijoa riisei.*

The aim of the present study was to (i) investigate the occurrence of species of cnidarians from St. Peter and St. Paul Archipelago in an attempt to contribute to the knowledge of the benthic fauna of this peculiar area and (ii) compare the morphometry of the skeletal characters of the coral species inhabiting St. Peter and St. Paul Archipelago (referred to as Archipelago throughout the text) and another region, situated 179 km from São Luís Island: Manuel Luiz Parcel (Maranhão State), 0^0 53'S; 44^0 16'W (Fig. 1) (referred to as Parcel throughout the text).

Fig. 1 Map of Brazil, showing Manuel Luiz Parcel, Saint Peter and St. Paul Archipelago, Rocas Atoll and Fernando de Noronha Archipelago

Fig. 2 Map of Saint Peter and St. Paul Archipelago, showing the larger islets



Material and methods

Samples were collected by hand or with chisels and hammers by scuba and snorkeling divers. Specimens were collected during five main Expeditions: August 1998, June, August and September 1999, and August 2000, from depths between 0 and 60 m. The material was collected in the pools from Belmonte Islet (Fig. 2) at a depth ranging from 4-18 m, in the entrance of the Belmonte Islet cove at depths of 18-40 m, and from the Almirante Graça Aranha Ship's float at an average depth of 45 m.

A quantitative study was not possible (with transects and/or quadrats) in any of the localities due to the strong currents and the depths in which the corals were located (at least 30 m deep).

Anemones and zoanthids were anesthetized in a solution of 8% $MgCl_2$ in sea water and fixed in 4% formalin. Coral skeletons were cleaned in a solution of 30% sodium hypochlorite, dried, and analyzed under a stereoscopic microscope equipped with a micrometric eyepiece. Data collected from corals included growth form, corallite diameter, number of centers per cm^2, corallite height, height of outer columella, distance between columella centers, septa width, number of septa of the first and of the last cycle, and total number of septa. Univariate analyses of variance (ANOVA) (Sokal and Rohlf 1983) were performed on colony means for the measured data. A significance level of $P<0.05$ was used for the statistical tests.

Results

The following 19 species of cnidarians and their bathymetric distribution were recorded:

Class Hydrozoa

Subclass Leptomedusae

Order Conica

Halopteris alternata (Nutting 1900)

Aglaophenia rhyncocharpa Allman 1877

Sertularella sp.

The hydroids are very uncommon, growing among algae and sponges, occurring from 2 to 30-40 m deep.

Class Anthozoa

Order Scleractinia

Madracis decactis (Lyman 1859)

At St. Peter and St. Paul Archipelago this species was only found in depths greater than 30 m, became abundant at 35 m, and were more flattened and incrusting than those of the Parcel. Color varied from dark green to purple, with some brown specimens. This species forms large colonies. At the Archipelago these colonies were flattened in shape and rocks served as substrate. Total number of septa per corallite was quite regular, with circular, homogeneous corallites symmetrically distributed (Table 1). At the Parcel, colonies of this species were considered abundant (except in regions near the surface, on pillars) and it was also observed and collected in deeper regions (30 m). Their growth form varied according to the locality. Color varied from green to brown, but some specimens were seen bleached.

The shape of the colonies at the Parcel varied from columnar to spherical, with small ramified lobules. Their substrate consisted of calcarious algae.

Scolymia wellsi Laborel 1967

At the Archipelago, specimens of this solitary coral species were only observed in depths greater than 30 m, being collected at depths up to 45 m, where they were quite abundant. Size varied considerably (Table 2). Color was green. Polyps were extremely thin, some with widths of only 1 cm, and adhered strongly to the substrate, making collection difficult.

At the Parcel, it was also observed and collected in deeper regions (30 m) and in shady areas (in caves and openings in the rocks). Specimens were small and flattened in shape, and color varied from brown to light green, with a few bleached individuals.

Astrangia braziliensis Vaughan 1906

This azooxanthellate coral depends on shaded substratum to grow. Polyps were collected on rocks at depths of 45 m and were brown in color. The number of septa varied between specimens, 31.2 ± 1.0198; however, the corallite diameter (3.52 ± 0.03742 mm) and the corallite height (3.7 ± 0.2 mm) were stable.

One azooxanthellate coral species, *Polycyathus* sp. was recently collected.

Order Actiniaria

Actinia bermudensis (Mc Murrich 1889)

Aiptasia pallida Verrill 1864

Anemonia sargassensis Hargitt 1908

Bunodosoma caissarum Corrêa in Belém 1988

B. cangicum Corrêa in Belém and Preslercravo 1973

Telmatactis roseni (Watzl 1922)

The anemones were relatively common on rocks up to *ca.* 12 m deep, occurring less frequently up to 18 m deep. This species usually lives below boulders in protected sites, under pebbles, in rock crevices, or attached to the lower surfaces of rocks in the lower mid-littoral as well as infralittoral.

Aggregations of *Aiptasia pallida* were also found, forming large clones, which covered the whole substratum. It could also be seen among *Zoanthus* spp. or sponges.

B. caissarum is known as an endemic Brazilian species, occurring along the entire Brazilian coast.

Order Zoanthidea

Zoanthus sociatus (Ellis 1767)

Z. nymphaeus (Lesueur 1817)

Palythoa caribaeorum (Duchassaing and Michelotti 1860)

Parazoanthus sp.

The zoanthids were very common up to 9 m deep, especially on horizontal bottoms. They were also common in tidal pools and in regions touched by the waves during low tide.

Order Telestacea

Carijoa sp. Only one small colony was collected.

Order Antipatharia

Antipathes sp.

Black corals were very common and easy to find starting at depths of 45 m, up to 60 m.

The specimens of Cnidaria from Saint Peter and St. Paul Archipelago are deposited in the "Laboratório de Ambientes Recifais" of the "Universidade Federal Rural de Pernambuco" (UFRPE).

Comparison between the corals *Madracis decactis* and S*colymia wellsi* of the Parcel and of Archipelago:

The coral *Madracis decactis* of the Parcel had smaller colonies (mean height ± se of 50.6 ± 13.11 mm; mean width ± se of 75.2 ± 10.36 mm) than the specimens from Archipelago (mean height ± se of 71.0 ± 12.22 mm; mean width ± se of 108.6 ± 20.62 mm) (Table 1). However, the morphometric characters (total number of septa, corallite diameter, distance between columella centers, and number of columella centers per cm^2) were not significantly different between locations (ANOVA; $p \geq 0.01$) (Table 3).

Table 1. Data, mean, and standard error for the studied characters for the coral *Madracis decactis* (n=5 for each locality). Measurements in mm.

Locality	Manuel Luiz Parcel		Saint Peter and St. Paul Archipelago	
Characters	Mean	Standard error	Mean	Standard error
Total number of septa	10.36	0.28124	10.48	0.42208
Septa width	2.116	0.03561	1.984	0.05074
Distance between columella centers	1.87	0.03847	1.894	0.04421
Number of columella centers per cm^2	24.5333	1.35178	29.2	2.33646
Colony height	50.6	13.1095	71.0	12.2597
Colony width	75.2	10.3605	108.6	20.6218

Table 2. Data, mean, and standard error for the studied characters of the coral *Scolymia wellsi* (n=5 for each locality). Measurements in mm.

Locality	Manuel Luiz Parcel		Saint Peter and St.Paul Archipelago	
Characters	Mean	Standard error	Mean	Standard error
Total number of septa	78.6	3.655133	82.8	4.892852
Number of septa of the first cycle	12	0	11.2	0.374166
Number of septa of the last cycle	8.2	1.113553	12.8	1.854724
Septa width	0.824	0.1161292	1.042	0.057131
Outer columella width	6.38	0.32619	8.22	0.469468
Corallite diameter	36.74	1.285146	51.68	1.560256
Corallite height	27.74	3.026153	25.0	0.221359

Table 3. Summary of ANOVA for characters of *Madracis decactis* of both localities (Manuel Luiz Parcel – Maranhão State and Saint Peter and St. Paul Archipelago).

Factor	GL	Total number of septa	Corallite diameter	Distance between columella centers	GL	Number of centers per cm^2
Locality	1	0.0038	0.2866	0.0140	1	0.5440
Colonies	4	15.5081ns	41.1081ns	20.3508 ns	4	82.0385 ns
Residue	90				20	

Ns = not significant

Table 4. Summary of ANOVA for characters of the coral *Scolymia wellsi* of both localities (Manuel Luiz Parcel – Maranhão State and Saint Peter and St. Paul Archipelago).

Factor	GL	Total number of septa	Number of septa of the 1^{st} cycle	Number of septa of the last cycle	Septa width	Outer columella width	Corallite diameter	Corallite height
Locality	1	0.473	4.571	4.521	2.837	10.360**	54.626***	0.471
Residue	8							

****** = $p < 0.05$

*** = $p < 0.01$

When comparing the coral *S. wellsi* collected in both localities, it was observed that the specimens from the Parcel had a greater number of septa in the first cycle (12 ± 0) and higher corallites (27.74 ± 3.03 mm) than those of Archipelago (11.2 ± 0.37 and 25.0 ± 0.22 mm, respectively) (Table 2). The other morphometric characters (total number of septa, number of septa of the last cycle, width of septa, width of the outer columella, and corallite diameter) studied for this species were also greater for the corals of Archipelago. However, when ANOVA was applied to all morphometric characters studied, only two were statistically significant ($p \leq 0.01$): outer columella width and corallite diameter (Table 4).

The specimens collected at the Parcel were found on calcarious algal substrate, unlike those collected at Archipelago, which were found growing on rocks, and had flattened shapes. Corallite diameter was smaller and the corallites were taller than of those collected at St. Peter and St. Paul Archipelago.

Discussion

St. Peter and St. Paul Archipelago has a lower richness of cnidarians species (19) than Fernando de Noronha Archipelago (03^0 51'S, 032^0 26'W), located 650 km to the southwest, which has a total of 37 species of cnidarians (Pires et al. 1992). However it is comparable with Manuel Luiz Parcel and Rocas Atoll (03^0 52'S, 033^0 48'W), which have a total of 20 (Amaral et al. 2000) and 21 cnidarian species reported (Echeverría et al. 1997), respectively.

As the Brazilian coast is extremely diversified and extensive, with many inaccessible places, several invertebrate taxa are poorly known, like for instance the sea anemones (Zamponi et al. 1998). On the mid-littoral and consolidated substrate *Bunodosoma cangicum* and *B. caissarum* are conspicuous. In tide pools and under rocks, specimens of *Actinia bermudensis*, *Anemonia sargassensis*, *Aiptasia pallida* and *Telmatactis roseni* occur (Zamponi et al. 1998). According to Belém (1988), *Bunodosoma caissarum*, a Brazilian endemic species, occurs along the mainland coast although dense groupings are only found on firm substrata in the infralittoral zone along open coastlines or in sheltered bays and coves in the mid-littoral zone, where they may occur on semi-stable substrate. Fernando de Noronha Archipelago is densely populated by this species, which is most commonly found in the mid-littoral zone inside shady sea-caves and rarely in tide-pools. In contrast, at Archipelago, it is mostly found in intertidal rock pools.

The occurrence of Zoanthidae species, especially *Zoanthus sociatus* and *Palythoa caribaeorum*, has been largely reported from the intertidal zone to infralittoral on reef platforms and on rocky shores of tropical areas (Sebens 1982). According to Sebens (1982), these species are resistant to desiccation and wave action as well, which could explain their success in this turbulent region.

Eleven new occurrences for the Archipelago were recorded: *Halopteris alternata*, *Aglaophenia rhyncocharpa*, *Sertularella* sp., *Actinia bermudensis*, *Aiptasia pallida*, *Anemonia sargassensis*, *Bunodosoma caissarum*, *B. cangicum*, *Telmatactis roseni*, *Zoanthus nymphaeus*, and *Parazoanthus* sp.

The small number of corals (n=4) found at the Archipelago, compared to other locations off northeastern Brazil (a total of 18 scleractinian corals were reported by Laborel 1970 and Leão 1986), can be partially explained by the great distance between this area and other shallow waters (Edwards and Lubbock 1983). The Southern Equatorial Current, coming from the coast of Africa and streaming West, is another obstacle to larvae dispersal to the East. If the larvae had to follow the current along the south of the Atlantic Ocean, the time taken would be longer than that necessary for fixation and the temperature near the South Pole could be lethal for these organisms (Pereira 2000). Besides, we suspect that, at least for scleractinian corals, the lack of suitable habitat available over a long geological time frame may be an important factor influencing the present fauna rather than just the geographic distance from Brazil and West Africa. The velocity and frequency of Atlantic surface currents should make this area accessible relatively frequently given known survival rates for coral larvae. Therefore, other physical and ecological factors may explain the faunistic composition as much, or even more, than the geographic distance.

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References

Amaral FD, Hudson MM, Coura MC (2000) New findings on corals and hydrocorals from the Marine Park of the Manuel Luiz Parcel (Maranhão State) Abst 9th Int Coral Reef Symp, Bali 1: 294

Belém MJC (1988) Anatomy and biology of *Bunodosoma caissarum* Corrêa, 1964 (Cnidaria, Anthozoa, Actiniidae). I – Systematic position and morphological and microanatomical revision. Anais Acad Bras Cienc 61 (3): 342-353

Belém MJC, Preslercravo JC (1973) Contribuições ao conhecimento da fauna de cnidários do Espírito Santo, Brasil. I. Considerações sobre Actiniaria do Município de Aracruz–ES. Bolm Mus Biol Prof Mello-Leitão, (Zool) 80 (1): 1-14

Campos TF da, Neiva AMR, Hartmann LA, Mata JMLS (2000) Petrologia e geoquímica das rochas e seus minerais do Arquipélago de São Pedro e São Paulo. Livro de Resumos. I Workshop Científico/Ambiental/ Programa Arquipélago p 38

Echeverria CA, Pires DO, Medeiros MS, Castro CB (1997) Cnidarians of the Atol das Rocas, Brazil Proc 8th Int Coral Reef Symp, Panama 2: 443-446

Edwards A, Lubbock R (1983) The ecology of Saint Paul's Rocks (Equatorial Atlantic). Journal Zool London, 200: 51-69

Hudson MM (2000) Hidrocorais e corais do Parcel do Manuel Luiz (Maranhão) e corais do Arquipélago de São Pedro e São Paulo. Monografia de Bacharelado. Universidade Federal Rural de Pernambuco, Recife, 50pp

Laborel J (1970) Madréporaires et hydrocoralliaires récifaux des cotes brésiliennes. Rés Sci Camp Calypso. 9(25):171-229

Leão ZMAN (1986) Guia para identificação dos corais do Brasil. Salvador. Universidade Federal da Bahia. 57pp

Lima MM (1999) Diversidade, distribuição e abundância do Ictionêuston, ocorrente na Zona Econômica Exclusiva (ZEE) do Nordeste do Brasil. Recife. Monografia de Engenharia de Pesca. Universidade Federal Rural de Pernambuco 58pp

Macêdo SJ, Flores Montes M de J, Muñiz K (1999) Distribuição dos nutrientes dissolvidos na região oceânica do nordeste brasileiro. Libro de resumenes ampliados. VII Congreso Latino americano sobre Ciencias del Mar, Trujillo. 8(2): 666-667

Maida M, Ferreira BP (1997) Coral Reefs of Brazil: an overview. Proc 8th Int Coral Reef Symp, Panama 1:263-274

Pereira AA (2000) Ictionêuston do Arquipélago de São Pedro e São Paulo. Monografia de Bacharelado em Ciências Biológicas. Universidade Federal Rural de Pernambuco 56pp

Pires DO, Castro CB, Migotto AE, Marques AC (1992) Cnidários bentônicos de Fernando de Noronha, Brasil. Bol Mus Nac, N S Zool. Rio de Janeiro. (354): 1-21

Sebens KP (1982) Intertidal distribution of zoanthids on the Caribbean coast of Panama: effects of predation and desiccation. Bulletin of Marine Science 32 (1): 316-335

Sokal RR, Rohlf FJ (1983) Biometry. The principles and practice of statistical in biological research. 2ed. WH Freeman, New York. 859pp

Travassos P, Hazin FHV, Zagaglia JR, Advíncula R, Schober J (1999) Thermohaline structure around seamounts and islands off North-Eastern Brazil. Arch Fish Mar Res 47(2/3): 211-222

Zamponi MO, Belém MJC Schlenz E, Acunã FH (1998) Distribution and some ecological aspects of Corallimorpharia and Actiniaria from shallow waters of the South American Atlantic Coasts. Physis. Buenos Aires Secc. A 55(128-129): 31-45