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ARTICLE

Intertidal Anthozoans from the coast of Ceará (Brazil)

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ABSTRACT: (Intertidal Anthozoans from the coast of Ceará, Brazil). The diversity and distribution of anthozoans were studied from intertidal regions along the state of Ceará, in nor**the**astern Brazil. The material was collected between 2002 and 2004 from sandstone reefs (beach rocks) on 17 beaches that are part of this tropical coastline. Eight species were surveyed in ecological zones with high faunistic similarities. Environmental aspects of the analyzed beaches revealed important and predominant factors related to the presence or absence of these species.
Key words: cnidarians, distribution, beach rocks.

RESUMO: (Antozoários intermarés do litoral do Ceará, Brasil). Aspectos da diversidade e da distribuição de antozoários foram estudados no litoral tropical sudoeste do Atlântico, em zonas intermarés no estado do Ceará, Nordeste do Brasil. O material foi coletado em recifes de arenito (*beach rocks*) em 17 praias ao longo desta linha de costa tropical, entre os anos de 2002 e 2004. Oito espécies foram encontradas em zonas ecológicas com altas similaridades faunísticas. Alguns locais de coleta apresentam grande heterogeneidade ambiental, formando microhabitats que favorecem a fixação e a sobrevivência desses invertebrados sésseis. Características ambientais específicas de cada praia analisada mostraram-se como importantes fatores predominantes na presença ou ausência das espécies de antozoários.
Palavras-chave: cnidários, distribuição, recifes de arenito.

INTRODUCTION

The intertidal zone is exposed to air for a certain period of time during the day, and most physical factors that influence this environment vary more in air than in water (Velasco *et al.* 2010). The animals that live in this area are subject to variations in temperature, desiccation and hydrodynamics, in addition to competition and predation. Abiotic and biotic factors influence the distribution of marine organisms (Menconi *et al.* 1999), as well as the type of substratum and life strategy. The rocky intertidal areas of these regions have three-dimensional spaces in the form of holes and crevices, which is a major refuge from predators and grazers. These areas are generally composed of crustose algae and the failure of a single group of organisms to occupy a majority of the space available is maintained by the combination of extreme heat, desiccation, and stress from ultraviolet light (Coutinho 1995).

With over 9,000 living species, the phylum Cnidaria is a morphologically diverse group that includes jellyfishes, corals and hydrozoans, which are commonly benthic forms on reefs (Longo *et al*. 2009; Kikuchi *et al.* 2010). Cnidaria have high ecological importance because they have associations with a wide variety of species, and are often represented by a high diversity of species in reefs (Leão *et al*. 2009).

Despite their great ecological importance, the Anthozoa fauna from Northeast Brazil is poorly known (Laborel 1970, Pires *et al*. 1992, Hetzel & Castro 1994, Maida & Ferreira 1997, Barradas *et al*. 2008, Neves *et al*. 2010), and the anthozoan communities in many areas with beach rocks along the Ceará coast are poorly studied (Laborel 1967, Neves 2004, Rabelo 2007, Amaral *et al.* 2009). The goals of this study were to present a survey and the geographic distribution of the Anthozoa from intertidal beach rocks on the coast of Ceará, and to increase the knowledge about this group in northeastern Brazil.

MATERIALS AND METHODS

Study site

The coast of the state of Ceará, in Northeast Brazil, is 573 Km long, and exhibits considerable ecological diversity (e.g., dunes, sandy and rocky beaches, mangroves). The predominance of sand along this coast is occasionally interrupted by rocky outcrops, such as beach rocks. Beach rocks occur predominantly in the region between high tide and low tide, have a table shape, are slightly tilted seawards and are formed by sand cemented by calcium carbonate and ferrous oxide. The occurrence of tide pools is peculiar in these rocky

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environments. These pools are a microcosm for marine life in the intertidal zones, are easily accessible when the tide is low and have a depth that ranges from 0.2 m to 1 m. Mean temperature in this region is very high and it scarcely rains, which characterizes the semi-arid climate (Morais *et al*. 2009). There are no considerable seasonal variations in the physic-chemical characteristics of this coastal environment, such as salinity and temperature. The area of study already has regions with high levels of environmental disturbances, which could potentially increase in the near future (Maia *et al.* 1998).

As part of the subproject "Marine Biota from the West coast of Ceará" of PROBIO (*Projeto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira* – Project for Conservation and Sustainable Use of Brazilian Biological Diversity) and ZEE (*Zoneamento Ecológico-Econômico do litoral do Ceará* – Ecologic-Economical Zoning of Coastal Ceará), collections were made on 17 beaches along the coastline of Ceará (Figure 1) in order to characterize the marine biota, and the anthozoans were studied from this region. The environmental characteristics of each beach, such as substrate type and anthropogenic impact, were also analyzed. Table 01 shows the geographic location of each beach studied.

Manual collections were periodically made, between the 2002 and 2004, on consolidated substrata (from 0 to 1 m deep) during the springtides. All of the collected material was stored in plastic bags, properly labeled, anesthetized with a 7.5% magnesium chloride solution and fixed with 4% saline formaldehyde. The material was sorted in a laboratory and the animals were transferred to 70% ethyl alcohol, for the taxonomic analysis by the authors, and then incorporated into the collections of the Invertebrate Marine Laboratory at the Biology Department of the Universidade Federal do Ceará (UFC).

Table 1. Geographic location of studied beach rocks.

Site	Geographic Localization of Samples in Southwestern Atlantic Coast
Redonda	4° 39'24.81'' S 37° 26' 59.51'' O
Canoa Quebrada	4°31'44.91"S 37°41'33.98"O
Pontal do Maceió	4°24'1.68"S 37°47'8.79"O
Caponga	4° 2'16.32"S 38°11'29.84"O
Meireles	3°43'21.41"S 38°29'17.27"O
Pacheco	3°41'9.67"S 38°38'5.13"O
Pecém	3°32'34.38"S 38°48'47.24"O
Taíba	3°30'18.92"S 38°53'36.73"O
Paracuru	3°23'50.15"S 39° 0'29.54"O
Lagoinha	3°20'42.18"S 39° 8'4.85"O
Flecheiras	3°14'16.69"S 39°13'54.42"O
Mundaú	3°10'42.42"S 39°22'12.42"O
Baleia	3° 8'51.94"S 39°26'20.67"O
Caetanos	3° 5'5.00"S 39°33'24.75"O
Icaraí de Amontada	3° 1'14.15"S 39°38'36.61"O
Jericoacoara	2°47'25.14"S 40°31'14.53"O
Farol do Trápia	2°51'34.94"S 40°54'13.56"O

RESULTS AND DISCUSSION

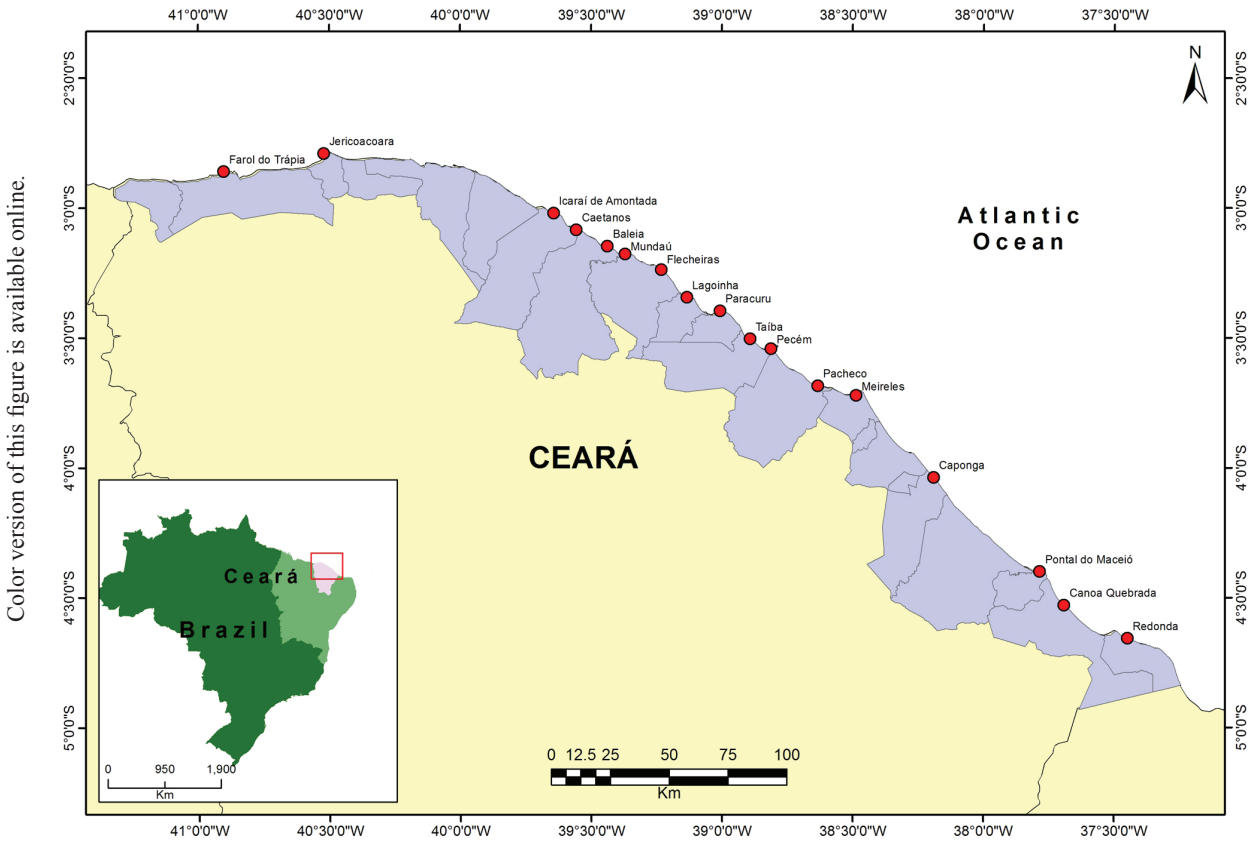

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Figure 1. Area and sampling stations on the Atlantic coast of Ceará, in Northeast Brazil.

Table 2. Distribution of Anthozoa species along the coast of Ceará. Abbreviations: Cap (Caponga), Mei (Meireles), Pac (Pacheco), Pec (Pecém), Tai (Taíba), Par (Paracuru), Fle (Flecheiras), Mun (Mundaú), Bal (Baleia), Cae (Caetanos), Ica (Icaraí de Amontada), Jer (Jericoacara), Far (Farol do Trápia). "X" represents the presence of a species.

Species	Cap	Mei	Pac	Pec	Tai	Par	Fle	Mun	Bal	Cae	Ica	Jer	Far
Favia gravida Verrill, 1868		X			X	X	X	X			X		
Isaurus tuberculatus Gray, 1828						X	X				X		
Palythoa caribaeorum (Duchassaing and Michelotti, 1860)			X	X		X	X	X			X		X
Protopalythoa variabilis (Duerden, 1898)				X	X	X	X		X	X	X		
Siderastrea stellata Verrill, 1868		X	X	X	X	X	X	X	X	X	X	X	X
Telesto riisei (Duchassaing and Michelotti,1860)	X			X									
Zoanthus sociatus Ellis, 1767	X	X	X			X			X	X	X		X
Bunodosoma caisarum Côrrea, 1964			X			X	X						

The results of this study revealed the presence of eight Anthozoa species (Table 02) on the coast of Ceará. Among the Anthozoans from this region, zoanthids are predominant. They usually form large colonies incrusted on reef formations of the intertidal zone. Some of the sampled beaches displayed an absence of anthozoans, which is probably due to adverse environmental characteristics for colonization.

The eight collected species of Anthozoa were the following: *Zoanthus sociatus, Isaurus tuberculatus, Favia gravida, Siderastrea stellata, Protopalythoa variabilis, Palythoa caribaeorum, Carijoa riisei* and *Bunodosoma caissarum*. The species diagnoses are based on the literature and collected material.

Zoanthus sociatus Ellis, 1767

Diagnosis: The color of the polyps ranges from bright light green to bluish dark green. The diameter of the oral disk is approximately 5 mm and the height of the polyp ranges in the analyzed material from 5 to 20 mm. Mesogleal sphincter muscle in two parts. Zooxanthellae. Generally believed to be a hermaphroditic spawner, similar to most corals. The genus *Zoanthus* can be distinguished from most other zoanthid genera by its lack of sand and/or detritus uptake. Although *Isaurus* spp. (also Family Zoanthidae) are similar because they do not incorporate detritus into their tissue, they differ because polyps of *Isaurus* species usually have tubercules and *Zoanthus* polyps are uniformly smooth on their outer surface.

References: Laborel (1967); Pires *et al.* (1992); Rohlfs & Belém (1994); Neves *et al.* (2002); Longo (2002); Rabelo (2007); Amaral *et al*. (2009).

Distribution in Brazil: Southeast and Northeast Brazil.

Remarks: Colonies of *Z. sociatus* may form dense mats in rocky intertidal zones, and are also abundant in the subtidal zone. Polyps usually expand when submerged. Zoanthus *sociatus* displays a high resistance to environmental disturbances and has a well-developed, regenerative capability (Pires *et al.* 1992).

Palythoa caribaeorum (Duchassaing and Michelotti, 1860)

Diagnosis: P. caribaeorum develops colonies with the walls of the polyps united by a common coenenchyme, forming a continuous cover on the substratum. The diameter of the polyp ranges from 6 to 10 mm on the oral disk. It is brownish or green on the internal face of the oral disk. The genus *Palythoa* is characterized by its ability to incorporate sediment in the mesoglea layer during growth, which acts as a sustentation structure.

References: Laborel (1967); Hetzel & Castro (1994); Neves *et al*. (2002); Boscolo & Silveira (2005); Rabelo (2007).

Distribution in Brazil: Southeast and Northeast Brazil.

Remarks: P. caribaeorum is common in the permanent humid zone, and displays little resistance to desiccation, although it is a strong competitor for space.

Protopalythoa variabilis (Duerden, 1898)

Diagnosis: P. variabilis has large polyps, ranging from 8 to 14 mm from the oral disk and 15 to 40 mm from the column length. The polyps are light brown. Whether this species is within the genus *Protopalythoa* or *Palythoa* remains in a state of confusion. What makes *Protopalythoa* unique is it grows as a solitary polyp, although it is often found in small tightly clustered groups. Species of *Palythoa* are distinguished by polyps that are connected through a mat, called the coenenchyma.

References: Pires *et al*. (1992); Longo (2002); Neves *et al.* (2002); Boscolo & Silveira (2005); Rabelo (2007).

Distribution in Brazil: Southeast and Northeast Brazil.

Remarks: P. variabilis may appear isolated or form aggregations on sand or consolidated substrata, where it competes against other zoanthids for space. The long column allows this species to live buried in the sand with the oral disk on the surface (Sebens 1982).

Siderastrea stellata Verrill, 1868

Diagnosis: Coral with a compact colony, almost spherical outside. Colonies that live in very shallow waters have a reddish color and are usually small (diameter

ranging from 5 to 10 mm), have calyxes with a diameter ranging from 2 to 3 mm. The fourth cycle of septa is incomplete only in *Siderastrea radians*. The significant variation in corallite diameter, columellar distance, and number of septa indicates that the skeletal morphometry of *S. stellata* can vary considerably at the interpopulational level (Neves *et al*.2008).

References: Laborel (1967); Laborel (1969, 1970); Leão (1986); Pires *et al.* (1992); Hetzel & Castro (1994); Pires (1997); Neves *et al.* (2002); Neves *et al*. (2008); Neves *et al*. (2010).

Distribution in Brazil: Northeast and part of Southeast Brazil.

Remarks: S. stellata is an endemic coral, widely distributed on the Brazilian coast (Neves & Silveira 2003). It is very similar to the Caribbean species, but has bigger calyxes, a more delicate septa and wider interseptal spaces. This coral displays a morphological variation that distinguishes colonies of shallow waters from those who occupy deep waters (deeper than 5 m) and *Siderastrea radians*.

Favia gravida Verrill, 1868

Diagnosis: This species has solid, spherical and hemispherical colonies, bearing a light brown or yellowish color. Their calyxes are unequal, roundish, oval or long, and often deformed. *Favia gravida* has a dense colony with an encrusting or hemispherical growth form, strong epitheca beneath, evenly rounded above, with equal, rounded, oval, and often deformed, deep cells, which are somewhat prominent above the general surface, and separated at equal distances, leaving concave, strongly costate interstices between them.

References : Laborel (1967); Laborel (1969, 1970); Leão (1986); Pires *et al.* (1992); Hetzel & Castro (1994); Neves *et al.* (2002); Amaral & Ramos (2007).

Distribution in Brazil: Southeast and Northeast Brazil.

Remarks: This species is very resistant to environmental variations, particularly regarding temperature, salinity and water turbidity. *Favia gravida* and *Siderastrea stellata* are the most common corals in shallow tidal pools on the emerged portion of the reefs and even on non-reef substrata on beaches. *Favia gravida* is an endemic to Brazil. This species displays high morphological plasticity, which might contribute to its ability to occupy a great range of habitats (Amaral & Ramos 2007).

Isaurus tuberculatus Gray, 1828

Diagnosis: I. tuberculatus has large tubercles on the body surface that are usually arranged in longitudinal series, or sometimes irregularly, and are greenish brown. These polyps may reach 50 mm of length, united by a common coenenchyme at the base. They display small tentacles. Crown tubercules well-formed, clearly delineating oral disk area from capitulum. Polyp surface coloration cryptic and varies with environment (white, gray, red, purple), often reflecting surrounding seaweed and corals. Average length of polyps approximately 2 cm, though smaller and larger polyps are common.

References: Pires *et al.* (1992); Grohmann & Peixinho (1995); Rabelo & Matthews-Cascon (2007).

Distribution in Brazil: Northeast Brazil and western tropical Atlantic.

Remarks: I. tuberculatus usually forms fixed aggregations on consolidated substrata, has a protruding oral cavity, and keeps its column perpendicular to the substratum at night in order to catch food. This species may form very dense groups or can be isolated, and occurs in humid areas of the intertidal zone on walls or rocky horizontal substrata that receives light (Larson & Larson 1982; Muirhead & Ryland 1985).

Carijoa riisei (Duchassaing and Michelotti, 1860)

Diagnosis: Arborescent colonies, with polyps that are usually over 30 cm long. This species has a body wall with eight grooves, normally distinct. The lateral polyps have calyxes 3-5 mm high and 1-5 mm in diameter. Polyps united in pairs or forming groups of three on the column. They display spicules on the body wall. *Carijoa riisei* is an octocoral that forms erect, branching colonies with flexible stems. Each tall axial polyp has many short lateral polyps. Polyps, when extended, have eight white pinnate tentacles, like the rays of a snowflake, unlike stony corals which have six tentacles.

References: Almeida *et al.* (2005); Neves *et al*. (2007); Lira *et al.* (2009).

Distribution in Brazil and World: North, Northeast, Southeast and South regions of Brazil.

Remarks: C. riisei is usually found in shallow waters, forming dense groups, which develop associations with various organisms, such as bryozoans, flatworms, nemerteans and crustaceans. *Carijoa riisei* is reported to grow in turbid water, like on the coast of Ceará, that is rich in organic matter and zooplankto, which it feeds on. It requires a firm surface that it attaches to using stolons (root-like structures). It also grows well on artificial hard surfaces, such as metal, plastic and concrete (Pecém Harbor). It is a passive filter feeder and needs moderate amounts of water flow, which is provided by waves and tidal or long-shore currents.

Bunodosoma caissarum Corrêa, 1964

Diagnosis: Spherules on the edge below the tentacles. Its column has spherules in the edge that are not adhesive, and it displays numerous (approximately 200), short tentacles. Freshly collected specimens reddish brown to pink; vesicles same color as column. Diameter of distal column exceeding that of proximal column, expanded individuals with a trumpet- or vase-shaped form. Margin with endocoelic vesicles atop marginal projections; each projection bears a single holotrichous acrorhagus on its oral surface. Tentacles may be pink,

orange, or purple, with an opaque white longitudinal stripe and white crossbars.

References: Belém (1988); Russo & Solé-Cava (1991).

Distribution in Brazil and World: Endemic to Northeast and Southeast Brazil.

Remarks: This species is more common in shallow, warm water; however, individuals can be found in deeper water and on the beech where there are tides. It grows as a fixed solitary polyp on rocky substrates, sediment or adhered to jellyfish, seaweed and the shells of mollusks. This species ranges between 1.5 cm and 5.0 cm in diameter.

The beaches with the greatest variety were Paracuru, Icaraí de Amontada and Flecheiras. The higher diversity on these beaches is due to the great heterogeneity of microhabitats in these areas. The consolidated substratum on Flecheiras is formed by ferruginous beach rocks of hard consistency that consequently helps with the fixation of the benthic community. The Flecheiras beach rock complex represents one of the biggest reef platform beaches on the coast of Ceará. Paracuru and Icaraí beaches have extensive beach rock formations with lots of loose pebbles. These beaches also have very conspicuous tidal pools that are of several sizes and depths, contain a diverse fauna and, therefore, form a special protective and foraging area for benthic organisms (Matthews-Cascon & Lotufo 2006).

However, these ecosystems have been periodically subject to anthropogenic disturbances, such as seasonal tourism, construction on dunes, uncontrolled fishing and the collection of ornamental invertebrates (Leão *et al*. 2009).

Anthozoans were not found on the following beaches: Redonda, Canoa Quebrada, Pontal do Maceió and Lagoinha. The absence of anthozoans on some beaches is probably due to the environmental characteristics of these areas, which are generally not appropriate for colonization by marine benthic organisms, or the sampling effort needs to be increased (e.g., at Lagoinha and Pontal do Maceió). At Redonda beach, the intertidal zone comprises a belt of sandy substratum and another belt of rocky substratum, and has sparse pebbles that are remnants of sea cliffs of various heights, which eroded without forming tidal pools. At Canoa Quebrada beach, the sampled area included a very narrow belt of rocks. The intertidal zone seems to be poor in species and has a low diversity of macroalgae. This beach has a considerable amount of anthropogenic impact, mainly from tourism and over fishing.

The Meireles beach belongs to the metropolitan region of Fortaleza and is heavily impacted by bathers, clandestine sewers and trash, as well as construction on its ridges that alter the morphology of the beach because of an increase in sediment deposition (Maia *et al.* 1998). Despite the high level of anthropogenic impact, some beaches show a representative fauna, which might indicate that these communities were much richer in number of species before these impacts increased (Coutinho 1995).

Lower diversity was found at the Jericoacoara and Caponga beaches. This is probably due to the fact that these environments are different in relation to the others. The reefs in Jericoacoara beach are different from the other beaches on the coast of Ceará because they are made of metamorphic rocks, while the others are made of beach rocks (sedimentary formations). This might have inhibited the colonization by benthic Anthozoa, who require an adequate substratum for stability. At Caponga beach, the sandy belt in the intertidal zone is longer than the rocky belt, which is closer to the low tide. The rock that constitutes the reef is very solid, both fauna and flora are poor, with fewer species showing a high abundance of individuals. Intense anthropogenic activity was observed in this area. Thus, the smaller environmental surface available for colonization promotes the low diversity in species.

In order to colonize the intertidal zone, organisms need adaptations that allow them to survive (Matthews-Cascon & Lotufo 2006). For each kind of substratum in the intertidal zone, there are several animal associations, which may indicate, due to their needs and ecological tolerances, divisions in the inhabited areas. The physical environment exerts influence over spatial structure and species composition of sessile communities by forming a combination of physical factors that stipulates larval settlement and promotes survival of the organisms (Tkachenko & Zhirmunsky 2002).

Due to their relatively sedentary lives, benthic organisms are constantly subject to environmental changes that are natural (e.g., deposition/formation of sediments by water flow or changes in salinity, rainy season) or anthropogenic (e.g., over fishing, a river silting up, pollution). Thus, the degree of exposure to adverse factors, which is different for each studied beach, influences species composition (Bittencourt *et al.* 2008; Leão *et al.* 2009).

Changes in composition and abundance take place in many time and spatial scales. There is a clear need to recognize that natural environments are intrinsically variable and that a detailed analysis of this variability is a prerequisite to the acquisition of ecological knowledge (Menconi *et al.* 1999).

Beaches with similar fauna (Caetanos/Baleia and Icaraí/Flecheiras/Paracuru) probably have the same environmental conditions (Matthews-Cascon & Lotufo 2006). The high similarity among environments and their proximity might explain this fact; given the water flow may favor the transportation of larvae between beach rocks on adjacent beaches.

Co-occurrence among species shows that some of them need similar environments, which offer common resources for their survival. *Siderastrea stellata* and the zoanthids *Z. sociatus*, *P. variabilis* and *P. caribaeorum* compete for space on the rocky substrata of the inter-

tidal zone. This competition leads to damage or death of opponents, which make use of several competitive strategies (Sammarco 1985; Rabelo 2007). Interspecific competition among invertebrates is an important factor in the building and establishment of communities and has been studied in many marine ecosystems (Tkachenko & Zhirmunsky 2002).

The distribution of *C. riisei* was probably restricted based on the type of substratum were it occurred, and was only found on two of the sampled beaches. *Favia gravida a*nd *I. tuberculatus* are species typically found in the subtidal zone, or occasionally in the intertidal zone, where they form small colonies. The specific conditions that are required for colonization to take place probably regulate the occurrence of these species. In addition, *B. caissarum* was found on all beaches, showing it can adapt to many environments. According Russo & Solé-Cava (1991), *B. caissarum* is commonly found in the intertidal zone as isolated polyps in the rocky or sandy substrate; moreover, it occurs in polluted areas and is an environmental indicator species.

Water turbidity is the main limiting factor (Bittencourt *et al.* 2008) that influences the occurrence of hermatypic coral reefs along coastal Ceará, due to the high deposition of sediments along the shore. Thus, the presence of coral reefs on the coast of Ceará is rather insignificant, and they occur mainly in spots or sites as isolated colonies or aggregates. Despite this, their role in the ecosystem is very similar to the one they play when forming reefs (Leão *et al.* 2009), at least as "primary producers", because the zooxanthelae are a food source to animals that specialize in their predation. In addition, hermatypic corals act as a substratum or shelter for other fauna, which are boring or opportunists, from several taxonomic groups.

CONCLUSIONS

A survey of the coast of Ceará, Brazil, revealed eight species of Anthozoa. Their geographic distribution on intertidal beach rocks appears to be quite heterogeneous in different coastal environments, which is probably due to the specific requirements for each species, such as availability of substrate and competition for space. The data collected during this study about the anthozoan composition of Ceará may be used in future conservation and sustainable projects in this region.

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