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# CORAL DISEASES IN NORTHEASTERN BRAZILIAN REEFS

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**Abstract:** In the last decade, corals from northeastern Brazil have experienced bleaching events linked to thermal anomalies, the consequences of which have been the appearance of disease outbreaks affecting different species. As a way to explain and monitoring diseases progression and other characteristics regarding the identification in the field for coral diseases, this article aimed to demonstrate the particularities that follows each diseases symptom. This study presents the results of an assessment of the presence of coral diseases on six coastal reefs in northeastern Brazil, including marine protected areas. After 300 hours of visual censuses, a total of 875 colonies were observed; of these, 114 colonies had some disease, representing 13.02% of the colonies analyzed. Five diseases/syndromes were recorded in four host coral species: white syndrome, white plague, red band, dark spots, and white band. This is the first record of white band on the Brazilian coast. The massive coral *Siderastrea stellata* showed colonies with all registered diseases, which arouses great concern for conservation of the Brazilian coast.

**Keywords:** Coastal reefs; red band; white band; white syndrome.

Corals are sensitive to climate changes. These changes can cause the expulsion of photosymbionts and limit the supply of nutrients to the cells of these animals (Stimson *et al.* 2002). With the expulsion of the symbiotic algae, the coral can suffer from bleaching, damage that affects the energy supply of the coral and causes a decrease in innate immunity. With low immunity, the proliferation of microorganisms, present in the environment or in the coral's own flora, increases and can lead to the onset of diseases, most of which have worse effects than those caused by temperature bleaching (Woodley *et al.* 2016).

Unlike mammals and other animals, which have both innate and adaptive immunity, corals, since they are basal individuals, have only innate immunity acquired through RNA and leucine pathways. This characteristic makes them more susceptible to diseases with a longer time of resilience and lower survival rate on the part of the species (Miller *et al.* 2007, Weiss *et al.* 2013).

It is not yet known exactly what causes coral diseases. Some researchers believe that part of it is due to the weakening of the coral body by the lack of nutrients, as well as exposure of the skeleton through cuts and breaks, facilitating the entry of microorganisms into cells. Regardless, it is known that part of the proliferation is related to the effects caused after a severe bleaching event (Sumich 1996, Lirman 2000, Bruno *et al.* 2007). Not only bleaching events are leading to diseases outbreaks, as a variation on the correct system of the coral and its immunity as explained early, but also changes of any scale in local warming are becoming a seasonal threat to corals all over (Howells *et al.* 2020).

The first records of disease in corals date from the 1970s, with dark band disease being the first to be identified and described in 1973, followed

by white band disease in the 1970s (Garrett & Ducklow 1975). The two diseases described initially are band diseases, in which a tissue necrosis band is formed by microorganisms and progresses rapid (Richardson 1998, Raymundo *et al*. 2008)**.** In Brazil, the first work containing records of disease in corals was in 2008, in which dark band, red band, and dark spots were identified in the South Atlantic after a mass bleaching event (Francini-Filho *et al*. 2008).

Brazil has a small percentage of coral species compared to all species known in the world. However, even with this low percentage, Brazilian reefs have a high rate of endemism. With climatic problems becoming more and more frequent in the last decade, the Brazilian reef fauna is increasingly being threatened with extinction (Leão *et al*. 2003).

In the last decade, studies carried out in different parts of the Brazilian coast have recorded the presence of diseases in corals (*e.g.* Francini-Filho *et al*. 2008, 2010), however, there is still a need to better describe the external aspects of these diseases, as well as providing images that assist in their identification in the different locations where they are registered. The present study is the result of research to identify the diseases that affect hermatypic corals in shallow coastal reef areas on the coast of northeastern Brazil, which include marine protected areas such as Costa dos Corais Protected Area at Tamandaré.

The objectives of this study were to identify and quantify the diseases previously registered for Brazil to provide a brief external characterization of colonies infected with different diseases, present a list of host species, and register possible diseases not yet described for the Brazilian coast. As pointed out by Raymundo *et al*. (2005), this background information is important for future studies on specific diseases or syndromes, rates of progression, and other impacts on the reef ecosystem.

Visual surveys were performed on six coastal reefs in northeastern Brazil, with 300 hours of intensive observation between November 2014 and March 2017, mostly comprehending summer and spring in each year, when the water visibility is increased. The studied reefs are in the states of Rio Grande do Norte, Paraíba, Pernambuco, and Alagoas.

In each reef, ten linear transects of 10 $m^2$ were made. The transects were used in order to better demarcate the total sampled area of each reef, with 100 $m^2$ of each area being sampled, with a total of 600 $m^2$ of tropical reefs being sampled along the areas. The fieldwork period did not coincide, in any year, with mass bleaching events for the areas.

In the state of Rio Grande do Norte, the reefs studied were the Parrachos of Maracajaú Beach (5°21'12"S, 5°25'30"S and 35°14'30"W, 35°17'12"W). These reefs are on average 6 km from the coast of Maracajaú beach, with a depth between 0.5 and 3 m at low tide (Mayal *et al*. 2009). According to Leão *et al*. (2003), these reefs have "pinnacle" formations, referring to a unique coral growth form that consists of isolated narrow pillars whose crest are expanded laterally.

In the state of Paraíba, censuses were carried out on the beaches of Seixas (7°09'21"S, 34°47'10"W), Cabo Branco (7°08'39"S, 34°47'59"W), and on the reefs of Picãozinho (7°07'00"S, 34°48'28"W). The reef formations at Seixas and Picãozinho are on average 1 km from the beach line, while the reefs in Cabo Branco extend to the beach, featuring a fringed reef. In the three beaches, the reefs can be immersed for a few hours, depending on the amplitude of the tide (Dias & Gondim 2016).

In the state of Pernambuco, censuses were carried out in the reef formations of Tamandaré (8°45'08"S, 35°05'19"W), while in Alagoas the reef visited was Francês Beach (9°46'07"S, 35°50'05"W). According to Maida & Ferreira (1997), the Tamandaré reefs are arranged in three groups of reef formations disposed parallel to the shore. Collections were performed in the second group, which is located on a sandy lagoon between the beach line and a third line of reefs, which is farther from the beach. This second reef line arises at a depth of 1 to 8 meters and the tops of the reefs may be exposed during low tide. At Francês beach, reef formations form an extensive fringe, parallel to the coast, with approximately 3.5 km in the north/south direction and are located about 240 m from the beach (Gondim *et al*. 2013).

All study sites have similar reef formations, being home to species common to the area such as the scleractinian coral *Siderastrea stellata* Verrill, 1868; *Porites astreoides* Lamarck, 1816, *Favia gravida* Verrill, 1868 and animal species

in addition to corals such as black and purple urchins (*Echinometra lucunter* Linnaeus, 1758, *Lytechinus variegatus* Lamarck, 1816 and the most varied families of small fishes.

During the surveys, coral species observed with signs of disease were recorded on PVC plates and photographed. The characterization of diseases followed the descriptions and images presented in Raymundo *et al*. (2008), with the addition of information observed *in loco*. Each photo was documented for later confirmation of the diseases-like symptoms through additional bibliographies.

A total of 875 colonies were observed; of these, 114 colonies had some disease, representing 13.02% of the colonies with some type of disease-like, and another 431 were observed showing some type of damage, in which the most common was sedimentation on the colony. Five diseases/syndromes were recorded, including white syndrome-like, white plague-like, red band-like, dark spots-like, and white band-like. This represents the first record of white band-like on the Brazilian coast (Figure 1). The most frequently reported diseases were white syndrome-like (56.14%) and white plague-like (23.68%).

Both diseases have similar patterns in terms of necrosis of coral tissue and patterns of white color. Despite this, white syndrome is characterized by presenting a gradient-shaped border between the exposed part of the coral and the area not yet affected. Even though the conformation of both is remarkably similar, they have different patterns of progression, which facilitates their identification in the field. In addition, they can be differentiated from bleaching due to thermal anomalies, as they do not present polyps in the necrotic tissue and exposed skeleton (Figure 1).

As a third damage type, contact with algae, especially in an algae-dominant environment, can bring harm to coral species, such as being a trigger for the development of diseases (Nugues *et al*. 2004). However, symptoms found in colonies are not only related to the colonization of filamentous algae on the colonies, but as a late stage in the progression of the disease (Figure 2).

Red and white band diseases-like accounted, together, for only 9% of registered cases. Both have linear patterns of progression, with the diffuse linear white band being white and the red, linear, diffuse band being red brown. This is the first documented white band record for the South Atlantic and the causative pathogen is not yet known. The coral *S. stellata* was the host of all diseases recorded in this study. In general, the diseases-like observed, based on diseases description of Raymundo *et al*. (2008), and their respective hosts are listed in Table 1.

The reef that shown the highest percentage of diseased colonies was Seixas, with a total of 36 colonies, representing 31.57% of the colonies with some type of disease-like.

The percentage of sick colonies is worrying and requires urgency to better understand how disease progression and colony contamination occurs, especially considering that two diseases were more frequent and affected a greater number of colonies (white syndrome and white plague). According to Dias & Gondim (2016), the high incidence of sick colonies on the reefs of Seixas may be a consequence of the bleaching event of 2010. In Bahia, Miranda *et al*. (2013) did not observe an outbreak of diseases in the community of corals after the 2010 event, however, in other parts of the world, the link between bleaching events and disease outbreaks was highly related. At the studied sites we identified or reported any mass bleaching between the surveys time. This results on the prevalence of coral diseases may increase after the reported bleaching event in 2019 for the Brazilian northeastern, especially shallow and turbid water corals (Duarte *et al*. 2020).

According to Bruno *et al*. (2007), thermal water anomalies and coral cover are clear drivers of white syndrome disease in Australia's Great Barrier Reef. In the Virgin Islands (United States), Muller *et al*. (2008) found a positive relationship between mass bleaching and disease incidence in *Acropora palmata* (Lamarck, 1816); in the Florida Keys (United States), Brandt & McManus (2009) confirmed this in other coral species (*Orbicella faveolata* (Ellis & Solander, 1786), *Siderastrea siderea* (Ellis & Solander, 1786), and *Colpophyllia natans* (Houttuyn, 1772).

In Brazil, concerns about coral diseases are recent. Over a decade ago, Francini-Filho *et al*. (2008) recorded the occurrence of disease in corals from Abrolhos Bank, state of Bahia, in which the most frequent disease was the white plague disease, although the white syndrome, red

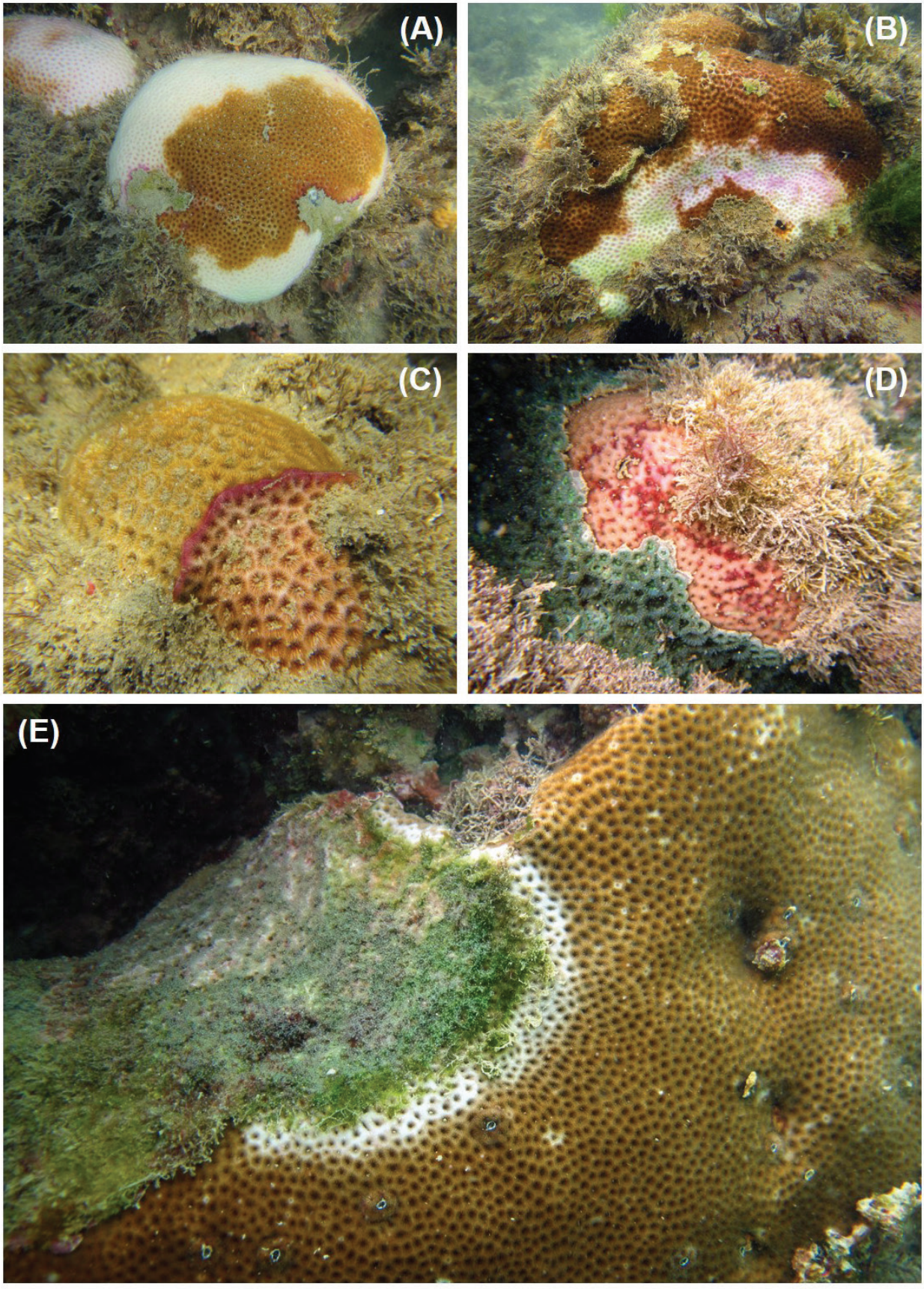


**Figure 1.** Five diseases/syndromes-like recorded in the study. (A) white syndrome-like, (B) white plague-like, (C) red band-like, (D) dark spots-like, and (E) white band-like (this represents the first record of white band on the Brazilian coast). Photos: Thelma Dias and Camile Avelino.

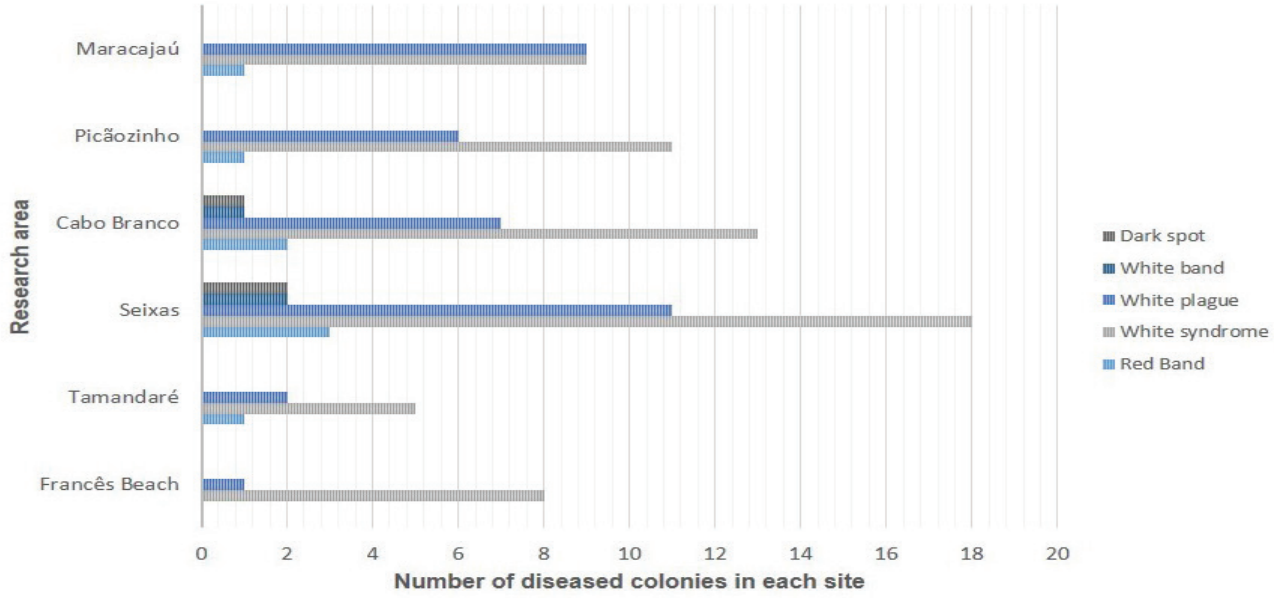


**Figure 2.** Number of diseased colonies per site. Each disease was found exclusively in colonies of *Siderastrea stellata*.

band, and dark spots were also recorded. Later, Francini-Filho *et al.* (2010) analyzed the seasonal prevalence of white plague disease in the endemic coral *Mussismilia braziliensis* Verrill, 1868 and suggested that the prevalence of the disease is linked to thermal anomalies.

Considering that the development of diseases may be linked to the fragility generated in the coral's innate immune system by recurrent bleaching (Woodley *et al.* 2016), the presence of disease shows that the effects of bleaching and the superficial heating of ocean water causes damage to the quality of life of coral, causing a cascade of consequences much more serious than the temperature bleaching itself (Richardson 1998). In the reefs of Seixas and Cabo Branco, larger colonies showed less signs of disease and damage (Avelino 2017, unpublished data), corroborating the hypothesis that larger colonies have a more robust immune system, and that this results in a more resistant defense system and less contamination by external agents (Woodley *et al.* 2016).

The present study is the first record of white band-like disease in the South Atlantic; considering this, an worrying fact, the presence of one more disease on the Brazilian coast further increases the impact on coral communities. In addition, this disease affected the coral *Siderastrea stellata* , which despite being considered a species with a high degree of resistance and resilience, is under various pressures related to whitening, coastal sedimentation, habitat destruction, and impacts of coastal tourism (Barros *et al.* 2021). Previously, white band disease had only been recorded in branched corals of the *Acropora* genus in the Caribbean and Puerto Rico (Randall & van Woesik 2015, Woodley *et al.* 2016) and was also linked to post-bleaching.

White band disease is highly contagious through direct contact between healthy and affected coral tissues, through the water if the tissue is injured, and can also be transmitted through coral-eating gastropods, as is the case of *Coralliophila abbreviata (*Gignoux-Wolfsohn *et al.* 2012). These authors stated that *C. abbreviata* acts not only as a vector of the disease but also as a reservoir of the pathogen that causes white band disease. Ongoing studies on the coast of Paraíba and Alagoas point to the presence of gastropods of this genus in some of the studied reefs. Diseases may still be linked to the damage observed, such as the high frequency of colonies with sediment on their surface. Coral mucus production increases when the colony is under sedimentation as a strategy to clean and remove most of the sediment over the coral. The high mucus production also can be one of the indications that the coral's immune system is weakened and deregulated with an increase or decrease in the production

**Table 1.** Description of diseases and syndromes affecting corals in northeastern Brazilian coastal reefs

| Disease/syndrome | General description | Infected species |
|---|---|---|
| White Syndrome | Diffuse patterns of tissue loss with no band on the outside of the coral, unlike White Band and White plague diseases. No patterns in pigment loss and its progression occurs from the base to the apex of the colony with diffuse margins. | *Siderastrea stellata* Verrill, 1868, *Porites astreoides* Lamarck, 1816 |
| White Plague | Lesions begin focal and become multifocal throughout the colony, with a linear margin, depending on the morphology of the coral colony in which it is found. It has characteristics like white syndrome disease in terms of tissue loss. | *Siderastrea stellata*, *Favia gravida*, *Porites astreoides*, *Montastraea cavernosa* Linnaeus, 1767 |
| Red Band | Presence of a band of red or reddish-brown color that can be linear or irregular depending on the morphology of the infected colony. The necrotic area usually has filamentous algae cover. Progression of the disease is rapid to moderate. It is mainly common in octocorals, occurring also in massive corals. | *Siderastrea stellata* |
| Dark Spots | The lesions can be focal or multifocal with or without regular margins; they can expose the skeleton over time but only in late stages. It has colors ranging from brown to lilac, depending on which species is affected. It mainly affects species of the genus *Siderastrea*. | *Siderastrea stellata* |
| White Band | Presence of diffuse or circular band with skeleton exposure, usually linear, but can be found irregularly depending on the colony's morphology. The area of necrotic tissue has a rapid growth of filamentous algae due to low mucus production. It a rapid or moderate progression and its infection is high. | *Siderastrea stellata* |

of biochemical molecules that would guarantee sediment expulsion (Augustin *et al*. 2009).

This study identified at least five symptoms of diseases/syndromes affecting four species of scleractinian corals in coastal reefs in northeastern Brazil. The massive coral *Siderastrea stellata* presented colonies with all registered diseases, including the first record of white band-like disease, which until now was registered only in branched corals of the genus *Acropora*. In addition to the varied impacts that Brazilian reefs constantly suffer, the presence of diseases in a large part of the population is yet another threat to the health and balance of these ecosystems. Studies aimed at verifying the rates of progression and prevalence are essential to understand the real impact of diseases on the affected populations, and also studies that aims the accurate identification of pathogenic agents causing each set of symptoms. Special attention should be paid to reefs used as tourism spot , such as the reefs of Maracajú (Rio Grande do Norte) and Seixas (Paraíba), as they are priority areas for studies and conservation.

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