ETHNOBIOLOGY AND CONSERVATION

RESEARCH ARTICLE

Ethnobiology and Conservation, 13:21 (29 July 2024)
doi:10.15451/ec2024-07-13.21-1-15
ISSN 2238-4782 ethnobioconservation.com

Conservation Consequences of Corallivore Gastropod Predation on *Plexaurella grandiflora* (Cnidaria: Octocorallia) Populations in Tropical Reefs

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ABSTRACT

Octocorals are extremely important animals for forming coral reefs and maintaining life in the marine environment and are widely distributed. The focus species *Plexaurella grandiflora* is an endemic species from Brazil. It is subject to the most varied external stressors, from ocean surface warming, pollution, damage caused by tourism, and predation by other animals. In this sense, the present study aimed to survey the population characteristics of *P. grandiflora* in a shallow tropical reef in northeast Brazil. Furthermore, we evaluated the stress and damage caused by coral-eating gastropods of the Muricidae family, found associated with colony structure. Through free dives between the years 2016 and 2017, 143 colonies of *P. grandiflora* were marked and observed, and they were analyzed in their size, supporting substrate, distribution, presence of damage, and impact by coral-eating gastropods. The cataloged colonies were larger than those recognized in the literature and were distributed in aggregate. A total of 85 gastropods of two species (*Coralliophila aberrans* and *Coralliophila salebrosa*) were recorded preying on gorgonians. The damage ranged from light to deep, from polyp removal to exposure of the protein axis. Predation occurred predominantly at the base of the colonies. As it is an endemic species and in need of studies, this study warns of the need for studies focused on the ecology and conservation of this gorgonian and its critical habitats.

Keywords: Gorgonians; Gastropod corallivory; Coral reefs.

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SIGNIFICANCE STATEMENT

This work constitutes the first study on *Coralliophila* predation on gorgonians. In addition, the work brings new information about *Plexaurella grandiflora* as an endemic species, as well as possible stressors and their consequences for an already reduced population of the species. This study also reveals the negative affect coralivorous mollusks can have in an already decreased octocoral population in reefs that are already degraded and how the relationship between the coralivorous and its prey can be used as bioindicator to detect unbalanced marine environments.

INTRODUCTION

Plexaurella grandiflora is an endemic species of the Brazilian coast, extending from the coast of the state of Rio Grande do Norte to Rio de Janeiro at a maximum depth of 30m (Cordeiro et al. 2021). The distribution of octocorals in different habitats is linked to the adaptation of species and their physiological requirements. Exposure to light and the availability of plankton, their main sources of energy, are closely associated with the extent of branches in gorgonians (Preston and Preston 1975). For instance, the distribution of octocoral species is constrained by the availability of a suitable substrate, necessitating a solid base like a rocky outcrop or other subtract that guarantee their settlement and growth (Bayer 1961).

Those environments that present physiological stress, with unpredictable variations in resources, limit the diversity of species in a given habitat since the octocorals are susceptible animals to environmental changes (Preston and Preston 1975). In some areas around the world, gorgonian forests are among the most economically and ecologically important biotopes, as in the Mediterranean Sea (Ponti et al. 2016; Liconti et al. 2022). As with other gorgonians, *P. grandiflora* is used by other organisms, whether in harmonious or disharmonious relationships, as is the case of predation (Ruesink and Harvell 1990).

Predation by gastropods on other reef animals is already something studied in the tropical reefs of northeastern Brazil, mainly for large gastropods such as *Cassis tuberosa* (Dias et al. 2017). However, unlike this species which is known to control the community of other animals that are its prey, corallivorous gastropods can cause varied damage to the coral colony tissue according to prey specialization. More specialist predators cause deeper damage, such as exposure of the proteinaceous axis, allowing colonization by other organisms, which characterizes more severe losses and even death of the individual, depending on the speed of recovery of the colony (Ruesink and Harvell 1990).

The complexity of the damage varies according to some factors, ranging from the specialization of the predator to the scale and location of the damage. The depth of the injury caused is another factor that influences the recovery time and functionality of the colony, associated with environmental factors (Harvell and Suchanek 1987).

The diversity, abundance and association with other organisms are extremely important for ecological studies on gorgonians (Goh et al. 1999). Gastropods of the genus *Coralliophila* (Family Muricidae) are typical predators of scleractinian corals, but have also been described preying on octocoral species (Miller 1981; Del Monaco et al. 2010). Some species of octocorals are important in the diet of *Coralliophila salebrosa* (H. Adams & A. Adams, 1864) as well as for other species of the genus. When relating factors such as abundance, handling time and availability, a preference for octocorals is observed when compared to coral species (Del Monaco et al. 2010; Hamman 2018).

Mollusks are among the epibionts commonly associated with Gorgonian branches. Furthermore, the gastropod *Cyphoma signatum* (Pilsbry & McGinty, 1939) (Family Ovulidae) is a rare specialist of this species and causes severe damage, often exposing the proteinaceous axis of the gorgonia, with the ingestion of all the tissue and organic material (Ruesink and Harvell 1990), through the radula scraping (Whalen 2008).

The presence of deep wounds is also a parameter that indicates disturbances in Gorgonian populations, being able to categorize the level of conservation of a marine ecosystem (Kipson et al. 2014). Despite this, the action of predators, causing injuries to octocorals, is not seen as an isolated factor for the destruction of colonies, being combined with damage (e.g. algal colonization) that demand greater energy expenditure for recovery and, consequently, displacement of energy to the competition of individuals within a community (Preston and Preston 1975; Lasagna et al. 2014).

Even though they comprise the most visible and characteristic species of reef ecosystems, little is known about the ecological aspects of octocorals, although in the last 10 years the research considering them has become more widely spread (Preston and Preston 1975, Lau et al. 2020). In Brazil, the presence of gorgonians as part of the benthic landscape is scarce since the coastal reefs of the Northeast are dominated by macroalgae and other benthic components (e.g. zoanthids, rhodolite beds). This makes population studies of octocorals incipient. In addition, the rapid expansion of tourism in shallow reefs can lead to the loss of gorgonian forests without their being studied and protected.

This study also seeks to verify the degree of conservation of gorgonians, based on the presence of damage caused by epibionts and sediment and unpublished data on a population of endemic octocorals in a shallow coastal reef, appearing as the first contribution on the population size structure of the gorgonian *Plexaurella grandiflora* and its interactions with the associated fauna during daytime.

MATERIAL AND METHODS

Octocoral target species

Plexaurella grandiflora (Figure 1) was described by Verrill (1912), having a type locality “Mar Grande, Brazil," in the state of Bahia. According to Cordeiro et al. (2021), the distribution of *P. grandiflora* is greater, extending from Rio Grande do Norte to Rio de Janeiro.

Castro et al. (2010) classify *Plexaurella grandiflora* into two morphotypes according to the length and width of the branches: *P. grandiflora* with ‘long branches’configure colonies with thinner branch length and tall stature, while *P. grandiflora* with ‘short branches’ has a reduced length and thick branches (Figure 1a-b). According to this adopted classification, the target species of the study is characterized as long branches *P. grandiflora*.

The species is made up of branches connected to a base that attaches to the substrate, being calcareous rock, rhodolite or another consolidated substrate that guaran-

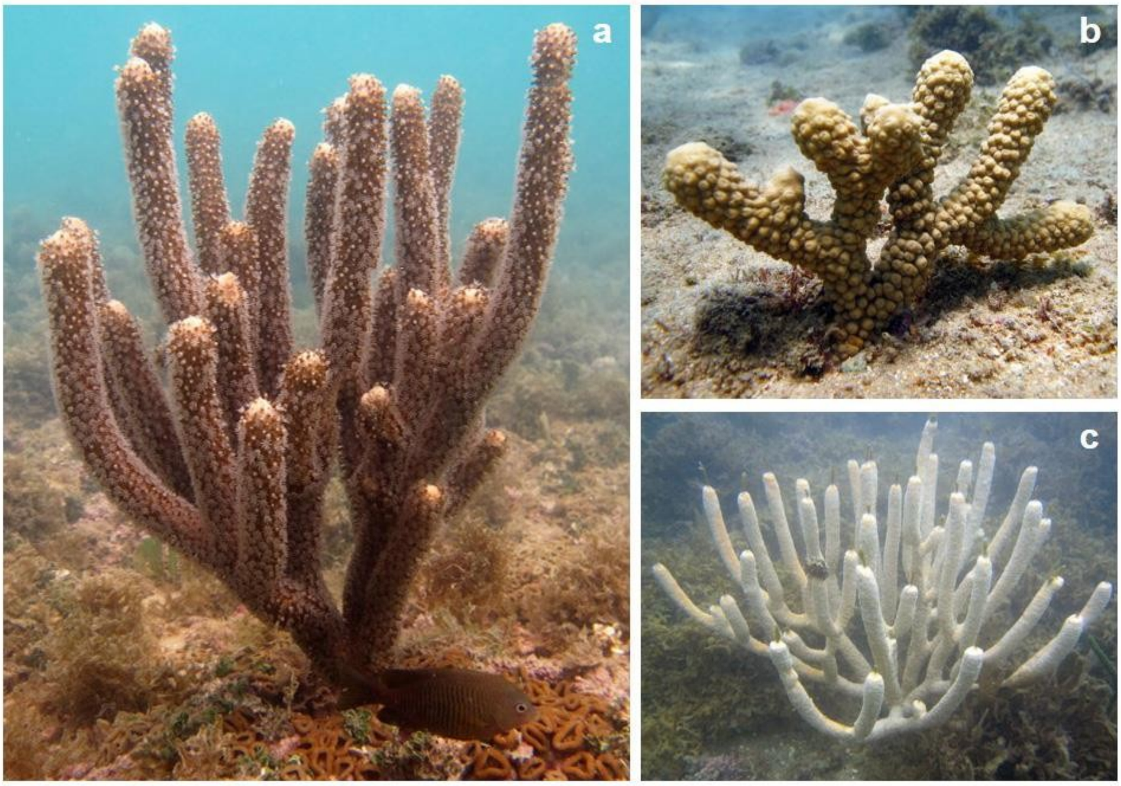

Figure 1. Individuals of *Plexaurella grandiflora* in the natural reef habitat: (a) *Plexaurella grandiflora* with long branches (Seixas reefs, PB); (b) *Plexaurella grandiflora* with short branches (reefs at Francês Beach, AL), and (c) bleached colony of *Plexaurella grandiflora* during the mass bleaching event that occurred in 2010 (Seixas reefs, PB) (DIAS; GONDIM, 2016). Photos: Thelma Dias©.

tees the needs for colony development. Its endoskeleton consists of a rigid proteinaceous axis that guarantees the support of the branches, which is covered by a scleratinized matrix where the polyps are inserted (Castro et al. 2010). This species develops in very peculiar areas, such as peaks of dead coral skeletons of shallow reefs, with high availability of light and cavities in the reef formation (Hetzel and Castro 1994).

Study areas

The present study was carried out on the reefs of Seixas Beach (7°9'21"S and 34°47'10"W), located in the city of João Pessoa, on the coast of Paraíba, northeastern Brazil (Figure 2). The reefs are located about 600 meters from the beach line and are formed by sandstone rocks, algae and corals, reaching a depth of 1 to 4 meters at syzygy low tide (Dias and Gondim 2016).

According to Dias and Gondim (2016), during most of the year, the Seixas reefs are subject to strong wave action and seawater turbidity. In the months between November and March, corresponding to the dry season, the action of the waves decreases and allows better water visibility.

The underwater environment of Seixas beach is a heterogeneous habitat formed by the presence of coral colonies, seaweed banks, rhodolith banks, sandstone rocks, *Halimeda* gravel bottoms and sand banks. The structure of the reef forms the natural pools that are visible at low tide. This diversity of habitats enables the existence of a diverse fauna that provides food and shelter for existing species.

In recent years, the Seixas reefs have become one of the main tourist attractions in the city of João Pessoa, as they have natural pools, which together with fishing contribute to the local economy (Dias and Gondim 2016). Currently, the reefs of Seixas began to receive a much larger flow of tourists, with impacts caused by boats and tourists (reference on the flow and impacts).

The high number of tourist/recreational boats in the area is remarkable, as well as smaller speedboats, jet-skis and kayaks, especially on weekends. The direct impacts on the environment can be easily observed, such as the breakage of hydrocorals and the anchoring on gorgonian banks (Figure 3).

Sampling procedures

Fieldwork was carried out by snorkeling continuously from December 2016 to March 2017, a period with better water visibility, until all colonies present in the area was counted. A pilot research was carried out in order to find places with greater abundance of the target species of the study, since the octocoral population is not well distributed through the reef, with patches in distinctive sites of the reef, and with depth from 75 cm to 1.2 m in the low tides (e.g. 0.0 to 0.4 tides sizes).

Each colony found was marked using PVC plates that were attached to the base of the colony with the aid of plas-

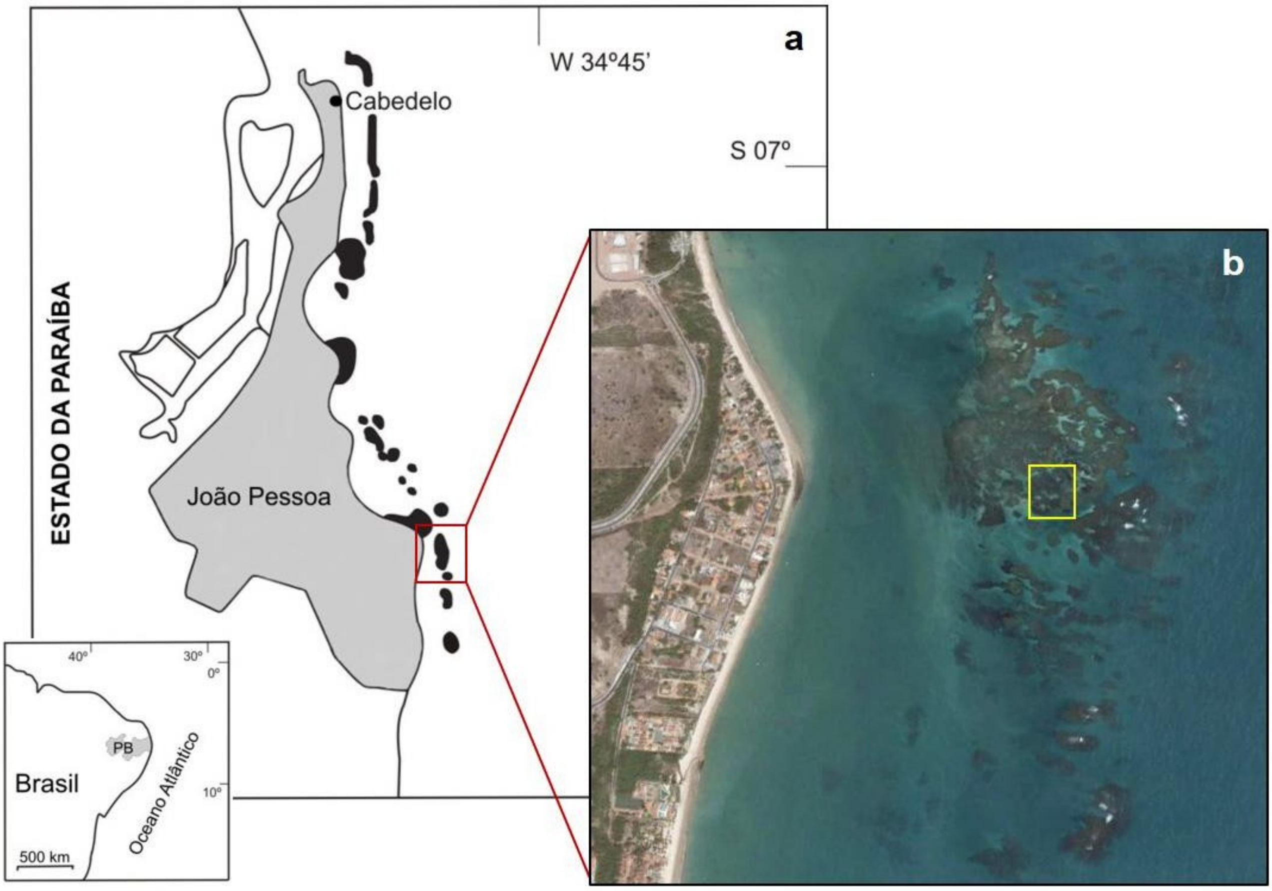

Figure 2. (a) Location of the study area on the coast of Paraíba (b) Google Earth view where the studied Plexaurella grandiflora are found (yellow square). Fonte: Google Earth®.

tic ties. Each plate contained the date of data collection, the colony number (following the observation sequence) and the indication that it was part of scientific research (Figure 4). The marking of the colonies was necessary to avoid the recounting of the colonies and the removal by fishermen and turists who frequently visit the areas where the colonies are located. After field research, all tags were removed.

For each marked colony, the following information was obtained: height, width and number of branches (Table 1), type of substrate where the colony was fixed based on Coral Reef Check protocol, distance from the nearest colony, presence of epibionts and, if present, to which taxon it belonged, type of observed interaction and location of the epibiont in the colony. Taking into account other studies that use the number of branches as the main morphological descriptor (Rossi et al. 2018), we will use this attribute to carry out the analysis and to discuss the results.

The aggregation of colonies was classified according to the distance of the marked colony from another of the same species. Thus, colonies located at a maximum distance of 30 cm from the closest individual were classified as aggregated, and those whose closest individual was more than 30 cm away were classified as solitary distribution (Figure 5).

The corallivory interactions of two species of corallivorous gastropods of the genus *Coralliophila*, namely *Coralliophila aberrans* (C. B. Adams), 1850 and *Coralliophila salebrosa*, were evaluated. The predation was determined by the deep wounds left in the coral tissue and previously recorded for the species. Being the coral and the gastropods, both animals, the action of removing tissue for feeding characterizes the predation.

To evaluate the interactions of predation by gastropods, the following data were obtained: (a) place of mollusks interaction in the colony, being classified as basal, median and apical; (b) number of organisms found in each colony; (b) size of the predator in cm (measured from the apex of the shell to the end of the symphonic notch); (d) species classification and (e) marks/evidence of predation left by these organisms in colonies of *Plexaurella grandiflora.*

To assess the conservation status of the colonies in a complete way, as done for Chimienti et al. (2023), damage was identified and classified as any alteration in the morphological structure of the gorgonians as a result of coralivory (e.g. predation lesions, periphyton film, growth of leafy or calcareous macroalgae, or growth of other organisms on the colony) or materials present in the environment, for example, sediment (Figure 6). The damages found in the colonies were also categorized in relation to their position in the colony, namely: basal (when the damage was close to the part of the octocoral in contact with the sediment, in the half down portion), median (way from the fixation part but yet away from the top of the branches, median portion of the octocoral structure) and apical (close to the branches end). They were classified as described in Table 2. Abiotic data such as depth, temperature, salinity

Table 1. Description of morphometric data obtained from colonies of Plexaurella grandiflora on the reefs of Seixas Beach, João Pessoa, Paraíba.

Measure	Description
Colony height	Distance from the base of the colony to the apical portion of the highest branch.
Colony width	Distance from the first left side branch to the last right side branch.
Number of branches	Number of apical branches of each colony.

and visibility were obtained in the field, in addition to the georeferencing of each observed colony.

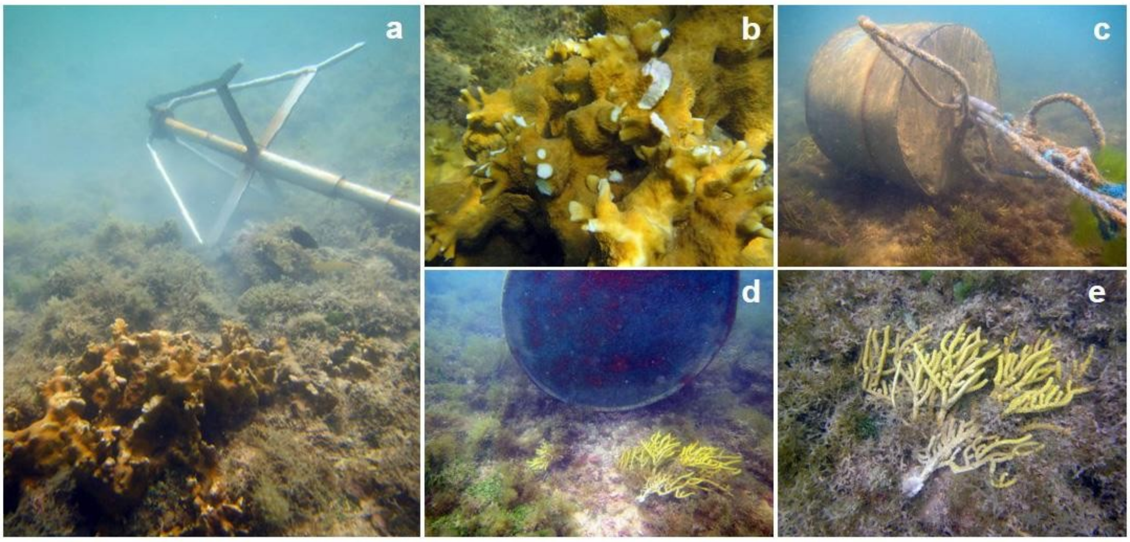

Figure 3. Some impacts recorded on the reefs of Seixas caused by the presence of boats and tourists: (a) anchors near colonies of *Millepora alcicornis*, (b) Colony of *Millepora alcicornis* damaged by the impact of an anchor, (c, d) concrete structure for boat anchorage left near colonies of *Muriceopsis sulphurea*, and (and) *Muriceopsis sulphurea* broken after being hit by boat anchorage structure. Photos: Thelma Dias© e Luis Carlos©.

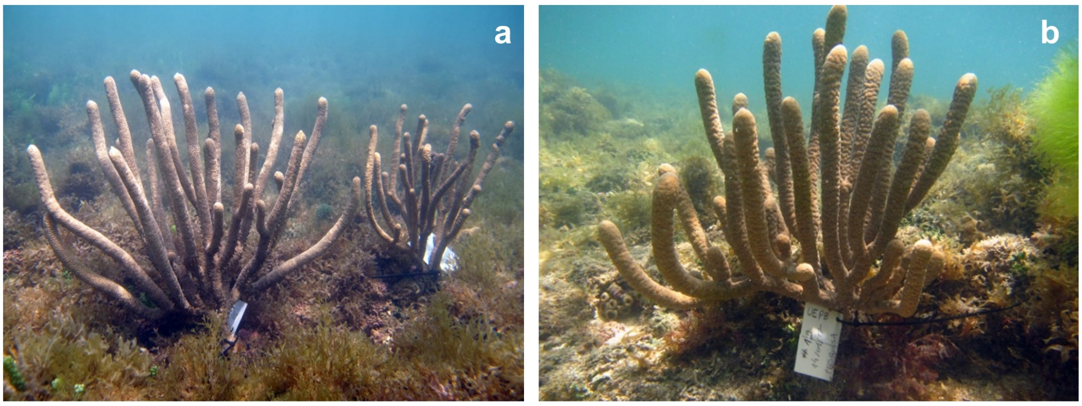

Figure 4. Field work on the reefs of Seixas, PB. Markings of colonies analyzed with PVC Plates containing individual marking data. Photos: Thelma Dias©.

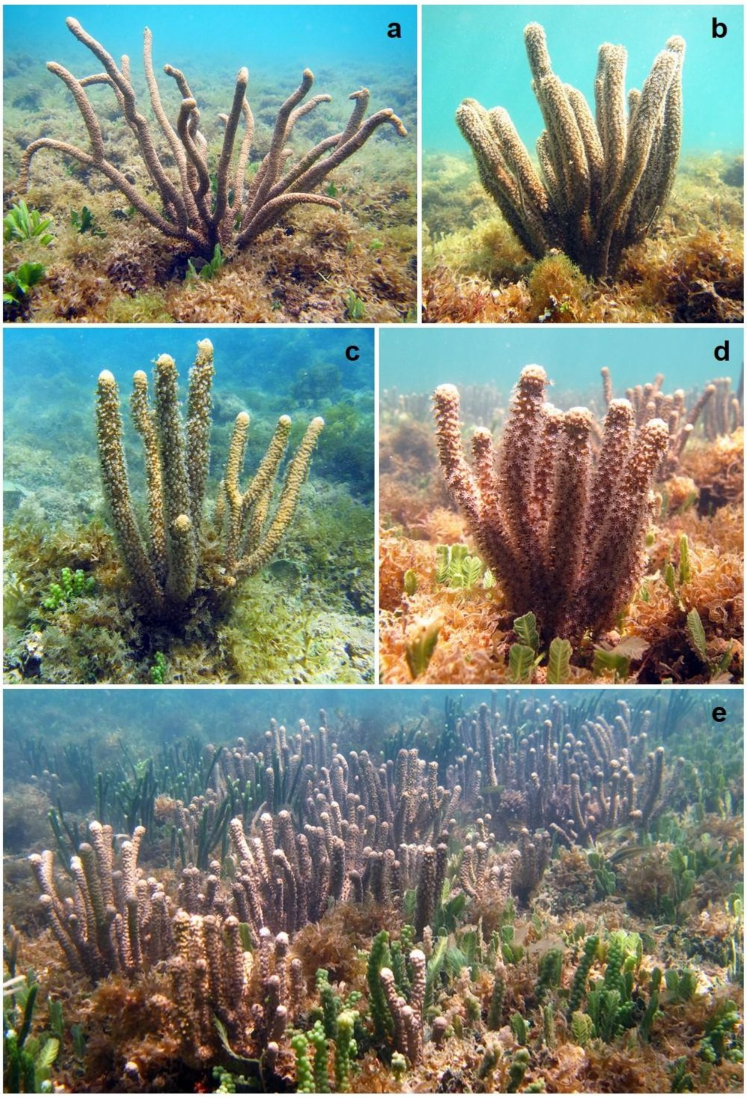

Figure 5. Individuals of *Plexaurella grandiflora* on Seixas reefs, João Pessoa, PB. (a-d) Individual colonies with different sizes and degree of branching. (e) Aggregation of colonies surrounded by macroalgae of different species. Photos: Thelma Dias©.

Data Analysis

To analyze the population characteristics of *Plexaurella grandiflora*, we correlated the morphological attributes (height, width and number of branches) of the individuals to verify if there is a body pattern. Descriptive analysis of the morphological data is presented, and the individuals were grouped into size classes (from the number of branches of the individuals) in order to verify the structure of the *P. grandiflora* population.

A principal component analysis was applied to verify whether the size structure of *P. grandiflora* colonies correlated as a function of the type of substrate on which they were fixed in the environment (calcareous rock or rhodolite) or as a function of their distribution (aggregate or solitary). The PCA analysis was conducted using the Software PRIMER 7.

Coralivory data were analyzed descriptively, a Pearson's correlation was applied to verify whether the number of predators sheltered by octocoral colonies is related to the number of branches that the colony presents. The damage recorded in the colonies was treated in a descriptive way and presented graphically for a better visualization of the state of health of the octocoral population. Analyzes were performed using the software BioEstat version 5.0 with its functions previously available.

RESULTS

Plexaurella grandiflora population structure

In total, 143 colonies of *Pleuxarella grandiflora* were analyzed in an area of approximately 1.54 ha (=15,410 m^2). The average height of the colonies was 19.34 cm (±6.2, SD), with a minimum recorded height of 5 cm and a maximum of 40 cm. The width found was an average of 14.32 cm

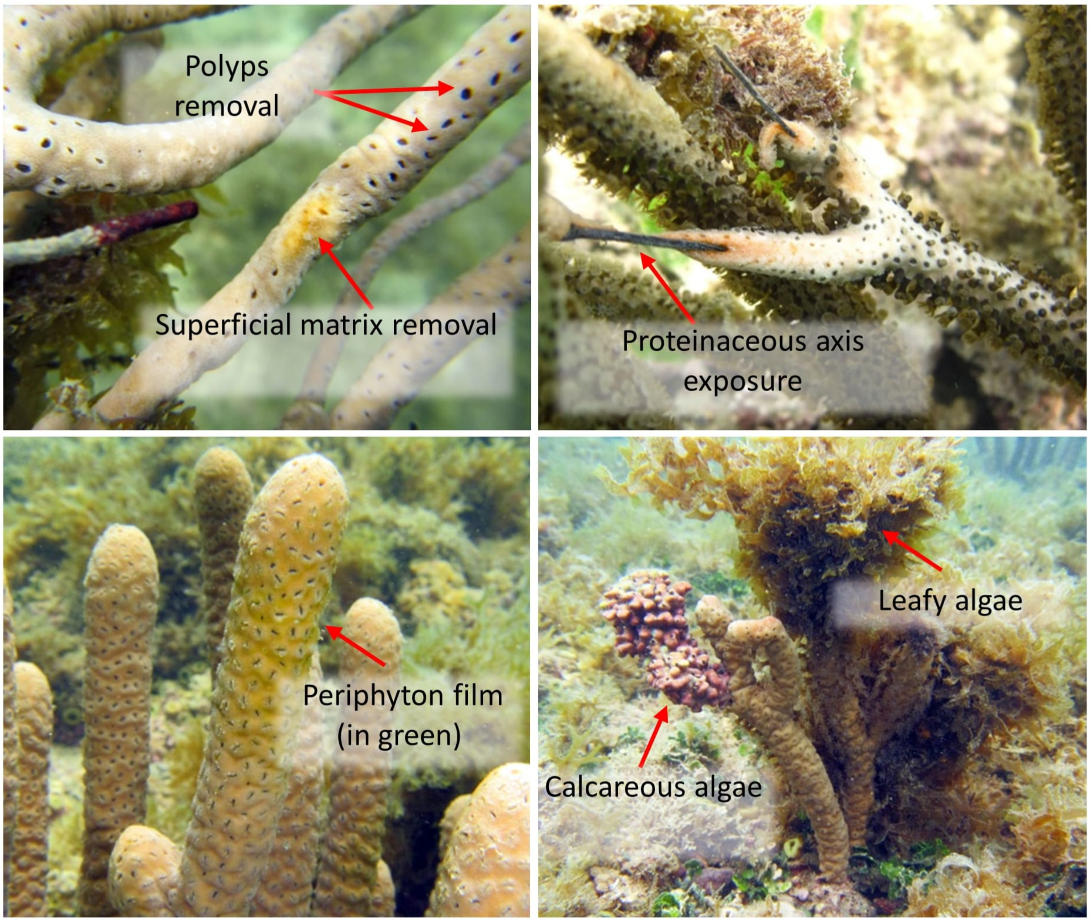

Figure 6. Examples of damage found in colonies of *Plexaurella grandiflora* on Seixas reefs, João Pessoa, Paraíba. Photos: Thelma Dias©.

Table 2. Characterization of damage recorded in colonies of *Plexaurella grandiflora* on the reefs of Seixas Beach, João Pessoa, Paraíba.

Degree of damage	Description
(1) Superficial	Characterized only by the removal of polyps.
(2) Moderate	Characterized by removal of polyps and scleratinized matrix, without exposure of the proteinaceous axis.
(3) Severe	Characterized by the deep removal of the scleratinized matrix, causing the exposure of the proteinaceous axis.
(4) Algal colonization	Characterized by periphyton film growth,leafy or calcareous macroalgae at some point in the colony.
(5) Sedimentation	Characterized by the presence of a thin layer of sediment over some part of the colony.

(±7.3, SD) with a minimum width of 3 cm and a maximum width of 45 cm. As for the number of branches, an average of 14.62 (±8.2, SD) branches per colony was obtained, with a minimum of 2 and a maximum of 44 branches. In general, the population of the gorgonian *P. grandiflora* predominantly belongs to the initial size classes, considering a number of branches between 1 and 22 branches (Figure 7).

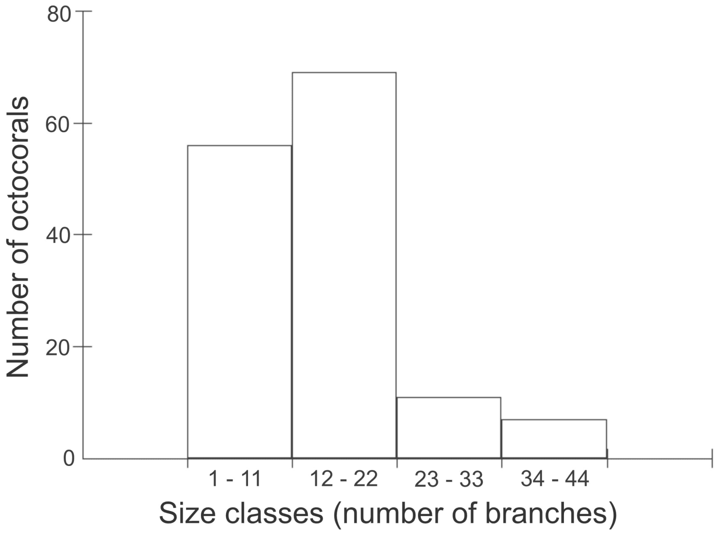

Figure 7. Distribuition of *Plexaurella grandiflora* individuals on size classes consideranding the number of branches.

The registered colonies predominantly used two types of consolidated substrates, Calcareous rock (92.3%) and rhodolite (7.7%). Of the total colonies analyzed, 72% were aggregated, that is, at less than 30 cm from the nearest colony (N = 103 colonies).

The morphological attributes of the *P. grandiflora* population are positively correlated, indicating that there is a morphological pattern of individuals and any of the attributes can be used as a descriptor of individual size (width x height: $r = 0.76$, $p < 0.001$; height x number of branches: $r = 0.64$, $p < 0.001$; width x number of branches: $r = 0.80$, $p < 0.001$).

The PCA analysis showed that the morphological attributes of the colonies correlated regardless of the type of distribution (aggregate or solitary) (cumulative explanation = 94.7%) or the type of substrate on which the colonies were (Calcareous rock or rhodolite) (cumulative explanation = 100%) (Figure 8).

Population structure of *Coralliophila* spp. and predator-prey interactions

Out of the 37 colonies in which predators were present (25.9% of the studied colonies), 83.3% were attached to the basal part of the colony (83.8%) (Figure 11 a-c).

In total, 85 gastropods were recorded preying on the gorgonians (i.e. removing coral tissue with radula movements leaving behind a wound when removed from the octocoral colony), 40 individuals of *Coralliophila aberrans* and 45 of *C. salebrosa* (Figure 10). The mean size of *C. aberrans* was 1.78 cm (±0.45). For *C. salebrosa*, the average size observed was 1.74 cm (±0.41). The population of gastropods in general consisted mainly of young individuals (1-2 cm) with 57.6% of individuals, while 37.6% were adults (>2 cm) and 4.7% recruits (< 1 cm) (Figure 10).

The maximum number of predators recorded in a single colony was 12 individuals. Most of the predatory gastropods (96.5%) had the external surface of the shell completely colonized by calcareous algae similar to those that occupy the surroundings of gorgonians, suggesting a high rate of inactivity and permanence in the *P. grandiflora* colonies.

There was no correlation between the size of *P. grandiflora* individuals and the size (height) of the predatory gastropods ($r = 0.06$; $p > 0.05$). However, there was a positive correlation between the number of branches in the colony and the number of sheltered predators, indicating that individuals of *P. grandiflora* with a greater number of branches also harbor a greater number of predators ($r = 0.34$, $p < 0.05$).

Predation by the species *Coralliophila aberrans* and *C. salebrosa* occurred in the basal and median regions of *Plexaurella grandiflora* colonies.

Damage on *Plexaurella grandiflora*

Among the colonies with the presence of gastropods, 89.2% (n = 33) had visible damage. In the predated colonies on the Seixas reefs, when removing the gastropods from the place where they were attached, consuming the colony, it was possible to observe the evidence of predation left by the two species of *Coralliophila*.

The scar is characterized by a circular and deep lesion, with the proteinaceous axis exposed in the center of the lesion. In cases of superficial damage, only polyps and the coenenchyma. In 29.7% of the colonies with predators, the damage left was characterized only by the removal of polyps (i.e., superficial damage, level 1), but in 48.6% of the colonies, the damage was multiple (e.g. more than one type in the same colony) (Figure 9 d-g).

As for general health status, 112 colonies (78.3%) of *Plexaurella grandiflora* showed some damage (including predation marks by *Coralliophila*). When scaling the damage presented by the individuals, the studied population is predominantly shown on a scale of level of damage at level 4 (algal colonization) (N = 68; 60.7%) (Figure 12). A total of 83% of damaged colonies have multiple damages (2 to 7 different types of damage in the same colony).

The solitary or aggregated distribution of colonies in the habitat also influenced the number of predators and

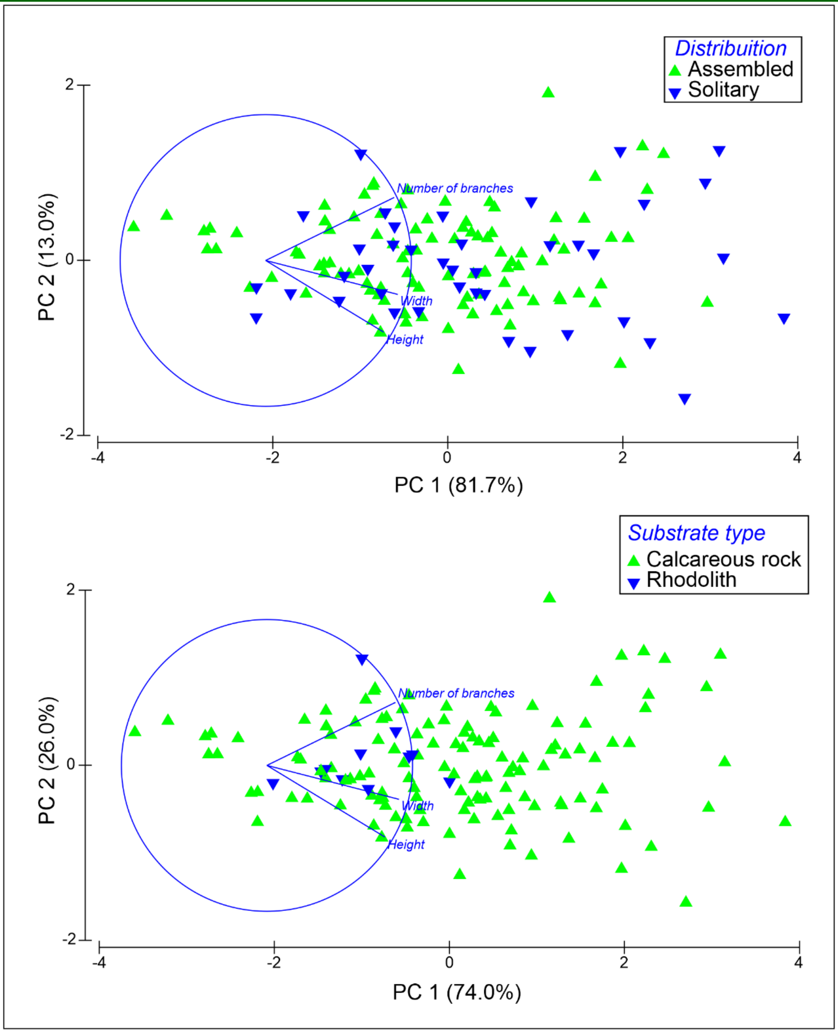

Figure 8. Principal Components Analysis (PCA) of morphological attributes of *Plexaurella grandiflora* in function of the factors distribution and substrate type.

the conservation status of the colony. Solitary gorgonians tended to have a greater number of predators and consequently more damage than aggregated colonies. In the study, a single solitary colony was observed with 12 predatory gastropods concentrated exclusively at the base of the colony.

DISCUSSION

Knowledge about the population structure, distribution and state of conservation of these organisms provides information that makes it possible to understand the dynamics of communities and reef ecosystems. The increase in observations of infestation by corallivores raises concerns about the correct maintenance of these systems and how balanced are the reefs where prey and predator are situated.

Regarding the morphometric characteristics, the maximum height found (40 cm) was higher than that indicated by Hetzel and Castro (1994), where the species can reach 35 cm in height and the branches can reach 1.5 cm in diameter. The colonies in the studied area are large, mainly related to the average number of branches. This suggests that the population studied may already have been established in the area for a long period of time. Photographic records dated from 2007 already showed the presence of this population in the reefs of Seixas beach.

According to Hetzel and Castro (1994), the favorite habitat of this species is shallow areas with a lot of light, being commonly located amidst concentrations of leafy algae. Such characteristics are similar to the habitat where the species was recorded in this study, however, even with the marked presence of leafy algae in the Seixas reefs, the algal species closest to *P. grandiflora* colonies are smaller and have a more delicate structure, like the genera *Dictyopteris*, *Halimeda* and *Caulerpa*, when compared to the species found by other authors.

Of the total colonies analyzed, 72% of the colonies showed aggregation between colonies, which may suggest a trait of the species, with the presence of colony banks located in certain areas of the environment that are better for colonization, either due to the quality of the fixation substrate or by the set of needs for the development of the colonies, such as a well-lit place, with mild currents and food resource. This distribution pattern is common for gorgonian species since they are considered ecosystem engineers (Verdura et al. 2019).

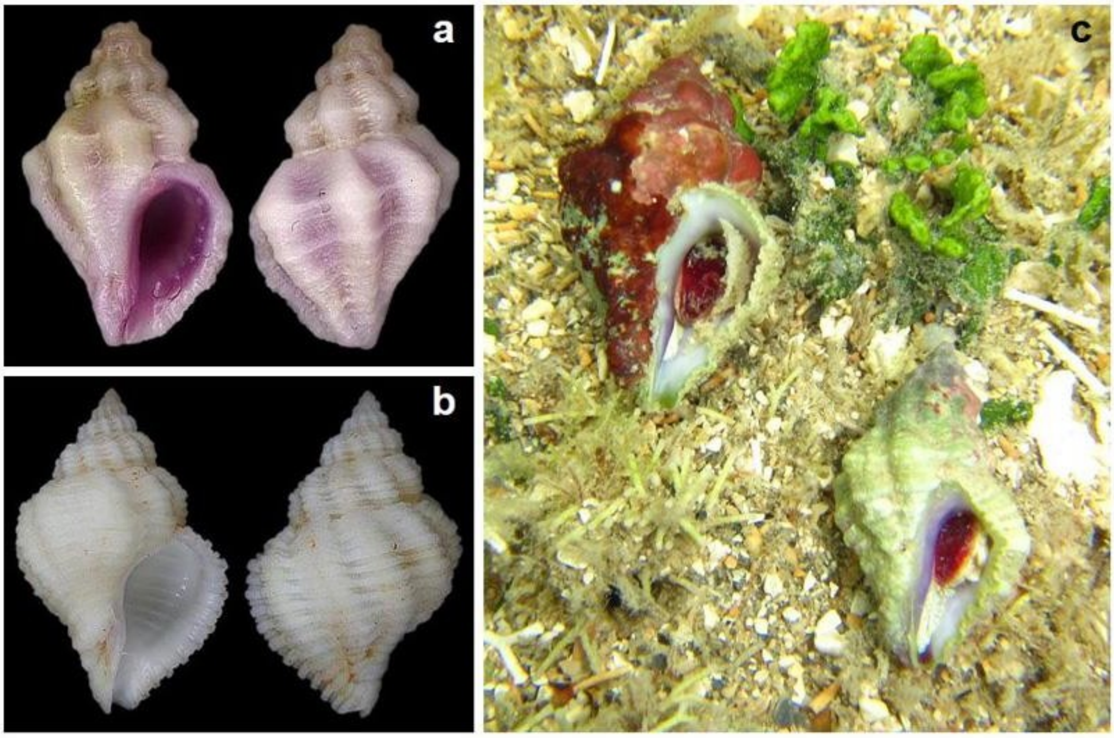

Figure 9. Predatory gastropods of gorgonians. (a) *Coralliophila salebrosa*, (b) *C. aberrans* e (c) individuals de *C. caribaea* removed from the colonies of *Plexaurella*. Photos: (a-b) Femorale©, (c) Thelma Dias©.

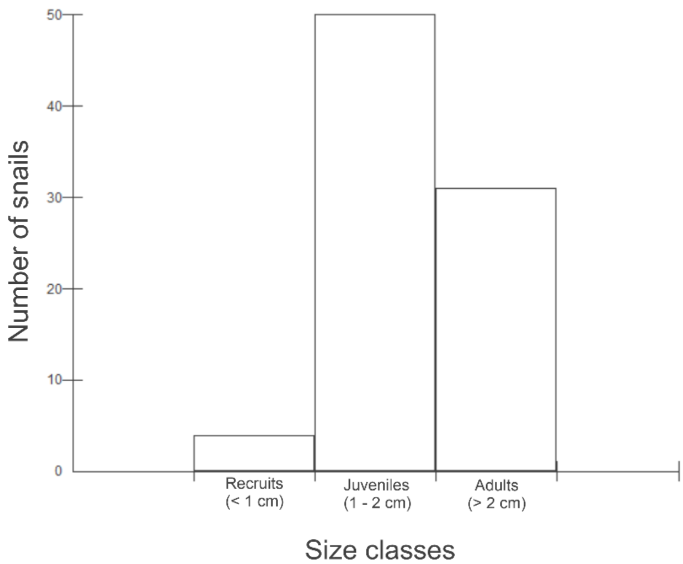

Figure 10. Distribuition of *Coralliophila* individuals divided into classes.

In open areas, relatively eutrophic and have moderate occurrence of macroalgae, gorgonians can be dominant organisms, especially in healthy environments (Ballesteros 2006). However, this aggregate form of occurrence can be a threat to populations, as any harmful event, such as fishing with nets, disorderly tourism or even natural events (e.g., surface water warming, hazards and natural disorders), can drastically affect the local population. In the studied area, the gorgonian population was already affected by a mass bleaching event that affected coralline communities around the world, including the Brazilian coast (Alemu and Clement 2014; Dias and Gondim 2016). In addition, the area is heavily used for tourism and recreation, with recurrent traffic of boats and people potentially threaten-

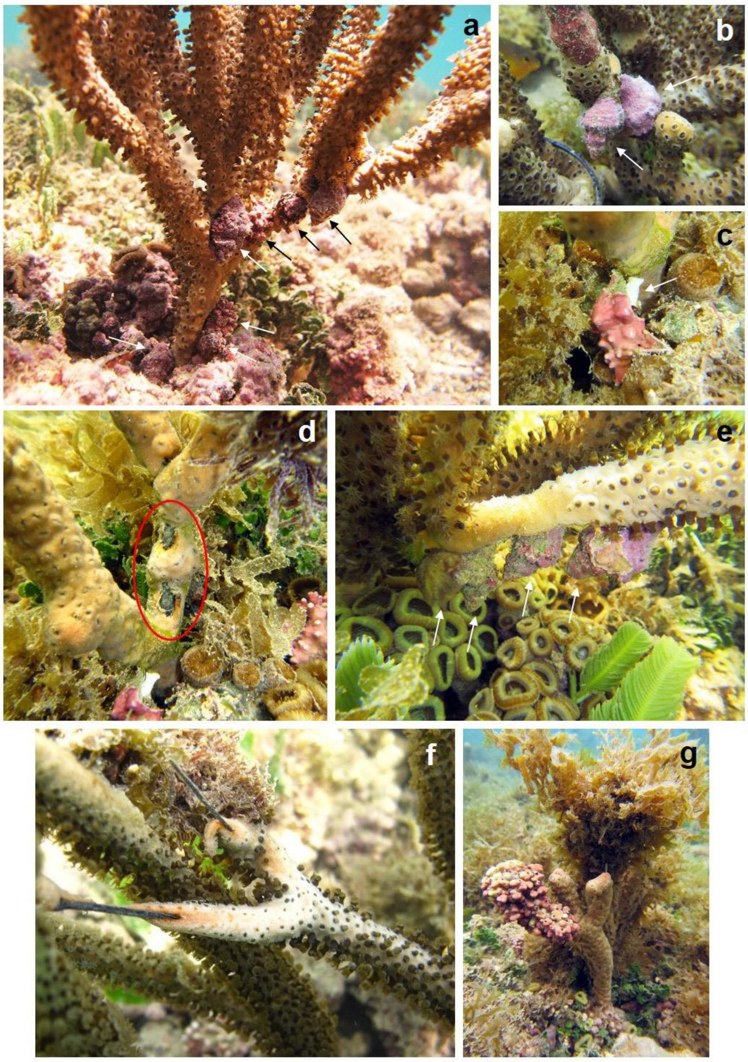

Figure 11. Predation and damage recorded in colonies of *Plexaurella grandiflora*. (a, b, e) *Coralliophila* spp. adhered to the colony feeding (arrows). (c) Coralivorous predator with prominent proboscis (arrow). (d) Highlight for two predation scars by *Coralliophila* shortly after removal of predators. (f-g) Damage such as loss of polyps, matrix and algal growth in colonies. Photos: Thelma Dias©.

ing the studied population. Therefore, there is an urgent need to seek protection possibilities for the places where this species occurs and its surroundings.

The role of gorgonians as a habitat for a variety of symbionts has already been studied in different parts of the world (e.g. Patton 1972; Goh et al. 1999; Mortensen and Mortensen 2005; Sánchez 2016), but in Brazil, such studies are specific, for example by Pinto et al. (2016), who cite the occurrence of the gastropod *Cyphoma macumba* preying on two species of gorgonians of the Plexauridae family in reefs off the coast of Alagoas, northeastern Brazil.

Regarding predation, two species of predatory gastropod mollusks from the Muricidae family were found feeding on *Plexaurella grandiflora*. Regarding the size of coralivorous mollusks, the size structure of the two species follows the pattern for the genus and may vary when compared to animals present in the protected area (Shaver et al. 2018). For the *C. salebrosa* individuals found, the shell size values are similar to those found by Potkamp et al. (2017) in Curaçao in the Caribbean Sea. Gastropods of the genus *Coralliophila* are common in the Caribbean as corallivores that consume a wide range of hosts (Potkamp et al. 2017). *C. abbreviata*, for example, is a corallivore that feeds on at least 14 species of scleractinian corals (Miller 1981). However, the predation of *Coralliophila* on gorgonians is recorded for the first time in this study, both in Brazil and in the scientific literature.

Predation of Plexauridae octocorals by Ovulidae gastropods is well documented in the literature (e.g. Ruesink and Harvell 1990; Reijnen et al. 2010), but this prey-predator interaction between gorgonians and Muricidae gastropods of the genus *Coralliophila* is a new record. In Brazil, until then, only Martinez et al. (2012) cited the occurrence of *C. salebrosa* in the reefs of Maracajaú (RN) and Souza et al. (2011) mentioned *Latiaxis mansfieldi* preying on five different coral species in reefs on the southern coast of Bahia, the second of which does not belong to the Muricidae family. In this sense, on the Brazilian coast, coralli-

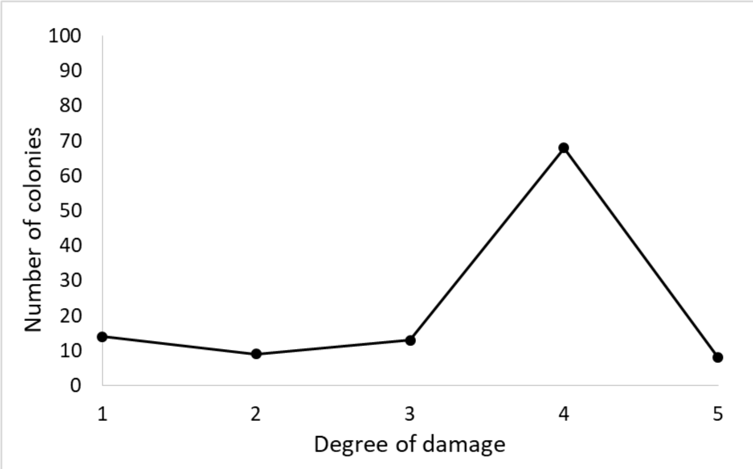

Figure 12. Characterization of the health status of the *Plexaurella grandiflora* population according to the degree of damage presented by the individuals.

vores of the genus *Coraliophilla* are expanding their possibilities of prey, affecting populations of endemic and poorly studied octocorals in their distribution area, as occurs for *P. grandiflora*. This is another conservation concern.

The percentage of colonies with predatory gastropods on Seixas reefs is similar to the percentage found by Potkamp et al. (2017) in corals in the Caribbean (25.3%), which can be characterized as a corallivore infestation (Baum et al. 2003). As observed in this study, in which predation predominated in basal portions of colonies, in the study by Brawley and Adey (1982) carried out in Haiti, *Coralliophila* species also preferred basal marginal portions of corals for predation. According to these authors, the tendency of these mollusks to feed on the margin of living tissue would be a protective strategy because the basal areas of each colony generally have dead zones caused by a wide variety of factors, and the feeding rate would allow the colonization of algae disguised the presence of mollusks.

In the case of the present study, despite the structure of the gorgonia being different from a scleractinian coral, the use of basal portions may also be linked to protection against predators. Branches from colonies would easily display any organism, exposing it to predators and other factors such as light. According to Brawley and Adey (1982), *Coralliophila abbreviata*, a very close congener of the species recorded in this study, presents a much higher feeding rate at night, suggesting that these predators move along the colony and forage at night. In this case, if *C. aberrans* and *C. salebrosa* are also more active organisms at night, the basal presence in the colonies may indicate protection against strong daylight, since the base of the colonies is more protected from light due to the presence of macroalgae and rhodoliths around them.

This characteristic suggests that the predators really remain for a long time in the basal part of the colonies and that they are usually not very active, allowing calcareous algae to colonize the shells. This cover of the shell with algae certainly favors the camouflage of the gastropods both in the environment in general and when they are adhered to the colonies by ingesting their tissues. This pattern corroborates other studies involving gastropods of the genera *Coralliophila* and *Drupella*, which are responsible for serious damage to corals in the Caribbean and Indo-Pacific, respectively (Bruckner et al. 2017; Kaullysing et al. 2019).

According to Potkamp et al. (2017), the distribution of predators per colony is not random, suggesting that larger colonies tend to have a greater number of individuals because they have a larger feeding area, in addition to their greater concentration among the gorgonian branches. It is important to note that this finding refers to *Coralliophila* as predators of scleractinian corals. For octocorals, this needs to be better evaluated.

The predation exercised by corallivores on gorgonians raises great concern for several reasons. One of the most important comes from recent studies that claim that predation scars can influence host susceptibility to pathogens. According to Nicolet et al. (2018), due to the deep lesions caused, coralivorous invertebrates, including *Coralliophila*, act as vectors and increase the transmission of diseases. It has already been confirmed that gastropods of the genus *Drupella* transmit diseases to healthy corals (Nicolet et al. 2013) and *Coralliophila abbreviata* acts as a vector of the bacteria that causes White Band Disease in corals of the Acroporidae family, one of the most important families in the construction of reefs in the world (Sutherland et al. 2011). Furthermore, predation can hinder colony regeneration after mass bleaching events (Bruckner et al. 2017). The removal of tissue itself affects the structure of the colony.

The predation of the gastropod *Coralliophila abbreviata* directly influences tissue removal in *Acropora palmata*, with a significant reduction in tissue loss being observed in corals where predators have been removed, contributing to coral conservation (Miller 2001). Removing polyps from the colony subjects the organism to greater vulnerability since one of the functions of these polyps is to protect the gorgonians against attachment by other individuals. Without this mechanism, the animal is subject to faster degradation of the colony, going through the removal of the scleratinized matrix, exposure of the proteinaceous axis until its colonization by calcareous or leafy algae, which can lead to the death of the colony (Smith et al. 2006).

The increasing tourism that occurs in the reefs can be a source of damage to the *Plexaurella* population studied. The location in shallow waters with good visibility attracts bathers and divers who easily trample and damage the gorgonian forest. In addition to these direct threats, natural events such as thermal anomalies threaten the integrity of

Plexaurella grandiflora and its associated fauna.

According to Dias and Gondim (2016), after the mass bleaching event that occurred in 2010 and affected the gorgonians, the colonies began to show signs of disease and damage, and it was possibly under these conditions that coral-eating gastropods began to prey on the colonies, at least in greater abundance. Bruckner et al. (2017) reported that after a mass bleaching event that occurred in 2016 in the Maldives, a population outbreak of coral-eating gastropods of the genus *Drupella* affected the wide coverage of corals. According to these authors, this abnormal abundance of corallivores was a response to the great reduction of corals, causing corallivores to concentrate in the surviving colonies. In the Seixas reefs, although there is no quantitative data on post-bleaching mortality, the reduction in coral cover has favored the colonization of gorgonians by gastropods.

CONCLUSION

This study revealed the presence of a population aggregation of gorgonians endemic to the Brazilian coast under strong threats from human activities, natural events and coralivorous predators. The colonies presented a size consistent with a predominantly adult population, although young individuals of smaller size are present in the area. Coralivorous gastropods used the colonies as an important source of food, from which they ingested the scleratinized matrix and polyps, leaving a scar of circular predation, predominantly located in the basal portions of the colonies.

Several damages were present in the colonies, both in the presence and absence of associated macrofauna, which included algal colonization and sedimentation on the branches. The data presented here represent an important step towards expanding studies on the functional role of these gorgonians in the reef ecosystem while raising serious conservation concerns. To better understand how coralivory by *Coralliophila salebrosa* and *C. aberrans* affects the population of *Plexaurella grandiflora*, future research is needed to assess the degree of tissue loss in gorgonians, the predatory behavior of the gastropod and the possible vulnerability of colonies to diseases resulting from the impact of predation.

ACKNOWLEDGMENT

We thank Luis Carlos Pereira Damasceno and Katiane Bezerra de Albuquerque for assistance in fieldwork. We also thank PADI Foundation for the essential financial support granted to C.D. Avelino (2015 Grants 14807) and FACEPE (Fundação de Amparo à Ciência e Tecnologia do estado de Pernambuco - IBPG-0235-2.05/21) for the scholarship granted to C.D. Avelino.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: CDA, TLPD.
Carried out the experiment: CDA, TLPD.
Carried out the data analysis: ELSM.
Wrote the first draft of the manuscript: CDA, ELSM, TLPD.
Review and final write of the manuscript: AIG, RRNA, TLPD.
Supervision: CDA, TLPD.

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Received: 10 April 2024
Accepted: 22 July 2024
Published: 29 July 2024

Editor: Ulysses Albuquerque