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Quali-Quantitative Evaluation of Algae from the White Beach, Guarujá, São Paulo, Brazil

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ABSTRACT: *The study aimed to present the biodiversity of the marine benthic phycological flora of White Beach, located in the municipality of Guarujá, Baixada Santista, State of São Paulo. Objective: This study will assist in the inventory of the phycological flora of the Baixada Santista Metropolitan Region, given that specific studies on algae have already been carried out, but nothing has been inventoried so far. Method: Sampling was carried out on low tide days according to the tide table provided by the Brazilian Navy. Samples of material were collected by scraping the algae from the substrate with a spatula, the material collected was inserted into plastic bottles, fixed in 4-5% formalin and exsiccated after its taxonomic identification. Results: We identified 33 taxa of marine macroalgae in White Beach, distributed in 4 large groups: Rhodophyta, Chlorophyta, Heterokontophyta and Cyanophyta. Conclusion: It is necessary to prioritize the need for on-site studies, as it is a place of difficult access and theoretically better preserved, enriching the collection of data on communities, facilitating the preservation and conservation of existing environmental resources in the city.*

Keywords: *marine macroalgae, taxonomy, White Beach.*

I. Introduction

This study aimed to present the biodiversity of the marine phycological flora of White Beach, located in the southwest northeast of the municipality of Guarujá (Fig. 1), metropolitan region of Baixada Santista, State of São Paulo. Santo Amaro Island emerged in its current form at the end of the Ice Age, between 10-20 thousand years, when the Bertioga Channel and the Santos estuary were opened, with the continuous rise in the level of the Atlantic Ocean and created the current island. , separating it from the mainland. The municipality of Guarujá has an estimated population of 265,155 inhabitants. Frequented by fishermen, shellfish gatherers, tourists, we find algae on its rocky shores, in addition to vegetation characteristic of the Atlantic Forest.

In country of the White Beach we find a caiçara community listed by CONDEPHAAT (Council for the Defense of Historical, Archaeological, Artistic and Touristic Heritage) in 1992. The community of White Beach is located in the eastern portion of the municipality of Guarujá, known as “Rabo do Dragão”, and is one of the few traditional communities found in the Baixada Santista region, with family groups that have lived there for over a hundred years. The place is named Village White Beach, due to its 1350 m beachfront formed by white sand (Fig. 2). One of the main accesses to the site is through a trail, which starts near the Guarujá-Bertioga barge (Fig. 3). Access to the beach is well signposted, with an easily accessible trail attracting tourists and surfers. White Beach also has strong waves, rip currents and rough seas.

Macroalgae or macroscopic algae can be found encrusted on surfaces such as rocks or floating, they can be only millimeters long or exceed 50 meters, forming true aquatic forests, they can also have a fragile aspect or a calcareous skeleton and due to their different pigments photosynthesizers have extremely varied

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colorations. They are separated into several large groups, such as red algae (Rhodophyta), green algae (Chlorophyta), brown algae (Heterokontophyta) and cyanobacteria (Cyanophyta).

They have great ecological importance, especially on rocky shores, where they play a fundamental role in providing oxygen, food and refuge, especially for invertebrates, in addition to being used as a nursery for various organisms. However, they are also very important to society. Algae serve as a food source, mainly in Asia and are used worldwide for the extraction of phycocolloids (agar, carrageenans and alginates).

They are also used as bioindicators to assess the environmental quality of coastal ecosystems, as they are at a lower trophic level and are periodically exposed to stressful conditions such as temperature variation, lighting, salinity, waves and other variables. Several genera of macroalgae have been used as bioindicators, in Pernambuco, Brazil, a study developed an environmental quality index with macroalgae as bioindicators, marine macroalgae were also used for this same purpose on beaches of the North Coast of the State of São Paulo.

The inventory, that is, the identification and collection of macroalgae, plays a very important role in understanding the local ecosystem, allowing us to understand the dynamics of the ecosystem. Little is known about the phycological flora of White Beach, although occasional studies on algae have already been carried out, nothing has been inventoried so far, it is unknown what actually exists in the algal biota. And at the present time in the Baixada Santista Metropolitan Region, it is not known to what extent human action has influenced the distribution of these algae, the loss of biodiversity and ecological importance. There is the possibility of sustainable exploitation, generating employment and income, which are some of the objects of investigation of this work.

Subsidize the local population of the importance of the algal biota for the maintenance of aquatic species, many of them a means of subsistence for the residents, most of whom are artisanal fishermen and small traders. Emphasizing that the municipality of Guarujá has been suffering a lot from ecological disasters in recent times, lacking awareness of the population, companies and inspection by the government.

Finally, the project aimed at a taxonomic survey of marine algae so far, it is unknown what actually exists in the algal biota of White Beach, in order to inventory the phycological flora of the Baixada Santista Metropolitan Region. With the objective of knowing, identifying, classifying, the genera, species, varieties and taxonomic forms of the representatives of marine benthic algae in the place and using such data to collaborate with knowledge about the biodiversity of the State of São Paulo, in addition to evaluating the use of morphological, metric and meristic characteristics as diagnostics for the separation of genera, species, varieties and taxonomic forms of algae, serving as a subsidy for works focused on cytology, genetics, ecology, physiology, biochemistry that demand the taxonomic identification of algal representatives.

Fig. 1. Map of the municipality of Guarujá, on the right the location of the White Beach.
Source: www.issa.net.br

Fig. 2. Partial view of White Beach.
Source: Passeiobaratosemsp.com.br

Fig. 3. Entrance to the access trail to White Beach.
Source: www.issa.net.br

II. MATERIAL AND METHODS

During the study, the widest possible sampling of the site was carried out in as uniform coverage as possible, with materials that present an equivalent representation of populations. Studies were always carried out at low tide in order to facilitate the work of sampling, for this purpose, spatulas and pocket knives were used to scrape materials adhered to the substrates, flasks and polypropylene bags for material storage. The samplings were carried out, preferably, close to the margin, in the coastal zone of the systems, where floating and fixed aquatic plants, totally or partially submerged, commonly occur. These environments are considered to be benthic algae concentrators.

Whole specimens were sampled. Information on the geographical source of the material (as complete as possible), including the date of collection and the name of the collector, were recorded.

Fixation and preservation of the materials were provided immediately after collection, still in the field, with 3-5% aqueous formalin solution (40% commercial formaldehyde) in glass or plastic bottles. Immediate fixation prevents the rate of cell division from being accelerated due to adverse conditions (sample concentration), which can promote the appearance of anomalous phenotypes. The algae were sorted and cleaned with running water, stored in a dark bottle in order to avoid discoloration of the algae. After 4 h in 4% formalin, the seaweed is removed and placed on a paperboard, this inside a tray with water, organizing the seaweed with the aid of a brush on the sheet of paperboard. The material is removed from the tray, placed between sheets of newspaper, then between sheets of cardboard, tied in the press, taking the material to the oven at 60ºC for a period of 48 h in order to lose moisture, after loss of this, the material is removed from the greenhouse, making the exsiccates, in order to supply the herbarium, under construction, of UNIP – Santos/Rangel.

The preparation of slides for observation under the optical microscope will follow the following routine: (1) cutting of reproductive structures or transverse sections of the thallus in order to assist in the identification of the species will be placed on a common microscope slide; (2) a drop of lugol's alcoholic solution may be added to the material to reveal the starch (pyrenoid); and (3) a coverslip was placed over the set of drops, taking care not to form a bubble. In some cases, a drop of methylene blue was also added to show mucilage and another drop of pure glycerin, to densify the medium and, consequently, facilitate the rotation of the structures on themselves and observe them from other angles.

The quantitative variables of the two areas were evaluated in their absolute and relative values, for qualitative analysis, at least 10 slides prepared from the material from each sampling unit were examined. The aim is to observe the largest possible number of specimens of each type and taxonomically exhaust each sample unit. The observation of the specimens was performed using a binocular optical microscope brand Olympus® CX31, with eyepieces of 10 magnifications and objectives of 4, 10, 40 and 100 magnifications. Carl-Zeiss® binocular loupes were also used in order to help identify the taxa. For each characteristic, as many measurements were taken as necessary (and/or possible) with the sole objective of accurately describing each identified species, variety or taxonomic form. Obviously, the minimum number of specimens observed depended on the size of the populations available in the preparations. The analysis of three preparations without a representative of any species, variety or taxonomic form not yet identified in that sample unit is admitted as taxonomic exhaustion. In the present study, however, for greater certainty of taxonomic exhaustion, 10 preparations from the same sample unit were examined without new species, varieties or taxonomic forms of algae.

The individuals found only once during the study were only identified when they presented their unequivocal diagnostic characters or when they did not present morphological variation or this variation was too small and considered negligible. The description of each species, variety or taxonomic form identified included all the diacritical or meristic morphological characteristics of the vegetative and reproductive phases of its life history that could be observed in the examined materials. When varieties and/or taxonomic forms other than the typical of the species have been identified, their descriptions only address the distinctive characters in relation to the respective typical. When it exists, it was related to the homotypic (nomenclatural) synonymy and, in particular, the basionym component. The heterotypic (taxonomic) synonyms were considered, however, only those that could be evaluated.

III. RESULTS

Thirty-three marine macroalgae taxa were identified in White Beach (Table 1), distributed in 4 large groups: Rhodophyta (16 taxa), Chlorophyta (10 taxa), Heterokontophyta (05 taxa) and Cyanophyta (02 taxa). In representative terms (Figure 5), the largest number of species was recorded in August, followed by July and December.

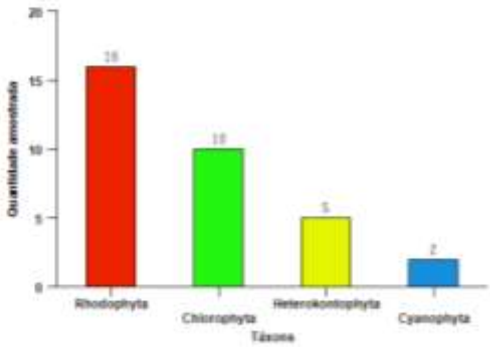

Fig. 4. Number of samples by taxonomic group.

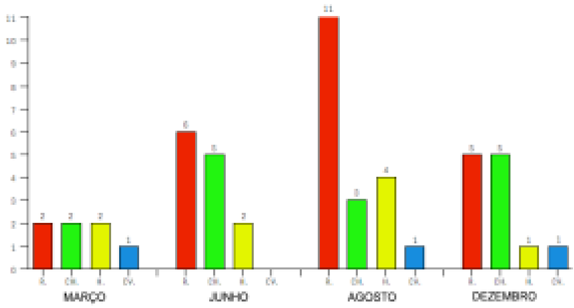

Fig. 5. Frequency of large groups of macroalgae inventoried of the White Beach, Guarujá, São Paulo, Brazil (period of August 2018 to July 2019).

Table 1. Macroalgae taxa identified in White Beach.

Species	Authors	Morphological description	Height	Width	Localizaton
Bryothamnion seaforthii	(Turner) Kützing	Flat thallus of fleshy consistency; pinnate branching; and with a red-orange color.	7 cm	0.8 mm	NA*
Bostrychia tenella	(Lamouroux) J. Agardh	Flattened stalk forming clumps; pinnate branch.	2.8 cm	0.1 mm	Intertidal region, growing on rocky substrate in areas with low wave incidence.
Caulerpa racemosa (Fig. 6A)	(Forsskål) J. Agardh	Greenish stalk; cylindrical rhizomatous portion; erect stalk formed by short pedunculated globoid branches resembling a bunch of grapes.	1.5-4.0 cm	0.1-2.0 mm	Infralittoral in protected regions.
Centroceras clavulatum (Fig. 6B)	(C. Agardh) Montagne	Tallus with dark red coloration; apices ending in tenacious; dichotomously branched; with nodes and internodes, the latter being covered by small cells.	1.0-3.0 cm	NA*	Present in the intertidal region, both in sheltered areas and exposed to the incidence of waves.
Ceratodictyon variabile	(J. Agardh) Norris	Cylindrical stalk; vinous to slightly greenish; solid; hard; irregularly branched; rhizomatous portion; discoid appressor.	2.4-4.8 cm	0.3-0.5 mm	Present in the midlittoral to infralittoral region; resistant to wave shock.
Chaetomorpha antennina	(Bory) Kützing	Filamentous green stalk; without branches; tufts form; discoid appressor.	2.5 cm	NA*	Plants forming isolated tufts on the rocky shore, in a place with high incidence of waves.
Chaetomorpha spiralis (Fig. 6C)	Okamura	Dark green stalk; delicate; without branching; filament formed by a row of cells.	2.5-4.5 cm	NA*	Found on rocky shores, in the coastal region.
Chondracanthus acicularis (Fig. 7A)	(Roth) Fredericq in Hommersan d	Cylindrical stalk; vinaceous; tapered apex; grows in the mid-coastal region; form tangled tufts.	1.7-4.0 cm	0.2-0.5 mm	Mesolittoral.
Chnoospora minima	(Hering) Papenfuss	Filamentous stalk; dichotomous branch.	4.5 cm	1.0 mm	Inhabits the intertidal region of the rocky shore.

Species	Authors	Morphological description	Height	Width	Localizaton
Cladophora corallicola	Børgesen	Olive-green filamentous stalk; dichotomous branching; cylindrical.	5.5-7.0 cm	1.0 mm	Coastal region of rocky shores.
Cladophora prolifera	(Roth) Kützing	Dark green stalk; forming tufts; dichotomous branching; rigid consistency.	1.8-1.9 cm	0.1 mm	Protected areas of the rocky shore.
Colpomenia sinuosa (Fig. 7B)	(Roth) Derbès & Solier	Stem in the form of a hollow globose bladder; brownish coloring.	1.5 cm	1.6-1.7 cm	Usually growing on other plants, from the intertidal region, in an environment with moderate incidence of waves.
Corallina panizzoi	Schnetter & Richt	Light pink calcareous thallus; irregular branching; segments longer than wide; interspersed by regions without calcium carbonate impregnation.	1.7 cm	NA*	NA*
Derbesia marina (Fig. 7C)	(Lyngbye) Solier	Stem forming delicate tufts; filamentous; olive green coloring; chloroplasts distributed along the filament; sharp apex.	3.0 cm	NA*	Infralittoral.
Dictyopteris delicatula (Fig. 8A)	Lamouroux	Brown colored stalk; in the form of a narrow ribbon; with midrib; dichotomous branch.	2.5-4.7 cm	0.5-4.0 mm	Lower part of the intertidal zone and infralittoral.
Gelidiella ligulata	Dawson	Vinaceous stalk; erect; prostrate cylindrical stoloniferous portion; fixed by appressoria formed by compact cells; leafy fronds; presents a central “rib” on the foliate thallus.	1.7-2.3 cm	2.0 mm	Protected locations.
Gelidium pusillum	(Stackhouse) Le Jolis	Erect stalk; simple or bifurcated apex; short branches.	1.0 cm	1.0 mm	Grow on rocky substrate or shells in the infralittoral.
Gymnogongrus griffithsiae (Fig. 8B)	(Turner) Martius	Vinaceous to greenish color; bifurcated apex; erect thallus arising from a prostrate thallus; grows in dense tufts; multiaxial organization.	1.0-1.7 cm	0.4-1.0 mm	Mesolittoral.

Species	Authors	Morphological description	Height	Width	Localizaton
Hypnea cervicornis	J. Agardh	Vinaceous thallus; gelatinous consistency; curved thallus branches.	1.5-2.5 cm	0.1 mm	Rocks in the mesolittoral.
Hypnea musciformis (Fig. 8C)	(Wulfen) Lamouroux	Pink thallus; cylindrical; much branched forming tangles; short thorn-like branches, often ending in hooks.	4.0 cm	1.0 mm	Present in both exposed and protected areas from the crash of waves.
Jania crassa	Lamouroux	Calcareous thallus; articulated; light pink; cylindrical; abundant dichotomous branching; segments separated by small decalcified regions called genicula.	2.5-3.0 cm	NA*	Shore beaten in the mesolittoral and infralittoral.
Laurencia dendroidea	J. Agardh	Vinaceous colored thallus; cylindrical; alternate branch; flaccid cartilaginous consistency; apical cell located in the thallus depression; discoid appressorium with stoloniferous portion.	3.0-3.5 cm	1.0 cm	They grow on rocks or other algae, in the intertidal region, in places with moderate incidence of waves, and in the infralittoral region.
Lobophora variegata (Fig. 9A)	(Lamouroux) Womersley ex Oliveira	Brown thallus; fan-shaped; whole; little cracked; growth by a margin of apical cells.	2.0-4.5 cm	1.5-3.3 cm	Present in the infralittoral.
Lyngbya martensiana	Meneghini ex Gomont	Filamentous thallus; brownish-green; form tangled tufts.	1.0 cm	NA*	Mesolittoral.
Lyngbya majuscula (Fig. 9B)	Harvey ex Gomont	Filamentous thallus; brownish-green; form tangled tufts.	1.5-2.0 cm	1.0 cm	Present in the mesolittoral.
Padina gymnospora	(Kützing) Sonder	Thallus with split fronds; brownish coloration; fan shape; curled margin.	1.8-3.0 cm	0.8-2.0 cm	Intertidal regions with low wave impact.
Pyropia acanthophora (Fig. 9C)	(E.C. Oliveira & Coll) M.C. Oliveira, Milstein & E.C. Oliveira	Thallus pinkish, greenish to brown; membrane; leafy stalk; discoid appressor.	1.8-7.0 cm	0.8-6.0 cm	Supralittoral.
Ulva fasciata (Fig. 10A)	Delile	Foliaceous thallus wavy in the form of a ribbon; light green.	6.0-9.0 cm	1.4-4.0 mm	Mesolittoral over rocks.

Species	Authors	Morphological description	Height	Width	Localizaton
Ulva flexuosa (Fig. 10B)	Wulfen	Light green thallus; tubular.	2.0-6.0 cm	1.0 mm	Mesolittoral to infralittoral.
Ulva lactuca (Fig. 10C)	Linnaeus	Emerald green foliaceous thallus.	1.1-6.0 cm	1.0-2.8 cm	Mesolittoral to supralittoral over rocks and mollusc shells. It can withstand the waves.
Ulva rigida (Fig. 11A)	C. Agardh	Light green thallus; foliaceous.	1.0-1.5 cm	1.0 cm	Intertidal zone, in a place protected from the collision waves, but with a lot of water movement.
Wrangelia argus	(Montagne) Montagne	Dark pink thallus; forms small tufts on beaten shore; main thallus with short branches arranged in whorls, densely branched; pointed end cell.	1.7-14.0 cm	0.1-1.0 mm	Present from the intertidal region to 7 m depth.
Wrangelia penicillata (Fig. 11B)	(C. Agardh) C. Agardh	Dark red to greenish stalk; delicate; evident main axis; lateral branches arranged vertically.	1.5-4.4 cm	NA*	NA*
NA*: Not applicable. Information not found in the bibliographic references.					

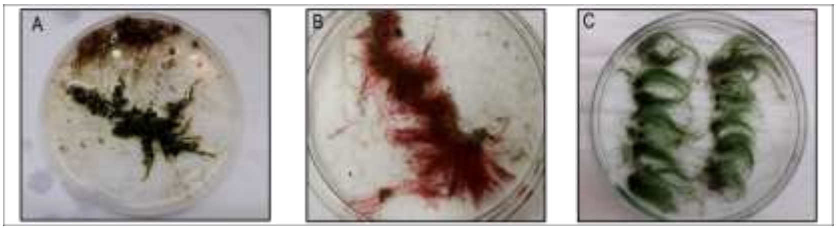

Figura 6. A. *Caulerpa racemosa*. B. *Centroceras clavulatum*. C. *Chaetomorpha spiralis*.

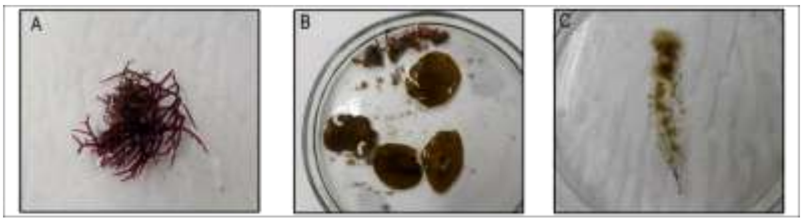

Figura 7. A. *Chondracanthus acicularis*. B. *Colpomenia sinuosa*. C. *Derbesia marina*.

Figura 8. A. *Dictyopteris delicatula*. B. *Gymnogongrus griffithsiae*. C. *Hypnea musciformis.*

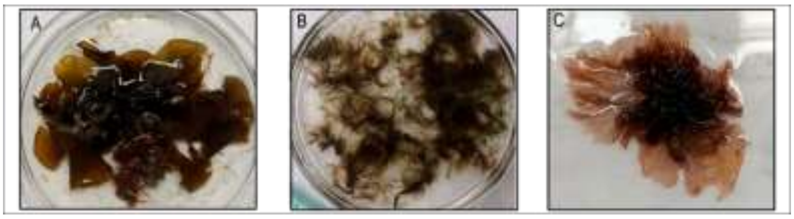

Figura 9. A. *Lobophora variegata*. B. *Lyngbya martensiana*. C. *Pyropia acanthophora*.

Figura 10. A. *Ulva fasciata*. B. *Ulva flexuosa*. C. *Ulva lactuca*.

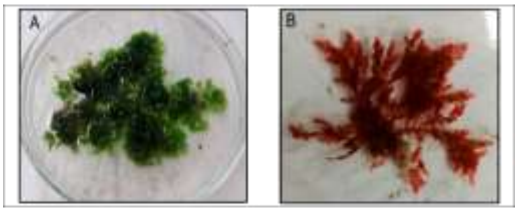

Figura 11. A. *Ulva rigida*. B. *Wrangelia penicillata*.

IV. DISCUSSION

The presence of certain algae may indicate anthropic environmental impact, as they serve as bioindicators of pollution. Algae of the species *Hypnea musciformis*, *Ulva lactuca*, *Cladophora* spp., *Gymnogongrus griffithsiae*, *Centroceras clavulatum*, *Ulva fasciata* and *Chaetomorpha antennina* found in White Beach are used as bioindicators in studies carried out by SOARES (2010) and on the north coast of São Paulo (2010) these taxa are used as bioindicators of eutrophication. Furthermore, ORTEGA (2000) describes the species *U. fasciata*, *U. flexuosa* and *U. lactuca* as indicators of high levels of organic matter, thus, a possible eutrophication. SOARES (2010) concludes in both works that the higher frequency of green algae, Chlorophyta, generally indicates a eutrophic environment, but there are some species of Rhodophyta, which were also found in the present study, that also grow disorderly in such environments. However, to reach conclusive answers, a quantitative and comparative study is necessary, taking into account the frequency of macroalgae taxa. Still on macroalgae as bioindicators, the species that stand out in trampled places (places with high anthropic action, usually closer to the area or with easy access), such as species of the genus *Chondracanthus*, are good indicators of anthropic impacts related to tourism, as there is strong tourism in the region, studies on the subject can reach interesting results on the anthropic impact caused by disordered tourism, even more so when evaluated in periods of high and low season. The composition of algal communities varies in the environment and reflects any environmental impact. According to REYNOLDS (1988), such composition depends on several biotic and abiotic factors, such as light, salinity, temperature, nutrients, diseases and predators. The month of March (Fig. 5) had the lowest species richness, which may be related to the intense beating of waves at this time of year. However, the lower species richness in March and the higher richness in August may also be a direct effect of tourism, considering that March is the end of the high season, when there are more tourists, and August is low season, when there is less tourists. However, for this hypothetical situation, a periodic study over a large amount of time is necessary. This study constitutes a first step, opening perspectives for several studies involving macroalgae in White Beach.

V. CONCLUSION

Faced with difficulties in accessing the site and sampling points, slippery places, very rapid tidal variation and the presence of a rough sea, the scarcity of data is a reality. As a result, studies on the site are necessary, as it is difficult to access and theoretically well preserved, giving an overview of the algal community on the coast of São Paulo with little anthropic interference, enriching the collection of data on them, facilitating the preservation and conservation of resources. environment in the city. In addition, the results obtained show that a future quantitative and comparative analysis of the algae found would be of interest, to understand if there is a relationship between the bioindicator species of environmental impacts and the other species.

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