Northeast Gulf Science

Volume 11
Number 1 *Number 1*

Article 1

7-1990

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DOI: 10.18785/negs.1101.01

Northeast Gulf Science Vol. 11, No. 1 July 1990 p. 1-10

OBSERVATIONS ON THE SIZE, PREDATORS AND TUMOR-LIKE OUTGROWTHS OF GORGONIAN OCTOCORAL COLONIES IN THE AREA OF SANTA MARTA, CARIBBEAN COAST OF COLOMBIA

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ABSTRACT: Gorgonian communities of the Santa Marta area are dominated by species with large numbers of large colonies (height ⩾40 cm) in contrast to that reported for other Caribbean sites where species with large numbers of small (<10 cm in height) colonies are predominant. *Cyphoma gibbosum* and *Hermodice carunculata* are the main predators of gorgonians in the area, but *Cyphoma signatum* and the fishes *Alutera scripta*, *Acanthostracion quadricornis* and *Chaetodipterus faber* were also observed feeding on gorgonians. Tumor-like outgrowths commonly appear in species of *Pseudoplexaura* and in *Plexaura flexuosa* and contain a chlorophyte *Entocladia* sp. Tubercle-like outgrowths in *Plexaura homomalla, P. flexuosa, Pseudopterogorgia americana* and *Plexaurella grisea* were found to contain a variety of invertebrates.

RESUMEN: Las communidades de gorgonáceos del área de Santa Marta están dominadas por especies con gran número de colonias grandes (altura ⩾40 cm) en contraste a lo registrado en otros sitios del Caribe donde predominan especies con gran número de colonias pequeñas (altura ⩽10 cm). *Cyphoma gibbosum* y *Hermodice carunculata* son los principales predadores de gorgonáceos en el área. *Cyphoma signatum* y los peces *Alutera scripta, Acanthostracion quadricornis* y *Chaetodipterus faber* también fueron vistos comiendo gorgonáceos. Formaciones parecidas a "tumores" aparecen comunmente en especies de *Pseudoplexaura* y en *Plexaura flexuosa* y contienen un alga clorofita, *Entocladia* sp. En *Plexaura homomalla, P. flexuosa, Pseudopterogorgia americana* y *Plexaurella grisea*, aparecen comunmente formaciones parecidas a "tubérculos" que contienen una variedad de invertebrados.

Gorgonian octocorals of the area of Santa Marta-Tayrona National Park are abundant and diverse (Botero 1987a). Dense gorgonian growth most commonly occurs (a) on hard, steep substrata adjacent to the coastline, (b) on shallow coral-octocoral patches in the middle of inlets, (c) on and around large submerged rocks whose tops emerge 2-3 m from the water surface (piedras ahogadas) and (d) around islets. Botero (1987a,b) described and quantified the zonation, density and diversity of gorgonian communities of the area. She concluded that the main environmental factors affecting their zonation and depth distribution are water movement, general unavailability of hard consolidated substratum below 20-25 m and relatively low water transparency (compared to other Caribbean locations).

The present paper adds to what is known about octocoral communities of the Santa Marta area by describing height frequency distributions of species at two representative sites, where examples of the gorgonian communities of the area can be found. It also reports on the main gorgonian predators of the area and on tumor and tubercle-like outgrowths appearing in certain species.

MATERIALS AND METHODS

The study area is located in the Departamento del Magdalena, Caribbean Coast of Colombia (Fig. 1). Botero

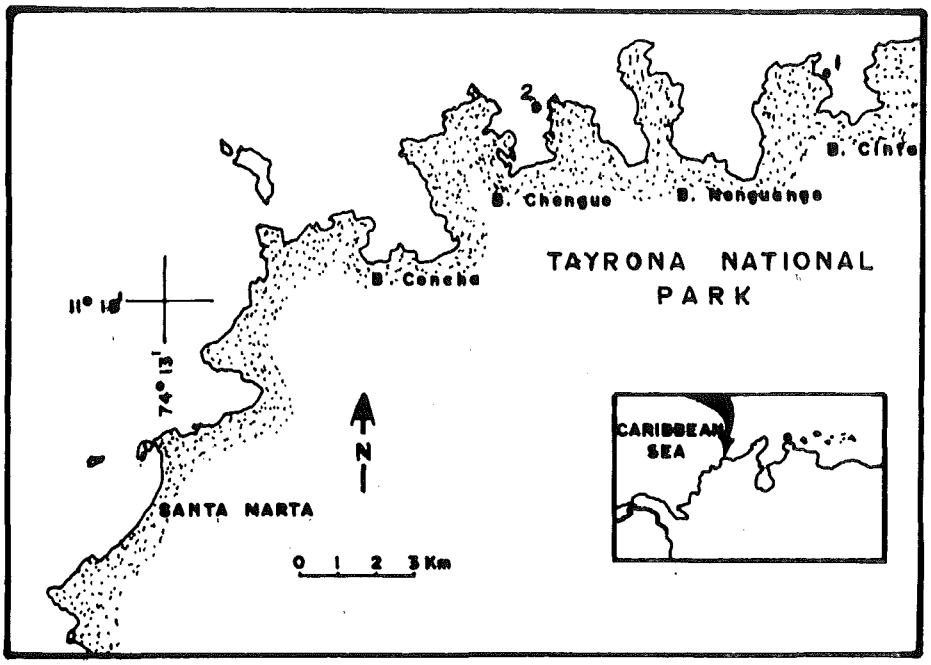

Figure 1. Study area showing the location of Stations 1 and 2.

(1987a,b) gives a detailed description of the prevailing environmental conditions affecting the area. Fieldwork was carried out during 1984.

Station 1. Located on the western side of Cinto Bay, it is exposed to strong trade winds blowing from the northeast and to strong wave agitation. Its depth is 9-12 m. The bottom substratum is a hard metamorphic rock platform covered with small sheet (encrusting) and mound-like scleractinians intermingled with calcareous sand patches and sheet and mound-like sponges. The most abundant scleractinians are *Montastrea cavernosa, Diploria* sp., and in a smaller proportion *Colpophyllia natans*. Gorgonian colonies are very abundant and tall, and the community as a whole has a characteristic pattern given mainly by the shape, height and predominance of the gorgonian *Plexaurella grisea*.

Station 2. Located on the eastern side of Chengue Bay, it is protected from strong wave agitation caused by the northeast tradewinds. Bottom slope is approximately 20-25° and the substratum is mainly hard metamorphic rock covered by scleractinian and gorgonian corals. The most abundant scleractinian species are *Montastrea annularis, M. cavernosa, Diploria* sp. and *Siderastrea* sp. Below 14-15 m depth the substratum changes to coarse sand and pebbles with some algal growth, and gorgonian and scleractinian corals disappear. Gorgonian colonies occupy a depth range of 0.5-14 m.

At each station, a 30 × 15 m plot was demarcated with nylon rope and subdivided into 5 × 5 m quadrats. All colonies in each quadrat were identified to species and their height was measured with a metered stick.

For coverage determinations a point-line transect method was used (Loya, 1978). Since gorgonians have a tree-like pattern of growth, both substratum and spatial (canopy) coverage determinations are important. A 50 m polypropylene line marked at 0.5 m intervals was laid 1.5 m above the bottom and counts were made of the number of points intercepting gorgonian branches and stolons. Interception of branches was used for spatial

DOI: 10.18785/negs.1101.01

(canopy) coverage determinations while stolon interception was used for substratum coverage determinations.

Counts of snails (*Cyphoma gibbosum*) on colonies of the different species were made once within the 30 × 15 m submarine plot. Each colony within the plot was examined.

Qualitative observations were made of tumor and tubercle-like outgrowths and of predation on gorgonians by other organisms.

RESULTS

Coverage

Canopy coverage is defined here as the area of substratum shaded by, or lying beneath the gorgonian "foliage". Substratum coverage is defined as the area encrusted or directly covered by the colony's basal stolon or by branches in direct contact with the substratum as can happen with very short colonies. Percentage coverage of gorgonian species is not necessarily directly related to their frequency of occurrence or to their density. It is a measurement that depends mostly on colony size, size of basal attachment or stolon, shape, and branching pattern. On the other hand, these may vary with age of the colony, from species to species and even from habitat to habitat within the same species. At Station 1 coverage of the substratum by gorgonians was 35% and was dominated by *Plexaurella grisea, Eunicea fusca* and *Eunicea succinea* (Table 1), the rest of the substratum being covered by scleractinian corals, sponges and sand. At station 2, where a depth gradient is noticeable, highest substratum coverage by gorgonians occurred at 8 m depth, was equal to 28% and was dominated by *Gorgonia ventalina* (Table 2). Canopy coverage was in all cases much higher than substratum coverage and this was expected since gorgonians occupy much more space (which is reflected on larger shaded areas on the substratum) in the water column than on the substratum (Tables 1 and 2). Sites with high frequencies of large-sized species such as *Pseudoplexaura flagellosa, Pseudoplexaura porosa, Pseudoplexaura wagenaari, Plexaurella grisea, Gorgonia ventalina* and *Plexaura flexuosa* have higher canopy coverage than sites where small species such as *Eunicea succinea, Muricea muricata,*

TABLE 1. Substratum and canopy coverage of the different species of octocorals found at Station 1. Data indicate number of points in the line transect intercepted by octocorals. Transect was layed at 10 m depth.

SPECIES	CANOPY COVERAGE	SUBSTRATUM COVERAGE
Gorgonia ventalina	2	0
Pseudopterogorgia acerosa	2	0
Pseudopterogorgia americana	8	1
Plexaura flexuosa	4	2
Plexaurella grisea	21	8
Plexaurella dichotoma	6	3
Pseudoplexaura wagenaari	1	0
Eunicea fusca	7	7
Eunicea succinea	7	6
Eunicea tourneforti	1	1
Eunicea asperula	6	3
Eunicea knighti	3	3
Eunicea calyculata	2	1
Subtotal	70	35
Corals, sponges, sand	30	65
Total	100	100

TABLE 2. Substratum and canopy coverage of the different species of octocorals found at Station 2. Data indicate number of points in the line transect intercepted by octocorals. C = canopy; S = substratum. Transects were layed at 4, 6, 8 and 12 m depth.

DEPTH / SPECIES	4 m		6 m		8 m		12 m	
	C	S	C	S	C	S	C	S
Gorgonia ventalina	14	9	10	4	13	9	3	1
Pseudopterogorgia americana	1	0	0	0	4	1	13	4
Pseudopterogorgia acerosa	0	0	0	0	1	2	0	0
Plexaura flexuosa	13	5	3	2	7	4	0	2
Plexaura homomalla f. *hom.*	2	0	0	0	0	0	0	0
Plexaura homomalla f. *kuk.*	4	0	1	1	5	2	2	1
Pseudoplexaura wagenaari	3	2	3	1	5	2	3	2
Pseudoplexaura flagellosa	3	2	0	0	3	1	0	0
Pseudoplexaura porosa	0	0	0	0	9	4	0	0
Plexaurella dichotoma	1	0	1	0	0	0	2	0
Eunicea fusca	0	0	0	0	0	0	1	3
Eunicea succinea	0	0	0	0	0	0	1	1
Eunicea asperula	0	0	2	1	4	1	1	0
Eunicea calyculata	0	0	1	1	3	1	1	0
Muriceopsis flavida	2	1	2	0	0	0	3	0
Muricea muricata	0	0	1	1	1	1	1	1
Muricea pinnata	0	0	0	0	0	0	1	0
Subtotal	43	19	24	11	55	28	32	15
Corals, sponges, sand	57	81	76	89	45	72	68	85
Total	100	100	100	100	100	100	100	100

Muriceopsis flavida and *Pterogorgia citrina* are most abundant. At Station 1, canopy coverage was 70% and was dominated by *Plexaurella grisea*. At Station 2, canopy coverage varied between 30-55% being highest at 8 m depth and was comprised mostly of a combination of several species (*P. flexuosa, P. homomalla, G. ventalina, P. wagenaari, M. flavida*).

Height

Height frequency distributions for some of the most common species in Stations 1 and 2 are shown in Figures 2 and 3. *Plexaurella grisea* and *Pseudoplexaura porosa* exhibited the largest heights (1.75-3.00 m); small colonies of these species were rare. *Gorgonia ventalina, Plexaura flexuosa, Plexaura homomalla, Pseudoplexaura wagenaari, Plexaurella dichotoma*, and *Pseudopterogorgia americana* had mostly intermediate heights (0.50-1.25 m) while *Muricea muricata, Eunicea fusca, Muriceopsis flavida*, and *Eunicea succinea* were small species (0.20-0.25 m).

Observations on *Cyphoma* and other predators

Figure 4 presents information on the frequency of occurrence of *C. gibbosum* on different gorgonian species and on the relative number of gorgonian colonies inhabited by *C. gibbosum. G. ventalina* and *P. acerosa* were the only species having more than 10 snails on the same colony at any one time. *Cyphoma signatum* was found only on colonies of *Plexaurella dichotoma* or *Plexaurella nutans*.

Egg capsules of *C. gibbosum* were observed on colonies of *G. ventalina, P. flexuosa, E. fusca, P. grisea*, and *P. dichotoma* in September and October when water temperature was highest.

Predation of gorgonians by other species was also observed. The polychaete *Hermodice carunculata* was abundant in the study area and was often seen eating the tips of gorgonian branches by introducing as much as 2 cm of a branch into its buccal cavity. When the worm had finished eating, the

DOI: 10.18785/negs.1101.01

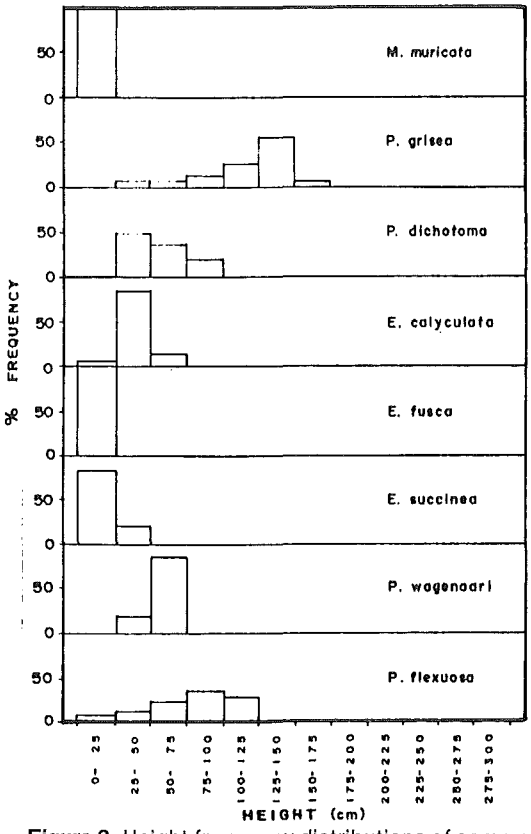

Figure 2. Height frequency distributions of some of the most abundant gorgonian species at Station 1.

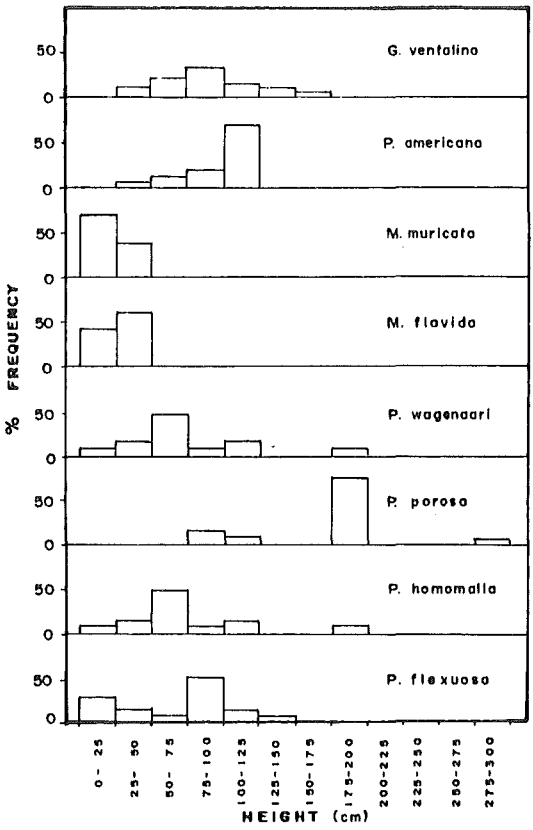

Figure 3. Height frequency distributions of some of the most abundant gorgonian species at Station 2.

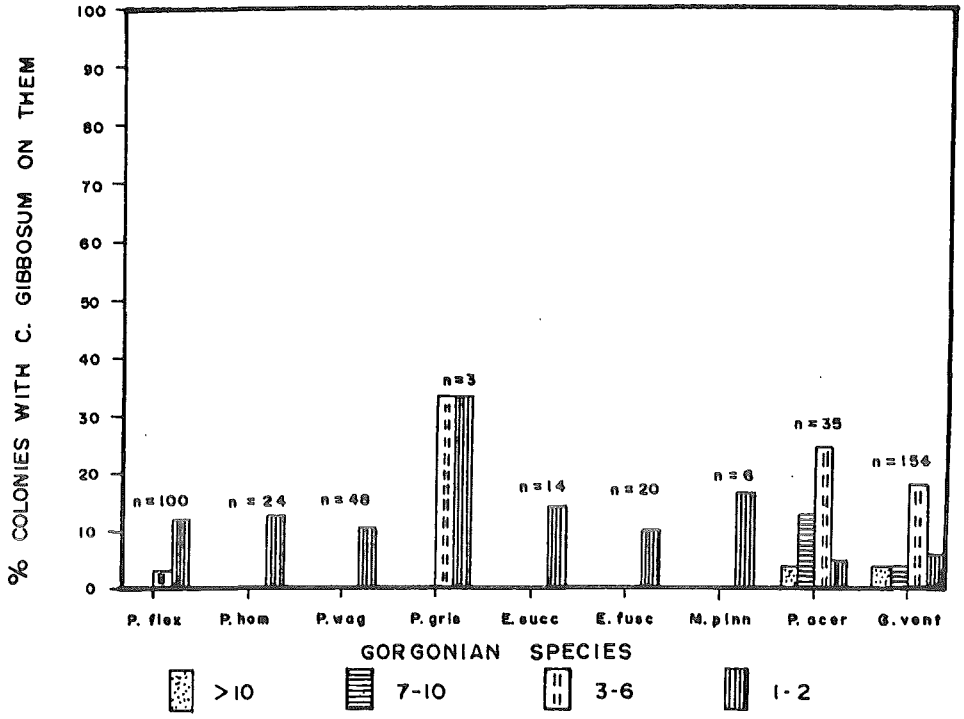

Figure 4. Percentage frequency of occurrence of gorgonian colonies with *Cyphoma gibbosum* on them. n = number of colonies observed. Bar pattern indicates number of snails per colony.

branch tip would be completely denuded of its coenenchyme and polyps, and only the bare horny axis remained. The fishes *Alutera scripta, Acanthostracion quadricornis* and *Chaetodipterus faber* were seen feeding on gorgonians, and stomach contents of *C. faber* revealed a substantial amount of *G. ventalina* (A.Acero comm. pers.).

Tumors and tubercles

Colonies of *Pseudoplexaura porosa, P. flagellosa, P. wagenaari* and *Plexaura flexuosa* often exhibited tumor-like outgrowths very similar to the "algal tumors or nodules" described by Goldberg & Makemson (1981). Tumors were flabby (soft) and varied in size between 3-8 cm in longest dimension and 2-4 cm in thickness (Fig. 5). The external tissue or coenenchyme may or may not have polyps; when present on the surface, polyps were always retracted even if those on the rest of the colony were extruded. The infesting alga was identified as a Chlorophyte, *Entocladia* sp. It was contained within "chamber-like" spaces that were surrounded by a layer of gorgonin. In between these chambers, normal-looking coenenchyme with spicules was found (Fig. 6). In *P. flexuosa*, infesting algae were surrounded by coenenchyme, but no chamber-like spaces surrounded by gorgonin were observed.

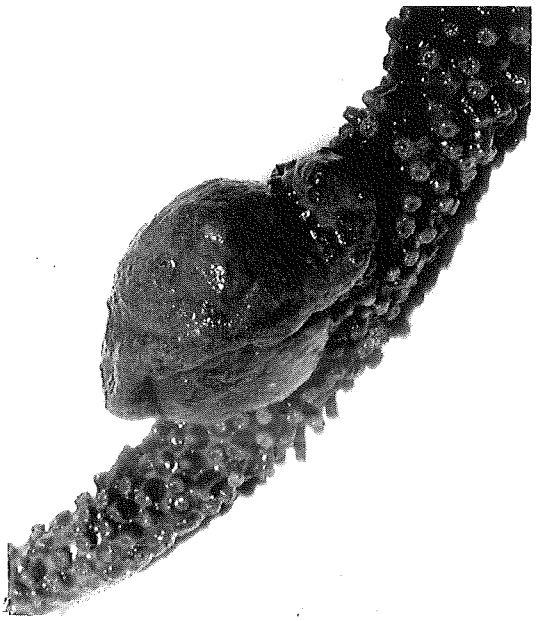

Figure 5. Photograph of a tumor-like outgrowth on a branch of *Pseudoplexaura porosa* (fixed specimen).

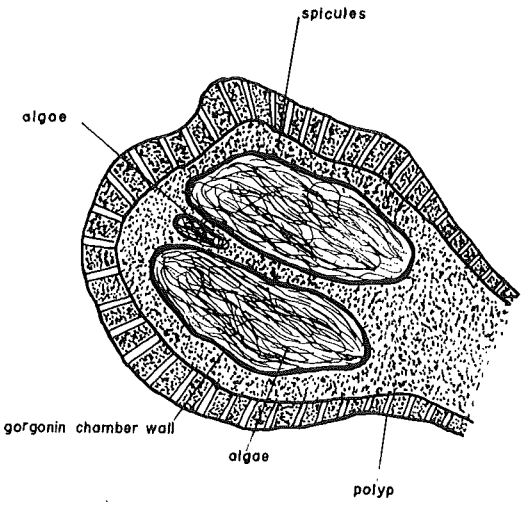

Figure 6. Schematic representation, in cross section, of the inside part of tumor-like outgrowths appearing in *Pseudoplexaura porosa*.

Colonies of *P. homomalla, P. flexuosa, P. americana* and *P. grisea* commonly exhibited hard, tubercle-like outgrowths (Fig. 7). After dissection in the laboratory, they were found to contain a variety of organisms some of which were alive and some dead. Dead barnacles and empty molluscan shells were common, but small crabs, shrimps, bivalves (*Lithophaga* sp.), sipunculids and sponges were usually found alive. They were all enclosed by a thick horny layer of gorgonin that was itself covered by coenenchyme and polyps. Communication with the external water column was only through very small openings. I speculate that these organisms had probably settled on exposed gorgonian axes and were subsequently overgrown by the octocoral's axial and cortical tissues.

DISCUSSION

Lasker & Coffroth (1983) noted that among octocorals at Carrie Bow Cay

DOI: 10.18785/negs.1101.01

(Belize) species with low recruitment rates (as evidenced by the absence of small colonies) were never the most abundant members of the community. In contrast, species with large numbers of small (<10 cm) colonies were always the predominant species. The authors propose that this is due to the unstable substratum of their study area which will no longer hold colonies after they reach a certain size. In my study area, height frequency distributions are very different from those found at Carrie Bow Cay; this probably reflects differences in environmental conditions between the two areas, particularly substratum. Species with large numbers of large colonies (>30 cm) were always predominant and, in general, communities were dominated by large colonies (≥40 cm). The maximum height of adult colonies of the different species must be taken into account. *Eunicea fusca, Eunicea succinea, Muricea muricata* and *Muriceopsis flavida* are small species, which are reproductively mature at maximum heights of 30-40 cm. Larger colonies of these species were never found in the area, and colonies smaller than 10 cm were low in numbers. Colonies of large-sized species (Bayer, 1961) such as *Pseudoplexaura porosa, Pseudoplexaura flagellosa, Plexaurella grisea, Plexaurella nutans, Plexaurella dichotoma, Plexaura flexuosa* and *Plexaura homomalla* were most commonly found in my study area with heights ≥50 cm. Colonies of *Plexaurella grisea* and *P. dichotoma* smaller than 40 cm in height were never found, even though they were the dominant species at Station 1. Here, most colonies were ≥1 m. *Pseudoplexaura* showed a low proportion of small colonies at the different stations. I suggest that recruitment to octocoral communities of Tayrona National Park does not occur as often as in Carrie Bow Cay or other locations where calcareous substratum is unstable and easily bioerodable. At Tayrona National Park, hard metamorphic rock substratum is very stable and catastrophic storms (hurricanes) have not occurred, thus, mortality of high colonies because of toppling is low, even at exposed wave surge sites. In general, I found that in agitated places in Tayrona National Park, gorgonians remain firmly attached to the substratum. Overall, colonies are longer-lived and recruitment is not common or constant. Bak & Engel (1979) described three life-history patterns in scleractinians: 1) abundant juvenile recruitment; 2) abundant vegetative reproduction and 3) low rates of recruitment and high survival. If applied to gorgonians of Tayrona National Park, I hypothesize that low rates of recruitment and high survival of colonies is the dominant pattern.

Figure 7. Photograph of a tubercle-like outgrowth on a branch of *Plexaurella grisea* (dried specimen).

Opresko (1973) reported maximum heights for species in the area of Miami.

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His values are lower, especially for the tall species, than those measured in Tayrona National Park. While *Plexaurella grisea* reached 1.5-1.7 m in my study area, maximum heights in Miami were 25-46 cm. *Pseudoplexaura porosa* attained heights of 3 m in Tayrona National Park while in the Miami area it reached a maximum height of 1.16 m and its average size was 36.5 cm.

Dominance of large colonies in Tayrona National Park can account for the general low densities if compared to other studied Caribbean sites (Belize, Jamaica, Miami) where densities are higher but colonies are smaller. Wahle (1985) and Lasker & Coffroth (1983) reported densities of 16-30 colonies/m² in Jamaica and Belize, respectively. Opresko (1973) and Goldberg (1973) measured densities of gorgonian colonies as high as 25 colonies/m² in the Miami area. In Tayrona National Park maximum recorded densities were 6 colonies/m². I hypothesize that the large sizes of gorgonians in Tayrona National Park and their consequent low density are due to their higher survival (longer life span), which in turn is a result of the stable substratum and lack of hurricanes or catastrophic storms (which reportedly account for high mortalities at other Caribbean sites, Cary, 1914; Woodley *et al.*, 1981). Cary (1914) concluded that protection from storms is one of the major factors determining the size of gorgonian individuals in a population.

Since the number of colonies of each gorgonian species observed differed, it is difficult to conclude whether the snails preferred one or several species of gorgonians over others. Frequency of occurrence of snails on the different gorgonian species could have depended on the availability of species rather than on preferences. Birkeland & Gregory (1975) found gorgonians of the family Gorgoniidae, especially *Gorgonia* spp. to be preferred by *C. gibbosum* over plexaurid (family Plexauridae) gorgonians, and preference was not clearly influenced by previous meals. Behety (1980) reported that *C. gibbosum* preferred plexaurid over gorgoniid species in agitated places because of their higher rigidity. In contrast, in deeper and calmer places, *C. gibbosum* selected species in relation to their texture, *i.e.* softest species were preferred regardless of their rigidity. At my study site, 2 species of Gorgoniidae (*Pseudopterogorgia acerosa* and *Gorgonia ventalina*) were the only ones found to have more than 10 snails per colony at any one time and they also produced the largest percentage of colonies (45% and 33%, respectively) with snails on them. Qualitative observations in several sites of the study area showed more snails on *G. ventalina* than on any other species, regardless of agitation conditions and of the presence of plexaurid species. Where *G. ventalina* was low in numbers (as in Station 1), *C. gibbosum* was most common on the most abundant species (*Plexaurella grisea* at Station 1).

Theodor (1964), Morse *et al.* (1977, 1981), Goldberg & Makemson (1981) and Goldberg *et al.* (1984) reported and described algal tumors similar to those reported here, appearing in axes of certain gorgonians, mainly *Gorgonia ventalina* and *Pseudoplexaura* spp. At my study area, tumors were never found on *G. ventalina*. In *Pseudoplexaura* spp. the infecting alga was identified as a Chlorophyte, *Entocladia endozoica* by Goldberg *et al.* (1984). In Tayrona National Park the alga was identified as *Entocladia* sp, and possibly it could be the same species. The tumors consisted of masses of this filamentous green alga that separated normally tightly apposed laminae of the gorgonian horny skeleton.

DOI: 10.18785/negs.1101.01

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