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ASPECTS OF THE BCOLOGY OF PSEUQUPTEROGORGIA AMERICANA

?AND PSEUDOPTERCWORGTA? ACERISA?

by

Beverly Buchanan Yoshioks

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CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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AND PSEUDOPTEROGORGIA ACEROSN?

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abstract

Poeudopterogongia americana and P, cerocs are among the most abundant gorgonian species on meny western Atlantic reefs. P, americana can be distinguished fro ¥. acerooa in the field by its sliminess. The two species are found to- gether over a wide range of depths and habitats. Small seale dispersion patterns, densities, age frequencies, mortality, recruitment, growth, reproduction, end interactions with other organisms were studied.

Studies of small scale dispersion patterns revealed

that substrate heterogeneity contributes to aggregated dispersion patterns of gorgonians. The nunber of gorgonians was inversely related to the amount of coral and other sessile organism cover which may also contribute to these aggregated dispersion patterns. The aggregated dispersion pattern of P. americana on even substrate may be due to a Limited ability of the larvae to disperse

The relative densities of the tuo species differed at Gifferent sites. Site (1) had the highest densities of both species with P. americana being far more abundant than P. acerosa, while P. acerosa was almost as or more abundant than P. americana at other sites which had lover absolute densities of both species. Age Frequency percentages were uoually not significantly different between the two species at different sites indicating that they respond similarly

to a variety of factors which control age frequencies. Re~

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cruitment studies indicate that gorgonians compete with each other and other sessile organisms for space, and the extremely high recruitment of P. americana in cleared quadrats suggests that it is a colonizing species. Yortality was not significantly different from recruitment indicating that populations were stable over the study period.

Growth rates were measured by annual length increments

in colonies and compared to growth estimates based on col-

ony length per growth ring. Rings were found to be annual and were used to estimate grovth rates at all sites. Linear growth rates were about 5 en/yr for P. americana and 6 cm/yr for P. acerosa. Length-veight comparisons indicated that the grovth form of the two species is similar, Growth rates are higher for colonies exposed to higher Light levels, and this explains about 20% of the variability in growth rates

Sexes are separate in colonies of the two species P. anericana had a slightly higher ratio of females than males, while P. ecerova had an even ratio between sexes Gonadal volume was used as an index of revroductive perio- @ieity, and synchrony within and between sexes for the two species are discussed. Small colonies usually lacked gonads indicating that reproduction is delayed for at least three to five years.

Damage by Cyphona gibbosum, an ovulid gastronod which

stazes on gorgonian tissue, is sometimes responsible for

encrusting organisms settling on gorgonians and thus may

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contribute to mortality. Other conmensal or parasitic

organisms found on the two species did little obvious

damage, Thalascoma bifasciatu, the bluehead wrasse, was

often seen picking at gorgo:

s, but gut contents had few,

if any, gorgonian remains.

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cknow

edgements

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All students of the Department of Marine Sciences who accompanied me diving. especially Ms. Ana Sardales and Ms. Ileana Clavijo who also aided by collecting fish.

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type this manuscript

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helped me complete this study

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Introduction

Gorgonians are among the most conspicuous anc abund:

fauna on western Atlantic coral reefs. The familes Plexauridae and Gorgoniidae, in particular, are nore abundant and diverse in the West Indies than anywhere else in the world (Bayer, 1961). Nevertheless, very Little work has been done on the population dynamics of individual species, Particularly in the western Atlantic.

Peeudopterogorgic anericana (Gmelin) and Pseudopterogorgia acerosa (Pallas) are very similar congenerics which frequently cannot be distinguished by sight in the field.

Both species are pinnately branched plumose gorgonians with slightly flattened branchlets. Polyps lie in single or biserial rows on the edges of the branchlets. Preliminary study revealed that P. americana and P, accrosa do not differ in the size of the polyps, the number of polyps per branchlet, or the number of branchlets. Branchlets are usually in one plane for both specious, but tend to vary more in large specimens of P. acerova. ?his, plus a tendency for large P. acerosa to be paler in color than large P. americana tends to make large colonies of the tuo species distinguish-able by sight. The extreme sliminess of P. anertcana versus the ?dry" or waxy texture of P. acerosa is @ very reliable means of distinguishing the two species in the field. This

copious mucus production of P. americana may be related to

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the very large number of synbiotic vooxunthellae found in this species compared to the munber found in. evinosa (ayer, 1961).

Both P. americana and P. aceroua are reported through-out the Caribbean, the Gulf of Mexico, Florida, and Bermuda (ayer, 1961), P. anerteana is reported to occur from the

surface to 45 m deep, while P. acerosa is reported to occur
from 4 to 33m (Kinzie, 1970, 1973).

The order Gorgonacea is divided into the suborders of Seleraxonia and Wolaxonia. Only two species of scleraxonians were found on the study sites, and both of these are en crusting or lobate forms. Due to their growth form, sclera- xonians were included with encrusting organisms such as corals for the purpose of this study. The term ?gorgonian?

refers to holaxonian

gorgonians only in this study

The objectives of this study are to (1) compare patterns of distribution and abundances of Peeudoptorogorgia americana

and Peeudopterourrgia ace

and (2) to conpare factors which
may influence their distributions and abundances, such as mortality, recruitment, growth, reproduction, and interactions

with other organisms

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Literature Review

Bayer (1961) summarized the ecology and zoogeography of Caribbean gorgonians. Kinzie (1970, 1973) did the most complete work to date on gorgonian abundances and distributions for the Caribbean. He defined ten zones with characteristic gorgonian species assemblages in Jamaica. Although a "Peeudopterogorgia zone" was not present on the north coast of Jamaica, he noted its presence elsewhere. Other descriptive or quantitative studies on gorgonians in the Atlantic were done by Cary (1914, 1917, 1918), Goldberg (1973a), Opresko (1973) and Preston and Preston (1975). Grigg (1970, 1977) intensively examined the population dynamics of two species of Muricea in California.

Factors affecting gorgonian distributions include tenperature, light, salinity, water motion, and sedinentation Temperature and salinity tolerances were measured by Cary

(2917, 1918) and Goldberg (19734). In the latter study optinel salinity ranges for sudop crogoryia ave rscana

ranged from 30 to 43*/.., and temperatures ranged from 19.5

to 29.5°C. The relatively low upper temperature limits for P. americana may have been due to excessive mucus production under laboratory conditions. Temperature and salinity may have effects on gorgonian distributions (veinberg, 1979). The amount of light available is important for gorgo-

nians containing symbiotic algae (Kinzie, 1970, 1973;

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Weinberg, 1976, 1978). shallow water symbiotic gurgonians appear to be more dependent upon theix zooxanthellae than hard corals are (Goreau, 1964; Kinzie, 1970, 1973, 1974b) and should therefore be dependent upon light.

Both presence and absence of vater movements are limiting for gorgonians (Barham and Davies, 1968; Kinzie, 1970, 1973; Birkeland, 1974). Heavy mortality and damage such as abrasion is most frequently caused by storm waves

(Cary, 1914, 191:

Goreau, 1964; Stoddart, 1962; Glynn, et

at., 1964). Gary (1914) and Weinberg and Weinberg (1979) noted that large colonies are more vulnerable to wave stress than small ones, Birkeland (1974), however, in a study on storm effects on Gorgonia found that detachment due to storm waves may set an upper limit to colony size, but the greatest. mortality was in the smaller than average size ranges. Although storm waves may be the immediate cause of mortalities, bicerosion of the substrate beneath the colony largely controls the strength of the attachment (Goreau and Hartman, 1963; Kinzie, 1970; Birkeland, 1974)

Small colonies, in particular, are vulnerable to heavy sedimentation (Weinberg, 1978). Preston and Preston (1975) concluded that gorgonians thrive even on a reef subject to high siltation and turbidity. Cary (1914) indicated that newly settled gorgonian polyps, due to their rapid growth perpendicular to the substratum, heve an advantage over

newly settled scleractinian polyps. We also notes that

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storm waves stripped the tissue off of the bases of colonies, and he attributed this to a "twisting" of the colonies by waves.

Biological factors affecting distributions have not been well studied. Kinzie (1970, 1973) found that the availability of hard substrate was the single most limiting factor to gorgonians. Although substrate space is a physical factor, Grigg (1970, 1977) indicated that suitable substrate may be limited by competition. He found no evidence for competition for space between the two species of Muricea but concluded that this was due to the heavy competition for space with other organisms. Kinzie (1970) found that Murices taza Verrillis capable of damaging other gorgonians with its large, spiny spicules. The heavy settlement of gorgonians in storm or artificially cleared areas (Cary, 1918; Opresko, 1974; Kinzie, 1970, 1977; Birkeland, 1974) is strong evidence for the existence of competition for space. Stoddart (1963) indicated that gorgonians in storm devastated areas recover more rapidly than hard corals

Encrustation by other organisms, especially Millepore sp., {8 @ common cause of mortality in gorgonians (Cary, 1914; Theodor, 1964; Kinaie, 1970; Grigg, 1970). Even apparently benign attached animals such as the bivalve, Ptemia spp., may contribute to mortalities by their weight and water resistance (Weinberg and Weinberg, 1979). Randall (1967)

found significant gorgonian remains (greater then 5%) only

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in the gut contents of the filefish, Azutc

»ta (Osbeck)

Known invertebrate grazers of gorgonians include the amphi-noaid polychaets (Kinzie, 1970; Birkeland, 1974), and gas-tropods of the genera Cyphona, Simnia, and Coraliophila ayer, 1961; Ghiselin and Wilson, 1966). Birkeland and Gregory (1975) found cypkowa gibbocum (Linnaeus) to be a ?prudent predator" in the sense that it rarely overgrazes individual colonies. Cyphona gibbosum is a major source of mortality to Jamaican octocorals (Kinzie, 1970). Denuded parts of the skeleton are potential sites for infestation by encrusting organisms (Cary, 1914; Kinzie, 1979, Birkeland

1974). Weinberg and Weinberg (1979) found similar results for Heostmnia epelta speita (Linnaeus) which feed on Ewsicella singularts (Esper) in the Mediterranean. The effects of predation on small colonies have not been reported. Many motile invertebrates such as Astrophyton muricatum (Lamarck), the basket star, and members of the genus ophio- thriz occur on gorgonians (Bayer, 1961; Clark, 1933). Astro phyton murieatun frequently utilizes Pseudopterogorgia spp. as a substrate from which to filter feed in the water column (Wolfe, 1978). The caridean shrimp, rozcuna carolinensis Kingsley, is known to occur on Peeudopterogoria spp. (Bayer, 1961). Harpacticoid copepods and other organisms such as algae have been found in swellings on gorgonians (Theodor,

1964)

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Growth rates of gorgonians vere measured by (ary (1914), Grigg (1970, 1974, 1977), Kinzie (1970), and Weinberg and Weinberg (1979). Growth rates measured by the increase in branch length or colony height varied from 1 to 6 em per

year. Grigg (1974) also aged colonies by using growth rings.

Strong currents or surge affect the growth forns of gorgonian colonies (Theodor, 1963). Gorgonians which are fanlike or branch in one plane tend to orient themselves normal to the direction of water motion (Barham and Davies, 1968; Theodor and Denizot, 1965; Wainright and Dillon, 1969; Rees, 1969; Grigg, 1972). Originally thought to be an adaptation for feeding (Laborel, 1960; Barham and Davies, 1968), orientation has been shown to be controlled by hydrodynamic factors (Theodor and Denizot, 1965; Wainright and Dillon, 1969; Rees, 1969; Grige, 1972).

Roushdy and Hansen (1961) showed that gorgonians are capable of filtering phytoplankton. They believed, however, that zooxanthellae comprised a major part of the diet Kanwisher and Wainright (1967) established the importance of zooxanthellae to coral nutrition. Attempts to observe Polyps actively feeding have been largely unsuccessful (Rees, 1969, 1972; Wainright, 1967). Grigg (1970) observed active feeding on zooplankton by furicea spp., a gorgonian which lacks zooxanthellae, Kinzie (1970) observed Peeudo-Pterogorgia bipinnata and other gorgonians feeding on par-

ticulate matter but found them unable to capture live z00-

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Plankton. Bayer (1961) stated that some gorgonians with abundant zooxanthellae have few or no nematocysts. A com Parison of day versus night polyp activity to zooplankton abundances indicated that most polyps were open during the day when zooplankton are scarce (Wainright, 1967). Pseudo. Pterogorgia spp., however, were usually expanded at night.

Early reproductive work on octocorals in the Red Sea by Gohar (1940a, 1948) indicated that colonies have separate sexes and gonads are born on the six sulcal mesenteries. Sperm are formed in sacs called spermaries which are re-leased from the polyp intact and open shortly after to release ripe sperm. Bayer (1974) implies that spermaries are not released, but are resorbed after releasing the sperm Ova are often retained and fertilized internally, and octo-corals may be viviparous or oviparous (Gohar, 1940a, 1940b, 1948; Gohar and Roshdy, 1961). Bayer (1974) and Goldberg, and Hamilton (1974) found no sign of developing larvae or dividing eges in Plezaura homomatta (Esper). Kinzie (1970) found Peeudopterogorgia bipinnata (Verrill) and Pseudoptero-gorgia elisabethae (Bayer) to be viviparous. Grigg (1970, 1977) found an even sex ratio of colonies, and colonies as old as ten years had no reproductive activity. He discovered that turicea fructicoca (Verrill) contained gonads at about four years and M. eatifornica (Aurivillius) at six years.

He pointed out, however, that it might be another four to

six years before gonads achieved the size found in older

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colonies. Goldberg and Hamilton (1974) studied reproductive

Periodicity in Plezauxa homomatia.

Larval development and metamorphosis have been studied

by Gohar (1940a, 1940b, 1948), Gohar and Roushdy (1961),

Theodor (1967b) estimated the survival rate of Funicelle

stricta (Rossi) larvae as one in 60,000 for the first year.

Kinzie (1970, 1974b) reported that planulae may swim for

some time or fall quickly to the bottom where they crawl

Larvae of Eunicedia singutaris (Esper) crawl over 2 to 40 m

of bottom and attach about 30 hours after emission (Weinberg

and Weinberg, 1979). Funicetta eingulanie larvae exhibited

photopositive behavior in laboratory studies, but this was

difficult to confirm in the field (Weinberg, 1979b). Prefer-

ence for rugose bottoms was noted by Cary (1914), Gohar

(4940b), Bayer (1961), and Theodor (1967b). Kinzie (1970)

found no significant preference for light versus dark or

smooth versus rugose substrate, The survival of very small

colonies (under 1 cm) has not been reported, though Weinberg,

(2979a) believed it to be important

Gorgonians were found to exhibit some antimicrobial action in bioassays (Burkholder and Burkholder, 1958). The discovery of large amounts of prostaglandins in Piezaura homomatia (Weinheimer and Spraggins, 1969) encouraged extensive examination of gorgonians for chemical compounds Since then a number of organic compounds in gorgonians have

been found to have weak antimicrobial activity which possibly

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inhibits overgrowth and predation by other organivns

(Ciereszko, et al., 1960; Ciereszh

et al., 1960; Weinheiner,

et at., 19682). Weinheimer, e¢ al., (1968) found sesquiterpene hydrocarbons in Peeudopterogorgia ancricana.

Bayer (1951, 1953, 1959) published a number of works on gorgonian systematics, zoogeography, and evolution followed by the most comprehensive taxonomic study on West Indian gorgonians to date (Bayer, 1961), The first study which included West Indian gorgonians was by Duchassaing and Nichelotti (2860, 1864). Kukenthal (19162, 1916b, 1919) did a comprehensive account of West Indian gorgonians, Deichman (1936) Published a monograph on the alcyonarians of the Blake expedition. A number of other papers include species Lists of gorgonians found in particular areas of the western Atlantic (Rargitt and Rogers, 1900; Gonzélez-Brito, 1970a, 1970b; Rees, 1973; Voss and Voss, 1955)

According to BayerQ961) spicule characteristics are the most distinguishing features betucen these two species of Poeudopterogorgia. Spicule sizes are in the same range, but F. americana has strongly curved scaphoids with spiny convex sides while P. acerosa has slightly curved scaphoids with smooth convex sides. He also mentions the extreme sliminess

of P. americana versus the "dry" or waxy texture of P. acerona.

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Materials and Methods

Physical Measurements

All field work was performed using SCUBA gear. Field data were recorded on plastic slates or underwater paper Depth was measured either with a capillary or of! filled depth gauge. Temperatures were measured with an ordinary

laboratory centigrade the:

oneter. Slope angles were measured to within 5° with a plastic protractor equipped with @ plumb line, Visibility, surge, and currents vere visually estimated whenever sites were visited and are relative be- tween sites

Study Sites

Site (1), near Magueyes Island, was chosen for intensive and temporal measurements. It is @ patch reef located ap- proximately 300 m SE of the channel between Cayo La Gata and Cayo Caracoles, almost in @ direct line between the channel and Cayo Turromote (Figure 1). The reef is approximately

250 m long and 200 m wide, and dept!

s vary from 3 to 15 m

The top of the reef is a gently sloping plateau which slopes

sharply downward at a depth of 4 to 6 m, whe:

e it may be

Perpendicular or undercut to the reef base (about 15 m deep).

?The shallowest depths are on the northwestern side of the

reef which is dominated by living and dead sercrora palmata.

Gorgonians are very abundant to the east with occasional

large heads of stony corals such as Yendvogyns eylindricus

Or Montastrea annularis. ?cropora cervicornis stands occur

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Figure 1. Map of south west Puerto Rico

showing the study site locations.

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randomly on the reef plateau. The substrate on the plates: area is uneven rock with frequent small patches of sand.

In addition to the abundance of gorgonians, this reef was chosen as the major study site because of its proximity to the laboratory and easy access in most weather. Dis-advantages of this area included poor visibility and strong surge action. Visibility ranged from about 2 to 15 im with an average of 6 m. Surge vas often strong on the plateau due to shallowness and exposure of the reef to the prevalent southeast winds and waves, while surge on the slopes (even on the fore reef) was much less, Temperatures were uniforn from the top to the bottom of the reef on the two times measured, and a thermocline was rarely noticed. Current velocities were weak and did not exceed 13 cm/sec. When apparent, currents were fron the southeast which is the direction of the prevailing winds. Orientations of the plane

Of branching of gorgonians have been suggested as indicators Of the presence and direction of strong surge or currents (Barham and Davies, 1969); and on this reef are strongly oriented with the plane of branching perpendicular to the surge. Accumulated sediments and poor visibility indicate a high siltation rate on this reef. The reef base, especially, receives a great deal of sediments which are moved there by surge action from the plateau.

Site (2) is located approximately 10 km SSE of La

Parguera on the shelf edge reef and approximately 150 mE

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of the "buoy" site (Figure 1). The shelf edge reef runs

in an east-west direction, roughly parallel to tie coast The north side is bounded by a sandy area about 50 m wide and 22 m deep known as the "moat". From the moat, the reef

rises to the south approxi

ately at a 20° angle and gently
levels out to a platform 16 to 18 m deep and about 150 m wide. The platform slopes gently to the south until reaching the shelf edge break at about 26 m in depth. The region near the shelf edge slope is often cut by sediment chutes, sand channels, which run perpendicular to the fore reef slope. Unlike site (1), the rock substrate is mostly even with few Patches of sediment.

Visibility is between 13 and 50 m (averages 20-25 m). Siltation is probably less than on site (1). Surge is not ?as common as at site (1), but may be very strong when present Currents are sporadic, mostly westerly, the direction of the wind, and often strong. Gorgonian orientation is normal to the surge rather than to the current. Strong thermoclines are infrequent, and temperatures are only a few °C cooler or the sane as on site (2)

Site (3) Lies seaward of the fore reef slope of Cayo Margarita which is located about 9.4 km USW of La Parguera (Figure 1). Margarita, a long, exposed reef, runs in an east-west direction parallel to the coast. The area examined was on a very gentle slope from ahout 7 to 15 m deep.

The study area was located about mid-distance along the

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length of the fore reef where there is a moderately even Fock substrate with infrequent sandy areas. Although located some distance from the shelf edge, this reef is exposed to the prevailing winds and seas. Both currents and surge are probably often strong in this area, though very little current was present during four visits. Temperatures were not recorded. Visibility ranged from 6 to 24 m and seems to be intermediate between the first two sites. Sedimentation also appears to be intermediate.

Site (4), located approximately 10 km W of Punta Guanajibo on the west coast of Puerto Rico, is a part of Tourmaline reef (Figure 1). The area sazpled was a moderately level platform from 11 to 15 m deep from where it Sloped steeply downward. Only the platform area 11 to 13 m deep was sampled, and the site was visited once.

Physically this site resembled site (3) in surge, visibility, sedimentation, and depth. It is far enough offshore to receive little influence from the rivers which empty into Mayaguez Bay. There was no current or surge during the sampling, though the presence of sudden strong currents in this area 1s common knowledge. The substrate was very similar to sites (2) and (3)

Sessile fauna on the different sites were roughly compared, Gorgonians were abundant and diverse at all four sites, but they appear to be most abundant at site (1) and least abundant at site (4). Between 20 and 28 species

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w

eccurred at site (1), and many of these were present at the other sites as well. All four sites also had abundant and

Civerse coral growth. It was estimated that 15 to 20 coral

pecies occur at site (1) with coverage decreasing from the top to the bottom of the reef. Zoanthids, actiniarians, and corallimorpharians were more abundant at site (1) than at any of the other sites. Sponges were most abundant at sites (1) and (2), but many of the species differed at the two locations. Sites (3) and (4) appeared to have more simi-

larities in the sessile fauna to site (2) than to site (1)

which may indicate a stronger effect of substrate type and

exposure than other physical conditions such as turbidity

or sedimentation,

Distributional studies

Pooudopterogangia anevi.

na and P, acerona were usually

identified in the field by feel. Pocudopterogorgia anericana

fecls very sliny, while P. acorosa feels "dry". This method

is very accurate for P. avon?eana, but may contain a small

amount of error for P. aesnova due to the infrequent pres-

ence of simtlar species, Identifications were sonetines

confirmed by spicule exa

nation. The spicules were examined

uinder @ compound microscope after the organic material vas

renoved with sodium hypochlorite.

Quadra Studies

on study site (1), two 50 m long plastic transect line:

were placed parallel to each other about 25 m apart. Both

---Page Break---

n

ran from the base of the fore reef slope, up the ace of the

reef, and well onto the plateau (Figure 2). Thes Lines

aided orsentation and placement of permanant quad.ats on

the reef, A random stratified sanpling pettern, which al-

loved all of the depth strata to be sampled while random-

izing the samples within each stratum, was used to select

Positions for the permanent quadrats. The reef was arbi-

trarily divided into three 3.3 m depth strata fr:

depths

of 3.3 mo 13.3 m, Four depths were selected randomly

within each stratum, These depths were used to position

twelve 1m quadrats with six on each transect line. Quad
rats were marked by thin nylon lines secured tightly to the
bottom either by nails or strings tied to bottom features.
Poeudoptevogorgia americana, P. aceroea, other gorgonians,
and other sessile fauna (corals, zoanthids, corallimorphar-
tans, sponges, scleraxonian gorgonians, eve.) were mapped
in all of the permanent quacrats.

Twelve other 1 m® quadrats at the sae depths were
first mapped ané then cleared. Corners wre marked by nails
so that a metal 1m? quadrat could be placed repeatedly in
the sane position. All sessile organisms were renoved from
the six quadrats along transect 1 with a hanmer, chisels,
and wire brushes. Hard corals which could not be chipped
out were scoured with a wire brush until all visible tissue
was renoved and the septa heavily damaged. Six quadrats

along transect 2 were cleared only of gorgonians using a

---Page Break---

Figure 2. Map of site (1) located south east
of La Parguera illustrating transect
Tocations and depth contours.

8

---Page Break---

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a9

havxer ant chisel to renove the tough holdfasts

A large 4 by 4 m quadrat, divided into 1 n® units by

lines, was tied on the plateau between transects 1

P. amerfcana, P. aecvoca, and other gorgonians were

mapped and lengths measured. Lengths were measured with a

Floxible 1.5 m long measuring tape, Mapping was accurate

enough to divide the quadrat down to 1/16 m® units.

Density and Size Frequency Studies

Density and size frequency data for P. anericane and

P. aeerosa were taken concurrently. Six depths vere sampled at site (1), five at site (2), two at site (3), one at site (4), and one shallow depth only for P. americana on El Negro reef near site (4). At site (1) two depths were selected randonly within each of three depth strata. At site (2) one transect was placed near the reef sand interface on the moat (29.8 m) while the four other transects were placed at randomly chosen depths over the reef. Transect depths at sites (3)

nylon transect line was temporarily placed along each depth

d (4) were selected haphazardly for convenience. A

contour. Colonies of each species within a meter of either side of the line were counted for the first ten meters to estimate densities. Colony lengths and the number of major branches for P. anericana and P. acorosa were measured for all colonies within a meter of either side of the line until 50 colonies of each species were recorded. Any colony over

3 om could be easily spotted. Because slopes along different

---Page Break---

contours varied, actual depth variations on a Line ranged

{rox less than 0.3 m to 1.5 m. Relative abundances of the

spectes were estimated fron the size frequency data by noting

the ratio of P.

covoca to P. americana when 50 of the more

abundant species had been counted.

jortality and

Since larvae of different species of octocorals cannot

tment,

be easily distinguished, and are difficult to collect, no atteapt was made to quantify larvae or to determine their rates of mortality. Therefore, newly settled polyps were regerded as recruits for the purposes of this study.

The permanent quadrats vere monitored for mortality and recruitment, P. americana and P. acerosa colonies vere sapped bimonthly; and the other gorgonians were mapped at six month intervals for a year. Any mortalities or recruit ments were noted and causes of mortality determined when possible, Cleared quadrats were checked bimonthly for recruitment.

Additional recruitment studies were carried out at an area on the shelf edge near site (2) known as the buoy. The buoy was secured to concrete blocks on the bottom by @ chain. While it was in place, the chain completely scoured an area nearly 100 m® removing virtually all of the corals, gorgonians, and sponges. The buoy vas removed in February of 1977, and the area was examined in August of 1979. Density and sizes

of all gorgonian colonies were measured over an area of

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a

20m? in the centur of the scoured area

Growth Studies

Lengrh ef a11 colonies in the 12 permanent quadrats were

uicaeused periodically. P. emvstecna and P, acerosa were

wusneed 4

enthly while other gorgonians were measured at

5 wonth intervals. Five colonies of P. americana and seven

were tagged ond measured bimonthly at site (2).

Colonies vere ta

iged by attaching Dymo tape tags by surgical

stee? or insulated electrical wire to the base of the colo-

nice. No damage other than localized chafing ever appeared

with either

re; in fact, gorgonian tissue or encrusting

orpabisus grev over the wire and tage and were periodically

wed off. Light readings vere taken with a Gossen Luna~

Pro light net

= in a waterproof case on @ cloudless day with

about 10 n of visibility under weter. Individual readings

vere taken for all Pecudepterogorgia in the permanent quadrats.
Growth rings were also examined. ALL colonies of P.

cnerigana and? aecrvea fr

mn the cleared quadrats at site
2) were collected, measured, vir dried, and weighed. A

number of colonies of each species were collected at the

her sites, and treated in the sane manner. Colonies on
sites other than (1) were efther collected haphazardly or
for a wide size range. The colonies were saved in cross
section as clese to the base as possible, and then ground
and polished oa a bench grinder equipped with a buffing

wheel. Rings were counted under @ dissecting microscope,

---Page Break---

2

chever branch had the greatest nucber of rings

fn both the base and main stem. Where difficult to die

Lingvish, rings vere also counted by making a cellulose

acetate peel

Reproduction

Nine colonies of each species were tagged near the

north end of transect 1 on site (1). Large colonies (greater

than 40 cm) were selected to minimize sampling effect. A

small branchlet (about 4 cn) vas clipped monthly from each

colony with

ming shears, bagged individually, and returned

to the laboratory, The elippings were examined alive under dissecting and compound microscopes equipped with ocular nicreneters. Sizes of the five largest eggs or spermaries were measured, and approxinate numbers of eggs or spermaries per polyp recorded. Several spermaries from each colony were broken open and examined microscopically. Ripeness of the sperm was determined by head size, head shape, and activity. Clippings from throughout two colonies (a male and @ female) were examine? to determine if there was any pattern in maturity of the gonads within the colony. Four colonies, two male and tvo female, vere sampled every four or five days for a month to determine if there was any short-term periodicity in gonadal maturity. Whenever necessary, histological sections were made to determine sex and position of the gonads. Polyps uere fixed in paraformaldehyde

and stained with hematoxylin and eosin.

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oviginal,

y, five colonies of each species were tagged

at ©

© (2). Three of these were not relocated apparently

due to less 0!

tags. lence, clippings were examined

monthly for only three colonies of P. americane and four

colonies of P. cserona.

ALL Peenderzeroya:

ia in the large 4 by 4 m quadrat

were exauined £1

gonads. Over 80% of the large colonies

were sexed to ?i

rmine how the sexes were dispersed rel.

tive co each other.

Grigg (1970) indicated that small colonies of Muricea as old as ten ycars did not contain gonads. For this reason, small colonies (under 30 cm) were collected at both sites (2) and (2) and examined under dissecting and compound mero-scopes for gonads. Ten of those which showed no evidence of gonads with these methods were examined histologically At the same time, medium to large colonies were collected and examined to provide an expected ratio of colonies with gonads absent to gonads present at that time.

Ecological Interactions

Coverage of sessile fauna other than gorgonians (corals, zoanthids, sponges, scleraxonians, etc.) was estimated on the 12 permanent quadrat maps. A plastic overlay divided into small squares was used to make the estimates. Gorgonian reervits in the totally and partially cleared quadrats were

counted.

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Corgonians growing with the bases touching were ex- amined for any sign of damage. Any damage such as abrasion, grazing, or encrustation from other organisms was recorded. Encrustations on gorgonians within the permanent quadrats Were measured bimonthly. Ocher organisms found on either species of Pseudoptercgorgia were examined and the apparent relationship established.

Colonies of P. acerosa or P. americana being grazed by Cyphona gibbosun were marked with emall subsurface buoys Placed near them and observed for several months. The scars

were measured after the C. gf:

bosum left and subsequent

healing or encrustation by other organisms noted. The ratio

of c.

gtbboewn to gorgonian colonies on site (1) was estimated.

As Thalascona bifasciatum (Bloch), the bluehead wrasse,

was observed to be picking at gorgonians frequently; seven

specimens were speared and the gut contents examined. A

small portion of the gut contents was examined for spicules

after first removing the organie matter with eodium hypo-

chlorite

Selective caging was attempted twice during the study.

Four cages 1/4 m® by 1/4 m high were constructed of 1/2 inch

hardware cloth. Two were open on top and two were closed

One of each was nailed onto tuo cleared quadrats. All four

cages were destroyed by surge and deterioration within a

month. A large number of Diadema anti2larum (Philippi)

were seen on one quadrat vhere many recruits had disappeared

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within one month, Two of the 1 m® cleared quadrats with

abundant recruits vere then fenced with chicken wire fas-

tened tightly to the bottes with nails. All D. antiltarum

were removed from one and ten placed in the other. These

cages vere intact for 22 days until they were removed by

sed by Hurricane David.

Diurnal activity of the two species was briefly ex-

anined, Counts of colonies divided into expanded, partially

ospanded, or retracted polyps were made during different

times of the day,

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Results,

Distrsbur

al Studies

Small Seule Dispersion Patterns

all scale dispersion patterns vere examined to de-

termine if gorgonians were evenly, randomly, or patchily

dispersed over various quadrat sizes. These patterns have

been used co

dy the results of recruitment, mortality,

and behavior of species, Stimson (1974), for instance,

Found that colonies of Poeitt

sora sp. were evenly dis-

tributed éue to the

voidance of existing colonies by

settling larvae,

Fisher's index of dispersion (1958) was used to de-

vemine spatial pattern, ?This index is based on the

Poisson distribution where variance equals the mean for

randomly dispersed populations. Average densities of

P. anericana, P. aeeroca, and total gorgonians were not significantly different between transects using a t-test.

This justified cosbining, q

drats between transects since

the assumption of the Poisson of variance equals mean is

not violated (Dana, 1976).

The highest variance to mean ratios occurred at 1 m?

indicating that 1m? approaches patch size (Table 1). The

random dispersion patterns for P. acereaa may be an artifact

of low densities because in such instances it is difficult

to distinguish statistically even and ageregated from randow

patterns. Quadrat studies were done only on site (1). The

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2

hetcrogen:ous substrate in this area may be a major factor

causing tie patchy distribution of gorgonians

Densities and Size Frequencies

Densities of Preudopterogorgia anericana and Pacudo-

Ptoreyergia aceroce at various depths within a site and at

different sites are shown in Table 2. Ratios were obtained

by dividitg the number of P. acerosa by the nunber of P.

omertcana when 50 of the more abundant species had been counted. A two way analysis of variance (ANOVA) was used

to compare abundances between depths and species at site (1). Abundances were log transformed to normalize data and equalize variances. No significant difference betueen depths was found for P. americana or P. acerca (Table 3, F-test)

P, americana was significantly more abundant than P. acerosa ($p<.001$,

test). On site (2) a two way analysis of variance (ANOVA) showed no significant differences between depths or species (Table 4). Site (3) had only two depths taken and they were very similar

A tuo way analysis of variance (ANOVA) for densities showed significant differences between the two species and Detween the first three sites (Table 5). Site (4) was not included as only one density measure was taken. The significant interaction ($p<.005$, F-test) is an indication that relative species abundances differ between sites. This interaction can also be inferred fron the ratio of abundances

in Table 2 where 7. amen:

na ig more abundant than P. eccroca

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TABL: 3. A two way analysis of variance (ANOVA) for

densities between depths and Pecudozterogorgia

na and Feoudepterogorgia acerosa for

a.

ss éf MSF ratio Significance

Between species 1.73 11.73 Fy 96.1 pe.001

Between depths 0.370.074 Fg ge 4.1 ns

Evror 0.09 50.018,

219° 11

SS=sum of squares, ¢:

FeP-cest

jegrees of freedom, MS=mean square,

TABLE 4. A two way analysis of variance (ANOVA) for densities

hetueen depths and Peculopteregeraie anezicane

and Paowlopterogorgia acenosa for Site

SS é@f MS F ratio Significance

Between species 0.01 10.01 Fy 420.17 Ns

Between depths 0.384 =??0.095. Fg 41.68 Ns

Error 0.23 8 0,088

Total 0.629

SS=sum of squares, dfedegrees of freedom, MS=mean square

FeF-test

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a

5. A two way analysis of variance (ANOVA) for

Gensities between Proutopterogorgta americana

and

?goudop verogorgia averosa and sites

_ ss af MS __Fratio Significance

F y,29°20 pool

Rotwoen sites 2.49 21.285 Fp 79t23.06 p<.005

Interaction 0.832 O.m5

F 0 p<005

Error 1.07

8.47 2

SS-sum of squares, df=degrees of freedom, MS-mean square,

FeP-test

TABLE ?. Comparisons of age frequency percentages between

Peeudopterogorgia anerioana and Peeudopterogorgia

accroog at the study sites. Probabilities ealeu-

a _lated from the Kolmogorov-Smirnov test

Depths berths Depths Combined

Lp Site(2) _p Site(3)_p Site(4) p Sites p

WS 19.8m NS 7.3m NS 1.9m NS Site(1) NS.

Sm NS 18.9m 05, 9.8m NS Site(2) xs

Tm 05, 18.3 HS site(3) ns.

78m NS 16.88 Site(4) NS

9.5m NS 2am

nm xs

1. By age 5, P. acerooa has a higher percentage

2. By age 4) P. accrosa has a higher percentage

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Conparigons of age Prequency percentages between

depths for Pscuderterogergia americana and

voudor tercgorgia accroea at Site (3).

Probabilities calculated from the Kolmogorov-

P. avorosa

Comparisons of age frequency percentages between

sites for Peeudopterogoraia americana. Site (2)

does not include data for 18.9 m and 19.8 mas

these are treated separately. Probabilities

___ calculated from the Kolmogorov-Smirnov test.

Site(2)| site(2)

SITES Site (1)]| Site (2) 18.9 | 19.8 m | site(3)| Site(4)

|site a - 01, D NS ons NS Ol,

sem) Pw Poy Po) es

eee i cr

| ws) Oly

?| +01,

1. By age 2, Site (2) has a higher percentage

2. by age 7, Site (4) has a higher percentage

3. By age 5, Site (2) has a higher percentage

4. By age 3, Site (4) has a higher percentage

5. By age 4) Site (4) has a higher percentage

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TA

Table 12.

11. Corparison: of age frecuency percentages between

?goudo: cevog-rgia aeerosa. Probabilities

sites for

ated from the

ov"

irhov test

Site (3) | site (4)

01 02,

-015 Ns

1g

1. By age 4, Site (1) has a hicher porcentage

age 4, Site (4) has a higher percentage

31 ay age 3! Site (2) has a higher percentage

4. Gy age 4 Site (4) has @ higher percentage

Comparisons of age frequency percentages between

stucy sites and Fl Repro reef for Peeudopterogoria

Probabilities calculated from the

Site(2) | site(2) |

Site (1) | Site (2) 189m |19:5m | site (3) | site (4) age 5, Site (1) has

age 4 Site (1) hes

age 8, Site (2) has

age 18, Site (2) 19.

age 9, Site (3) has

age 3, Site (4) has

higher percentage

higher percentage

higher percentage

m has a higher percentage

higher percentage

higher percentage

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%

at sites ?U) and (3) and less abundant or equal at sites

(2) ond

Size frequency data were converted to age frequencies

sing mean growth ¥}

s calculated for each species on each

site (sce growth section). Figures 3 through 8 show age

Fequeney distributions for cach species within sites at

4iEferent depths ang between sites. Age Frequency dis-

tribution for PL om

cane on El Negro reef is shown in

F:

gure 8. Cumulative percentages for age classes between

species, within depths on a site, and between sites were

compared using the Kolnogorov~

mirnov test (Tate and

Clellané, 1957). Cumulative percentages were from youngest

to oldest age classes. Tables 6 through 12 show probabilities for conparisons betucen these cumulative frequency percentages

Age frequencies of P. anericana or P. acerosa within each depth at each site were not significantly different in most cases (Table 6), Sone significant differences within depths may be due co multiple testing error where significance way be an artifact of the large number of comparisons nade

Where no or few significant differences vere found for cumulative size frequencies, the data were pooled for a species on a particular site, This alloved comparisons between sites. Thus age frequency data for P. aceroaa on all

sites and for P. aw

cana on sites (1) and (3) were pooled.

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Finure 3. Age frequency distributions of

Peeudept. sozargia amerivane at

different depths on site (1). N=

nunher of colonies used,

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Figure 4,

Age frequency distributions of

Poeudopterogorgia acerosa at

different depths on site (1). N =

number of colonies used.

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Figure 5.

Age frequency distributions of

Peeudopterogorgia americana at

different depths on site (2).

number of colonies used

Ne

33

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Figure 6.

Age frequency distributions of

Peeudopterogorgia acerosa at

different depths on site (2).

number of colonies used.

Ne

40

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ras ueew) E

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Figure 7

Age frequency distributions of Peeudo-

pterogorgta anerieana and Pseudoptero-

pergia acersea at different depths on

Site? (Jone depth on site (a), and

one depth for P. americana on Ei Negro

reef. N= number of colonies used.

aL

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Figure 8

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Age frequency distribution of Pseudo-

pievogorsia americana and Pasudoptero-

govzia azeroca on sites (1), (2), and

(GG). N= number of colonies used.

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cana on site (2) showed highly

01) between 19.8 m and all

S except 18.9 m which uns significantly different

(5.02) ?vom one other depth. Therefore, data for these

so Gapths were created seyarately, while the data for the

ooher three depths were pooted. The 19.8 m data were taken e sani-reef interface, uad are not significantly differ-

ent from site (1) or the 11 m depth on site (1) which is

wiso @ sand-reef interface. Although 19.8 m is significantly

air

ent from El Negro reef uhich is located near site (4)

(ps.05) for age frequencies of P. anericana this only becomes

?

© at the older age classes (Table 12). £1 Negro was

a shetlow protected reef area with frequent large sand patch:

The results of Tables 6 through 12 are summarized by Table 13 which ranks sites from those containing the Ereatest proportion of young to those containing the pTeatest. propertion of old selonies. Station ranks are similar for both species with the exception of the 19.8 m

depth for site (2). Thus, younger colonies of both P.

ang and T. acerose are more abundant at site (4) and elder colonies at site (3).

Reereitment and Mortalicy

The mean number of recruits per m? was 1.1 for P. auce'sen2, 0.1 for P. acenvve, and 2.4 for other porgonians.

A two way analysis of varionee (ANOVA) for recruitment be-

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tween depths and between ?. ancricana, P. ieerosc, and other gorgonians on site (1) showed no significan: differ- ences in recruitment between species (Table 14). ?Variances were equalized and data were normalized by log transfor- mations.) P. acerosa had significantly fewer recruits than ?other gorgonians" (p<.05, Neuman-Keuls, Sokal and Rohlf, 1969). A11 other comparisons were not significant. Estimates of recruitment are probably low for "other gorgonians" as they were checked only every six months.

Mean nunber of recruits per m* in all of the cleared quadrats was 9.2 for P. americana, 2.8 for P. acerosa, and 4.2 for other gorgonians. Recruitment in the uncleared (permanent) quadrats on transect 1 was compared to the quadrats cleared of gorgonians and to the totally cleared quadrats. A two way analysis of variance (ANOVA) with log transformed data shoved significant differences between quadrat treatment and between species (Table 15). P. america: had significantly higher recruitment than P. acerosa (p<.05, Neuman-Keuls). Other comparisons were not significant.

Totally cleared quadrats and quadrats cleared of gorgonians did not differ significantly, but both were significantly different from the uncleared quadrats ($p<.05$, Newman-Keuls). Therefore, recruitment is increased by the removal of adult gorgonians and encrusting organisms. Scoured corals and encrusting organisms in the totally cleared quadrats showed

recovery within four months, This may explain why reeruit-

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ment betueen totally cleared quadrats and gorgonien cleared quadrats was not significantly different. Recruits were noticeable at a height of 1 cn, and the most recruits for P. americana were seen in June and July. These recruits may be as old as 5 to 6 months (see discussion).

Densities of P. anericana and P. acerosa in a 20 m* quadrat near site (2) at the buoy scar site were compared to densities in two 20m? quadrats at the same depths and conparable positions at site (2). The 95% confidence limits for P. anericana and P. acerosa for the two positions at site (2) were from 0 to 11.3 colonies per 20 m® with a mean of 2.5 colonies for each species. The observed values for the buoy scar area were 14 colonies for P. acerosa and 17 colonies for P. americana per 20 m? suggesting that re- ervitment is also higher in cleared areas at site (2).

Mortality rates in the permanent quadrats on site (1) for P. americana, P. acerosa, and other gorgonians were calculated by dividing the nunber that died by the number monitored over one year. These percentages were 15.6% for P. americana (14/90), 6.7% for P. aceroza (1/15), and 17.3% for other gorgonians (43/249). None of these percentages were significantly different when coupared by an aresine transformation for comparing percentages (Sokal and Rohlf, 1969).

Size frequencies of mortalities for P. americana and

other gorgonians were compared with size frequencies of the

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gorgonians monitored (Figure 9). Cumulative freq)

ney

percentages showed no significant differences for P. americana. Thus mortality of a given size class is proportional to the relative abundances of that size class There is a significantly higher percentage of mortalities for small sizes in other gorgonians (p<.05, Kolmogorov-Sairnov test). Peeudopterogorgia acerose was not included as there was only one mortality.

?The number of mortalities were not significantly éifferent from the number of recruits in the uncleared (permanent) quadrats for P. americana ané other gorgonians (t-test) implying stable population sizes of gorgonians at site (1). ?. acerosa was not included as there was a total of one mortality and one recruit.

The causes of mortality could seldor be ascertained. Two or three mortalities appeared to be caused by weakening of the basal stalk due to encrustations. One colony under 15 em tall had the axial skeleton completely stripped of tissue when the mortality was first recorded. A month later the skeleton was gone. This was probably the result of grazing by Cyphoma gibbosun or an amphinoaid polychaet High mortalities occurred among the very small colonies (under 2 cm) in one of the cleared quadrats, and the cause could not be attributed to smothering by sediments or algae or to scouring by wave action.

---Page Break---

Figure 9.

Comparisons of the length frequency dis-
tributions of the gorgonians monitored
in the 12 permanent quadrats to the
Length frequency distributions of
mortalities in these quadrats. "Other
gorgonians? does not include Pseudo~
Pterogorgia americana or Peeucoptero-
gorgia aceroca.

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TABLE 15. A two way analysis of variance (4NOVA) between

Peeudopterogorgic americana and Peete; teregorgia

acerooa and quadrat clearing treatment

ss df oS F ratio Significance

Between species 1.35 20.675 Fy gg5.31 p 05

Between treatments 1.80 2 0.900 Fy. 4587.09 p 05

Interaction 0.61 4 0.153 Fy g5°1.20 NS

Error 5.73 45

Total 9.49 83

SSesum of squares, df-degrees of freedom, MS-mean square, FeF-test

TABLE 16. Annual growth rates (cm/yr) based on growth rates

for Pooudopterogorgia americana and Peeudoptero-

gorgia aceroea at the study sites

P. americana P. acerosa

Site cm/yr SDN cm/yr so "

qa) 5.6 2.1 43 6.0 2.0 19

(2) 5.9 2.5 20 6.9 a. 38

(3) 5.5 1.2 21 5.4 1.9 15

(a) 5.3 2.3 23 5.9 1.6 29

SD=standard deviation, N=nunber

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Figure 10.

Least squeres length-weight regressions

for Peeudopterogorgia americana (Fr)

and Pacudeptercgorgia aceroea (tp)

collected at site (1). P. ameritana

is represented by » and P. acerosa is

represented by e+

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Sites (1), (2), and (3) were briefly inspected after storm waves generated by Hurricane David devasted many shallow water reefs on 30 August 1979. On site (1) wave energy was strong enough to topple a large head of Pendrogyne cylindrica. Acropora cervicornis stands were broken and pieces scattered over the reef. The most commonly detached gorgonians were Plezuretla spp., Muricea spp., and Plecaura spp. on site (1). Pseudopterogorgia americana and P, acerosa were seldom detached. Pseudoptezaura spp., Pecudopterogorgia americana, and P. acerosa were frequently damaged by abrasion to branch tips. The removal of tissue on the bases of colonies as described by Cary (1914) was not seen on site (1), but was common on sites (2) and (3). The rock substrate on these two sites appeared to be scoured.

Growth

Length-weight regressions using log-log plots for the two species at the four sites are shown in Figures 10 through 13, ALL regressions were highly significant ($p<.001$, F-test, Sokal and Rohlf). The Linear equation form for the regressions, log Y = log b + m log X, can be written Y= b xX", Therefore

the slop

. m, of the Linear form is the exponent of length

in this case. These exponents were between 2 and 3 in all

cases indicating that both species weigh somewhere between

the square and the cube of the length times some constant

(always far less than 1). Slopes (or exponents) did not

differ significantly for any comparisons between species

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Figure 11.

Least squares length-weight regressions

for Peeudopterogorgia anericana (ry)

and Poeudopteragorgia acerosa (ty)

collected at site (2). P. aneriana

fs represented by » and ?. aocrosa

is represented by ¢

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WEIGHT (5)

---Page Break---

Figure 12.

Least squares length-veight regressions

for Peeudopterogorgia americana (r)

and Pecudopterogorgia acerova (rp)

collected at site (3). P. amertdane

is represented by « and ?. aceroea

is represented by ©.

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Figure 13.

Least squares length-veight regressions

For Pentdopteregoraia anenfonne Cy)

and Peeudopteregorgig acerosa? Cr

collected at sive (i). P. anerifana

is represented by «and P. sscroee is

represented by ©

---Page Break---

WEIGHT

LENGTH fom

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or sites. Significant differences in the regressions for

position were found between the tuo species at sites (2)

and (4) (P<.01) indicating that P. americana weighed more

for a given length than 7, acerosa at these sites. This

difference appears to cone from a difference in growth

Pattern of P. americana which is significantly heavier

(p<.01) for a given length at sites (2) and (4) than at

sites (1) and (3), while P. acerosa shows no significant

differences between sites

Growth rates measured for P. americana and P. acerosa were highly variable. Only colonies measured for at least 8 months were used. Mean growth was 4.4 cm/yr for P. americana and 5.3 em/yr for P. acerosa on site (1), and

6.4 em/yr for P. americana and 6.3 en/yr for P. acerosa on site (2). Grouth rates were not significantly different between sites (1) and (2) or species (t-test). Growth rates

did not vary with colony length on site (1) (least squares

regre!

ion, Figure 14). No relationship was found with Browth rates versus depth on site (1) (Tukey corner test), but a significant positive relationship accounting for about 20% of the variability was found between growth rates and light for P. americana (least squares regression, Figure 15). Peeudopterogorgia aserosa had too few colonies measured to show significance. Although light decreases with depth, individual colonies at the same depth may receive very different light levels due to shading. The amount of light

---Page Break---

Figure 14.

Annual growth versus initial colony

length for Peeudopterogorgia anvricanae

(e:5 and Peoudoporogengee aoeroea 0

Gh) on site (1). No relationship

wad? found between growth rates and

colony length (Tukey corner test).

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Figure 15.

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fnnual growth versus relative Light

levels for" Peoudopteregcrgta gnehiegnae

(Hy) and Pecutopterogorgie acerona Cea)O

ontsite (1) 2

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shown in Figure 15 has no absolute meaning, b:t should be considered as relative between colonies since it was measured only on one day.

Growth ring versus length regressions on log-log plots are shown in Figures 16 through 19. All regressions were significant (p<.01, F-test). Colony length was divided by the number of rings to give length per ring (cm/ring) for each colony and means cm/ring were calculated. Means of length per ring were not significantly different from annual growth rates for P. americana or P. acerova on sites (1) and (2) (t-test). Mean length per ring for ?. amerteana on site (1) was also compared to semiannual and biennial growth rate estimates and found to be significantly different from either one. Several colonies known to be under one year old did not have apparent growth rings. These considerations indicate that rings are added annually. Growth rings are Probably a better measure of growth rates than measured rates as they average growth over the life of the organism, and are therefore less affected by shorter term variations in growth rates. However, grouth rings in larger colonies

were more difficult to distinguish resulting in higher

Linear growth estimates for older colonies. Mean growth

rates based on growth rings for each species at each site

were used to make age estimates (Table 16)

---Page Break---

Figure 16.

Least squares length-growth ring re-

ressions for Preudopterogoraia americana

(ey) "and Peeudoptercyorots aseroea ty)

collected at site (1). ?. anerteane

is represented by » and ». acerosa is

respresented by ©.

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Figure 17,

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collected at site (2). P. americana

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Figure 18,

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Least squares length-growth ring re-

gressions for Peeudoptexogorgia americana

(xy) and Pseudopterogorsia aceroea (r4)

collected at site (3). P. amerceana

is represented by © and P. acerasa is

represented by ¢.

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Figure 19.

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Least squares length-growth ring re-

wessions for Peeuizpterogorgia americana

Cry "and Pocudopseroposnes oeecoan ey

collected at site (4). P. ancnicana fe

represented by @ and P. acerosa ia

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Reproduction

Sexes were found to be separate for all colonies examined at @ particular time. Either sex was found in colonies of all sizes which contained gonads. One colony of P. anericana which was sampled throughout the year appeared to switch from female to male. Sections examined in Septen-ber contained large eggs while sections examined in Decenber had well developed spermaries. No sign of gonads was found im October. Confusion of the colony with others was unlikely as the colony was tagged and not very close to other colonies. Male to female sex ratios were calculated from all colonies sexed throughout the study. P. anericana had 65% fenales to 38% males. The 95% confidence limits for the males ranged from 24% to 47% (population proportion confidence Limits, Tate and Clelland) indicating that P. americana does have a significantly higher percentage of females (84 colonies sexed). Pecudoptenoporgia aceroca had 57% fenales to 43% males, and the 95% confidence limite for the males ranged from 29% to 59% indicating no significant difference from an even sex ratio.

The nearest neighbor technique (Clark and Evans, 1954) @ispersion patterns of male and female colonies of P. americana from the large 16 m* quadrat were examined to determine if members of the same or opposite sex tended to

be near to each other. The distribution of males to females

was not significantly different from random. Hence the

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Sexes are not significantly associated (or dissociated) with each other. Pp. averoea had too few colonies to analyze.

As deseribed by Gohar (1940a, 1948), ova and spermaries were found on six of the eight messnteries. The larger ova oF spermaries lie in the bases of the polyps unattached or attached by @ very thin peduncle to the mesentery. Ova and spermaries were round or oblong in shape. The largest ova in P, americana and P. aceroea averaged 0.5 mm while the largest spermaries averaged 0.4 mn in diameter, Females of both species had two to four large ova per polyp when ova Giameters were greatest, and males four to six large spermaries at the same stage of development. No difference was found in the sizes or numbers of ova or spermaries from different parts of a colony at any one tine.

The degree of ripeness of the sperm varied from month to month, and even within a month for four colonies examined Ripe or very young sperm could be found in the sane colony at various times throughout a month. Since colonies were only sampled for gonads once a month, the size of ova or spermaries was used to determine reproductive periodicity. Gonadal volume was calculated monthly for each colony (Figures 20 and 21). The median nunber of eggs or spermaries per polyp was multiplied by the volume of the median ©88 OF spermary. The median diameters of the five largest eggs or spermaries were used to calculate this volume as-

suming that eggs and spermaries were spherical. ?The volume

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Figure 20.

Volume of gonads per polyp of indivi-

dual male and female colonies (symbols)

Of Pseudopterogorgia anericana sampled

at monthly intervals at site (1).

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Figure 21.

Volume of gonads per

dual male and female

Of Peeudopterogorgia

at monthly intervals

polyp of indivi-

colonies (symbols)

acerosa sampled

at site (1).

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of a sphere is 4/3ar? where v= radius. Since r = (d)iame-

ter/s, this equation can be written voluse = 14°/6.

The periodicity of gonadal volune wes compared within

a sex and between sexes for P. americana and P. acerosa by

a Kendall concordance test. Colonies which failed to re-

Produce actively (gonadal volune less than 0.1 throughout

the year) were excluded from analysis as well as the month

of September for which some values were missing. P. americana

showed strong synchrony between males (p<.005) and weak

synchrony between females (p<.10). P. accrosa shoved strong synchrony betueen males (p<.005) and between females (p<.025). Synchrony between males and females vas not significant for P. americana, but was quite strong for P. acerosa (p<.0l, Xendall-Tau rank correlation). Since there was not strong synchrony between males and females for P. americana, com-Parisons were not made between the two species. Peeudopterc-gorgia acerosa appears to peak in reproduction from August to October while P. accrieona seems to revroduce anywhere from September to April on site (1). Reproductive periodic-ty was not obtained for site (2) as most of the colonies tagged there never reproduced. This was an artifact of small sample size since several collections of colonies from site (2) had gonads in over 50%.

Egg production probably does not vary much between colonies of P. acerosa and P. americana. Estimates of the

average number of polyps per colony of a given height are

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only different where one of the species is bushier than the other. Since both species preduce from two to four eges

Per polyp in a season, estimates for egg production would be sinilar. Peeudopterogorsia americana, however, has Proportionally more females than ?. acerose so a given number of colonies will produce more eggs (at least on sites 1) end (2) vhere reproduction was examined). Otherwise the relative advantage of one species over the other repro-Guetively would depend on their relative abundances at different sites

No gonads were found in colonies of P. acorosa (n = 16) OF P. americana (n = 24) under 15 cm long. Ten of these showed no sign of gonads in histological sections. No sign Of gonads was found in 85% (17/20) of P. americana and 89% (26/18) of P. acerosa colonies examined between 15 and 30 em long. Observed percentages of older colonies (greater than 30 cm) with no gonads collected at the sexe times and locations as the small colonies were 58% (29/50) for P.

americana and 67.5% (27/40) for P. acre:

An aresine

transformation was used to compare the equality of per-centages (Sokal and Rohlf, 1969) between the adult ratio of those without gonads to the observed ratios for small colonies. For colonies under 15 om, highly significant

Aifferences were found for >. anericona and P. acerosa

(P<.001). For colonies between 15 and 30 cm long, P. ancricana

was significantly different from percentares in older colo-

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nies (p<.02) and », averose was not quite significantly

different (p<.06). A colony of or P. snerteana

of 30 cm would be about five years old and a colony of 15

em about three years old, The five colonies found with

gonads were between 16 and 19 cn long. Therefore, repro-

duction is usually delayed for at least three to five years

in both species. More samples would be needed to determine

i? one starts reproducing at a slightly younger age than

the other.

No dividing eggs or developing larvae were scen during this study, although clippings of P. acerosa were collected several times a week for several weeks when the eggs were largest

Ecological Interactions

Coverage by corals and other encrusting organisms was negatively correlated with gorgonian densities (Figure 22, $p<.05$, Tukey corner test). This might contribute to the ageregated dispersion patterns of the gorgonians on site (1).

Recruitment was enhanced in quadrats which vere totally cleared or cleared of gorgonians only compared to uncleared quadrats (see recruitment and mortelity). This was probably @ response to the greater availability of hard substrate suitable for gorgonian settlement.

Gorgonians of both species vere often observed

th the

bases in contact with each other or other gorgonians. The

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Figure 22. Number of gorgonians versus percent of

cover from corals and other encrusting

organisms.

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only damage of one gorgonian by another was minor fraying at the points where branches of colonies were in contact, Abrasive damage to Pseudopterogorgia spp. colonies by other gorgonians was most often by Muricea spp. which was most comuon near the base of the reef on site (1), However, contact with hard corals or other hard surfaces was the most frequent cause of fraying demage. Tips of colonics damaged by fraying were often briefly colonized by hydroids or the small anemone su:odiopsie antitlienais. Tips usually healed subsequently or fell off, but damage was seldom permanent.

Encrusting organisms are found most frequently on the base of large gorgonians. New encrustations were only observed on the bases of previously damaged colonies. Many organisms such as barnacles, algae, and hydroids are eventu- ally overgrown by regrowth of the gorgonian tissue. ?This was apparent when cross sections of colony bases revealed intact barnacle shells or traces of calcareous algae within the axial skeleton. Several sponges, Brianium (a sclera- xonian gorgonian), and Hitlepora alefcornis appear to be More successful at maintaining the infestation.

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Sponges and Briarium on the bases of gorgonian colonies in the permanent quadrats were measured over a year. Sponges and Briartum usually advanced slowly (about 3 cm/yr) if at all by overgrowing and smothering the gorgonian tissue.

Millepora atetcornis found on the bases of four gorgo-

nian colonies in the permanent quadrats grow up the gorgonian

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stalks at an average rate of 9.3 em/yr varying from 6 to 12 en/yr. A narrow band of dead gorgonian tissue in advance of the Nittepora is a good indication that the fire coral actively kills the tissue. A colony usually breaks off at some point on the basal stalk before being covered by Métte-pora. Many clunps of #£1lepoma atoteonnts on site (1) Fevealed gorgonian stumps chen they were broken apart.

Rew encrustations during the study periog on gorgonian colonies were only seen to occur on portions of axial skele-ton which had been previously denuded. One cenmon cause of damage to gorgonians is Cypiona gibbooun. Cyvhoma gtbbosum Brazes on the tissue leaving behind a denuded patch of axial skeleton. ¢. gibbocum was seen on 1 out of 500 gorgonians examined on site (1). This was low conpared to some areas

Buch as site (3) which had 2 C. gibsosum out of 200 colonies examined. ¢. gibbosum occurred on Pseudop terogorgia americana half as often as on any other gorgonians on site (A) out of 29 observations, This 4s a disproportionately large number as P. anericana accounted for less than one third of the total number of gorgonians. 2. efbbocum was seen on P. acerosa only once, and basal damage or encrus~ tation was unconmon on P. cevvosa on site (1). This suggests

that ¢, gibbosun is selective for Pp. ameizanz on site (1).

Ten out of 16 tagged colonies of P. enerizana with C. gibbosum healed within two monthe after the gastropod

left, The other six were infested with sponges or bryozoans.

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Cyphone were often found in pairs and when one me-ed to 2

different colony, the other usually folloved within a few days. Most of the geazing varage was near the base of the

gorgonians where ¢. obb2ew" was usually found. cyphoma

gibbooun were not usually sven high on the colonies except

at night. The abi

ty o£ the gorgonian to heal over a scar

Was less related to tis

extent of the scar than to what had

colonized the area. One cote

vas completely girdled for

over 5 om on the base and heated within a month. Four of the 16 colonies had cypiom: return to them at least once. Covaitiophita caribaea, another gastropod, ves found frequently near the bases of colonies. This genus is known to associate with sea fans. hamage to the gorgonians seemed to be limited to the immediate vicinity of the gastropod. & caribaea were not seen to change position on the gorgonians. Polychaets of the family Anphinonidac were occasionally Seen on gorgonians on site (1), but almost alvays on the Steep slope or near the | the Goel here hard corals are not abundant. Usually they were seen feeding high in the branches of gorgonians

A volychaet of the fami

y Syllidee was found within

the coenchyme of Peewdopt.

rgia acerose. The larger

Polychaets were usually free uithin the tissue, while smaller

specimens were encysted within a capsule possibly of their

own making. ?The polychaets vore usually not visible ex

ternally, and specimens were only found in polyps dissected

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for gonads. They vere found in all of the P. aocrosa

which were sampled monthly and were usually common. only

fone polychaet was found in P, ancricanc and it appeared

to be the same species. Sone menbers of the family Syllidae

are known to be parasitic on other invertebrates such as

sponges. Since the polychaet appears to live internally

im the gorgonian, it is probably a parasite. Other species

of gorgonians were not examined for its presence.

An isopod of the genus fscorattanz was commonly found

on P. acerosa but rarely on Pr. americana. It appears to be

free-living and the nature of its relationship to P. aceros.

is not known,

Other invertebrates known to associate with Paeudopterce

gorgia were seen frequently. These included Astrophyton

muricatun, the basket star, and Pteréa colynbus, the Atlantic

winged oyster. Astrophyton appears to cause little damage

when it wraps itself in the Peeudopterogorgia branchlets,

but may cause some abrasive damage to the colony. Te ts

common on either species of

udoptercgorgia. Pteria seems

to only cause damage at the attachment site. Small erinoids

were seen once clinging to several P, anericana at site (2),

but were not seen again. ?The caridean shrimp, Tozeuma earolinense, was not observed on gorgonians in this study,

but was seen once on a Peeudopterogareia sp. by Joseph

Kimmel (personal communication)

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Bluehead wrasses, ria

tus, were ob-

Served frequently picking at yorgonians. The gut contents

from seven individuals revealed most ly tsopod parts, a few

small erab and shrimp parts, ophiuroid arm parts, sponge

spicules, and only once a few gorgonian spicules. the

small isopods occurring on 7

aceroea axe probably a conmon

Prey, though this was not confirmed by gut content exani-

nations. Thataesoma bifasoiatum appears to ?clean? gorgonians

rather than graze on then. ?The red banded parrotfish, spari-

soma aurofrenatum, was observed picking at gorgonians oc-

casionally, and appeared to actually bite off small pieces

(eana Clavijo, personal communication)

Experiments using cages on the cleared quadrats were

mostly unsuccessful. The enclosure versus exclosure caging

for Piadena antéttarum on two cleared quadrats which had

high recruitment did indicate that D. anti2iarum had no

apparent effect on these recruits.

Pay versus night poly> expansion data showed that

P. americana and P. aceroe. follow the save trend and that

usually over 50% of the colonies have expanded polyps at

any one time (Figure 23). Pecudopterogoreia americana also

tended to have a slightly higher percentage of colonies

with open polyps, and this trend was significant at 1600

hours (p=.05) and 2130 hours (p<.001, arcsine transformation

for comparing percentages). Since no replicates were taken for the sane time periods, the diurnal pattern was not analyzed.

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Figure 23.

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Bescon of eglonies vith the polyps

expanded at different times of the

day. Pecudopterogorgia americana

is represented by 2, and Pocudo-

Pieresoraia acerea is represented

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Discussion

Distributional studies

Small Scale Dispersion Pat

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Grigg (1970) used variance to mean ratios to examine

the dispersion patterns of

wteca califoontea and Ht. fructteooa ona Lm? scale. He fornd H. eadéforntea to be age

Bregated and ¥. fructicona to be too rare to test. Ona smaller scale using a nearest neighbor analysis on an area which had great physical heterogeneity of the substrate and on an area with very even substrate, he found that although both areas were not significantly different from a random Gistribution, gorgonians had a tendency to be aggregated on the heterogeneous substrate and evenly distributed on the homogeneous substrate. He concluded that substrate heter-ogencity was the strongest factor causing aggregation Pecudopterogorgia americana, hovever, was found to be eeeregated on a 1/16 n? senile in hoth areas indicating that

larvae may tend to settle clese to a col:

ny of the same species. The even distribution of total gorgonians on a 1/16 n? scale over the more homogeneous substrate may be a result of negative interactions between colonies due to very high densities. An area of lower densities of go:gonians and more even substrate than found on site (1) could provide

more complete answers to small scale dispersion patterns.

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Densities and Size Frequencies

Although the relative ubund

ces of >. anord ana and

P, aecrosa do not differ siynificantly at different depths

within a site, they do differ betwen sites. For instance,

P. ane

cana was at least three times more abundant at site

@) than P. acerosa, while P. aessvee was slightly more

abundant than Pp. ame:

ana at site (2). The area with the highest densities of Prexdoptersgorgta spp., site (1), had a much higher relative abundance of P. ancricana than P.

aceroca. Sites of lover P,

rogorgta spp. density showed an alnost equal or even higher abundance of P. acerosa than P, americana. Therefore, densities of these species may imply an advantage for one species over the other at a particular site.

low nunbers of colonies in the firet year age classes for both species of Poeudo; tersgovata are probably due to the difficulty of seeing very sna!l colonies (less than 2 em long). The fact that comp: {oni of the age frequencies between the tuo species did not differ within sites indicates that the species are not affected differentially by those factors influencing these age distributions. These factors

include var!

fons in recruitment rate and mortality rate

which may be due to factors such as light, surge, sedimen-

tation, competition, and predation.

I£ populations are in a fairly steady state, the high

Proportion of young colonies at site (4) indicates higher

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1

mortality for younger colonies than at other sites. ?The

more even age distributions and the large relative abundances

of older colonies at site (3) and Fl Negro reef (for P.

americana) implies low recruitment rates and low mortality

rates evenly distributed over the age spectrum

Grigg (1975) used the variabi

ty between successive

age classes as an indicator of habicat "stability". Vvari-
ability due to high recruitment and/or mortality would in-

dicate unstable habitat, He used the relative longevity of

the species to determine habitat "suitability". In these terms, site (1) would be the most "suitable" and "stable" site for both species. Site (3) shows the greatest variability between age classes for both species, but this may be due to lower numbers (100 for P. acerova and 78 for

P. americana). Due to the higher percentage of older colonies, site (3) is more ?suitable? than site (2) and perhaps as suitable as site (1). Recruitment at site (3) appears to have been low for sever) years

Recruitment and Mortality

Although the abundance of P. anerteas

is significantly

higher than P. aserosa on site (1), recruitment was not

significantly higher for P. americana. This may be due to

small sample size or to proportionately greater reproductive

Success for P. aceroea. Recruits were noticeable at a height

of Lom, and the most recruits for >, ansteana were seen in

June and July, Since most estimates for larval life span

---Page Break---

are short (about 30 hozrs for fwntcetle singutaris, Weinberg,

and Weinberg, 1979) and the most active reproduction period

for P. americana is during the winter months (see Repro-

duction), recruits may

25 old as five to six months when

they axe visible in the field, Therefore, es

mates for

mortality of young gorgonians do not include the earliest,

and perhaps most crucial, period of life

The higher recruttnent of P. ancvicana,

acerosa, and

other gorgonians in cleared versus uncleared quadrats implies that space is a Limiting factor for gorgonians at least on site (1), Since recruitment vas significantly higher in quadrats cleared only of gorgonians on site (1), gorgontans appear to compete with each other for space. The higher densities of P. ancricana and P. acerove at the buoy scar site

compared to areas of similar position at te (2) indicate

that space is limiting at site (2) even though overall gor-

gonian densities are lover

The higher reeruttaent of fen

than of other

Borgonians in the cleared quadrats is an indication that

P. americana may be a colonizing species. Although the re-

erultment of P, america was not significantly higher than

that of other gorgonians, relative recruitment rates are

higher because the abundance of 7. ancrican does not equal

the abundance of other gorgonians on site (1). The lover

number of reeruits for >, averoca does not necessai

ly mean

that it is not a colonizing species; rather it may be a

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a

result of the low abundances of F. avaron- compared to ?.

americana or other gorgonians

Since the percentages of mortalities were not signifi-

cantly different for P. aecnosa, ?. americana, and other gor-

gonians, the prominent causes of ortality are apparently not

species specific (at least for the tuo spe

tes of Peeudo~

Pterogorgia). ?The number of mortalities in a given size class Of P. americana was proportional to the relative abundance

of that size class indicating thet the rate of mortality is evenly distributed over all size classes of P. anericana. Other gorgonians (not including F. acerosz) had a propor- tionately higher rate of mortality in the younger size classes

As the numbers of recruits did not differ significantly from the number of mortalities for P. acerosa, P. americana, or other gorgonians, the populations of both species of Peeudopterogorgia and other gorgonians were stable over the period of the study.

Although causes of mortality are most commonly either detachment from the substrate fron bioerosion and/or wave force or encrustation by miIlepora spp. or sponges, the disappearance of large numbers of very young colonies in one of the cleared quadrats may be the result of grazing (see

ecological interactions), cypior

boeur, shown to be a

?prudent predator" by Birkeland end Gregory (1975), was rarely

direct source of mortality on any of the sites cxanined

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oweh

?The great similarity between length-weight regressions of P. americana and P. acercea at all sites indicates that the two species grow very similarly under a variety of con-

ditions. The greater weight of P. americana at two sites

is probably due to its greater "bushiness" at these tuo sites Since it is unlikely that the density of the material vhich makes up the colony would vary.

The variability of linear growth inevements in colonies measured over one year is real although some measuring error may be involved. Since there were no significant differences between growth rates of colonies of different length or at different depths, the effects of colony lengths and depth were not distinguishable, if present, due to the high variability in growth rates. Available light accounts for only about 20% of the variability. Grigg (1970, 1977) ateributes the high variability in the growth rates of murteea spp. to damage by abrasion, grazing, and intrinsic variability between individuals. As many incidents of negative growth occurred for P, americana and P, acerosa, especially on a bimonthly time scale, abrasion or grazing probably are responsible for much of the var

bility. Colonies showing no negative bimonthly growth increments also had a great deal of variability in growth rates suggesting intrinsic differences in growth rates between colonies. (Kinzie (1970) and

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fa

Weinberg and Weinberg (1979) also found high va.

ability in
grouth rates for the species they studied and attributed it
to abrasion, predation, and intrinsic differences

Mean growth rates of bout 5 cm/yr for P. anericana and
6 cm/yr for P. aceroea (as determined by length per growth
ring) were very close to or higher than other reported growth
rates. Grigg (1970, 1974) found a mean grouth of about 1.5
emlyz for Hurteea californica. Cary (1914) reported growth

ranges of 0 to 8.3 cm/yr for sorgonta flabeliun and PL.

Slezuosa. Plezaura homomalie grev at a mean rate of 2 ca/yr
(Kinzie, 1974). Kinzie (1970) measured growth rates in a
variety of gorgonian species and found them to vary from 2.8
to 8 em/yr depending upon the site and depth. Weinberg and
Weinberg (1979) reported grouth rates of 0 to 4.9 cm/yr in
Funicetta etngutarts. The growth rates reported by Kinzie

(1970, 1974) and Weinberg and Weinberg (1979) excluded in- cidents of negative growth and therefore are optinal and Probably higher than would be expected in nature. Growth Fates used in the present study included incidents of negative growth so that they could be used to determine age of colonies of @ given length

The positive relationship of growth rates to the rel- ative amount of light indicates that zooxanthellae enhance growth. Peeudopterogorgia arerieana contains more 200- xanthellae than P. accrosa (Bayer, 1961). Tf gro-th rates

were dependent upon zooxanthellae, P, anesteann should show

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a faster growth rate than P. acerocc, This, however, is not the case and may indicate that grovth rates are also de- pendent upon other factors

Annual periodicity in growth rings of gorgonians has been demonstrated in a temperate species (Srigg, 1970, 1974).

The existence of growth rings was shown in a tropical gorgonian, Plezauna horsnatta, by Opresko (1974), and he assumed rings to be annual. The agreement between measured growth rates and estimates based on length per growth ring in

P. americana and P. acerosa indicates thet growth rings are annual. Since growth rings are found in young colonies that are not reproductively active, they cannot be due to slowing of growth during reproductive periods. Seasonal fluctuations in temperature or light (in the nunber of daylight hours)

are probably responsible for these rings. Growth rings are most easily distinguished in gorgonians from site (1) and may be due to greater seasonal influences there. Although site Q) had the shallovest depths, vistbility there was frequent-

ly so low that light leve

are probubly not much, if at all,
greater than at the other sites

The length per growth ring data indicate that larger colonies grow faster than small ones. However, as actual measured growth rates did not vary with colony length, this

is considered to be an error due to the eifficulty of dis-

tinguishing all the rings in large colonies, Grigg (1970,

1974) plotted growth rings against age based on height and

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measured estimates of growth and found agicenent (one to one)

except for the largest colonies. ile

cluded that the exe

estimates for large colonies using growth rings vere low éae

to the difficulty in

tinguishing the rings on the periphery

Of cross sections. Grigg also found that measured linear

Browth rates in surteca catiforntca decreased slightly with

increasing colony size, while growth rings in Large colonies indicated an increased Linear growth rate over small colonies.

Mean growth rates based on colony length per growth ring con

Pared well with annual growth increments measured in P.

americana and P. aceroea; therefore, mean growth rates vere

used for all colony sizes to estinate age

Reproduction

Sexes are separate in both species of Paoudopterogore

Gohar (1940a) and Gohar and Roushdy (1961) found some Red

Sea octocorals to be hermaphroditic although most were dice-

cious. Grigg (1970) examined over 1300 colonies of Murtcea

californica and %. fructievra and concluded that sexes were

Separate since only four colonies (all i. fructiecva) con-

e

ned male and female sex cells. Sex change, if it does occur, is @ rare event as only one colony (P, anericanc) out of 18 sampled monthly on site (1) could have changed sex. Goldberg and Hantiton (1974) reported that several colonies Of Plecaura honcratla out of 75 appeared to change sex, but they attributed this to sampling error

If colonies do occasionally change sex, one reason might

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be to increase the proximity of males to femal

Therefore, a@ nearest neighbor technique should demonutrate if one sex tends to be closer to the other sex than to members of the

same sex. In material dis.

sssed here, the sexes vere not significantly associated or dissociated with each other. Since either males or females were found in colonies of all sizes, scx change, Lf it occurs, is not an age or size phenomenon.

Paeudopterogorgia anorieana was found to have a higher Percentage of females than males, while P, aecrosa had a fone to one ratio. The high proportion of fenales in P. americana assumes that colonies which could not be sexed id not contain a higher proportion of males than fenales It was not possible to determine if this was true for P. americanc since only nine colonies were sampled monthly

If P, anerteana does have 2 higher proportion of females than males, while 7. aceroca has an even ratio, P, americana might have an advantage over F. aocrosa if the fertilization rate is the same. No studies have been reported of fertil- ization rates in gorgonians.

Reproductive periodicity shows stronger synchrony be tween sexes of P. acerosa than P. americana at least on

site (1) for the year studied. Although 7. amerfoana may

reproduce for a longer period of time each year, the strong

synchrony between sexes in 1. asere.

might enhance its fer-

tilization rate. This could give P. aeeruee and advantage

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over. americana in areas of lower density of the tue

species such as sites (2), (3), and (4). Work on reproduc~

tive periodicity in an area of lovor densities might be

valuable to determine if syn

nrony patterns were the same

for the tvo species. tinfortunately not enough colonies of

the two species were sampled at site (2) to provide any

information on reproductive periodicity there

Griga (1970, 1977) found that both Pacific species of

Murteea delayed reproduction for four to six years, and go-

nads did not achieve the size found in large colonies for up to 10 years old. Pscudopterogorgia ancricana and P. acerosa also appear to delay reproduction for at least three to five years. Since the reproductive potential of a colony would depend upon the numbers of polyps and therefore the size of the colony, areas with a high proportion of larger (older) colonies should have a higher reproductive potential than areas with a higher proportion of small (young) colonies

I addition areas with a higher proportion of older colonies should have a far highor proportion of reproductively active colonies. Likewise, if one species is reproductively active at @ smaller size than the other, it could have a repro-ductive advantage. Many more samples would have to be taken to determine just when each species becomes reproductively active, Wo previous work on the size of the colony at onset of reproduction has been reported for othor species of West

Indian gorgonians. Great reproductive potential may be an

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important factor between species, bi

space

itation will

control the total number of recruits

Since space is limiting for gorgonians and the avail-

ability of space may occur at any time, the slight seasonal

differences in reproductive periodicity between the two

species of Peendoptorogorg!« may be thought to temporally

Separate the species. The cleared quadrats, however, were not settled substantially until anost ¢ year after the clearing, This is probably nor due to a seed to "age" the substrate, as other substrate vhich was cleared in the same manner was settled on within a few months by gorgonians (Paul Yoshioka, personal ccimuni cation).

Gohar (1940a, 19405, 1942), Gohar and Roushdy (1961) found oviparous and larviparous octocorals, Kinzte (1970)

found planulating individuals of Prewdoptesoorgia bipinnata,

P. elisabethac, Briariuy asboatinum, and turiccopets flavida, although in the last two species only one planulating indi-

vidual of each was seen. Savoral

cies of funtuotte have been shown to be larviporous (Theodor, 1867; Weinberg,

1979; Weinberg and Weinberg, 1979). Bayer (1974) and Gold berg and Hamilton (1974) found no sign of larvae or dividing eggs in Plezaura homonalia. No larvae or dividing eggs

were found in P. americava or P. acevoea, although colonies

with large eggs were checked frequently. Reproduction did

occur as recently settled colonies uere found. Therefore,

these two species are probably oviparous, }

re work should

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be done to

ermine if a particular species can be both

oviparous and larviparous.

Ecological Interactions

?The negetive relationship between coral coverage and gorgonians indicates that thoy do compete with each other for space and may be partially responsible for patchiness on site (1). Grigg (1970, 1977) concluded that the two Murteca spp. he studied appear to compete more strongly with other organisms than with each other for space. No new coral Polyps were noticed in the cleared quadrats on site (1) Suggesting that gorgonians colonize an area faster than corals. Stoddart (1963)indicated that gorgonians recover more rapidly than corals in storm devastated areas. This may be due to both heavy recruitzent of gorgonians in cleared aress and relatively rapid growth rates compared to many corals.

Gorgonians showed little obvious ability to danage each other. muricea spp. did cuuse some damage, and this was also reported for Murices ?x1 in Jamaica by Kinzie (1970). Peeudopterogorgia spp. with their high degree of branching are among the few gorgonians which may have the ability to shade (exclude light from) other gorgonians (Kinzie, 1970). Since gorgonians tend to be evenly distributed on even substrate (small scale dispersion patterns), either larvae tend

to avoid other colonies during settlement or interactions

do occur. The highly significant even pattern found on the

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°0

homogeneous substrate on sire (1) may be:

ted 60 extremely

high densities of gorgonians which would inercase abrasive

contact

No new encrustations were seen on colonies which had not sustained previous danage in this study. Bayer (1961), Kinzie (1970), and Grigg (1970) believe that encrusting organisms need exposed exial skeleton to settle on gorgonians.

this ¢

Therefore, the means by which

age is caused is very

important. Storm damage by heavy wave action is knoim to be

the most prevalent cause of heavy mortalities to gorgonians in many areas (Cary, 1914, 1918; Goreau, 1964; Stoddart, 1962; Birkeland, 1974). Storm waves may also eause damage which exposes the axial skeleton of the bases of colonies as well as abrasion to branch tips (Cary, 1914). Storm damage to the bases of gorgonian colonies was found on site (2) and is

Probably due to scouring by heavy sedimen: rather than twist-

ing of the colonies. Even in areag where damage to the basal

stalk during high storm waves is not conn, us on site Q)

encrustations on the bases of yorgonians ure common. Cy

gitbosun occurs infrequently on site (1), but its grazing damage is most common near the bases of gorgonians. Birkeland and Gregory (1975) found that c. gibbosur prefers gorgoniid to plaxaurid gorgonians, with a particular preference for Gorgonia spp., at least at the Tektite site in St. Jobns, Virgin Islands. c. ¢

oun seemed to prefer ¥. anericana,

also a gorgoniid, on site (1). Gergeuta spp. were rare on

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site (1). Since c. giztoow

lonies fre-

quently (Birkeland and Gregory, 1975), one gastropod ts capable of attacking many colonies. Since as many as 37% (6/16) of these attacks result in permanent encrustations, even small numbers of ¢. gibbocwn could have a significant indirect effect on the rate of mortalities. The ?successful enerustations? on gorgonians previously attacked by Cc. sibbosun were only observed for several months, and none of these included mi?icpora spp. ?The actual number of encrus-tations from organisms other than #!2iepora spp. resulting in mortalities is not known, but they do oceur. Although the extent of these infestations frequently does not in-

crease, if they are stable the colony may eventually topple

the weight becones too great for the basal stalk to sup-

Port, Auphinonié polychaets which do graze on gorgonians

were not seen on the basal stalk where most encrustations

are found

Enerustations by ?27 sora spp

6 the fate? of a

Particular gorgonian colony (Kinzie, 1970). Growtl rates

of Witlepora spp. of 9.3 cm/yr indicate that the hydrocoral

can outgrow a gorgonian, but usually gorgonians break on

the weakened basal stalk before being completely overgrown

Kinzie (1970) reported growth rates for H21teora spp. of

244 em®/yr on core:

ta spp. and 1.4% em/yr on branch tips of

Plezaurella spp.

exaune?ta spp. have a very thick cocn-

enchyme which may be more diffievlt for the hydrocoral to kill

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9

Kinzie (1970) reported that periodic algal blooms in

some areas may smother youny, colonies. No dense growths of

algae were noticed on sites (1) or (2) until efter storm

waves from Hurricane David scoured the bottom at site (2)

Dense mats of algal growth were not seen during the study

?The occurrence of a parasitic polychaete and an isopod

on P. acerosa and not on P. aner

na may be due to some

ehenical repellent in ?, cremfeana or just to the mechanical

AisFiculties of living in the slime produced by P. anericana.

The sliminess of P. americana may have movy advantages such

a8 a greater ability to slough off sediments and many dis-

advantages such as fouling fron its own mucus in the absence

of water currents. Excessive mucus production is a dis-

advantage to the species when kept in aquaria (Goldberg,

19736). Colonies of P. serosa which were infected with

the polychaete or isopod appeared to be in good condition.

The presence of /

yton murieatux or Pteria eolyn-

bus on colonies of Pecudor: megargia spp. @id not appear to cause mortality in gorgonians from excessive weight. How-

ever, Weinberg and Weinberg (1979) observed mortality from

"benign" encrusting organioms on Ewiicelic einteta. Large

individuals of 4. muricatum are usually found on corals

rather than gorgonians (Wolfe, 1978)

Thalassona bifacctatun appears to ?clean? gorgonians

rather than graze on them. Randall (1967) noted that

bifecciatun usually feeds on small crustaceans often

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?picking? at gorgonians, Occasionally the parrc-fish, Sparasona curofrenatin,

wae also seen plucking et gorgonians.

The disappearance of a large munber of very young col-

onies in one of the cleared quadrats remains unexplained.

No large storm waves, unusval algal growth, or heavy sedimentation occurred at the tine, and other cleared quadrats had few mortalities. Gaging experiments indicated that Piadena antiliarum, though abundant, was not responsible. Predation from fish or sone ovher source remains a good possibility.

The trend for a high percentage of both species of Peeudopterogorgta to be open day and night may indicate dependence upon catching food and zooxanthellae. Neither species was seen actively catching plankton at night, but the role of fine detritus in gorgonian nutrition has not

been reported.

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Sune

1, The distributions and sbundances of Pve

pterogor-

gia anerteara and Pp. averonc were studied on four different

sites. Mortality, recruitment, growth rates, reproduction,

and interactions with other orgaaisns were studied to deter-

mine what effect they nay have on these distributions and

abundances.

2. Substrate heterogeneity is largely re

ponsible for

the aggregeted dispersion patteras

gorgonians on site (1).

The presence of corals and other encrusting organisms may

contribute to these aggregated patterns since there is an
inverse relationship between coral or enccusting organism

cover and the nunber of gorgonians

Negative interactions nay occur between gorgonians
in areas of high density as indicated by the even dispersion
Patterns on relatively homogeneous substrate on site (1).

A single species, 7.

americana, was aggrezated on relatively

homogeneous substrate which my te due to a Limited ability

for the larvae to disperse

4, The relative abundances of F. anericana and P,

acerosa differ from site to site. Site (1), where the

absolute densities of both spreies are highest, had many

more P. ame

feana than P. aoen

2, The other three sites,

where the densities of the two species vere lover, had

almost as many or even more P. zceroca thin P. emenieana.

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5. The age Frequency iscribus fons of the tuo sp

were very similar on all of the sites studied indicating

that the two species are not affected differentially by

those factors influencing these distributions

Site (4) had the greatest proportion of young

colonies of both species while sice (3) had the greatest

Proportion of older colonies. Ther

re, site (4) prob-

ably has the highest mortalities «

mg young colonies while

mortalities on site (3) vere more evenly distributed over

the age spectrum

7. Site (1) appeared to have the most

Stable" ond

"stable" habitat for both species.

8. Gorgonians conpete with each other and other ses-

sile organisms for space as indicated by the significantly

higher recruitment in cleared versus uncleared quadrats.

P. anericana may be a colonizing species

ce its recruit-

ment was higher than that of other gorgonians

9. The nusber of mor: I icfes wore ner different for

P. anevicana, P. aceroca, and other go

sorians on site (1)

10. The nurber of mortalities im a size class of

P. americana on site (1) was proportional co the relative

abundance of that size class, while mortalitics were pro-

Portionately higher in the younger size classes of other

gorgonians (excluding P. aoresa). This did not include

very young colonies (under 2 cia).

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LL, Reersitment did not differ significantly from

mortality in. amos

ana, ®. aecroca, and ovher gorgonians

indicating that the populations w

re stable over the period

of the study.

12. Although cy:

un,

stropod, rarely

causes mortalit

+ its ability to bare the axial skeleton by
grazing does allow encrusting organisms to settle on por-
gonians. Usually, however, the gorgonfan heals over the

©. gibbosum sears.

13. Peeudopterogorgia americana and P. accrosa grow
at similar rates and have a similar growth form. Linear
Browth rates as estimated from grovth rings or measured over

one year are very vari

ble and are about 5 em/yr for P.
americana and 6 en/yr for P. aeonoen.

14, Growth rings were found to be annual for P. ameni-
eana and P. acévoea. Age estimates for older colonies are

low due to the difficulty in distinpuishing all of the rings.

15. Growth rates & pe Eleantly with col-

ony length or depth, but did show a nositive velation to increasing light. This accounted for about 20% of the variability im grovth rates. Other variability may be due to loss of length from grazing or abrasion, meacuring error, and intrinsic differences in growth Setwcen colonies

16. Sexes are separate in P. averieana and P. acer

colonies. P. crerteana had a higher percentage of female

than male colonies on site (1), while», averusa had an

---Page Break---

even ratio of males to Semiles. If the vertil

gation rare

are the same for the tvo

pecies, this my give r. anemteana

sone advantage over F. zesro:

17. Pseudopterogersia aooroea had strong synchrony in

reproductive periodicity (from gonad volume) both between

sexes and within sexes, while P. «i

?ieava had weak synchrony

within sexes and was not very synchronous between sexes.

P. aceroca peaks from late July to September, while P. aneri-

cana appears to reproduce

rom late Septeaber through March.

The strong synchrony in P. accross might be an advantage over

P. anericana in areas of low colony density vhere the fertil-

tzetion rate might be affected

18. Reproduction in both species of Pooudoptersgonsta

may be delayed for from three to five years since small col-

onies rarely contained gonads

19. Both species of Pocudopterogone

are probably

oviparous since no dividing eggs or Larvae were found in

the polyps.

20. Few gorgonians showed damage ax a result of contact with other gorgonians, although there is sone indication that high densities of gorgonians may cause negative interactions. Since light can aid growth, the high degree of branching of Peeudopterogorgta spp. may allow them to shade other gor-

gonians.

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21, No obvious damage or mortalities were neticed from

the isopods or parasitic syllid polychaets found on P. ac.

sa, Thalaccona bifasciatur, a wrasse, was frequently seen Picking at gorgonians, but gu: contents examinations showed

few, if any, gorgonian remains

only rarely seen picking at g:=gonians

22. A high percentage of colonies of both species expand their polyps during the day or night which may indicate that Peeutopcerogorsia spp. depend upon their

zooxanthellae and active fceding.

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