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Cryptobiota associated to dead *Acropora palmata* (Scleractinia: Acroporidae) coral, Isla Grande, colombian Caribbean

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Abstract: Cryptobiota of dead fragments of five branches in live position and five fallen pieces of the coral *Acropora palmata* each one of approximate 1dm^3, covered by filamentous algae were extracted from the north reef crest of Isla Grande (Colombian Caribbean), in April 1991. There were three groups of organisms according to size and position (on and within the coral): 1) mobile epibenthos, mainly microcrustaceans that live among the filamentous algae 2) boring microcryptobiota, located in the layer between the epilithic organisms and the coral skeleton itself and, 3) perforating macrocryptobionts that bore and penetrate the coral skeleton. Polychaetes, sipunculids, mollusks and crustaceans were most abundant in the last group. There were no differences in macrocryptobiont composition between standing dead branches and fallen fragments. There was a large variation in total biomass and type and density of macrocryptobionts, possibly associated to stochastic factors such as placement and thickness of branches and small scale variations in recruitment.

Key words: Cryptobiota, *Acropora palmata*, dead coral, epibenthon, Colombian Caribbean.

The structure and shape of reefs are the result of a dynamic system of constructive and destructive forces that constantly transform them (Schuhmacher 1978). The speed at which a reef is formed depends on rates of skeletongenesis and consolidation, while destruction rates depend upon physical, chemical and biological eroding processes (Risk and Sammarco 1982, Hutchings 1986).

In a healthy reef, bioerosion is very important since it increases the complexity of substrates, constantly creating free spaces for coral larvae and other organisms, thus maintaining diversity in species and renovating populations (Hutchings 1986); however in some zones such as the reef crest of Isla Grande where coral growth is limited, bioerosion can eventually kill the reef.

The purpose of this paper is first to describe the bioeroding cryptic fauna associated to skeletons of dead *Acropora palmata*, responsible for the bioeroding action. Cryptic fauna means organisms living in small pores, holes or cavities within the rock or inside organisms that cover them (Hutchings 1978, Peyrot-Clausade 1981, Scott 1987). Second, to establish whether differences exist between the cryptobiota inhabiting colony branches in life position and broken fallen fragments.

MATERIALS AND METHODS

Area: Rosario islands' (10°8'-10°15' N, 75°40'- 75°48' W) reef complex is formed by approximately 28 coralline islands, 45 kilometers southwest of Cartagena (Colombia); most of the islands are fringed by reefs and seagrass meadows, which are protected within the Rosario Coral Natural National Park (PNNCR) (Sarmiento *et al.* 1989). Isla Grande is the largest of the islands; parallel to its northern margin, and separated by a small reef channel, lies a large fringing reef reaching 950 m in length (Penereiro 1988). Initial studies in this zone describe a healthy coralline community (Pfaff 1969, Werding and Sánchez 1979). However, from 1982 onwards, a drastic reduction of coral cover, mainly of *Acropora palmata*, was detected, reaching a values as less as 0.2% of cover of living tissue in 1988 (Garzón-Ferreira and Kielman 1993). The origin and evolution of the degradating process are not yet well understood.

Methodology: coral fragments covered by filamentous algae were collected in April 1991. Five branches in live position and five fallen fragments, approximate volume of 1dm^3 each, of *A. palmata* were evaluated (Brock and Smith 1983, Grajal and Laughling 1984). Each fragment was covered with a tightly sealed cotton bag, then broken into small pieces with hammer and chisel over a thick blanket, preventing any loss of material. Macroscopic organisms were narcotized for six hours using magnesium sulfate, then fixed in 10% formaldehyde neutralized with borax and finally preserved in alcohol or formaldehyde, depending from the organims. The volume of each fragment was determined by water displacement (Young 1986).

The sediments and material contained in the bags, as well as the remains obtained after macroscopic sorting with hammer and chisel were meshed with a 100 micron mesh. The resulting material was observed with a stereoscope and the organisms found were preserved in 70% alcohol.

Mathematical analysis of macrocryptobiota was performed on a family level, the lowest taxonomic unit common to all organisms found. Bray-Curtis dissimilarity between fragments was calculated with density data (number of individuals per dm^3).

As an approximation to the total biomass (epibiont and cryptobiont), six pieces of coral were fragmented, then dried and calcinated until constant weight was reached. Results were expressed as percent of a coral's dry weight.

RESULTS

In a transversal cut of a branch of *A. palmata* three horizons can be clearly distinguished. The superior conformed by a film of filamentous algae and its associated organisms. Then, the middle part of the branche, that is skeleton, and the inferior horizont, formed by a crust of coralinaceous algae.

Then, dead *Acropora palmata*'s skeletons supports three types of organisms:

Mobile epibenthon: Composed by the fauna obtained from the examined sediments, living in associations over and under coralline surfaces covered by filamentous algae. Most abundant were small crustaceans, micropolychaetes and foraminifers. Gammarids and caprellids were common amphipods both found in all states of development, tanaidacea was very common and frequently found with eggs. Concerning isopoda, asellots were the most abundant in number while most of the species were flabellifers (*Dinamenella*, *Geocerceis* and *Exocoralla* genus). The most commonly found foraminifers belong to the genera *Triloculina* and *Qinqueloculina*, (Myliolidae) although individuals of the *Cyclogyra planorbis*, *Articulina mucronata* and *Sphaeroina bulloides* were also frequent. The *Nonionella*, *Rosalina*, *Bolivina*, and *Gipsina* genera were also well represented. Associated molluscs *Tricolia affinis*, *Anachis pulchela*, *A. obesa*, *Volvarina* sp., *Hyalina pallida*, *Cyclostremiscus* sp. and various species of *Caecum* were the species commonest found. It´s important to notice the presence of the gastropod *Marissa cornuaretis*, a freshwater mollusc frequently found in the fragments; mainly as empty juvenile shells that are possibly brought to the sea attached to the roots of "taruyas", *Eichornia crassipes.* This "taruyas" come from the Dique channel, which lies 45 kilometers apart from the Rosario islands, and that connects the Magdalena river with the Cartagena bay.

Boring microcryptobiota: Just underneath the growth of crusty coralinaceous algae, vermetids, and the base of filamentous algae, which penetrated the skeletal matrix, a thin band of perforation was seen. In these horizons evidence of anaerobic organic matter decomposition was found.

Macrocryptobiota: The central skeleton showed varying thickness depending on age and site where the colony was extracted. This skeleton seemed perforated by tubes and holes in an random manner. Cryptobiota, localized in the body of the coralline skeleton were the organisms quantitatively evaluated, measuring 5 millimeters or more. Polychaets were the most abundant followed by sipunculids, mollusks and crustaceans (Table 1), when 7574 individuals were counted and identified in 12.35 dm^3 of sample.

Polychaeta reaching a density of 328 individuals per dm^3 of coralline rock. Most abundant families were Eunicidae (185 I/dm^3) and Nereidae (123 I/dm^3). The Cirratulidae, Phyllodocidae, Polynoidae, Dorvilleidae, Terebelidae and Serpulidae families showed low densities. Furthermore there were fifteen types

TABLE 1

Main groups of macrocryptofauna

Group *	N	D	F
EUNICIDAE	1914	184.83	100
NEREIDAE	1280	122.69	100
LUMBRINEREIDAE	229	21.19	100
TYPE 1	196	17.33	100
SABELLIDAE	146	13.08	100
TEREBELIDAE	21	2.24	70
DORVILLEIDAE	16	1.74	60
POLYNOIDAE	6	0.68	50
SERPULIDAE	6	2.00	30
CIRRATULIDAE	3	0.34	40
PHYLLODOCIDAE	3	0.20	10
POLYCHAETA	3820	328.34	
Aspidosiphon sp.	1175	111.49	
Type 2	911	68.37	
ASPIDOSIPHONIDAE	2086	179.87	100
Phascolosoma sp.	340	36.57	
PHASCOLOSOMATIDAE	340	36.57	100
Type 1	9	0.77	20
SIPUNCULIDS	2435	213.47	
Fissurella angusta	29	2.55	
FISSURELLIDAE	29	2.55	50
Dendropoma corrodens	863	89.18	
VERMETIDAE	863	89.18	100
Lithophaga bisulcata	24	2.03	
L. antillarum	66	7.07	
Gregariella coralliophaga	16	1.63	
MYTILIDAE	106	9.66	100
Isognomon bicolor	7	0.61	
I. radiatus	4	0.56	
ISOGNOMONIDAE	11	1.06	60
Engina turbinella	3	0.34	
BUCCINIDAE	3	0.34	30
Acanthochitona sp.	2	0.11	
Choneplax lata	1	0.12	
ACANTHOCHITONIDAE	3	0.23	30
Ischnochiton striolatus	11	0.88	
ISCHNOCHITONIDAE	11	0.88	30
Gastrochaena hians	5	0.42	
GASTROCHAENIDAE	5	0.42	20
MOLLUSK	1031	95.02	
BARNACLE 1	26	2.60	80
Alpheus schmitti	44	4.50	
A. cristulifrons	4	0.38	
Thunor simus	44	4.57	
Sinalpheus fritzmuelleri	16	1.45	
ALPHEIDAE	108	9.81	100
Paraliomera longimana	24	1.94	
P. dispar	49	3.98	
XANTHIDAE	73	5.33	90
Petrolishtes rosariensis	5	0.39	
Pachycheles chacei	4	0.29	
PORCELANIDAE	9	0.61	40
Mitraculus sculptus	28	2.48	
M. corype	5	0.45	
MAJIDAE	33	2.00	90
Pachygrapsus gracilis	5	0.35	
GRAPSIDAE	5	0.35	10
Gonodactylus curacaoensis	1	0.16	
STOMATOPOD	1	0.16	10
CRUSTACEA	255	21.18	

*Number of individuals (N), density ind/dm3 (D) and frequency (F).

of polychaetes with few individuals that were not identifiable. Polychaetes were frequently associated to clionid sponges and foraminifers, a common situation in these habitats (McCloskey 1970, Lipps and Ronan 1974).

The second largest component in number of organisms were the sipunculids, reaching a density of 213 I/dm^3 (Table 1). The population was formed mainly by three genera. *Aspidosiphon*, type 2, and *Phascolosoma*, present in all fragments. Behavior is similar to that of polychaetes. Big populations were always present in the fragments but with large variations between them. Various sipunculid perforations communicated directly with the galleries of *Alpheus schmitti*, and not to the exterior. This was a frequent finding.

The vermetid *Dendropoma corrodens* is the most abundant mollusc (89 I/dm^3) found in the fragments extracted from the north reef crest of Isla Grande (Table 1). Bivalves were the next group in abundance. Caves belonging to bivalves showed intensive infestation by *Siphonodyction coralliphagum* sponge. Other mollusc individuals were poorly represented in the samples. These were *Fissurella angusta*, and chitons like *Acanthochitona* sp., *Ischnochiton striolatus* and *Choneplax lata*, of scraping habits. Others were the filtrating bivalves *Isognomon bicolor*, *I. radiatus* and free living gastropods such as *Engina turbinella* and *Leucozonia ocellata.*

We collected a total of 255 macrocrustaceans distributed in seven families and twelve species (Table 1). Eight *Thunor simus* cavities in the superior part of a 14 x 14 cm rock were found, each with an eigth shape. They measured 1.32cm maximum mean width and 3.42cm in length. Each of the chambers had a pair of adults; females, always with eggs, and using the larger chamber while the males the smaller. These cavities had no galleries or tunnels interconnecting them, and organisms appear to be completely covered by the skeletal crust of corallinaceous algae.

The most common boring species found in the *A. palmata* scaffold were *Cliona* cf. celata, *Cliona* spp., *Siphonodictyon coralliphagum*, *Geodia* cf. *gibberosa* and *Aka* sp. At a glance of dead branches, presence of any organism is nothing but conspicuous, for their openings to the exterior are through tiny pores. The biggest observed perforations belonged to *Geodia* cf. *giberosa* reaching a length of 5 centimeters. Those of *Siphonodictyon coralliphagum* were of intermediate size and *Cliona* sp. were the smallest.

Anemones of the *Lebrunia coralligens* and several species of fish were also found. Some sampling showed a Gobiessocidae *Gobiesox punctulatus* and the blennoid *Hypleurochilus springeri*; another two samples had an *Acanthemblemaria aspera*, and *A. rivasi* respectively, all of them inhabiting cavities built by other organisms (Greenfield and Greenfield 1982).

Representativity evaluation, based on density data of different families, showed that an acceptable sample is that of four sampling units of one dm^3 each. A dissimilarity dendrogram between fragments from both coral positions (Fig. 1) done according to quantified family densities, showed no difference between macrocryptobiota inhabiting live position and fallen fragment corals.

The obtained biomass values (Table 2) were similar throughout except the variation coefficient (80% to 88%).

DISCUSSION

The three kinds of described organisms are found in dead coral blocks (Brawley and Adey 1981, Rice and McIntyre 1982, Grajal and Laughling 1984, Scott and Risk 1988) as well as in rocky shores and submerged rocks, and are not restricted to this habitat and to this particular species (McCloskey 1970, Hutchings 1983,

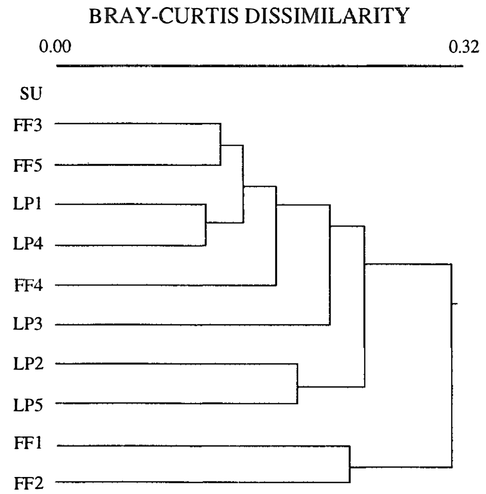

Fig. 1. Affinity dendrogram of cryptofauna between sampling units using Bray-Curtis index based on family densities data. SU: sampling units FF: Fallen fragments LP: Live position.

TABLE 2

Free ash biomass obtained from dry weight of dead Acropora palmata

	LP	FF
Number of coral pieces	60	60
Dry weight (g)	1072.14	982.12
Average biomass (%)	12.94	12.30
Standar deviation	10.30	10.89
Variation coefficient	79.57	88.58

Live position (LP) and fallen fragments (FF).

Marshall 1983), but are less abundant than those occurring in the Pacific ocean and in other classes of corals (Patton 1974, Reed and Mikkelsen 1987, Coles 1980).

Mobile epibenthon: Organisms found here (microcrustaceans, micromolluscs and foraminifera) are the most common elements of such habitats (Bell and Deblin 1983, Hutchings 1983, Klumpp *et al.* 1988). This order of abundance changes between reefs and zones, and depends upon biological cycles of the species (Klumpp *et al.* 1988)

These abundant kinds of organisms plays a very important roll acting as links between filamentous algae, very abundant in this kind of habitats (Navas *et al.* in press) and important as primary productors, and reef secondary consumers as fishes, crustaceans larvae and criptobiontes, etc (Brock and Smith 1983).

Boring microcryptobiota: Marshall (1983) and Hutchings (1986) showed that this band was formed by microperforations made by bacteria, fungus, cyanophitic algae, clorophytes and rodophytes and sponges. The predominant species of algae belongs to the genera *Hyella*, *Mastigocoleus*, *Plectonema*, *Ostreobium*, *Phaeophila* and *Porphyra* in caribbean (May *et al.* 1982).

These organisms are microperforators that allow the entrance of others due to their capacity of chemical dissolution of coral skeletons and are solid bases for microbenthic nourishment (Hutchings 1986 and May *et al.* 1982).

Macrocryptobiota: First of all we must consider that fauna diversity and abundance is seriously affected by:

1. Hammer and chisel method destroys an important amount of organisms.
2. Some very abundant individuals such as polychaetes were counted on a family level.
3. Organisms with few individuals impossible to identify were not considered for the quantitative analysis.

Classification analysis showed that there was no differences between the two coral positions (live and fragmented) this could happen because there is no differential colonization due to localization, or because the collected fallen fragments were not fixed to substrata so probably they had recently fallen from their branches.

The results of the homogeneity of the fragments and the reduced volume of coralline rock needed to evaluate the community were valid only on a family level. Variations of biomass, density and number of identified organisms on a more specific ground were too ample. This difference between the fragments was due to multiple factors such as:

1. The characteristic position of each fragment plays an important role in the determination of the type of cryptobiont larvae that colonize (Obrebski 1979, Hutchings 1981).
2. The monopolization of various sectors of the substratum by species of closed recruitment and asexual reproduction (Hutchings 1978).
3. Morphologic characteristics of each branch, thickness in particular, seem inversely related to the density of perforating organisms.
4. The type of epibiota, which favors, for filamentous algae, or reduced, for incrusting or carnivorous organisms, the settlement of the eroding larvae (Klumpp *et al.* 1988).
5. Territorial behavior of fish like *Microspathodon chrysurus* and *Stegastes dorsopunicans*. They are abundant in the crest, and protect sections of the coral where filamentous algae grow. This at last favor cryptofaunal colonization, particularly by sponge and sipunculids due to a probable increase in larval settlement, reduction in herbivory and an increase in food supply (Risk and Sammarco 1982, Winston and Jackson 1984).
6. Pioneering colonization during dry or wet season, which determines the ulterior composition of the community (Coles 1980, Hutchings 1981).

The biomass values showed intrinsic differences between each piece of coral, random location of individuals and their occasional presence give variable results.

A. palmata mortality in Isla Grande occurred in mass between 1982 and 1983, probably in association with high temperatures (Solano *et al.* 1992). Until 1992 there has not been a significant coral recolonization. What we have observed, though, during this survey, is the result of bioerosion and colonization processes after a period of approximately 8 years. In this succession stage and even though sponges population was not quantified, they seemed mostly responsible for bioerosion of *A. palmata* skeletons in Isla Grande. These organisms are the most important live or dead coral macroborers (Highsmith 1980, Moran and Reaka 1988). The present organisms community, specially polichaetes, according to Davies and Hutchings (1983), are important features in reefs under active degradation processes.

In the other hand some of the secondary colonizers such as vermetids *Dendropoma corrodens*, coralline algae and some sponges "fix" coral branches (Wilkinson 1983, Marshall 1983) and make the bioerosion process slower.

Finally, if antropogenic stressers such as pollution, tourism, high temperatures, freshwater inputs and sedimentation keep on acting over Rosario Islands' reefs and avoiding recolonization in affected areas, reef structures such as that found in the north crest of Isla Grande are sentenced to disappear.

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RESUMEN

La criptobiota de diez fragmentos coralinos muertos de *A. palmata*, de 10 dm^3 cada uno, cubiertos de algas filamentosas, se colectó en abril de 1991en la cresta arrecifal de Isla Grande (Caribe colombiano). Se halló tres grupos: 1) móviles epibentónicos asociados a las algas filamentosas y conformados princi-palmente por microcrustáceos; 2) microcriptobiontes perforantes, ubicados en la capa intermedia entre los organismos epilíticos y el esqueleto del coral y 3) macrocriptobiontes que perforan todo el cuerpo del esqueleto coralino (principalmente poliquetos, sipuncúlidos, moluscos y crustáceos). No se encontraron diferencias en la composición de los macrocriptobiontes que habitan los corales en posición de vida y los fragmentos caidos sobre el fondo. Se presentó una amplia variación en biomasa total, tipo y densidad de macrocriptobiontes, posiblemente asociada a factores estocásticos tales como la ubicación y grosor de las ramas, y variaciones del reclutamiento a pequeña escala.

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