

## Distribution of shallow-water crinoids near Santa Marta, Colombia

By

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With 1 figure and 2 plates

### Resumen

La fauna de crinoideos apedunculados (Echinodermata) en la región de Santa Marta, Colombia, es única en el atlántico trópicos occidental, tanto en la diversidad de las especies, como en la dimensión de las poblaciones. Siete especies fueron observadas hasta profundidades de 36 m. Se presenta una clave para estas especies de aplicación en el campo. La distribución y abundancia de estas especies en la región de Santa Marta, sugiere que las poblaciones más extensas se encuentran en las zonas protegidas del viento. Se considera que las surgencias de aguas son parcialmente responsables de la abundancia de esta fauna.

### Abstract

The fauna of unstalked crinoids (Echinodermata) near Santa Marta, Colombia, is unique in the tropical western Atlantic in both species diversity and population size. Seven species have been observed at depths above 36 m. A field key to these species is presented. The distribution and abundance of these species in the Santa Marta region suggest that the richest populations are located on the leeward sides of headlands and islands. Local upwelling in the region may be partly responsible for the richness of the crinoid fauna.

### Introduction

The diversity of comatulid (unstalked) crinoids in the shallow waters (< 36 m) near Santa Marta, on the Caribbean coast of Colombia, considered in terms of both numbers of species and population size, is the highest yet observed in these depths in the Caribbean Sea (see MEYER, 1973 a,b; MACURDA, 1973). Seven species have been recorded from the Santa Marta region as a result of two field trips to the area: one in 1969 by MEYER, the other in 1973 by MEYER and MACURDA. These species are: *Nemaster grandis* CLARK, *N. rubiginosa* (POURTALES), *N. discoidea* (P. H. CARPENTER), *Tropiometra carinata* (LAMARCK), *Comactinia echi-*

*noptera* (J. MÜLLER), *Ctenantedon kinziei* MEYER, and *Analcidometra caribbea* CLARK. The three species of *Nemaster* and *T. carinata* can be rated as common to abundant at several sites near Santa Marta, while *C. echinoptera* is also common at some sites. *Ctenantedon kinziei* and *A. caribbea* are rated as rare on the basis of current knowledge. As many as six of these species co-occur at a single locality. The following key has been designed to facilitate rapid field identifications; it should be generally applicable throughout the tropical western Atlantic for shallow-water species. See also CLARK, 1915—1950.

The living habits and ecology of these species in Colombia and elsewhere in the Caribbean have recently been discussed by MEYER (1972; 1973 a, b) and by MACURDA (1973). The uniqueness of the Santa Marta crinoid fauna warrants this separate paper in which we present detailed information on the distribution, abundance, color variation, and behavior of these crinoids and provide additional information toward interpreting this remarkable occurrence.

Localities examined by us in 1969 and 1973 are shown in Fig. 1. Observations were made by diving with S.C.U.B.A. to 36 m depth. In the following sections we give a detailed description of the fauna at each locality, along with behavioral observations.

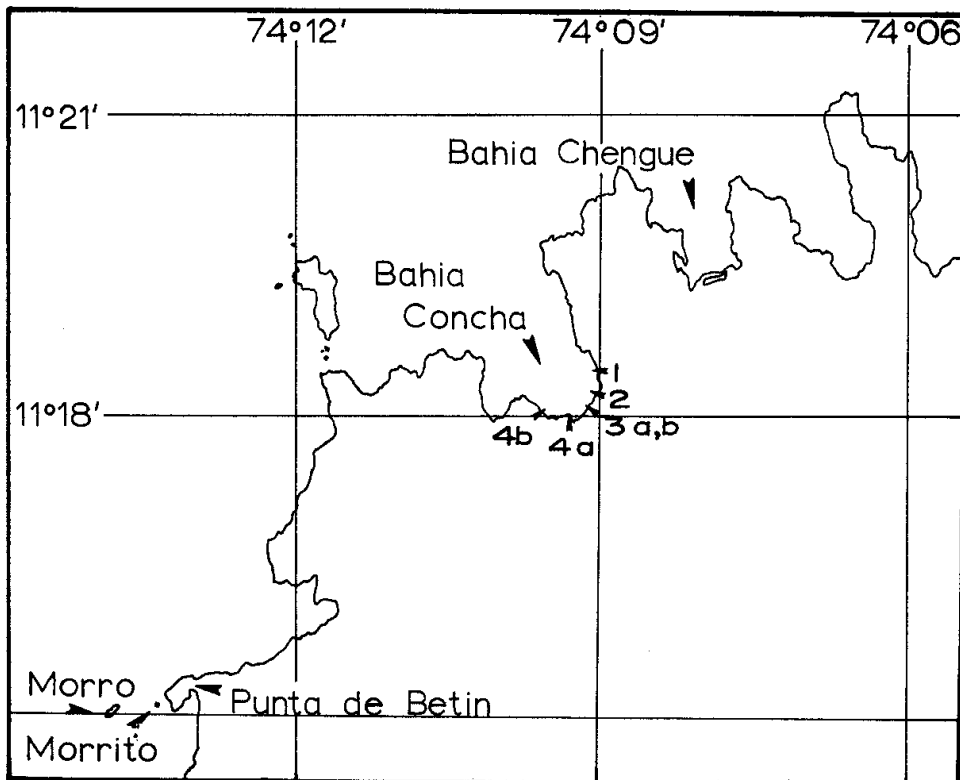


Fig. 1. Locality map of Santa Marta area showing localities for crinoids discussed in text.

### Field key to the shallow-water crinoids of the Santa Marta region

- |   |  |   |
|---|--|---|
| 1 | a. Ten arms  | 2 |
|   | b. More than 10 arms   | 5 |
| 2 | a. The 3—4 pinnules nearest the central disk on each side of an arm bear combs at ends   | 3 |
|   | b. Lower pinnules with no such combs, but taper to point   | 4 |
| 3 | a. 15—20 cirri, 10—12 mm long, composed of short segments; arms stout; found curled up beneath corals and in crevices.<br><i>Comactinia echinoptera.</i>   |   |
|   | b. 50—90 cirri, 17 mm long, composed of elongate, slender segments; arms with pairs of black spots; found beneath corals; crinoid will swim.<br><i>Ctenantedon kinziei.</i>  |   |
| 4 | a. Arms brown with bands of yellow; arm length 100—140 mm; attaches within crevices but extends arms.<br><i>Tropiometra carinata.</i>  |   |
|   | b. Arms grey with red bands; arm length to 90 mm; attaches in elevated positions to gorgonians, sponges.<br><i>Analcidometra caribbea.</i>   |   |
| 5 | a. Cirri 35 mm long, with 35 short segments, the outer segments having conspicuous serrate spines; arms and pinnules black, pinnules with white tips; lives with disk exposed on top of corals, sponges, gorgonians.<br><i>Nemaster grandis.</i> |   |
|   | b. Cirri 10—12 mm long, with 10—17 segments lacking serrate spines; pinnules arranged in 4 rows; attach beneath corals, in crevices with only arms exposed   | 6 |
| 6 | a. Pinnules usually have beaded appearance, are slender; arms lack median black stripe.<br><i>Nemaster discoidea.</i>  |   |
|   | b. Pinnules not beaded, stouter; arms usually have median black stripe; overall build more robust.<br><i>Nemaster rubiginosa.</i>  |   |

### Localities

#### Punta de Betín

A transect was taken along a 210° bearing beginning off the southern extremity of Punta de Betín, just below the weather station of the Instituto Colombo-Alemán. A coral community extends to a break in slope at 25 m where gently sloping sandy talus begins. From this point

a narrow tongue of rubble with scattered corals, octocorals, and sponges continues on the talus to about 30 m depth. Five crinoid species were encountered along this transect: *Nemaster grandis* (9—30 m), *N. rubiginosa* (6—22 m), *N. discoidea* (16—22 m), *Tropiometra carinata* (9—30 m), and *Comactinia echinoptera* (12 m).

*Nemaster grandis* (Pl. 2 C, D, E; 3 A, B, C) is abundant on the talus tongue between 25 m and 30 m, with about 74 individuals within an area of about 6 m × 9 m. Only five individuals were observed above 25 m. On the deeper part of the slope, one aggregation of seven *N. grandis* was observed, plus several pairs. During one dive here, a current of < 0.5 knot from the west was recorded, and during another dive a weaker current from the east was noted. Formation of the filtration fan in *N. grandis* under these currents was not very pronounced. Some extended the arms across the current but had the pinnules in radial arrangement. Others kept the arms arched over the disk despite the current. This behavior is peculiar considering that full formation of the filtration

Table 1. Bathymetric distribution of color varieties of *Nemaster discoidea* and *N. rubiginosa* off the southern tip of Punta de Betín, Santa Marta, Colombia. Data are numbers of individuals counted along a 1 m wide transect bearing 210 deg. from southern tip of Punta de Betín during one dive, VI—18—73. Color codes: *N. discoidea*, blk/wh = black arm with white beaded pinnules which may have yellow tips; or/wh = orange arm with white beaded pinnules; *N. rubiginosa*, or/yel = orange arm with black stripe, pinnules orange with yellow tips; or/wh = orange arm with black stripe, pinnules orange with white tips; blk/yel = black arm with black pinnules having yellow tips.

Depth, m	<i>N. discoidea</i>		<i>N. rubiginosa</i>		
	blk/wh	or/wh	or/yel	or/wh	blk/yel
6				1	
9				1	
12	1		1		2
15	1	2	2	2	2
18					
21		2	1		1
24	2	1			
27					
30					
Totals:	4	5	4	4	5

fan of arms and pinnules has been observed in this species in Curaçao under similar current conditions (MEYER, 1973 a).

Table 1 shows the distribution of color varieties in *Nemaster discoidea* (Pl. 3 D, E) and *N. rubiginosa* along this transect. These species are abundant along the upper slope, particularly *N. discoidea* in the beds of *Eusmilia fastigiata* (PALLAS) at about 15 m. *Tropiometra carinata* is also very abundant on this transect on the upper slope and on isolated coral blocks on the lower talus, with up to 25 individuals occurring on some blocks. Since *Comactinia echinoptera* is completely hidden from view during the day, curled up beneath corals or deep in crevices, it is difficult to estimate its abundance. Although a single specimen was recorded from this transect, the species is undoubtedly fairly common.

#### Pier pilings at Punta de Betín

The concrete pilings beneath the large pier at Punta de Betín support a rich encrusting fauna of sponges, hydroids, tunicates, bivalves, and also three crinoid species: *Nemaster grandis*, *N. discoidea*, and *Tropiometra carinata*. The pier runs in a northeast-southwest direction and is about 100 m long. It is supported by over 20 rows of square pilings with up to eight pilings per row. The pilings are sunk along a slope varying in depth from 3—15 m; and each piling is about 23 cm on a side. The pier is about six years old. The site was examined by us only in 1973 but crinoids were present on the pilings quite early.

*Tropiometra carinata* (Pl. 2 A, B) is present on practically all the pilings but the number per piling varies greatly (Table 2). Close to 100 individuals were counted on one piling in the second row from the southwest end. The numbers are highest toward the southwest end. The crinoids were observed forming the filtration fan normal to wave oscillations. The arms are held so that the food grooves of approximately five arms face the seaward direction of the surge while five face the opposite way (Table 3). In most individuals, the planar arrays of tube feet on each pinnule were observed to swivel with the surge so that the food groove of each pinnule reverses to face downcurrent every time (Table 3). A similar phenomenon has been observed in *Comactinia echinoptera* in Panamá. Those individuals on the same part of a piling had the same orientation of the fans, although orientation varied between pilings probably due to circulation around pilings (Table 3). A few *T. carinata* were observed holding the pinnules folded tightly along the arms. This behavior has been observed elsewhere but no explanation has yet been found for it. In the first row of pilings (Table 3), the north and east sides of the pilings are the preferred locations for *Tropiometra*. A qualitative survey of the third row revealed a similar distribution. This probably reflects the prevailing direction of wave oscillations. Most individuals are well-attached with the cirri in between the dense encrusta-

Table 2. Location of crinoids on pilings of dock 100 m E of Punta de Betín, Santa Marta.

	SW	Corner W	NW	Corner N	NE	Corner E	SE	Corner S	Total
Piling 1*						3 5-7 m			3
Piling 2				5 3-5 m	3 2-3 m	5 2-4 m		2 2-4 m	15
Piling 3				13 2-7 m	2 or 3 2-7 m	21 2-7 m		1 5 m	37
Piling 4		1 10 m		13 2-10 m	2 2-3 m	12 3-10 m			28
Piling 5*		1 2 m	1 2 m	17 2-8 m	6 2-8 m	12 2-8 m			37
Piling 6			2 2-5 m	34 2-10 m	2 2-7 m	13 2-7 m			51
Piling 7			1 2-10 m	11 2-10 m	7 2-10 m	4 2-10 m			23
Piling 8		1 3 m		2 3-8 m					3
Total:	0	3	4	95	22	70	0	3	197

\* 1 N. g. on each of 1 and 5.

tions of other invertebrates. Arm length of some individuals exceeds 200 mm.

The *Nemaster grandis* and *N. discoidea* seen on the pilings, while much less common than *T. carinata*, are quite large, with arm length between 200 and 300 mm. Some *N. grandis* are attached to metal scrap on the bottom beneath the pier, especially toward the north end at about 15 m depth. Despite the location well inside the harbor, the crinoid and other invertebrate fauna of these pilings seems to be quite healthy and prolific.

Table 3. Configuration of arms and colors, *Tropiometra carinata*, on pilings of dock 100 m E of Punta de Betín, Santa Marta. Corners of pilings face NE, etc.

	Loca- tion	Depth (m)	Arm Orien- tation	Color	Pinnule Reversal	
Piling 1	E	5—7	5N, 5S	Bl-yel	Yes	
	E	5—7	5N, 5S	Brw-yel	Yes	
Piling 2	E	5—7	8N, 2S	Bl-yel		Drift from S
	N	5		Bl-yel		Pinnules clumped
	N	5	3E, 7W	Brw-yel	Yes	
	E	5	5N, 5S			Small
	E	4	5N, 5S	Bl-yel	Yes	Arm length 150 mm
	E	4	6S, 4N	Bl-yel	Yes	Arm length 150 mm
	S	4	6E, 4W	Bl-yel	Yes	Arm length 190 mm
	E	3	6S, 4N	Bl-yel	Yes	Occasionally 2 or 3 arms with pinnules clumped
	N	3	4E, 6W	Bl-yel	Yes	
	N	3	6E, 3W	Brw-yel		One pinnules clumped
	N	3	6E, 4W	Red-yel	Yes	Juvenile
	NE	3	10 NW		No	
	E	3	4S, 5N	Bl-yel	Yes	2 arms, pinnules of irregular length
	NE	2	5NW, 5SE	Bl-yel	Yes	
	NE	2		Brw-yel		Arms oriented horizontally and vertically
E	2	5N, 5S	Bl-yel	Yes		
S	2	5E, 5W	Bl-yel	Yes		

Bl = black; yel = yellow; Brw = brown.

## Morrito

Two transects were made off Morrito, one from the southwest end, on a southwesterly bearing, the other off the south side. The latter profile was studied in 1969 and 1973. Five species were encountered on the southwesterly profile: *Nemaster grandis* (10—33 m), *N. rubiginosa* (10—33 m), *N. discoidea* (10—33 m), *Comactinia echinoptera* (15—18 m), and *Tropiometra carinata* (10—33 m). Off the south side the same five were found, along with *Ctenantedon kinziei* at 15—18 m. *Nemaster grandis* occurs in great abundance below the foot of the reef slope on both profiles, attached to isolated corals, rocks, etc. Along the

Table 4. Bathymetric distribution of color varieties of *Nemaster discoidea* and *N. rubiginosa* off the south side of Morrito, Santa Marta, Colombia. Data are numbers of individuals counted on dives in VII—69 and VI—73. Color codes: *N. discoidea*, blk/wh = black arm with white beaded pinnules having white or yellow tips; or/wh = orange arm with white beaded pinnules having white or orange tips; yel/wh = yellow arm with white beaded pinnules having white or yellow tips. *N. rubiginosa*, or/or = orange arm with black stripe, pinnules orange; or/wh = orange arm with black stripe, pinnules orange with white tips; or/yel = orange arm with black stripe, pinnules orange with yellow tips; blk/yel = black arm with black pinnules having yellow or orange tips; yel/wh = yellow arm with black stripe, pinnules white.

Depth, m	<i>N. discoidea</i>			<i>N. rubiginosa</i>				
	blk/wh	or/wh	yel/wh	or/or	or/wh	or/yel	blk/yel	yel/wh
6								
9		1					1	
12	6	3		1	2		1	1
		1				2		
15		1	2		1		1	
			1		1			
18		2		1		2	2	
	1	3	3	1	1	1	1	
21								
	1							
24					2	1		
27							1	
					1			
30	1							
			1					
33								
36								
Totals:	9	11	7	3	8	6	7	1



south side, aggregations of up to 15 individuals were observed on a single block. Off the southwest end, a current from the south-southeast was noted, but again the *N. grandis* showed little tendency to form filtration fans. Current along the south side was generally from the east during dives in 1969 and 1973, but some times of slack current were noted, as well as one occasion in 1969 of a current from the west. Fans of *Iciligorgia schrammi* Duchassaing along the south side are concave to the east, suggesting a prevailing current from that direction. In 1969 *N. grandis* along this slope was observed to form complete filtration fans in response to current, but again the threshold for fan formation seems higher than elsewhere.

*Tropiometra carinata* is abundant on the southwestern profile below 30 m where dense aggregations occur around the same isolated blocks inhabited by *N. grandis*. Although these *T. carinata* formed the filtration fan normal to the prevailing current, the arms on the downcurrent side were not observed to twist as in *N. grandis* (see MEYER, 1973 a). Hydroids on the same rocks were also oriented normal to the current, indicating a persistent current in the area.

Color varieties in *N. discoidea* and *N. rubiginosa* for both transects are summarized in Table 4. These species and *T. carinata* are particularly abundant on the reef slope at 15–19 m along the south side of Morrito. Several *C. echinoptera* were collected from the Morrito transects, suggesting that this species is fairly common. *Ctenantedon kinziei* appears to be rare, with only four specimens collected during the visits of 1969 and 1973, despite concentrated searching of this area.

### Isla del Morro

In 1973 two dives were made along a 210° bearing from the west end of Isla del Morro. The profile is similar to that off Punta de Betín and Morrito, but the abundance of gorgonian fans and *Iciligorgia schrammi* indicates the greater prevalence of wave and current action here. Six crinoid species were noted here: *N. grandis* (31–36 m), *N. rubiginosa* (6–19 m), *N. discoidea* (9–31 m), *C. echinoptera* (15–30 m), *T. carinata* (3–30 m), and *Ctenantedon kinziei* (1 specimen at 18–31 m). Again, *N. grandis* prevails just below the reef slope. At 33 m, 36 individuals were counted within a 6 × 9 m area. Despite a current from the southwest, these *N. grandis* were holding the arms and pinules in radial posture.

The population density of crinoids in this area is probably the highest yet observed at these depths in the Caribbean. In addition to the large *N. grandis* belt below the reef slope, *N. discoidea*, *C. echinoptera*, and *T. carinata* are abundant on the slope itself, with *N. rubiginosa* also quite common. In an area rich in *Eusmilia fastigiata* at 15–18 m, some 30 individuals of *N. discoidea* were counted within a few square

meters. This species exhibits an unusual diversity of color variants in this area as well (Table 5). The same area was found to support a great abundance of *C. echinoptera*. One clump of *Mussa angulosa* (PALLAS) less than 0.5 m across held five (5) individuals of *C. echinoptera*. Although these *C. echinoptera* are cryptic, they probably extend the arms for feeding at night, in accordance with observations elsewhere (MEYER, 1973 a, b). Some *N. discoidea* were also found completely hidden within the coral framework.

Table 5. Bathymetric distribution of color varieties of *Nemaster discoidea* off the western tip of Isla del Morro, Santa Marta, Colombia. Data are numbers of individuals counted along 1 m wide transects bearing 210 deg. from the western tip of Isla del Morro during two dives, VI—19 and VI—23—73. Color codes: blk/wh = black arm with white beaded pinnules having white or yellow tips; blk/yel = black arm with yellow pinnules having yellow or orange tips; or/wh = orange arm with white beaded pinnules having white, yellow, or orange tips; yel/wh = yellow arm with white beaded pinnules.

Depth, m	blk/wh	blk/yel	or/wh	yel/wh
6				
9	1			
12		1		
15			1	
18	15	1	13	2
21	3	6	5	
24				
27	1		2	
30	7	6	15	
33	2		4	
33	6	2	3	3
33	1	1	1	
36				
Totals:	36	17	44	5

### Bahia Concha

Crinoid populations were investigated at four sites within Bahia Concha (Fig. 1): 1, among corals at about 4 m depth just below the *Porites* reef at the northeast end of the beach; 2, at the foot of the

steep sandy slope off the swimming beach; 3 a, in the beachrock off the middle section of beach, and 3 b, on the sandy slope offshore from the beachrock; and 4 a, on the rocky face, and 4 b, among the corals just past the southwest end of the beach before reaching Punta Concha. Three species were recorded from these areas: *N. grandis* (sites 2, 3 b, 4 b; 10—15 m), *N. rubiginosa* (sites 1, 4 b; 6 m), and *T. carinata* (sites 3 a, 4 a, b; 0—10 m).

Off the beach itself *N. grandis* was found attached to the marine grass *Syringodium* sp., while southwest of the beach this species was living on the more typical substrata of corals, sponges, etc. *T. carinata* was quite common along the rocky face southwest of the beach at about 2 m depth, and also deeper, among the corals. In 1969 this species was common along the seaward ledge of the beachrock at site 3 a, but re-examination of this site in 1973 revealed that sedimentation had all but buried this ledge and no crinoids were found.

### Bahia Chengue

In 1973, one dive was made in Bahia Chengue, on the east side off the first point in from Punta de Gayraca. The coral community here gives way at 15—18 m to a sand-mud bottom with scattered sponges and gorgonians. Three crinoid species were recorded along this transect: *N. grandis* (18—25 m), *T. carinata* (4—16 m), and *Analcidometra caribbea* (18—24 m). The *N. grandis* occupy gorgonians and other projections on the sandy bottom. They were forming the filtration fan normal to a north-south wave oscillation. *T. carinata* was present on the reef slope and below but was nowhere as abundant as at Santa Marta. Two individuals of *A. caribbea* were attached to the gorgonian *Pseudopterogorgia* sp. and a third was attached to an antipatharian.

### Discussion

Available information suggests that biotopes supporting the highest diversity and abundance of crinoids in the Santa Marta region are somewhat localized. Although a more comprehensive underwater survey has not been possible, discussions with Dr. HARRY ERHARDT indicate that the sites we examined at Punta de Betín, Morrito, and Isla del Morro are the most prolific crinoid biotopes in the vicinity. We do not know whether similarly rich biotopes occur at other places to the northeast of Santa Marta but we suspect it is highly likely. A rich crinoid fauna (at least 4 species) has been reported from the vicinity of Cartagena (C. ROESSLER, pers. comm.).

The localized nature of crinoid populations has been noted elsewhere in the Caribbean where it is associated with favorable food-carrying

water movements (MEYER, 1973 a). According to WÜST (1964), current flow past Santa Marta is from the southwest during at least part of the year. The only available information on localized circulation patterns in the Santa Marta area is that reported above. In general, the association of crinoids with currents was found to be less pronounced in Colombia than in Curaçao, for example (MEYER, 1973 a). In Colombia, *N. grandis* not only occurs in embayments rather protected from currents such as Bahia Concha, but also appears to have a higher threshold for filtration fan formation in response to current flow. These considerations, along with the overall higher diversity and abundance of crinoids in Colombia as compared to several Caribbean islands studied, led to the hypothesis that food conditions may be more favorable closer to the continental landmass (MEYER, 1973 a). Such favorable conditions might be derived from higher or more diversified primary productivity resulting from nutrient enrichment due to run-off or upwelling. CURL (1960) found higher rates of primary productivity off the Santa Marta coast compared to Curaçao and suggested that upwelling may take place northwest of the Guajira Peninsula. BRATTEGARD (1973) has recently cited additional evidence for upwelling along the Santa Marta coast. He writes: "As the prevailing winds in the area are northeasterly one might expect local upwelling on the southwestern sides of the headlands. KAUFMANN and WEDLER (pers. comm.) found that the salinity of the water at the surface and at 1 m depth on the southern side of Punta de Betín in the period 15 April — 2 June 1971 ranged between 35.4 and 37.1 ‰ and that the lower temperatures, within an observed range of 23.5 to 28.9°, tended to be associated with the higher values obtained for salinity." During our visit in June, 1973, we observed fish schools active at the surface south of Punta de Betín. In the Bahia de Panamá, such activity is usually indicative of enhanced production due to upwelling.

The possible restriction of such upwelling to the southwestern sides of the headlands might shed light on the nature of crinoid distribution in the same area. It is perhaps significant that the three richest sites for crinoids are off the southwestern and southern sides of Punta de Betín, Morrito, and Isla del Morro. Although we still lack sufficient information for adjacent sides of these headlands and islands, we postulate that the rich crinoid populations thrive where they do because of either favorable upwelling currents or enriched food supply due to the upwelling or a combination of both these factors.

### Acknowledgments

The Instituto Colombo-Alemán has made this study possible by providing excellent facilities and a staff that has always been cooperative. We particularly thank Dr. REINHARD KAUFMANN, former director, and Dr. BERND WERDING, Director. R. H. CHESHER was responsible for first bringing the abundance of the Santa Marta crinoid fauna to MEYER's attention in 1968. W. K. SACCO provided photographic assistance to MEYER in 1969. In 1973, Dr. HARRY ERHARDT accompanied us in diving and contributed greatly to our understanding of the crinoids by sharing with us his knowledge of the underwater biotopes of the area. MEYER's visit in 1969 was supported by a National Science Foundation Graduate Fellowship, a Geological Society of America Research Grant, a Sigma Xi Grant-in-Aid of Research, and Yale University Graduate School. Our visit in 1973 was supported by National Science Foundation Grant 36439. Fig. 1 was drafted by Kaniaulono Meyer.

### Bibliography

- BRATTEGARD, T.: Mysidacea from shallow water on the Caribbean coast of Colombia. — *Sarsia*, **54**, 1—66, Bergen 1973.
- CLARK, A. H.: A monograph of the existing crinoids. Vol. 1. The comatulids. Pts. 1—4. — *U.S. Nat. Mus. Bull.*, **82**, Washington 1915—1950.
- CURL, H., JR.: Primary production measurements in the north coastal waters of South America. — *Deep-Sea Res.*, **7**, 183—189, London 1960.
- MACURDA, D. B., JR.: Ecology of comatulid crinoids at Grand Bahama Island. — *Hydro-lab J.*, **2**, 9—24, Freeport 1973.
- MEYER, D. L.: *Ctenantedon*, a new antedonid crinoid convergent with comasterids. — *Bull. marin. Sci.*, **22**, 53—66, Coral Gables (Florida) 1972.
- Feeding behavior and ecology of shallow-water unstalked crinoids (Echinodermata) in the Caribbean Sea. — *Marin. Biol.*, **22**, 105—129, Berlin 1973 a.
- Distribution and living habits of comatulid crinoids near Discovery Bay, Jamaica. — *Bull. marin. Sci.*, **23**, 244—259, Coral Gables (Florida) 1973 b.
- WÜST, G.: Stratification and Circulation in the Antillean-Caribbean Basins. — 201 p., Columbia University Press, New York 1964.

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## Explanations of Plates

### Plate 1

- A—B. Calyx and proximal pinnules (A) and median arms and pinnules (B) of *Tropiometra carinata* on pier pilings at Punta de Betín (1973).
- C. Aggregation of *Nemaster grandis* southwest of Morrito at 25—30 m with arms curved above calyx (1973).
- D. Solitary individual of *N. grandis* southwest of Punta de Betín at 25—30 m with tips of arms curled (1973).
- E. Aggregation of *N. grandis* southwest of Punta de Betín (1969).

### Plate 2

- A. Joint occurrence of *Nemaster grandis* and *Tropiometra carinata* at 25—30 m southwest of Morrito (1973).
- B—C. Individuals of *Nemaster grandis* with fanned arms southwest of Punta de Betín (25—30 m) and Bahia Chengue (20—25 m) respectively (1973).
- D. Arms of *Nemaster discoidea* extended from beneath *Montastrea*, southwest of Punta de Betín, near 15 m (1973).
- E. Closeup of arms of *N. discoidea* with pinnules in a radial array, pier pilings at Punta de Betín (1973).

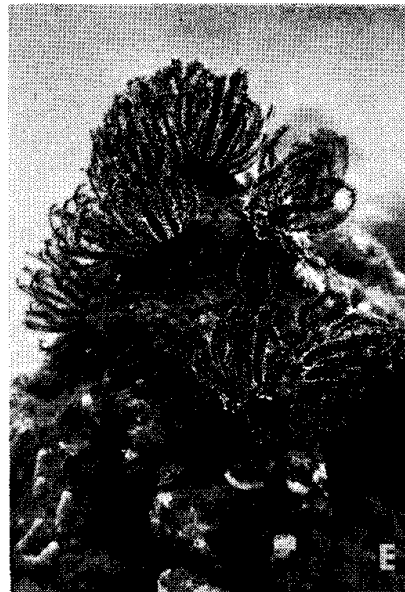
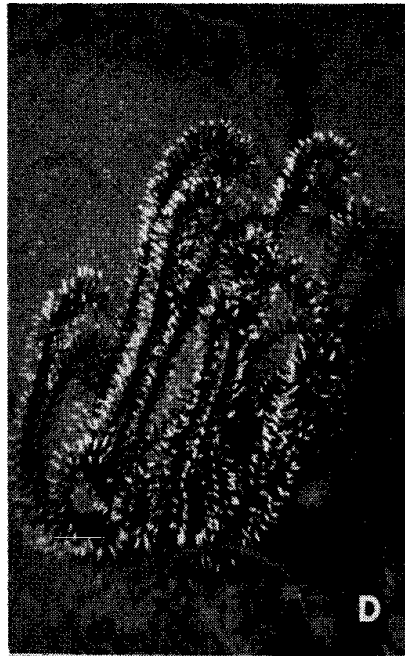
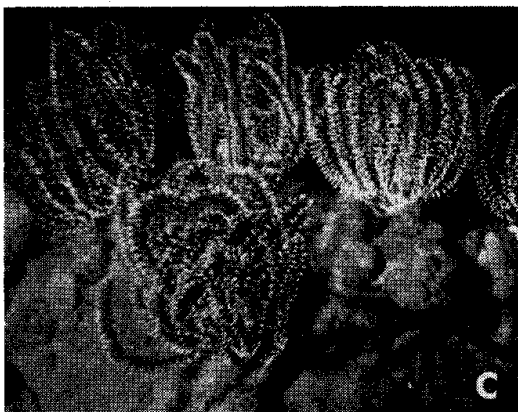


Plate 1

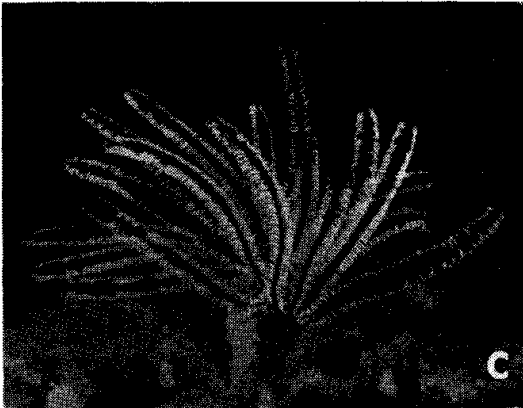
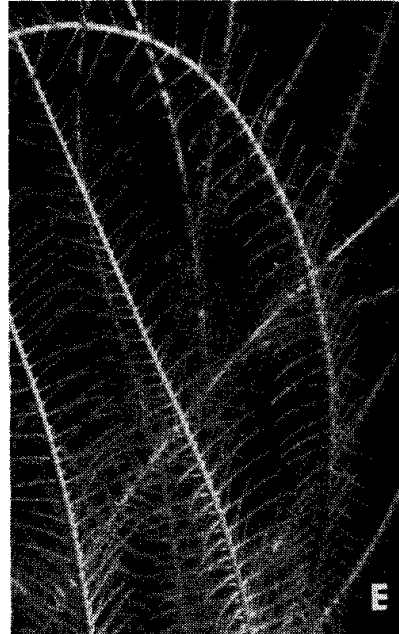
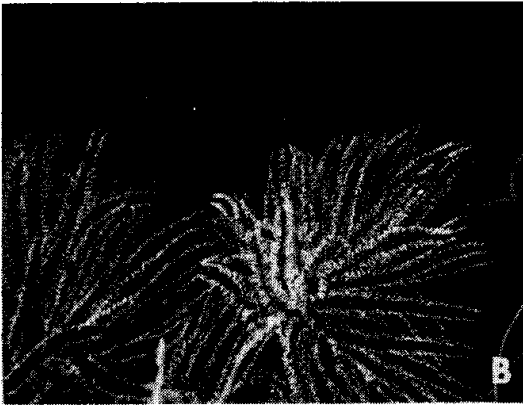


Plate 2