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# PLANKTONIC PROTOZOAN POPULATIONS ON FIVE WEST INDIAN REEFS

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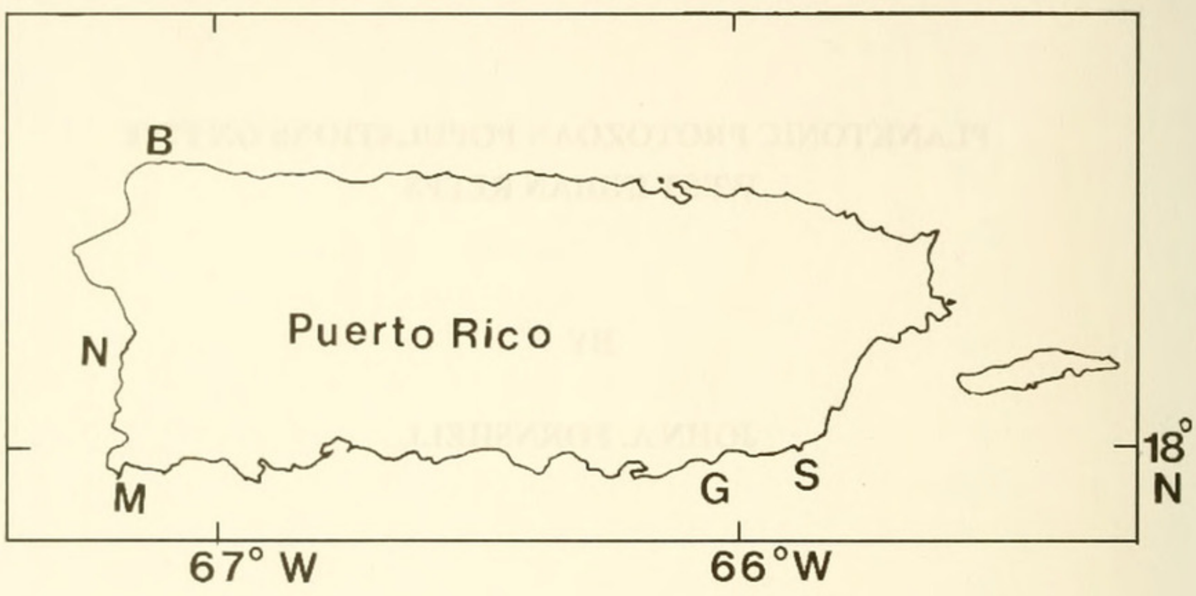


**Figure 1.** The positions of the five reefs where plankton samples were collected in this study: B = Bujuras Reef; G = Guayama Reef; M = Margarita Reef; N = Negro Reef; S = Sargente Reef.

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## ABSTRACT

A study of the Protozoan plankton on five West Indian reefs was conducted from August to November 1982 and in June 1983. Plankton tows were collected in five areas: Sargente Reef, Guayama Reef, and Margarita Reef from the northeastern Caribbean Sea, Negro Reef from Mona Passage between the Islands of Puerto Rico and Hispaniola, and Bujuras Reef in the tropical Atlantic Ocean. The Protozoan plankton were identified along with benthic Foraminifera collected in the plankton tows. Thirty-eight different species of armored Dinoflagellata were found on the five reefs in this study. Benthic Foraminifera and Radiolaria were also found in the plankton samples from all five reefs. Armored Dinoflagellata accounted for 62%, 72%, 22%, 28% and 45% on Bujuras Reef, Negro Reef, Margarita Reef, Guayama Reef and Sargente Reef, respectively. On Margarita Reef and Guayama Reef, Tintinnids were more abundant than armored Dinoflagellata, 30% and 38% respectively. Distinctiveness and diversity indices were calculated based on the armored Dinoflagellata populations on the reefs in this study. There was greater seasonal than spatial variation in the distinctiveness of the populations of armored Dinoflagellata in the study area. The populations were all typically diverse as would be expected in the tropics.

## INTRODUCTION

A study of the abundance and variability of planktonic Protozoans on five West Indian reefs in the northeastern Caribbean Sea and adjacent tropical Atlantic Ocean was conducted during the summer and fall of 1982 and summer of 1983. In addition to armored Dinoflagellata, other Protozoans were enumerated from the samples. This helped to determine the relative abundance of the armored Dinoflagellata in the microplankton of the reefs. In earlier works on the planktonic Protozoa in the study area, armored Dinoflagellata were reported as having a significant population density in coastal waters close to mangroves (Margalef, 1961). Glynn (1973) considered armored Dinoflagellata to be uncommon on reef flats. Marshall (1973) surveyed the Protozoa in

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open waters of this area during the winter month of January. He listed several armored Dinoflagellata, some of which he considered to have wide distribution in the northeastern Caribbean Sea. Armored Dinoflagellata have been studied in the southeastern Caribbean Sea on the Venezuelan coast by Halim (1967) and the western Caribbean Sea by Faust (2000). Faust (2000) found the armored Dinoflagellata to make up as much as 95% of the plankton in some areas on the Barrier Reef of Belize. Morton (2000), also working on the Barrier Reef of Belize, found considerable variability in biomass and diversity of the Protistan plankton in three ponds which he studied. General surveys of the microplankton, including armored Dinoflagellata in the Caribbean Sea, are found in Wood (1968) and Marshall *et al.* (1982). An ocean-wide analysis of the distribution of the genus *Ceratium* can be found in Dodge and Marshall (1994).

## MATERIALS AND METHODS

The plankton-sampling program was conducted on a noninterference basis during a project to conduct Lagrangian current measurements along the Caribbean shore of Puerto Rico (Fornshell *et al.*, 1984). Between August 29 and November 13, 1982 microplankton samples were taken from three Caribbean reefs along the southern shore of Puerto Rico: Sargente Reef, Guayma Reef and Margarita Reef. During this time period, microplankton samples were also taken from a fourth reef, Negro Reef, in Mona Passage between Puerto Rico and the island of Hispaniola. A fifth reef on the Atlantic coast of Puerto Rico, Bujuras Reef, was sampled in July 1983 (Fig. 1 and Table 1).

The length of each tow was adjusted to minimize the effects of clogging. As a result, different quantities of water were sampled on each reef. The volumes of water sampled on each reef in cubic meters were determined using a Tsukishima Kikai flowmeter. They are as follows: Sargente Reef, 43.2 $m^3$; Guayma Reef, 35.3 $m^3$; Margarita Reef, 49.6 $m^3$; Negro Reef, 24.7 $m^3$; and Bujuras Reef, 45.2 $m^3$. All of the plankton tows were made in the fore-reef zone following the 20 m-depth contour on Sargente, Guayama, Margarita, and Bujuras Reefs. Because of the steepness of the reef front, this was very close to the reef crest. On Negro Reef the plankton tows were made in the back-reef lagoon.

The Protozoan plankton and the benthic Foraminiferans that were collected in the plankton net were identified. All five of the reefs can be characterized as having a significant surf breaking over the reef. As a result of this wave action, a large number of benthic Foraminifera are lifted into the water column and are collected along with the plankton.

The distinctiveness and diversity indices of the armored Dinoflagellata populations were calculated. The armored Dinoflagellata were selected because they were abundant on all five reefs and good taxonomic data was available for this group. The distinctiveness index described in Menzies *et al.* (1974) is given by the formula:

$$\frac{\text{(Total number of species - number of species in common)}}{\text{(Total number of species)}} \times 100$$

The distinctiveness index gives a quantitative measure of the difference in the composition of two populations. The index represents the distinctiveness of the population as a percentage. It does not measure differences in relative abundance.

The diversity index provides a measure of the diversity of a single population. The diversity index as described in Menzies *et al.* (1974) is given by the formula:

$$\frac{\text{(Total number of species)}}{\text{(Total number of individuals)}}$$

Table 1. Dates and positions of the five reefs where plankton tows were made.

| Reef | Sampling Dates | Location |
|---|---|---|
| Sargente Reef | 3 tows on Aug. 29, 1982<br>2 tows on Nov. 13, 1982 | 17-58N; 65-54W<br>Off Punta Tuna, P.R. |
| Guayama Reef | 2 tows on Aug. 29, 1982<br>3 tows on Nov. 13, 1982 | 17-50N; 66-04W<br>Off Punta Figuras, P. R. |
| Margarita Reef | 5 tows on Sept. 2, 1982 | 17-56N; 67-13W<br>Off Cabo Rojo, P. R. |
| Negro Reef | 5 tows on Sept. 20, 1982 | 18-10N; 67-13W<br>Off Punta Guanajibo, P. R. |
| Bujuras Reef | 3 tows on July 8, 1983 | 18-32N; 67-12W<br>Off Punta Agujereada, P. R. |

## RESULTS

The data are summarized in Tables 2 and 3. Thirty-eight species of armored Dinoflagellata were found on the five reefs. Only seven species of armored Dinoflagellata were found on all five reefs: *Ceratium contortum*; *C. declinatum*; *C. furca*; *C. macroceros*; *C. massiliense*; *C. trichoceros*; and *C. tripos* (Table 2). *Globigerinoides ruber* was the only Foraminiferan found on all five reefs. Benthic Foraminifera were a significant component of the Protozoans sampled at each reef. Tintinnids were present in the samples from Bujuras, Guayma, and Sargente Reef, but not on Margarita and Negro Reefs. Radiolaria were found on all five reefs (Table 3). The armored dinoflagellate population on Bujuras Reef was 160/cubic meter; on Negro Reef, 641/cubic meter; on Margarita Reef, 80/cubic meter; on Guayma Reef, 168/cubic meter; and on Sargente Reef, 133/cubic meter. These numbers represent 62%, 72%, 22%, 28%, and 43% of the total Protozoan plankton on each reef.

On three of the five reefs, Bujuras, Negro, and Sargente, the armored

Dinoflagellata are the largest single component of the net microplankton. On two of the reefs, Margarita and Guayama, Tintinnids were the largest single component of the microplankton, 30% and 38% respectively.

The samples from Guayma and Sargente Reefs, taken in August and November 1982 (Table 1), showed significant intra-reef difference in their distinctiveness (indices 71 and 92 respectively). Since these values are larger than inter-reef values (see Table 4), the seasonal variations are greater than the spatial variations observed in this study.

The distinctiveness indices show relatively little difference among the three reefs on the south coast, Sargente, Guayma and Margarita, and Negro Reef in Mona Passage. The distinctiveness indices between these four reefs and Bujuras Reef on the Atlantic coast are larger, an average of 56.5 vs. an average of 40 among the first four named reefs. This may be due to seasonal variations given the large amount of time, 10 months, between the sampling of Bujuras Reef and the other four reefs.

The diversity indices for the five reefs were as follows: Bujuras Reef, 0.055; Negro Reef, 0.0015; Margarita Reef, 0.038; Guayma Reef, 0.0027; and Sargente Reef, 0.0048. While these are small numbers in absolute terms, they are typical of diverse populations of marine organisms.

## DISCUSSION

Armored Dinoflagellata are not abundant in an absolute sense; however, they are a major component of the net microplankton. The benthic Foraminifera are believed to be suspended in the water column near the reef by the action of breaking waves. As such, they are available as food to plankton-feeding organisms. The armored dinoflagellates were found to be the largest single component in the microplankton on three of the five reefs surveyed.

There do not appear to be any significant differences in the armored dinoflagellate populations on the five reefs of this study. The intra-reef indices of distinctiveness observed on Sargente and Guayma Reefs over a period of 76 days, 71 and 92 respectively (Table 4), were larger than those between the reefs. The time spread of 10 months between the survey of the four Caribbean Sea reefs and the one tropical Atlantic reef could account for temporal or seasonal variations.

Table 2. Species of armored Dinoflagellata on the five reefs. The numbers of organisms per cubic meter are given.

| Species | Bujuras Reef | Negro Reef | Margarita Reef | Guayama Reef | Sargente Reef |
|---|---|---|---|---|---|
| *Ceratium* sp. | 0 | 4 | 0 | 1.1 | 0.9 |
| *C. belone* | 0 | 0.8 | 0 | 0.6 | 0.5 |
| *C. breve* | 0 | 0 | 0 | 0.6 | 0 |
| *C. buceros* | 0 | 0 | 0 | 2.8 | 1.4 |
| *C. candelabrum* | 0.9 | 0 | 0.4 | 2.3 | 0.9 |
| *C. concilians* | 0 | 0 | 0 | 0.6 | 0.4 |
| *C. contrarium* | 1.8 | 0 | 0 | 1.7 | 0 |
| *C. contortum* | 7.5 | 0.8 | 2.8 | 12.5 | 2.3 |
| *C. declinatum* | 4.4 | 4.6 | 8.9 | 5.9 | 3.7 |
| *C. eurarcuatum* | 0 | 0 | 0.4 | 2.8 | 4.6 |
| *C. fatulipes* | 0 | 3.2 | 0 | 0 | 0 |
| *C. furca* | 1.3 | 122.3 | 0.8 | 12.5 | 6.5 |
| *C. fusus* | 2.2 | 13 | 0 | 0.6 | 4.6 |
| *C. geniculatum* | 0 | 3.2 | 0 | 0 | 0 |
| *C. karstent* | 22.1 | 0 | 0 | 0 | 1.4 |
| *C. kofoid* | 0 | 1.6 | 0 | 0.6 | 1.8 |
| *C. longinum* | 4 | 2.4 | 0 | 24.4 | 1.4 |
| *C. linula* | 1.3 | 0 | 0 | 1.2 | 0.6 |
| *C. macroceros* | 29.2 | 157.9 | 8.9 | 30.1 | 12.5 |
| *C. massiliense* | 44.2 | 98 | 18.1 | 64.2 | 37 |
| *C. minutum* | 0 | 0 | 10.5 | 0.6 | 0.5 |
| *C. pavillardi* | 0.4 | 0.8 | 0 | 0 | 0 |
| *C. pentagonum* | 0 | 1.6 | 0.4 | 0.6 | 0.5 |
| *C. setaccum* | 0 | 0 | 0 | 0.6 | 0.5 |
| *C. teres* | 0 | 0.8 | 0.4 | 2.8 | 3.2 |
| *C. trichoceros* | 14.6 | 102 | 4 | 39.2 | 0.5 |
| *C. tripos* | 15.9 | 18.6 | 16.9 | 67.6 | 16.2 |
| *C. vultur* | 3.5 | 1.6 | 3.2 | 17 | 5.1 |
| *Gambierdiscus toxicus* | 0 | 0 | 0 | 0 | 0.5 |
| *Goniaulax dicantha* | 0 | 17 | 2 | 6.2 | 5.1 |
| *G. polygrama* | 0 | 34.8 | 3.2 | 19.9 | 12.5 |
| *Heterodinium* sp. | 0 | 0 | 0 | 2.3 | 0.9 |
| *Ornithocercus magnificans* | 0 | 0 | 0 | 0.6 | 0 |
| *Phalocoma argus* | 0.4 | 0 | 0 | 0 | 0 |
| *Peridinium* sp. | 0 | 2.4 | 0 | 0 | 0 |
| *P. depressus* | 1.8 | 23.5 | 0 | 5.6 | 1.8 |
| *P. divergens* | 1.8 | 17 | 0 | 1.7 | 1.8 |
| *P. fatulipes* | 0 | 0 | 0 | 1.7 | 0 |
| *P. grande* | 2.6 | 0 | 0 | 0.6 | 0 |

Table 3. Protozoan microplankton on the five reefs. The numbers given are the number of organisms per cubic meter.

| Microplankton | Bujuras Reef | Negro Reef | Margarita Reef | Guayma Reef | Sargente Reef |
|---|---|---|---|---|---|
| *Globergerinoides ruber* | 5.8 | 30.8 | 82.2 | 79 | 19.4 |
| *Pulleniantina obliguiloculata* | 0.9 | 6.5 | 13.1 | 7 | 0 |
| *Benthic Foraminiferans* | 68.1 | 157.9 | 77 | 108 | 34.2 |
| *Tintinnids* sp. | 0 | 42.1 | 111.3 | 8.5 | 1.8 |
| *Condonellopsis indica* | 0 | 0 | 0 | 24.4 | 0 |
| *Favella fistuticauda* | 0 | 0 | 0 | 2.3 | 0 |
| *F.markusorszkyi* | 1.8 | 0 | 0 | 24.4 | 5.6 |
| *F. panamensis* | 4.4 | 0 | 0 | 9.1 | 22.2 |
| *F. serata* | 0.9 | 0 | 0 | 0 | 0 |
| *Parafavella elegans* | 1.8 | 0 | 0 | 4 | 4.2 |
| *P. media* | 0 | 0 | 0 | 2.3 | 1.8 |
| *P. enflata* | 0 | 0 | 0 | 1.1 | 0 |
| *P. lata* | 0 | 0 | 0 | 52.8 | 0 |
| *Rabdonella* sp. | 0 | 0 | 0 | 84.1 | 0 |
| *R. amor* | 0 | 0 | 0 | 0 | 72.2 |
| *R. brandtei* | 0 | 0 | 0 | 11.4 | 0.5 |
| *R. quantula* | 0.9 | 0 | 0 | 0 | 0 |
| *R. spiralis* | 0.9 | 0 | 0 | 0 | 0 |
| *Radiolaria* sp. | 1.8 | 0.8 | 2.4 | 4.5 | 5.6 |
| *Heliosphaera actinota* | 0.4 | 0 | 0 | 0 | 0 |
| *Acanthara* sp. | 12 | 10.5 | 0 | 0 | 0 |

When compared with the studies of the eastern Caribbean Sea, we find that the first two species considered having wide distribution by Marshall (1973), *C. tripos* and *C. trichoceros*, were present in relatively large numbers on all five of the reefs in this study but the last named species, *C. fusus*, was present on all but one of the reefs. Thirteen of the 38 species found in this study were listed in the southeastern Caribbean Sea by Halim (1967). Six of the 38 species in our study were also listed by Faust (2000) in the western Caribbean. This implies greater variation in the east-west axis of the Caribbean Sea than in the north-south direction. Dodge and Marshall (1994) created six zones of distribution for the genus *Ceratium* in the North Atlantic and Caribbean Sea. Their warm temperate and tropical zones are essentially the same as these findings.

The armored Dinoflagellata populations are typical of tropical and warm temperate seas. They show no significant variations over the geographical range of this study. This is not surprising given the small horizontal variation in physical properties (Wust, 1964 and Fornshell, 1984). There are similarities with other studies from other parts of the Caribbean Sea but these similarities decrease with increasing distance

Table 4. Distinctiveness Indices for the five reefs. The numbers represent the percent distinctiveness of the population on each reef relative to the other reefs.

| | Bujuras Reef | Negro Reef | Margarita Reef | Guayama Reef | Sargente Reef |
|---|---|---|---|---|---|
| Bujuras Reef | 0.0 | 53.6 | 66.7 | 55.2 | 57.6 |
| Negro Reef | 53.6 | 0.0 | 54.2 | 44.8 | 30.8 |
| Margarita Reef | 66.7 | 54.2 | 0.0 | 50.0 | 46.2 |
| Guayama Reef | 55.2 | 44.8 | 50.0 | 0.0 | 33.3 |
| Sargente Reef | 57.6 | 30.8 | 46.2 | 33.3 | 0.0 |

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