Ecology and Systematics of Foraminifera in Two *Thalassia* Habitats, Jamaica, West Indies

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ABSTRACT

Buzas, Martin A., Roberta K. Smith, and Kenneth A. Beem. Ecology and Systematics of Foraminifera in Two *Thalassia* Habitats, Jamaica, West Indies. *Smithsonian Contributions to Paleobiology*, number 31, 139 pages, 38 figures, 8 plates, 34 tables, 1977.—Homogeneous *Thalassia* beds in back-reef flat (less than 1 m) and Discovery Bay (about 3 m) were sampled for 12 successive months in Jamaica, West Indies. Living foraminifera were enumerated in each of four monthly replicates consisting of 20 ml of sediment. At the sampling times, water temperature, sediment temperature, salinity, oxygen saturation, water pH, sediment pH, sediment median, sediment sorting, turbidity, particulate organic carbon, *Thalassia* weight, and weight percent silt plus clay were measured.

In all, 18,644 individuals belonging to 143 species were picked, sorted, and identified. The back-reef flat habitat contained 7,745 individuals belonging to 115 species, while the Discovery Bay contained 10,899 individuals belonging to 117 species. Fisher's log-series fits the distribution of species abundances at both habitats well. The number of species, information function, and equitability are usually greater at Discovery Bay for individual 20 ml samples.

A general linear model consisting of parameters for station differences, overall periodicity, interaction of station differences and overall periodicity, and environmental variables was constructed. The densities of the 19 most abundant species were statistically analyzed individually (univariate) and simultaneously (multivariate).

Univariate analyses indicate six species have significant station differences (95% level) and seven exhibit periodicity. The environmental variables are not significant for any of the species. Multivariate analyses indicate a significant difference between stations and an overall periodicity. As in the univariate analyses, environmental variables are not significant. The results suggest that in tropical habitats changes in species densities are regulated biotically.

The new species *Ammonia jacksoni, Elphidium norvangi, Fissurina goreaui, Discorbinella minuta, Glabratella altispira,* and *G. compressa* are described. Taxonomic remarks are presented for most of the species.

Contents

Ecology and Systematics of Foraminifera in Two *Thalassia* Habitats, Jamaica, West Indies

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Introduction

Most ecological studies of foraminifera try to relate patterns of distribution and abundance to environmental variables. The results of such studies show that foraminifera can be used to identify particular environments with relative ease. Relating patterns to environmental variables has proved much more difficult. While such studies number in the hundreds, only a handful exist where the researcher has sampled the same area quantitatively over the period of a year or two. Moreover, none of these are in a tropical environment.

The present study examines two habitats within homogeneous beds of *Thalassia* in Jamaica, West Indies. One habitat is a back-reef flat barely under water at low tide. The other is at a depth of about 3 m in the serene waters of Discovery Bay. Environmental variability is, as one would expect, greater at the former so the habitats provide a contrast along a stress gradient. Measurement of species densities and environmental variables were made monthly over the period of a year with replication to permit extensive statistical analyses.

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Specimens deposited in the National Museum of Natural History, Smithsonian Institution, are listed under the acronym "USNM" (for the collection numbers of the old United States National Museum).

Location, Field, and Laboratory Methods

Pear Tree Bottom (station 1) is located between Discovery Bay and Runaway Bay on the north coast of Jamaica, West Indies (Figure 1). About 80 m from shore a boulder crest is usually exposed at all tides. Shoreward lies a back-reef flat built up by accumulation of calcareous sediments and stabilized by *Thalassia* and *Diplanthera*. Station 1 is located about 20 m from mean-high water on the back-reef flat within a homogeneous patch of
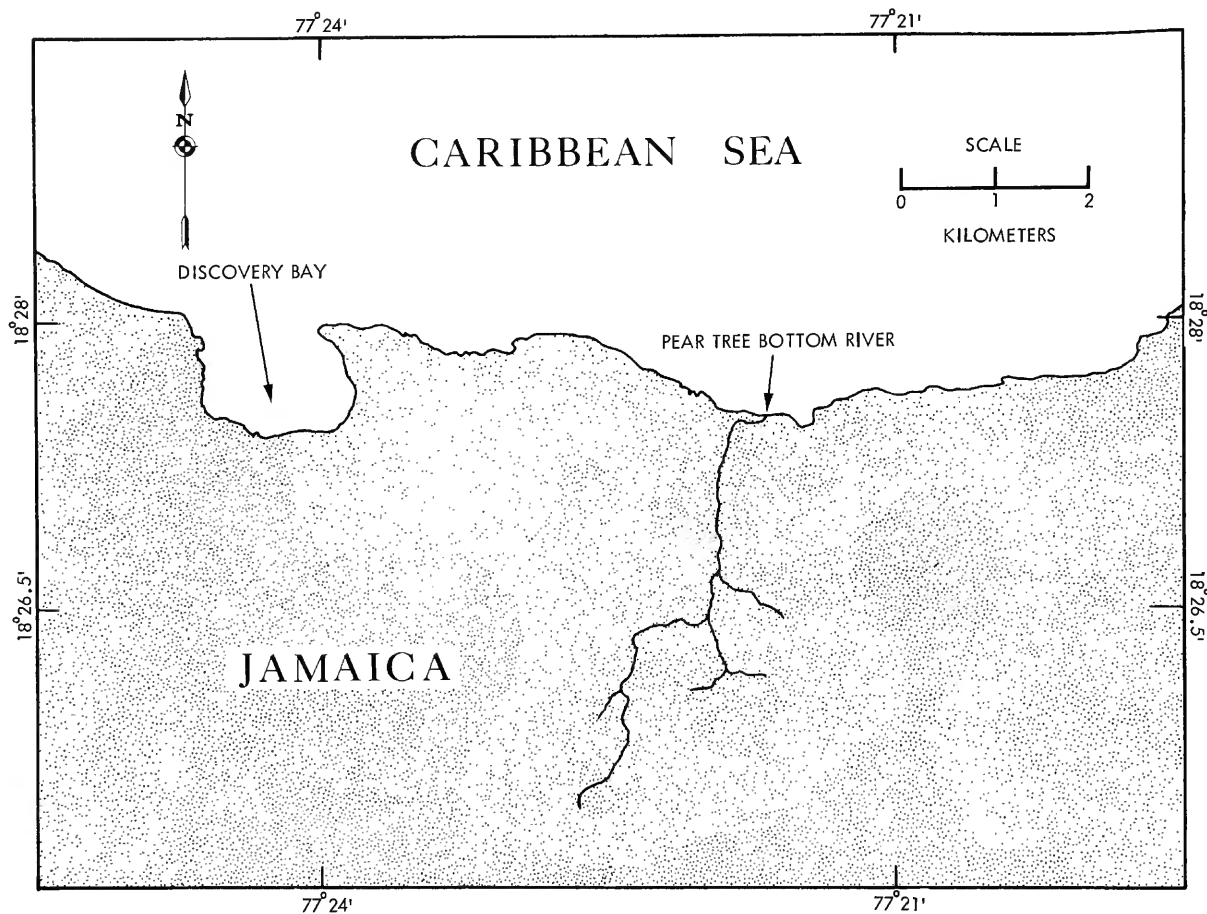
FIGURE 1.—Location of sampling areas.

Thalassia. During high tides the reef flat has an open circulation with the sea, while at low tides the reef flat is isolated and has a water depth of about 10–15 cm, and a weak counterclockwise current.

Discovery Bay (station 3) is roughly circular, measuring about 1 km in the east-west direction and 1.5 km north-south (Figure 1). A fringing reef coming to within 0.5 m of the surface separates the bay from the open ocean. The center of the reef is cut by a ship channel with a width of about 150 m and depth of 12 m. Station 3 is located within a homogeneous patch of *Thalassia* in the eastern part of the Bay about 60 m from shore and at a depth of about 3 m.

The details of the sampling procedures employed are given by Jackson (1972), who took the samples

and measured the environmental variables. A brief outline is presented here. Four replicate foraminiferal samples were taken each month by inserting core liners (internal diameter 2.54 cm) into randomly chosen cells. In all, 96 such samples were obtained over 12 successive months. Buffered formalin was added in the field, and upon returning to the laboratory the top 20 ml were washed over a 63 μ sieve and stored in alcohol.

The samples so obtained were then transported to the foraminiferal laboratory at the National Museum of Natural History for further processing. The day before examination 0.1 g of rose bengal was added to the sample. After shaking several times, the sample was washed over a 63 μ sieve, dried and floated twice in a mixture of bromoform and acetone having a specific gravity of 2.4. The

estimated recovery of tests using this procedure is greater than 95%. The floated portion of the sample was doled out into about 15 gridded petri dishes and rewet. All foraminifera were observed under transmitted and reflected light, and those showing stained protoplasm were picked wet and placed on slides for sorting and identification. Specimens of two abundant taxa, *Discorbis rosea* and one miliolid species, were retained for systematic purposes, but could not be used in this study because their test walls made it impossible to determine whether or not they were alive at the time of collection. We do not believe this omission changes the significance of the study. In all likelihood the only difference would be a slightly increased value for species diversity.

At the time of the field collections, 12 environmental variables were measured at each of the stations (Jackson, 1972). These were (1) bottom-water temperature, (2) sediment temperature, (3) bottom-water salinity, (4) bottom-water turbidity, (5) bottom-water particulate organic carbon, (6) bottom-water oxygen, (7) bottom-water pH, (8) sediment pH, (9) median sediment size, (10) sediment sorting, (11) sediment silt plus clay weight percent, (12) dry weight *Thalassia*/0.1m.²

Environmental Variables

A thorough description of the measurement and variation of the environmental variables is given by Jackson (1972). A brief summary is excerpted here to acquaint the reader with the salient aspects.

The sediment at Pear Tree Bottom (station 1) and Discovery Bay (station 3) is fine sand. Based on 48 observations the mean and standard deviation for three sedimentary parameters are:

	station 1		station 3	
	x	s	x	s
median (mm)	0.169	0.016	0.248	0.059
sorting	1.630	0.230	2.110	0.740
percent silt plus clay	10.610	5.160	12.600	5.010

Mean monthly variation of bottom water and sediment temperature with yearly means and standard deviations is shown in Figure 2. Although the overall difference in mean bottom-water temperatures between the two areas is only about 1°C, the shallow Pear Tree Bottom exhibits much more diurnal variation. On hot summer days the bottom-water temperature may reach 41°C, and in evening

as low as 25°C. Diurnal fluctuations, thus, may be as large as the annual temperature variation. At Discovery Bay, the diurnal variation is only about 1°C. Figure 2 shows that the sediment acts as a buffer to temperature change. While the difference between sediment and bottom-water temperature is minimal at Discovery Bay, at Pear Tree Bottom the difference during the summer may reach over 2°C. On hot summer days bottom-water temperatures may rise as much as 2°C/hr, but sediment temperatures rise only about 1°C/hr.

Mean monthly salinities, yearly averages, and standard deviations are shown in Figure 3. The low salinities at station 1 from April to September are due to the discharge of the Pear Tree River eastward (upcurrent) from Pear Tree Bottom. At low tide the reef flat is isolated from the open ocean and for a period of a few hours during the summer months salinities may reach as low as 15‰. Although no direct measurements were made, the sediment probably acts as a buffer and the variation in interstitial water is probably less than for bottom water. As Figure 3 indicates, salinities at Discovery Bay are nearly constant and in the range of normal marine salinities.

Figure 4 shows mean monthly turbidity values, yearly averages, and standard deviations. As might be expected turbidity values are higher at station 1 than at station 3. At Pear Tree Bottom turbid conditions often last for only a single tide; however, during storms or high rainfall, turbid conditions may prevail for a week or more. The high turbidity values recorded at station 3 are a reflection of winter storms. Visibility decreases to 0 during violent storms and sometimes remains less than 5 m for several days. During the remainder of the year, however, the water is clear with visibilities in excess of 15 m.

Mean monthly values, yearly averages, and standard deviations for particulate organic carbon are shown in Figure 5. Unlike temperature and salinity, the values fluctuate greatly. Most of the particulate organic carbon at station 1 is *Thalassia* (derived detritus). The reason for the very high value recorded in July is not clear, but substantially accurate. Most of the microbial community on such detritus consists of bacteria, various protozoa, and diatoms (Fenchel, 1970). At station 3, the bulk (70–80%) of the particulate organic carbon consists of diatoms and bacteria. Thus particulate organic
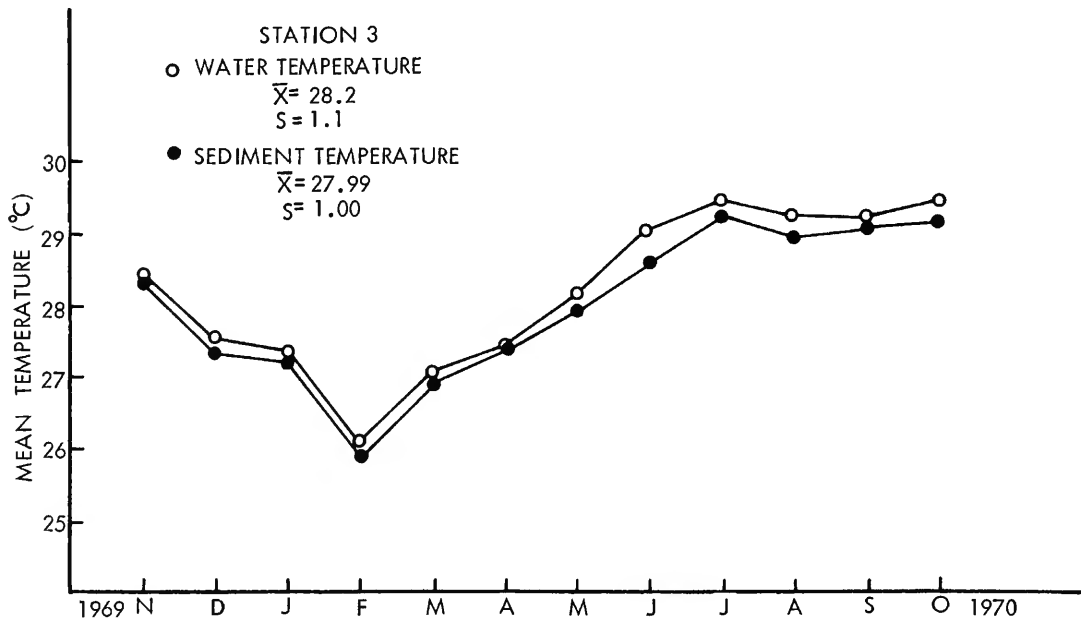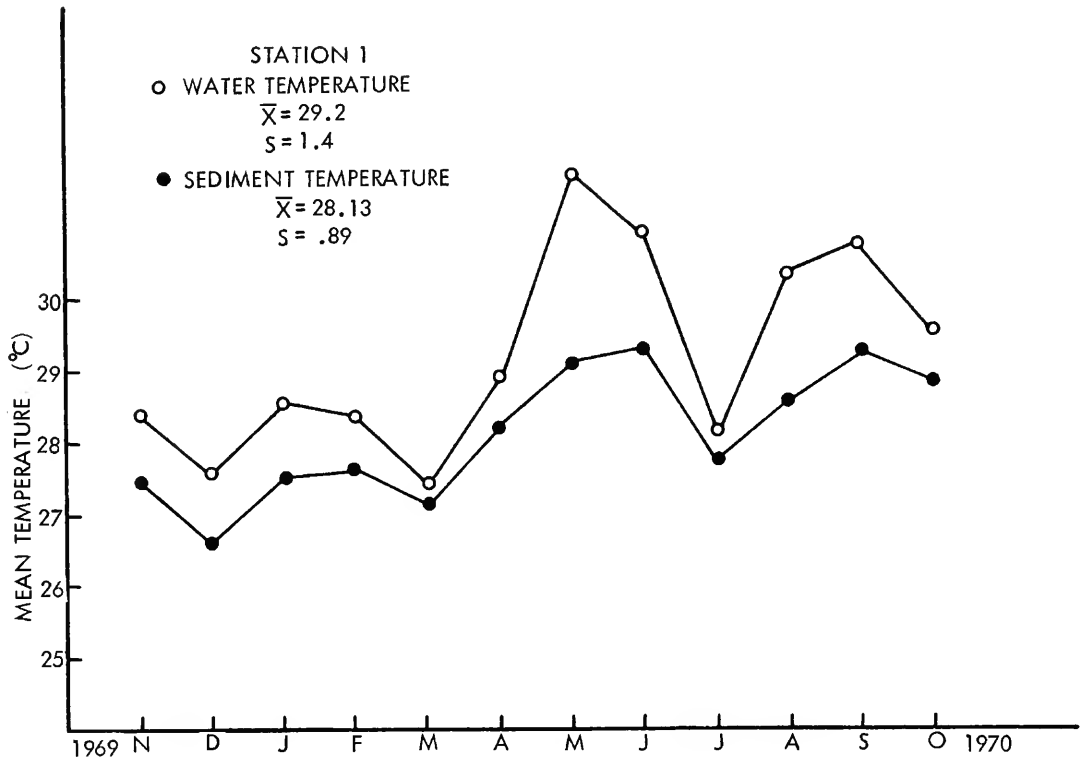
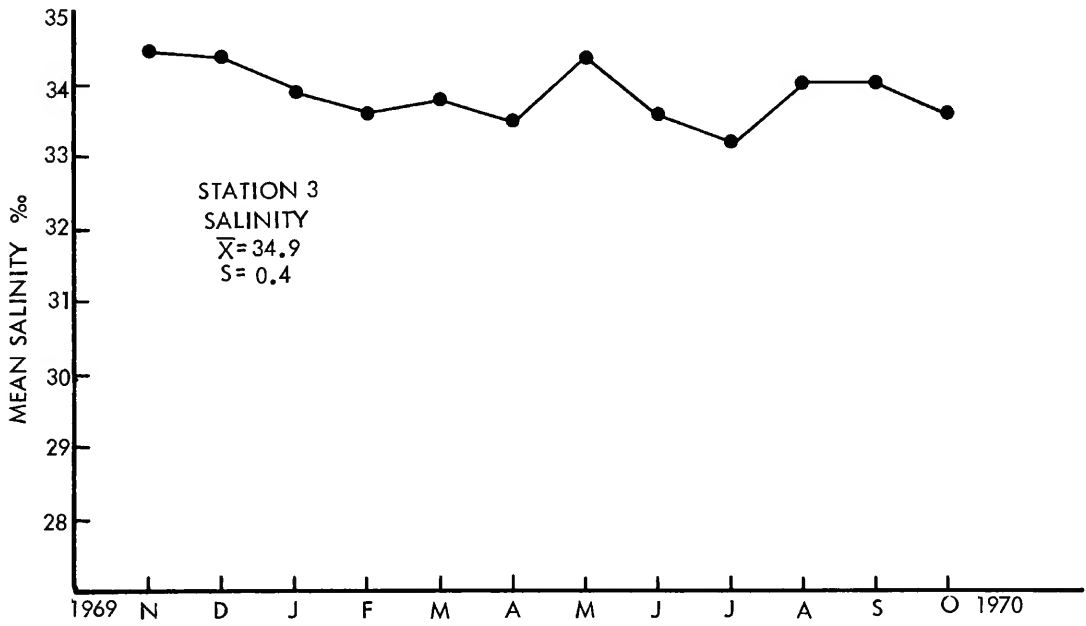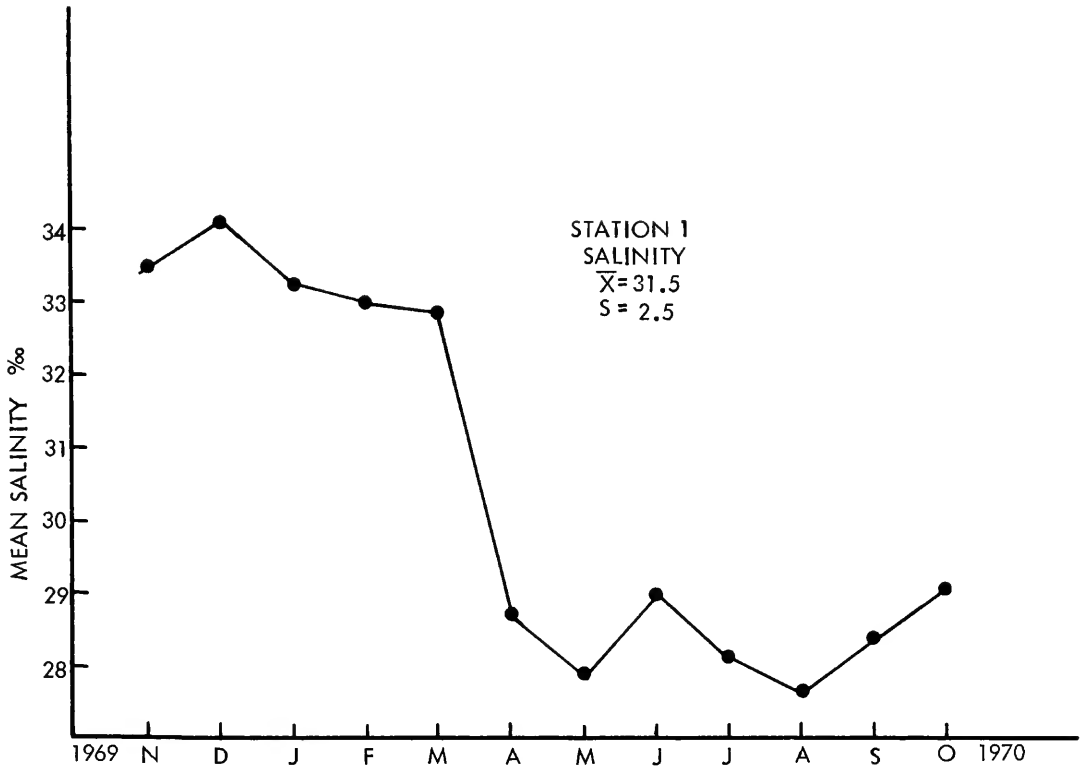FIGURE 2.—Monthly variations of temperature.
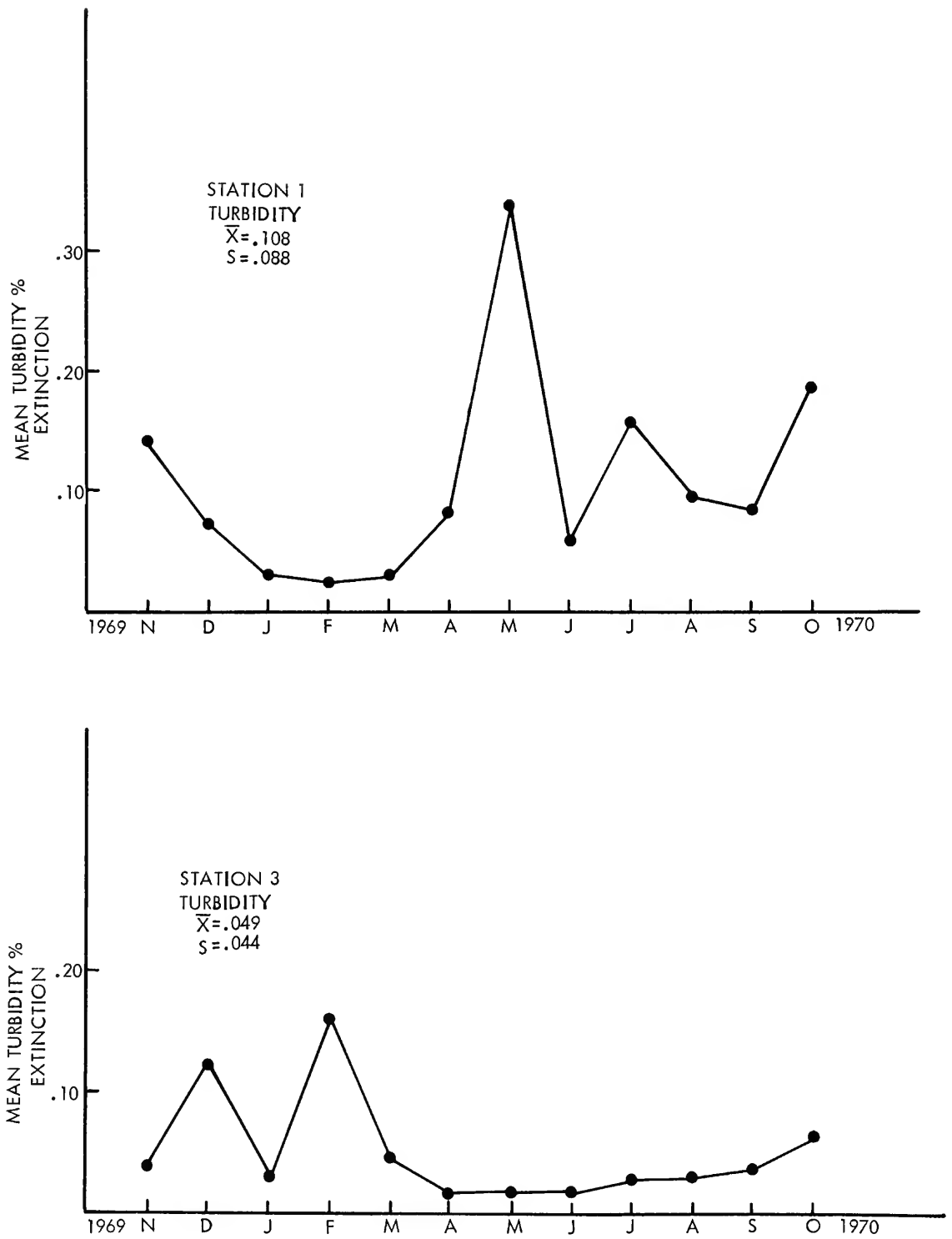
FIGURE 3.—Monthly variations of salinity.

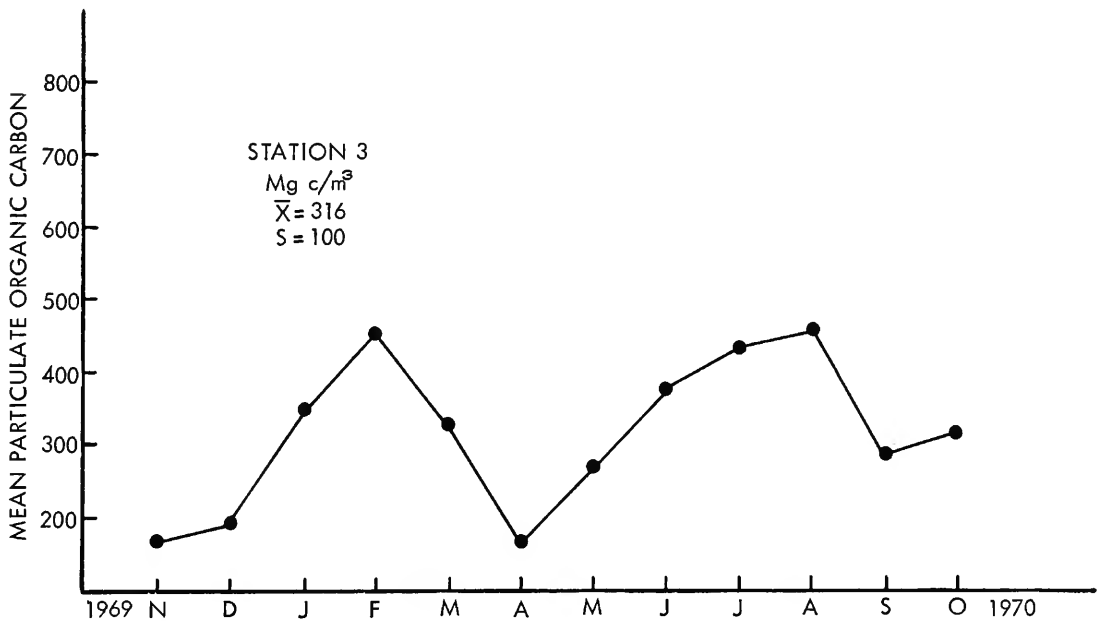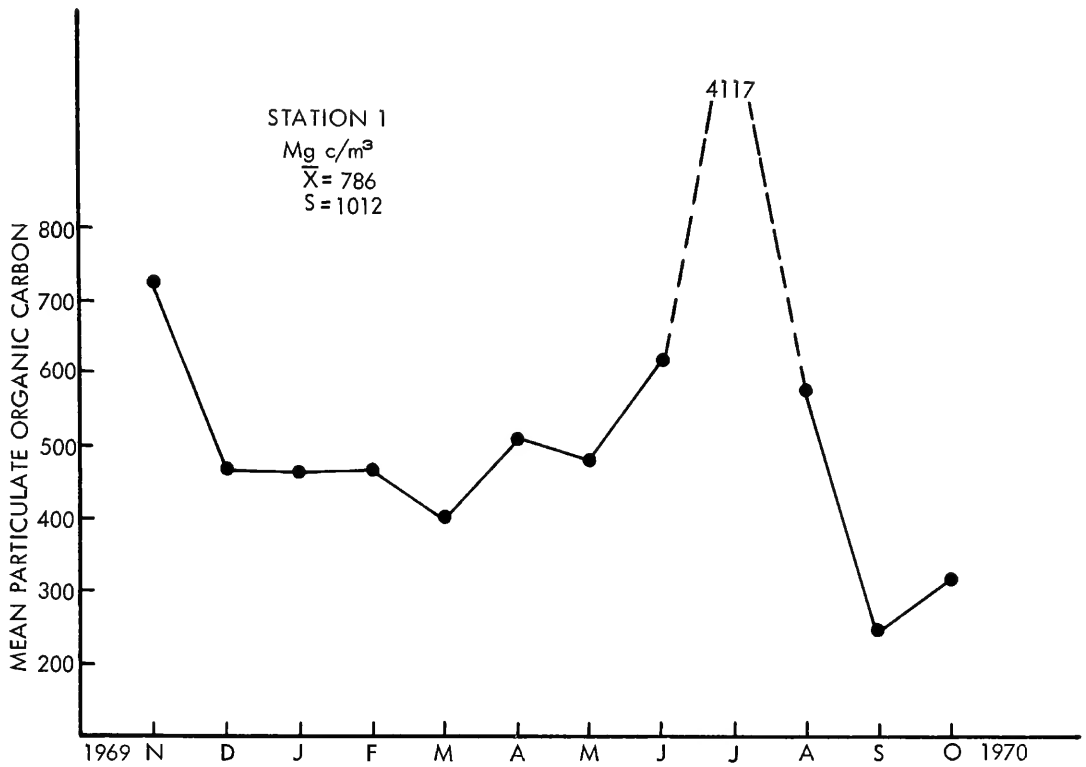FIGURE 4.—Monthly variations of turbidity.

FIGURE 5.—Monthly variations of particulate organic carbon.

carbon can be thought of as a crude measure of potential food for the foraminifera.

Figure 6 shows mean monthly values, yearly averages, and standard deviations for oxygen saturation. Both areas are supersaturated with respect to oxygen. The somewhat lower values at Discovery Bay are probably due to lower light intensities at the deeper station. Although no measurements were made at night, values presumably decreased below saturation due to the respiratory needs of the biota.

Figure 7 shows mean monthly bottom water and the sediment pH values, yearly averages, and standard deviations. As might be expected pH values in the sediment are lower than in the overlying water. Differences between bottom water and sediment pH are greater at station 1, and reducing conditions are usually present within two cm of the sediment surface at the back reef flat.

Mean monthly *Thalassia* dry weight, yearly averages, and standard deviations are shown in Figure 8. Like particulate organic carbon, values vary greatly during the year. The high value recorded in summer at Discovery Bay may reflect a mid- to late-summer peak.

Jackson (1972) calculated F ratios for the variances of the environmental variables. For salinity, particulate organic matter, turbidity, and oxygen saturation, station 1 has a significantly greater variance than station 3. At Pear Tree Bottom (station 1) mean values for salinity are lower, and turbidity and oxygen saturation higher than at Discovery Bay (station 3). Jackson used stress as a collective term for mean values, variance, and the pattern of variance. Considering all three, there is less stress at Discovery Bay than at Pear Tree Bottom.

Univariate Analyses

STATISTICAL MODEL.—We recall that four replicate samples were taken each month for 12 successive months at two stations to estimate foraminiferal species densities. At the same time 12 environmental variables were measured. An a priori general linear model was constructed to test hypotheses for: (1) an overall difference in species densities between the two stations, (2) an overall periodicity at the two stations, (3) different periodicities at the two stations, (4) a linear relationship between species densities and environmental variables.

The construction of such a model is discussed by Seal (1964) and Finn (1974). In matrix notation the general linear model, Ω, is written

$$\underset{(N \times 1)}{\mathbf{x}} = \underset{(N \times q)}{\mathbf{Z'}} \quad \underset{(q \times 1)}{\mathbf{B}} + \underset{(N \times 1)}{\mathbf{e.}} \quad (1)$$

The dependent variable, $\mathbf{x}$, is a vector of species densities for the $N = 96$ observations. Each element, x_{ijk}, is the observation (number of individuals) for the ith month, $i = 1, \ldots, 12$, the jth station, $j = 1$ and 3, and the kth replicate, $k = 1, \ldots, 4$. The matrix $\mathbf{Z'}$ is composed of $q = 22$ columns consisting of 12 covariates (environmental variables) and 10 instrumental or "dummy" variates whose makeup will be discussed below. The vector $\mathbf{B}$ has $q = 22$ parameters to "explain" the N observations of species densities. Finally, the vector $\mathbf{e}$, assumed to be $N(0, \sigma^2)$, is a vector of "errors" or "residuals" not accounted for by the model.

Table 1 shows the composition of the matrix $\mathbf{Z'}$, The vector z_1 is a column of units and because each of the other z' adds to zero, $\hat{B}_1$ is the mean of the 96 observations. The vector z_2 tests for any overall difference in species densities between the stations. Vectors $z_3, \ldots, z_{14}$ are the observed environmental variables. The vectors z_{15} and z_{16} repeat a sine wave for each of the stations, and test for overall periodicity. Vectors z_{17} and z_{18} also test for overall periodicity but with a periodicity of $\Pi/3$ instead of $\Pi/6$. Bliss (1958) discusses the use of such functions for analysis of periodicity. By multiplying $z_2 \times z_{15}$ and z_{16}, and $z_2 \times x_{17}$ and z_{18}, we obtain two sets of interaction vectors that test whether or not the stations have different periodicities.

By matrix transposition, multiplication, and inversion, the betas can be obtained from the relationship

$$\hat{\mathbf{B}} = (\mathbf{Z}\,\mathbf{Z'})^{-1}\,\mathbf{Z}\,\mathbf{x}. \quad (2)$$

Once the betas are obtained, the sum of squares of the residuals, ℓ_Ω, is solved for by

$$(N-q)\hat{\sigma}^2 = \ell_\Omega = ee' = \mathbf{x'x} - \hat{\mathbf{B}}'\,\mathbf{Z}\,\mathbf{Z'}\,\hat{\mathbf{B}}. \quad (3)$$

Hopefully, some of the parameters in the Ω model will prove to be superfluous and can be deleted. To test whether this is so, several restricted models are postulated by equating desired values of β to zero. These restricted models have s parameters and are called ω models:

$$\underset{(N \times 1)}{\mathbf{x}} = \underset{N \times s}{\mathbf{Z'}} \quad \underset{(s \times 1)}{\mathbf{B}} + \underset{(N \times 1)}{\mathbf{e.}} \quad (4)$$
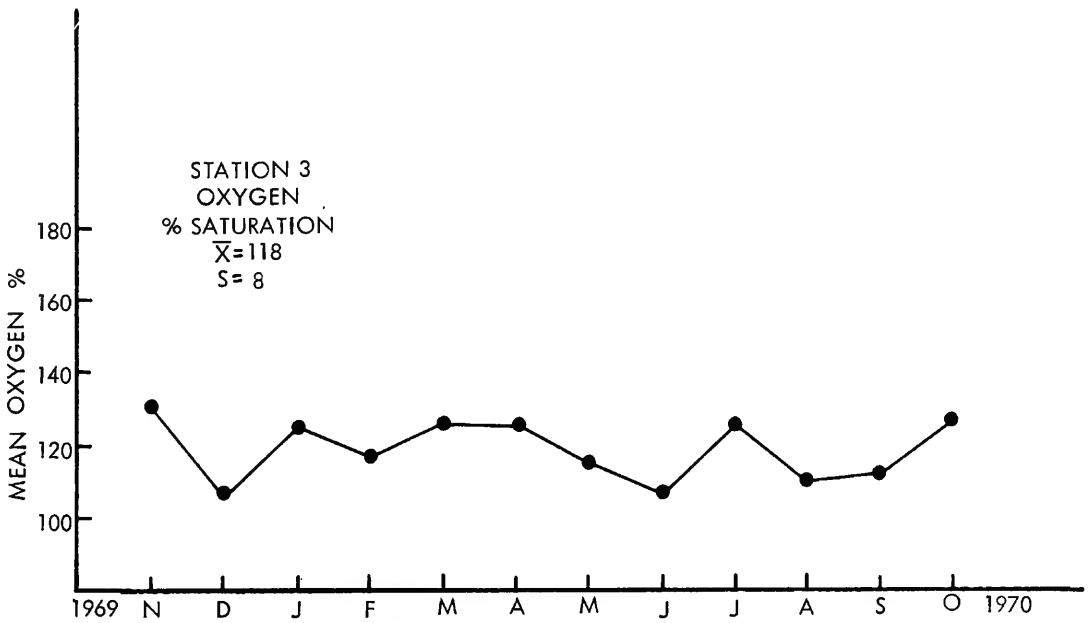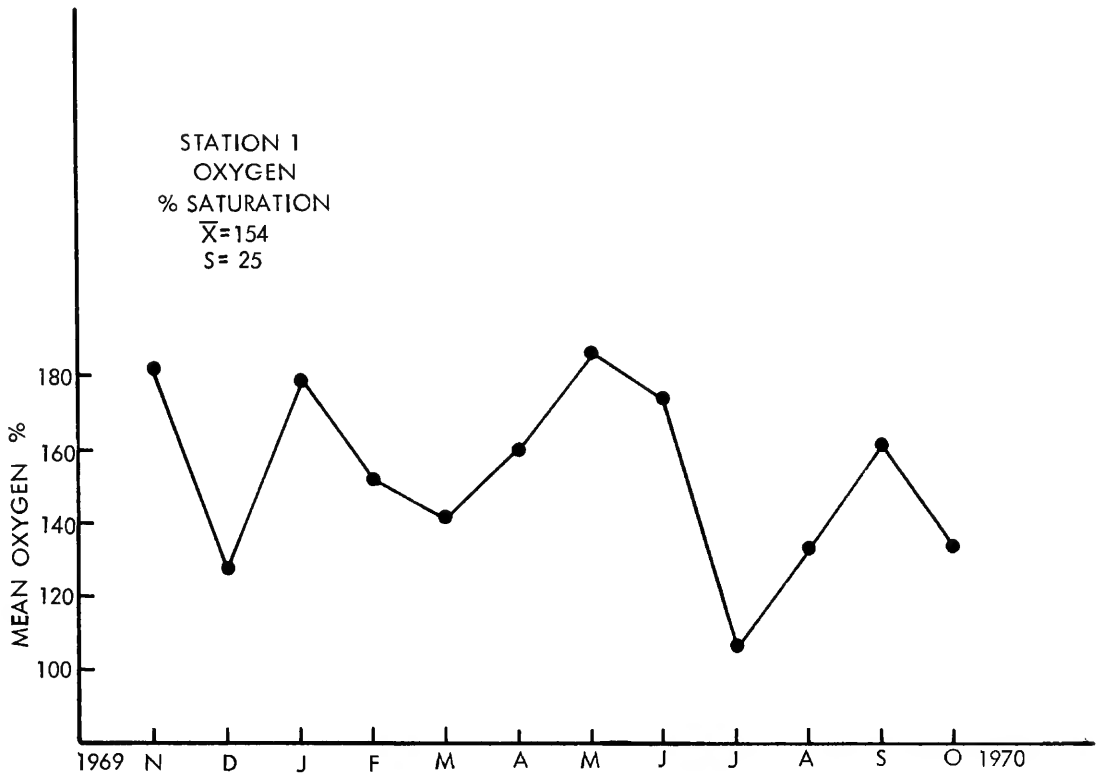
FIGURE 6.—Monthly variations of oxygen.
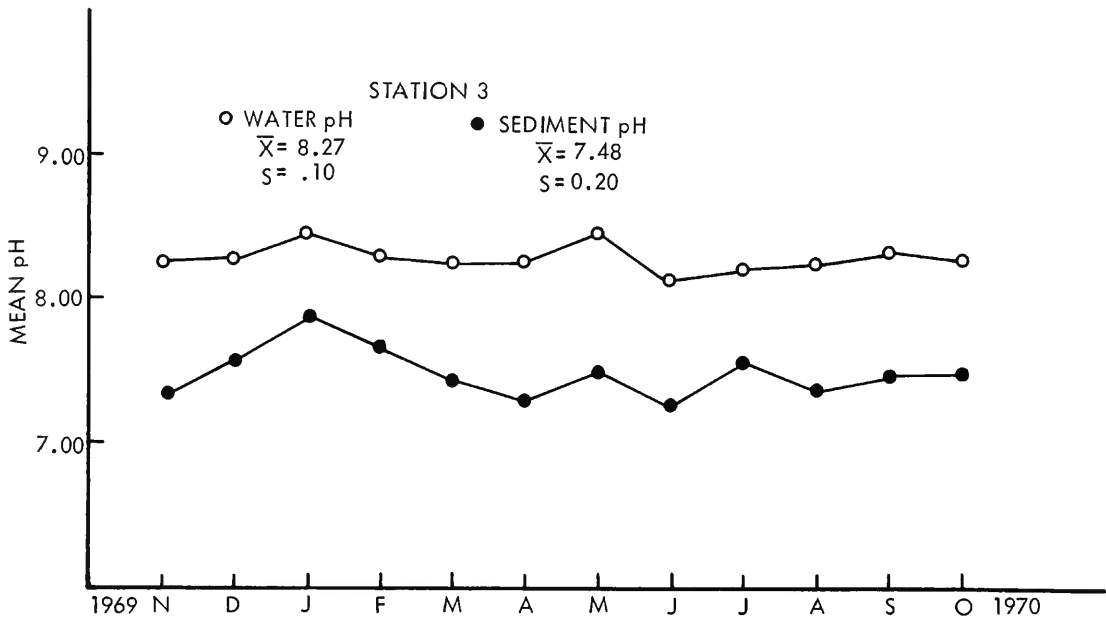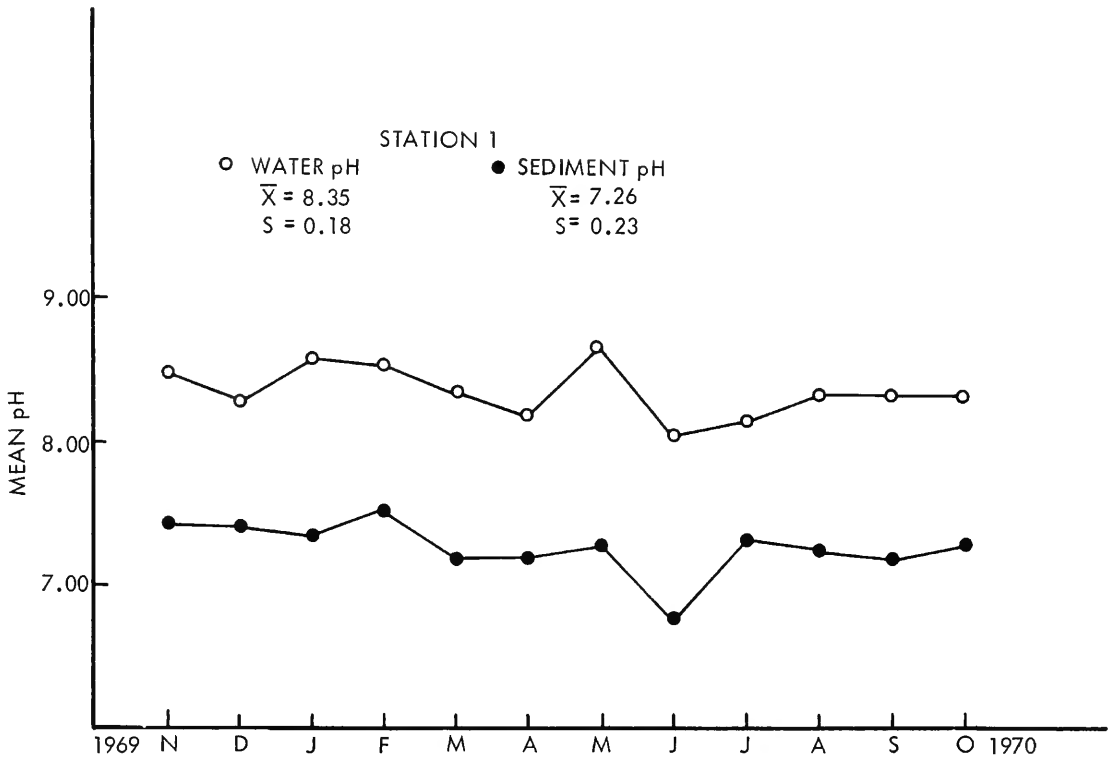
FIGURE 7.—Monthly variations of pH.
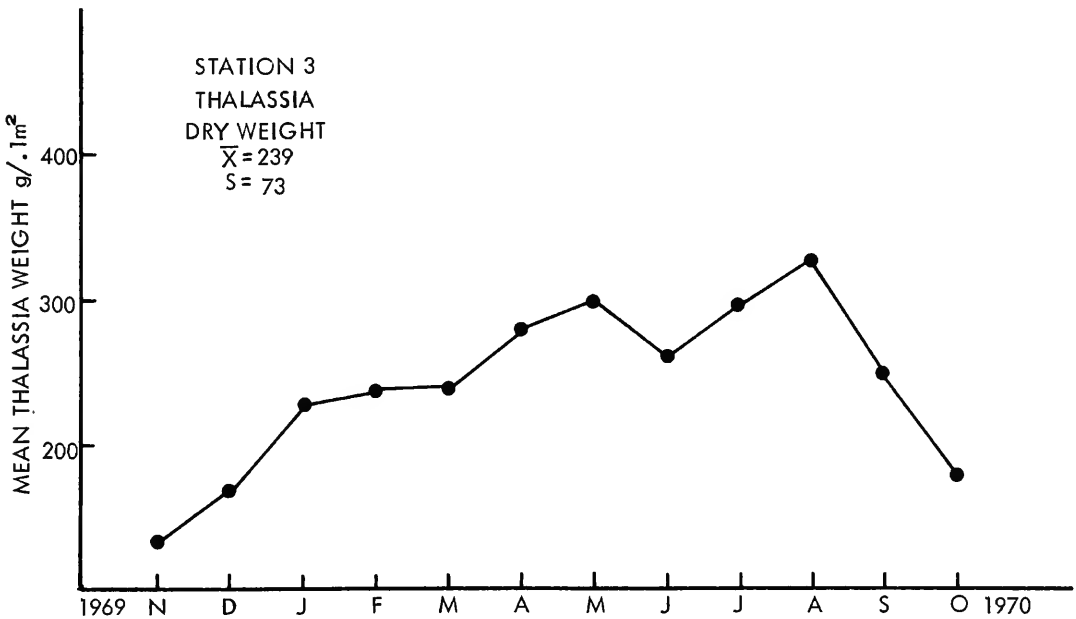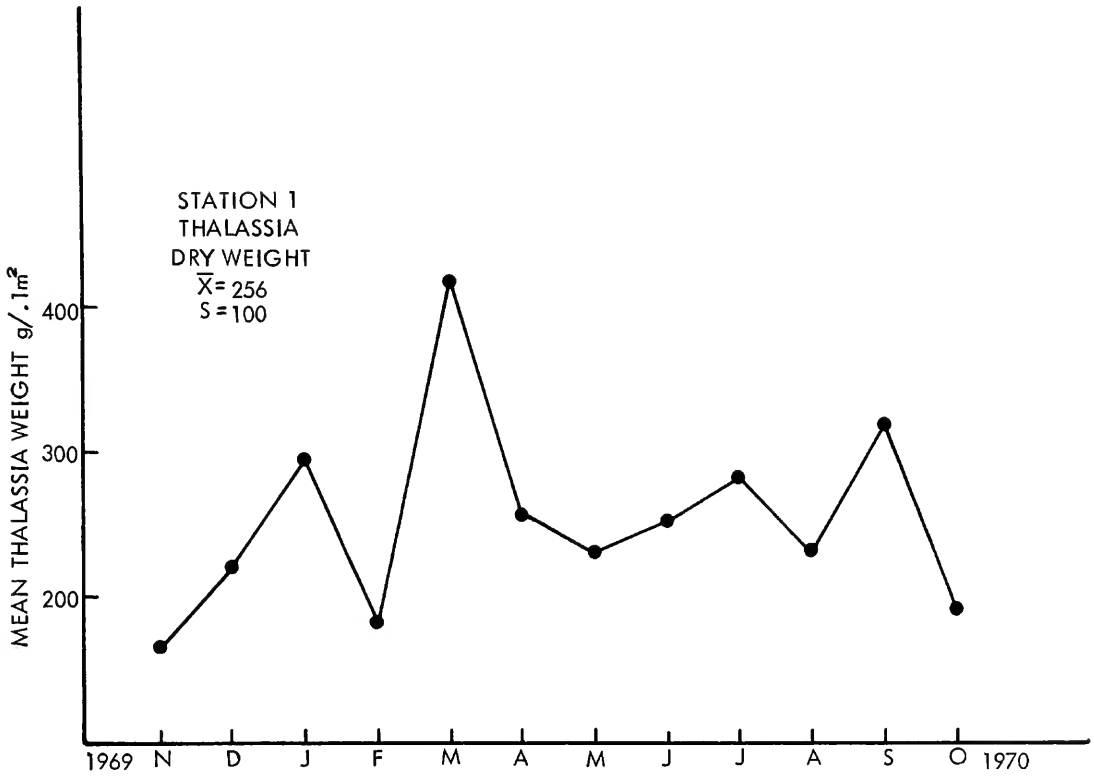
FIGURE 8.—Monthly variations of *Thalassia* dry weight.

TABLE 1.—Composition of matrix Z'

z_1 = a vector of units
z_2 = +1 for station 1 observations, -1 for station 3 observations
z_3 = salinity (o/oo)
z_4 = water temperature (°C)
z_5 = sediment temperature (°C)
z_6 = particulate organic carbon (Mg C/m^3)
z_7 = turbidity (% extinction)
z_8 = sediment median (mm)
z_9 = sediment sorting
z_{10} = Thalassia dry weight (g/0.1 m^2)
z_{11} = weight percent silt plus clay
z_{12} = percent oxygen saturation
z_{13} = water pH
z_{14} = sediment pH
z_{15} sin(m X π/6)   m = 1,...,12
z_{16} = cos(m X π/6)   m = 1,...,12
z_{17} sin(m X π/3)   m = 1,...,12
z_{18} cos(m X π/3)   m = 1,...,12
z_{19} z_2 X z_{15}
z_{20} z_2 X z_{16}
z_{21} z_2 X z_{17}
z_{22} z_2 X z_{18}

Utilizing equations (2) and (3), the sum of squares of the residual, ℓ_Ω, for the ω models are then evaluated. The significance of any set of $\hat{B}'_s$ can be tested for by comparing the restricted model to the general model by means of the relationship

$$\frac{(\ell_\omega - \ell_\Omega)/(q\text{-}s)}{\ell_\Omega/(N\text{-}q)} = F_{(q\text{-}s)(N\text{-}q)}.$$

SAMPLE SIZE.—Most of the 143 species recorded in this study are represented by only a few individuals. For both statistical and biological reasons, analyses based on a few occurrences in 96 observations are of dubious value. The decision of how abundant a species should be before being included in statistical analyses, however, is somewhat arbitrary. Greig-Smith (1964) showed that plots of the Poisson distribution became very asymmetrical as the mean number of individuals became less than 4. While few natural populations are distributed according to the Poisson distribution, nevertheless, his suggestion that the number of observations with no individuals should not exceed those with one individual is valid. When the mean number of individuals is very low, no transformation can restore symmetry. In the present instance, the number of observations with no individuals was examined for various species densities. In general, when the mean number of individuals is greater than one or two, more than 50% of the observations con-

tained at least one individual. Consequently, for the purposes of this study abundant species are defined as those having a mean number of individuals of at least 2 for the 96 observations. Jackson (1972) also chose a mean value of 2 in his studies of molluscs based on his observations and theoretical considerations discussed by Taylor (1961). Of the 143 species recorded, 19 meet this requirement and are statistically analyzed below. To stabilize the variance and make the distributions more normal, all counts were transformed to ln $(x_{ijk} + 1)$.

STATISTICAL ANALYSES OF SPECIES.—Bolivina striatula has a grand mean of 30.55 and is the most abundant species recorded in this study. The mean number of individuals observed each month, their yearly average, and standard deviations at the two stations is shown in Figure 9. At station 1, high mean values of 57.00 and 49.75 occur in November and May. Minima of 22.75 and 21.75 occur in March and April. At station 3, maxima of 39.75 and 45.25 occur in May and August. A minimum of 15.00 was recorded in January.

Table 2 presents the results of the statistical analyses in the form of an analysis of variance table. The sum of squares column is $\ell_\omega - \ell_\Omega$ for the various hypotheses, and ℓ_Ω for the residual. To simplify the interpretation of the significance of the various hypotheses, the last column gives the
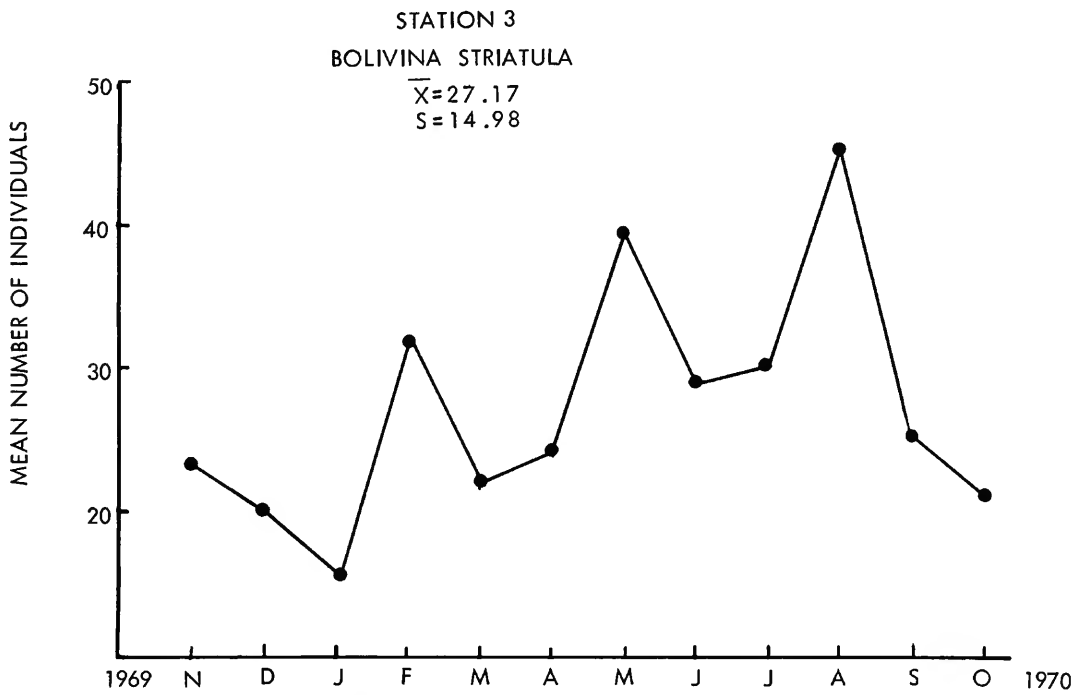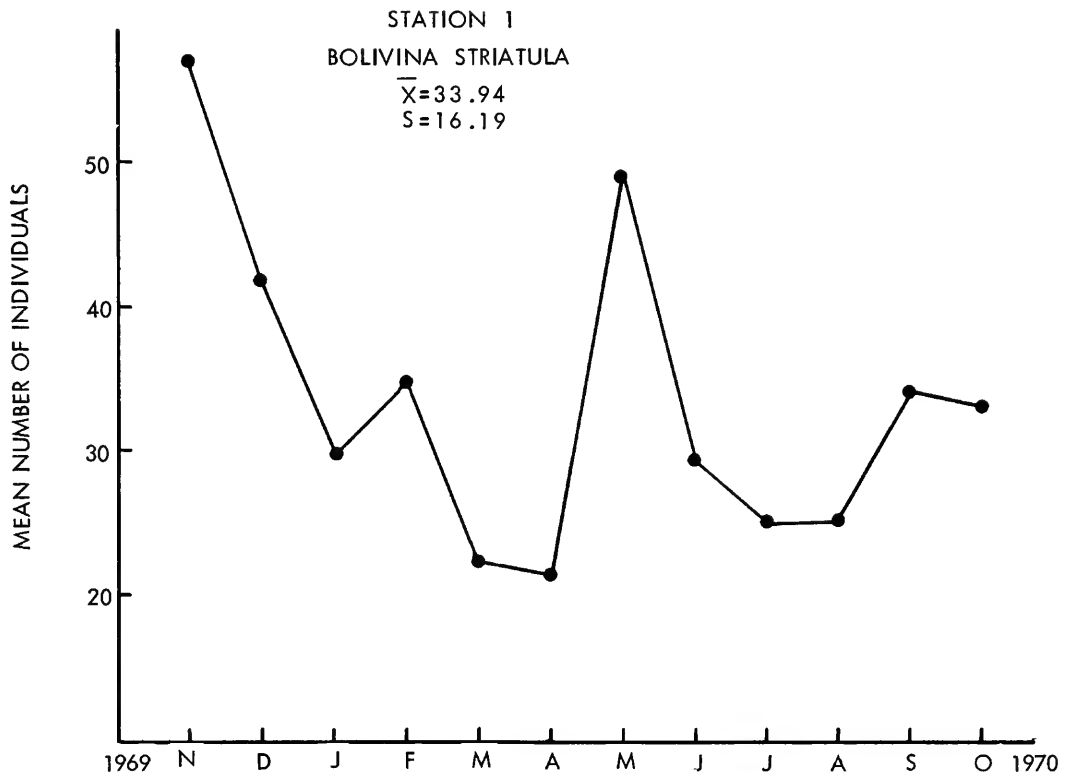
FIGURE 9.—Monthly variations in density of *Bolivina striatula*.

TABLE 2.—Statistical analyses for *Bolivina striatula*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.01	0.004	0.01	0.99
π/6 interaction	2	0.16	0.08	0.32	0.73
π/3 overall periodicity and interaction	4	0.51	0.13	0.51	0.73
π/6 overall periodicity and interaction	4	3.04	0.76	3.03	0.02
Environmental variables ...	12	4.76	0.40	1.58	0.11
Station differences	1	0.10	0.10	0.38	0.54
Residual	74	18.55	0.25	--	--

TABLE 3.—Statistical analyses for *Bolivina subexcavata*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.00	0.50	1.75	0.29
π/6 interaction	2	0.38	0.19	0.48	0.62
π/3 overall periodicity and interaction	4	2.91	0.73	1.81	0.14
π/6 overall periodicity and interaction	4	3.69	0.92	2.29	0.07
Environmental variables ...	12	5.76	0.48	1.19	0.30
Station differences	1	0.06	0.06	0.16	0.69
Residual	74	29.74	0.40	--	--

TABLE 4.—Statistical analyses for *Trifarina occidentalis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.19	0.59	1.54	0.22
π/6 interaction	2	0.19	0.10	0.25	0.78
π/3 overall periodicity and interaction	4	1.40	0.35	0.90	0.47
π/6 overall periodicity and interaction	4	3.71	0.93	2.40	0.06
Environmental variables ...	12	6.59	0.55	1.42	0.16
Station differences	1	0.05	0.05	0.14	0.71
Residual	74	28.59	0.39	--	--

TABLE 5.—Statistical analyses for *Ammonia beccarii*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.36	0.68	1.11	0.33
π/6 interaction	2	1.78	0.89	1.47	0.24
π/3 overall periodicity and interaction	4	1.61	0.40	0.66	0.62
π/6 overall periodicity and interaction	4	5.11	1.28	2.10	0.09
Environmental variables ...	12	3.47	0.29	0.48	0.93
Station differences	1	0.29	0.29	0.48	0.49
Residual	74	45.00	0.61	--	--

probability of obtaining the F values shown. The hypothesis $\Pi/6$ overall periodicity and interaction, having F = 3.03 and p (F) = 0.02, is the only one reaching statistical significance. We conclude that *B. striatula* has an overall periodicity and that it is the same at both stations.

Bolivina subexcavata has a grand mean of 19.57. Figure 10 shows a maximum mean abundance for this species of 36.75 in May. A minimum mean value of 15.00 was observed in March. At station 3 the maximum mean, 31.25, was also observed in May, and a minimum, 4.25, was observed in October.

Table 3 indicates the highest mean square value of *B. subexcavata,* having an F = 2.29 and p (F) = 0.07, is for the hypothesis $\Pi/6$ overall periodicity and interaction. While falling short of significance at the 95% level, this relatively high mean square value reflects the monthly periodicities shown in Figure 10.

Trifarina occidentalis has a grand mean of 19.18. Figure 11 shows a maximum mean value of 25.75 in May at station 1. Other monthly values at station 1 are all fairly close to the overall station mean. At station 3 a maximum of 43.50 also occurs in May. A minimum of 9.00 was recorded in January.

Table 4 shows the highest mean square value for *T. occidentalis* is for the hypothesis $\Pi/6$ overall periodicity and interaction. This hypothesis has a value of F = 2.40 with p(F) = 0.06. This hypothesis is nearly significant at the 95% level and reflects the observed monthly means plotted in Figure 11. As with the previous two species the other hypotheses have relatively low mean square values and do not approach statistical significance.

Ammonia beccarii has a grand mean of 18.78. Figure 12 shows station 1 has high mean values of 33.50 and 42.25 in November and May. The lowest monthly means occur in January, February, March, July, and August. At station 3, high monthly means of 40.00, 44.00, and 48.25 occur in February, May, and June. Low mean values of 6.75, 7.75, and 7.50 occur in December, September, and October.

Table 5 shows the highest mean square value is for the hypothesis $\Pi/6$ overall periodicity and interaction. This hypothesis has an F = 2.10 with p(F) = 0.09. While not reaching significance at the 95% level, this hypothesis is the only one approach-

ing any statistical significance, and reflects the importance of overall monthly periodicity at the two stations.

Rosalina globularis has a grand mean of 11.01. Figure 13 shows station 1 has a maximum mean in April of 10.00. A minimum of 1.75 was observed in November. Station 3 has high means of 35.75 in May and 49.75 in June. A minimum of 4.00 occurs in October.

Table 6 indicates that at the 95% level the hypotheses $\Pi/3$ interaction and $\Pi/6$ overal periodicity and interaction are significant. In addition, $\Pi/3$ overall periodicity and interaction are significant at the 90% level. Curiously, although the mean values are much higher at station 3, the hypothesis for station differences is not statistically significant. The high mean square value for $\Pi/6$ overall periodicity and interaction is probably due mainly to the overall periodicity exhibited by both stations with highs during spring and early summer. The relatively high mean squares for $\Pi/3$ interaction and $\Pi/3$ overall periodicity and interaction are apparently accounting for differences between the stations over the sampling period. This is the only species in the study to exhibit this phenomenon.

Discorbis mira has a grand mean of 7.76. Figure 14 shows maxima mean values at station 1 of 4.00, and 3.75 occur in May and October. A minimum of 0 occurs in November. Station 3 has a maximum of 29.00 individuals in May; however, in this case, the monthly mean was inflated by the occurrence of 60 individuals in a single observation. A minimum mean value of 6.00 was observed in January.

Table 7 shows a very large mean square value for the hypothesis station differences, F = 13.17 and p(F) = 0.0005. This is in keeping with the large differences in the number of individuals observed at the two stations discussed above and plotted in Figure 14. The hypotheses $\Pi/6$ interaction and $\Pi/6$ overall periodicity and interaction have relatively high mean square values. The first, $\Pi/6$ interaction, has an F = 2.68 with p (F) = 0.08, indicating the two stations differ with respect to their monthly periodicities. As Figure 14 shows, station 1 has relatively high values in January, September, and October, while these same months are relatively low for station 3. Station 1 exhibits an increase in early autumn and station 3 a de-

STATION 1
BOLIVINA SUBEXCAVATA
$\overline{X} = 21.96$
$S = 14.43$

STATION 3
BOLIVINA SUBEXCAVATA
$\overline{X} = 17.19$
$S = 12.04$
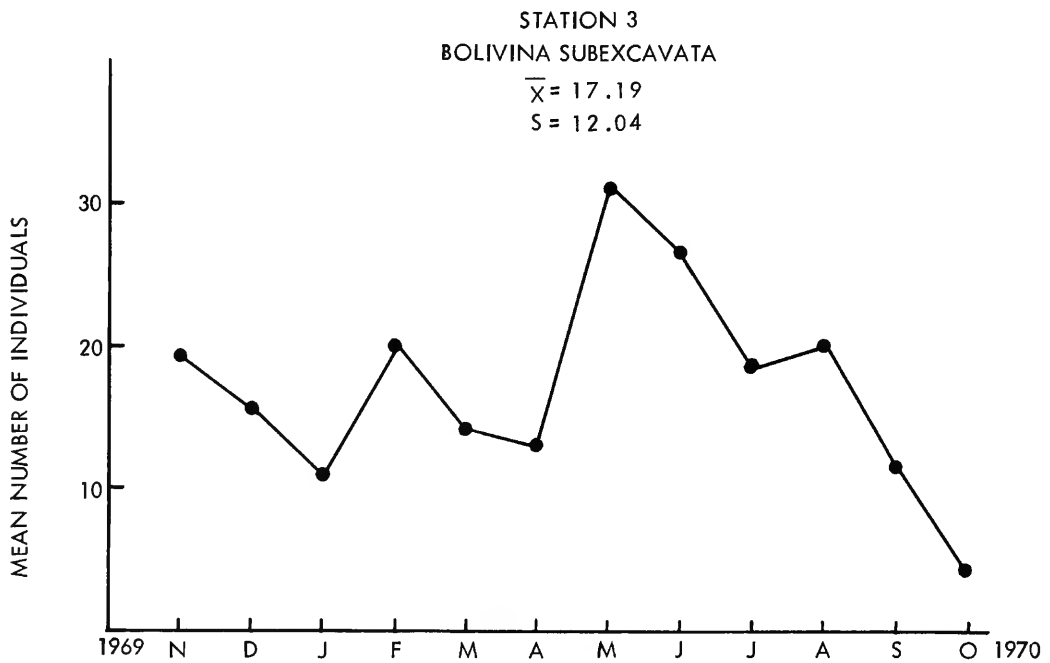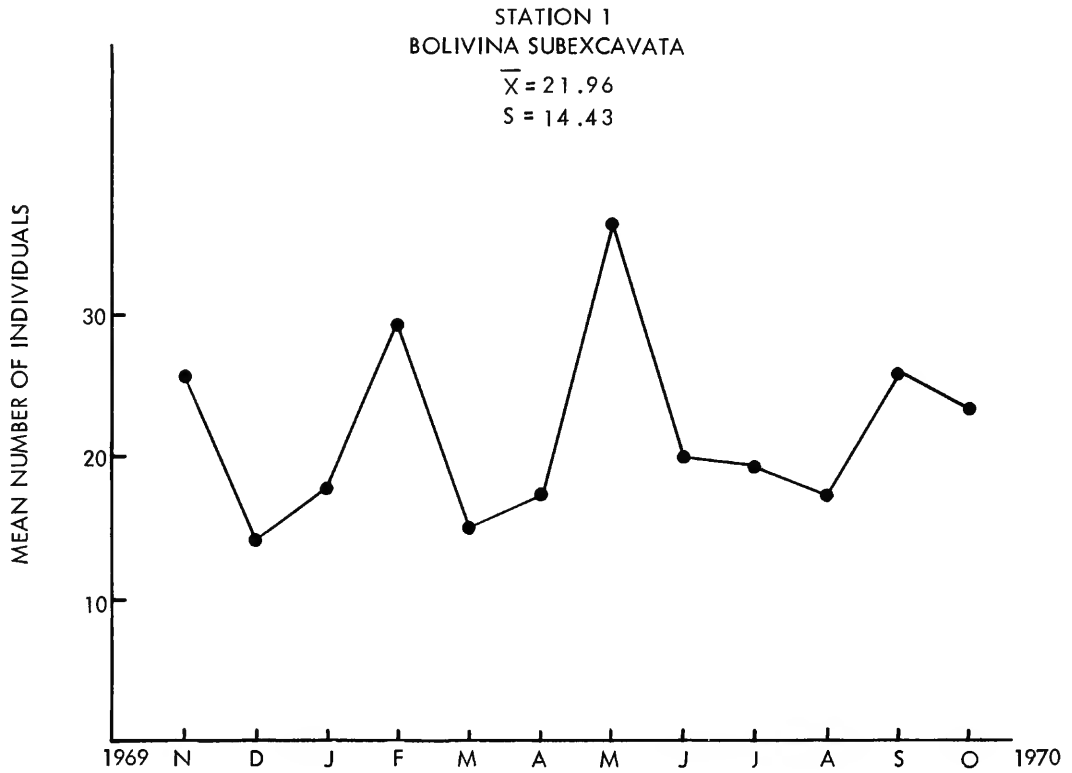
FIGURE 10.—Monthly variations of density of *Bolivina subexcavata*.
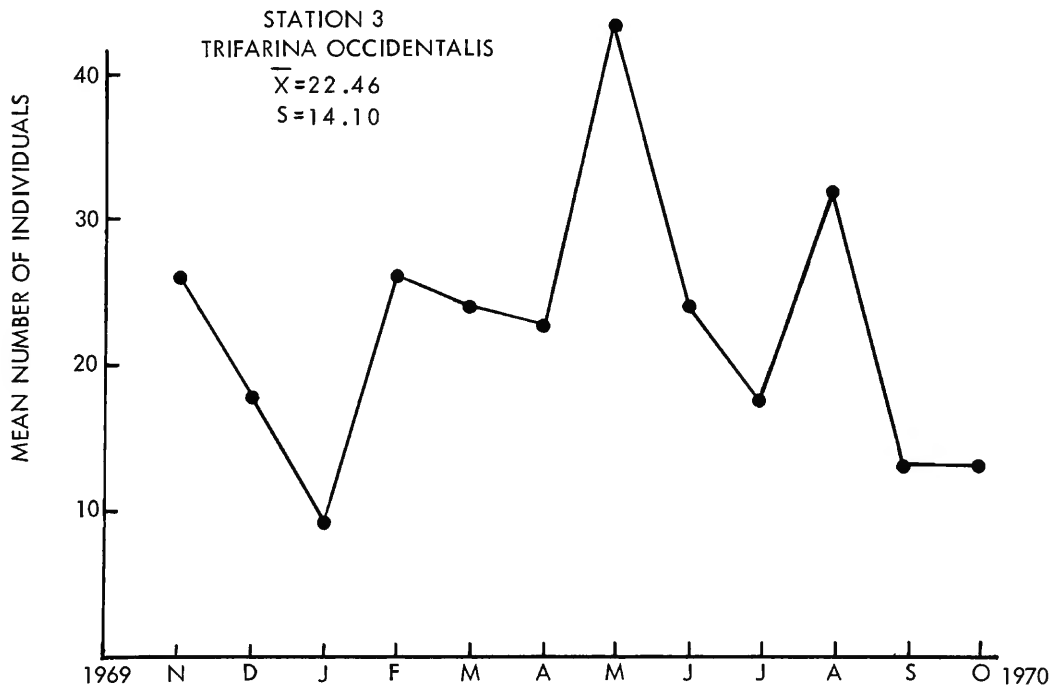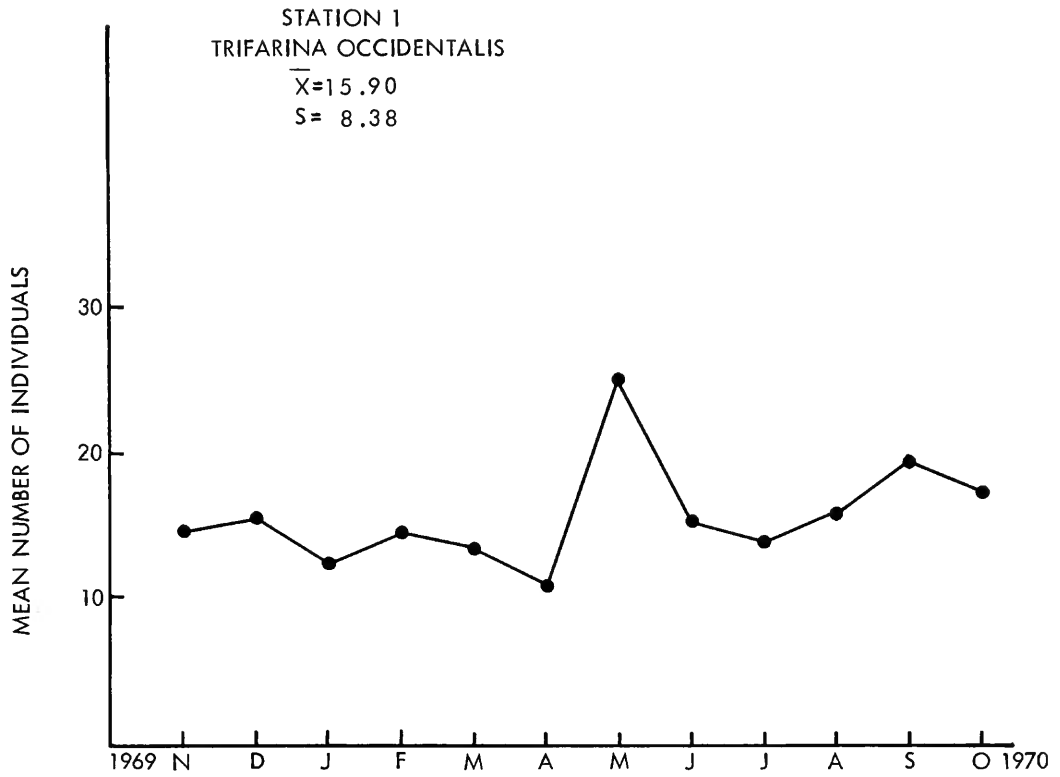
FIGURE 11.—Monthly variations in density of *Trifarina occidentalis*.
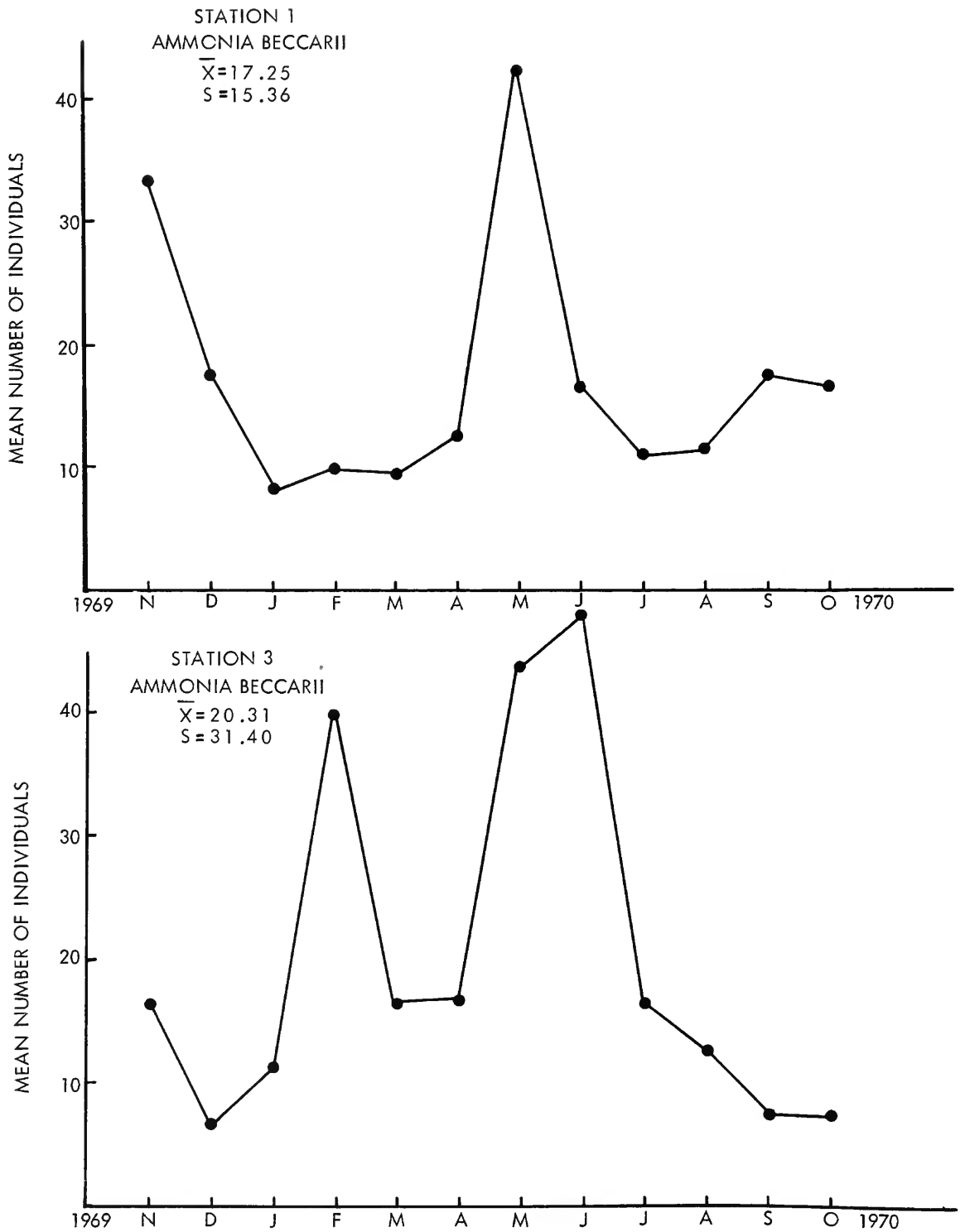
FIGURE 12.—Monthly variations in density of *Ammonia beccarii*.
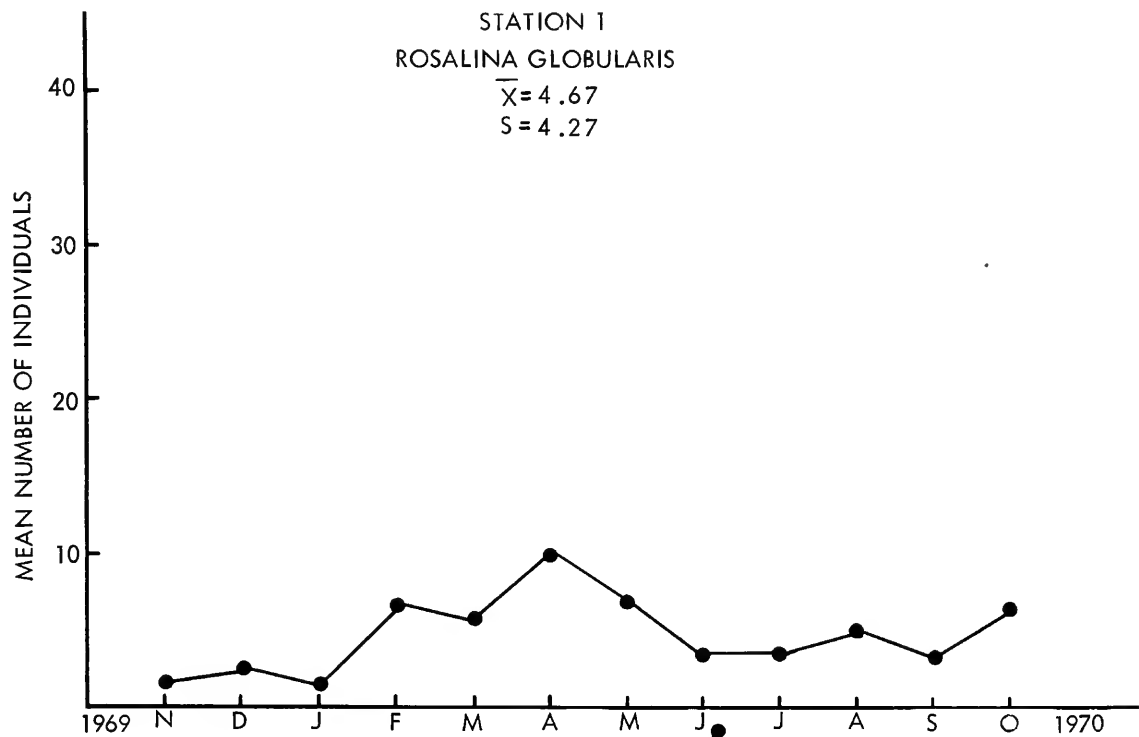
FIGURE 13.—Monthly variations in density of *Rosalina globularis*.
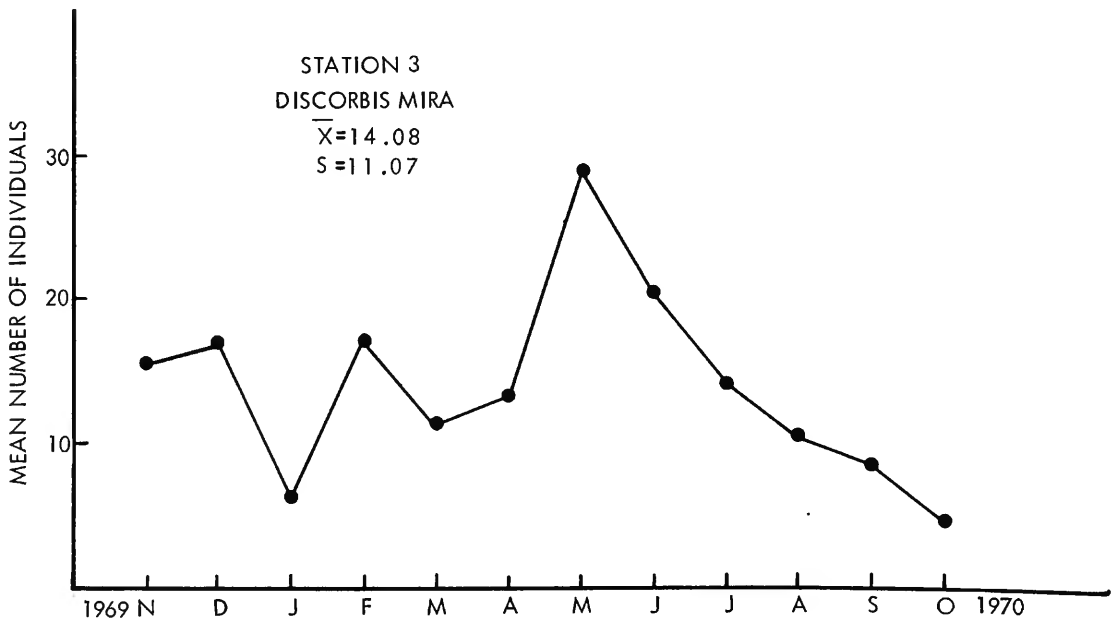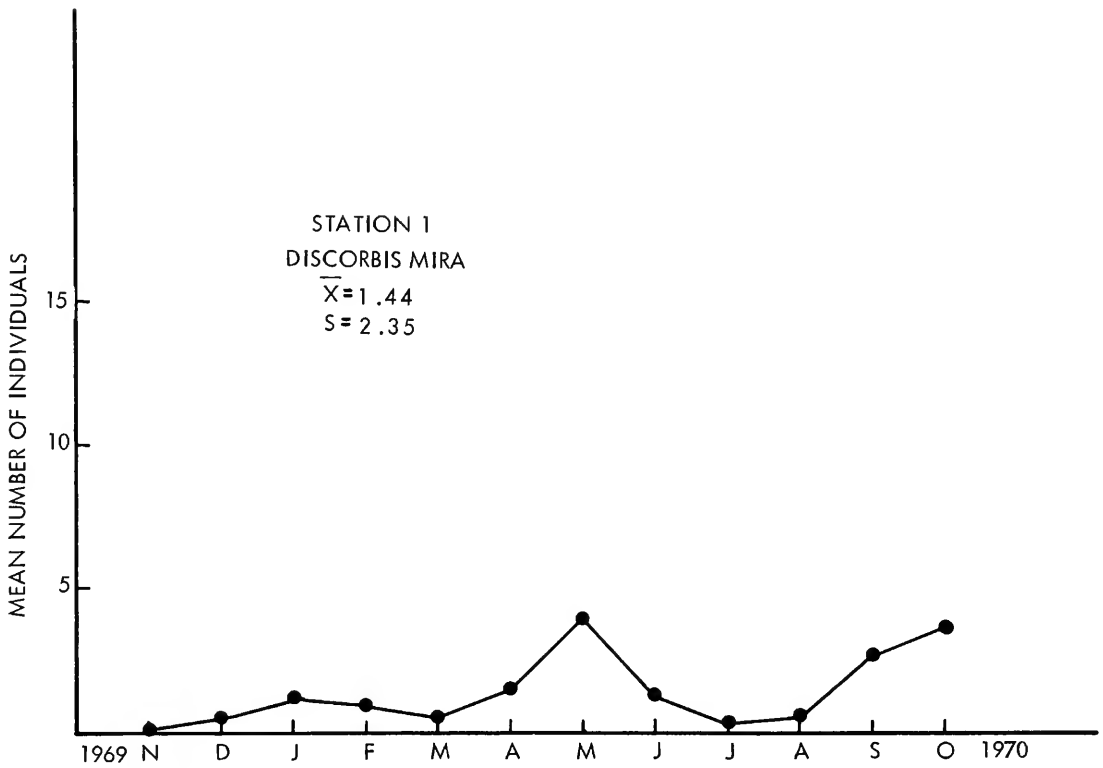
FIGURE 14.—Monthly variations in density of *Discorbis mira*.

TABLE 6.—Statistical analyses for *Rosalina globularis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	4.09	2.05	3.91	0.02
π/6 interaction	2	0.34	0.17	0.33	0.72
π/3 overall periodicity and interaction	4	4.52	1.13	2.16	0.08
π/6 overall periodicity and interaction	4	10.37	2.59	4.95	0.001
Environmental variables ...	12	5.51	0.46	0.88	0.57
Station differences	1	0.93	0.93	1.77	0.19
Residual	74	38.77	0.52	--	--

TABLE 7.—Statistical analyses for *Discorbis mira*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.37	0.68	1.25	0.29
π/6 interaction	2	2.95	1.47	2.68	0.08
π/3 overall periodicity and interaction	4	2.49	0.62	1.13	0.35
π/6 overall periodicity and interaction	4	4.27	1.07	1.94	0.11
Environmental variables ...	12	7.44	0.62	1.13	0.33
Station differences	1	7.24	7.24	13.17	0.0005
Residual	74	40.65	0.55	--	--

TABLE 8.—Statistical analyses for *Rosalina subaraucana*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.65	0.33	0.77	0.47
π/6 interaction	2	3.25	1.62	3.81	0.03
π/3 overall periodicity and interaction	4	2.02	0.51	1.19	0.32
π/6 overall periodicity and interaction	4	7.89	1.97	4.63	0.002
Environmental variables ...	12	3.91	0.33	0.76	0.69
Station differences	1	1.20	1.20	2.81	0.10
Residual	74	31.53	0.43	--	--

crease. The hypothesis Π/6 overall periodicity and interaction has an F = 1.94 with p(F) = 0.11 and reflects the overall monthly periodicity at the two stations.

Rosalina subaraucana has a grand mean of 6.88. Figure 15 shows a maximum mean value of 7.75 at station 1 in October. May with a mean of 4.50 is also relatively high. A minimum mean value of 0.50 was recorded in December. At station 3, a maximum mean value of 22.50 was observed in May, a minimum of 2.75 was recorded in January.

Table 8 shows the highest mean square values are for the hypotheses Π/6 interaction and Π/6 overall periodicity and interaction. The first has an F = 3.81 with p(F) = 0.03, and the second F = 4.63 with p(F) = 0.002. As Figure 15 shows, the stations do differ with respect to their periodicities, especially from December to January, March to April, and September to October. At the same time both show peaks in abundance in February
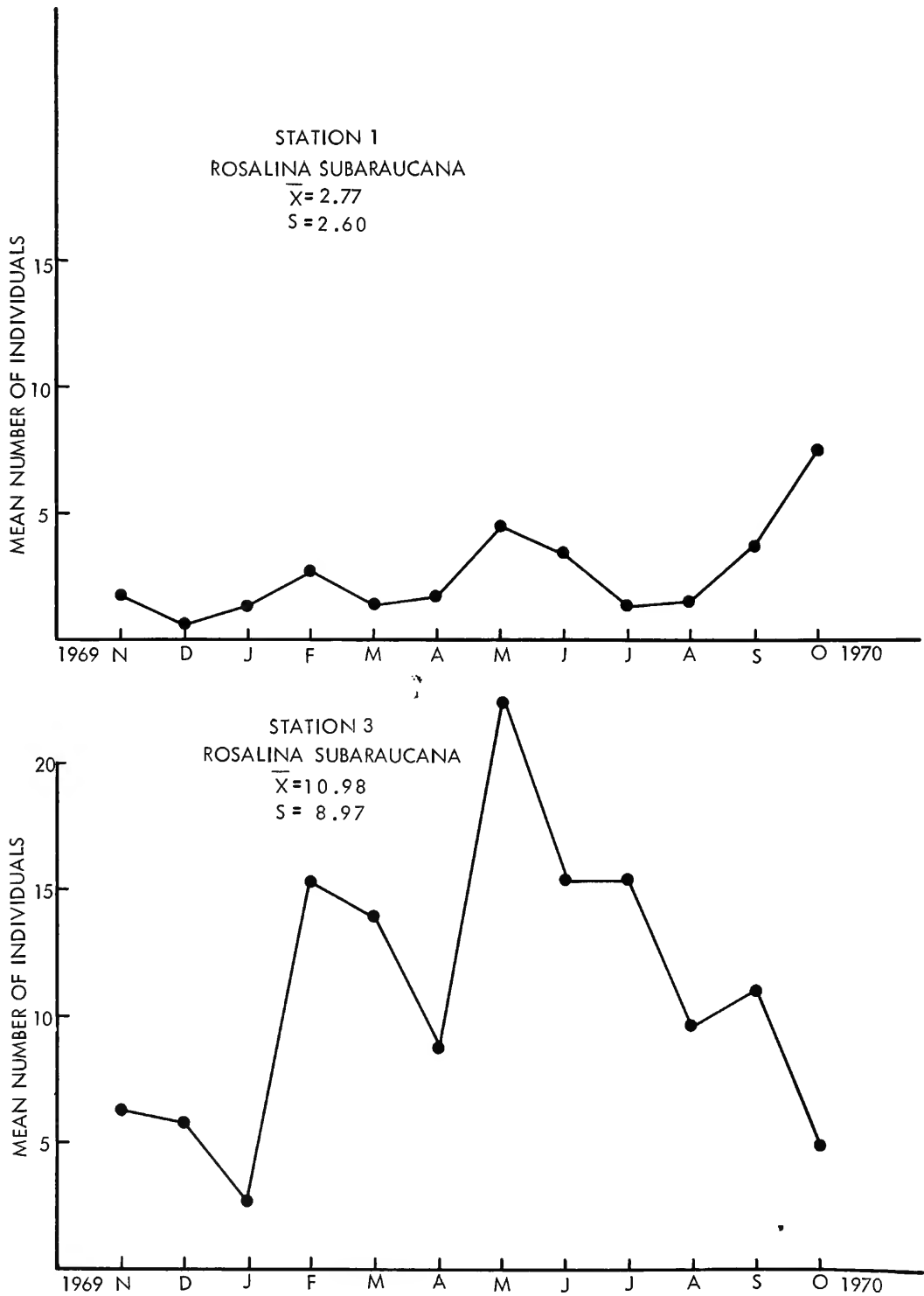
FIGURE 15.—Monthly variations in density of *Rosalina subaraucana*.

and May. We conclude that *R. subaracucana* has significant monthly periodicities and that these periodicities differ at the two stations.

Rosalina floridana has a grand mean of 6.71. Station 1 has high mean values of 17.25 and 18.50 in May and September (Figure 16). Low mean values of 4.75, 5.00, 4.75, and 5.25 occur from January through April. At station 3, a maximum mean value of 7.00 was recorded in September. Uniformly low values were recorded from February through April. Station 3 shows less variation in monthly means than station 1.

Table 9 indicates that only the hypothesis for station differences, F = 5.14, p(F) = 0.03, is significant for *R. floridana*. The remainder of the mean square values is very low.

Amphistegina gibbosa has a grand mean of 6.04. At station 1 little difference exists among monthly means (Figure 17). At station 3, a maximum mean of 33.75 occurs in June. In July, September, and October mean values of 18.50, 17.75, and 24.25, respectively, were recorded. A minimum mean value of 1.75 was recorded in December. In general, more

individuals were observed at station 3 during the last half of the sampling period.

Table 10 indicates that the hypothesis for station differences is highly significant with an F = 14.81 and p(F) = 0.0002. This is expected considering the large difference between mean values at the stations cited above. The hypothesis $\pi/6$ interaction has an F = 2.48 with p (F) = 0.09, and $\pi/6$ overall periodicity and interaction has an F = 1.95 with p(F) = 0.11. The relatively high mean squares for these hypotheses reflect the differences in mean monthly values between the stations (Figure 17).

Cymbaloperetta squammosa has a grand mean of 5.05. Figure 18 shows maxima mean values of 14.75 and 17.00 in September and October for station 1. One sample in October contained 47 individuals and accounts for much of the high monthly mean. Minima of 0.025 occurred in November and December. Station 3 has high mean values of 8.50 and 10.00 in May and June. A minimum of 0.75 occurs in October and low mean values of 1.75 occur in December, January, and March.

TABLE 9.—Statistical analyses for *Rosalina floridana*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
$\pi/3$ interaction	2	1.26	0.63	1.25	0.29
$\pi/6$ interaction	2	1.20	0.60	1.18	0.31
$\pi/3$ overall periodicity and interaction	4	1.64	0.41	0.81	0.52
$\pi/6$ overall periodicity and interaction	4	1.49	0.37	0.73	0.57
Environmental variables ...	12	6.35	0.53	1.05	0.40
Station differences	1	2.60	2.60	5.14	0.03
Residual	74	37.45	0.51	--	--

TABLE 10.—Statistical analyses for *Amphistegina gibbosa*

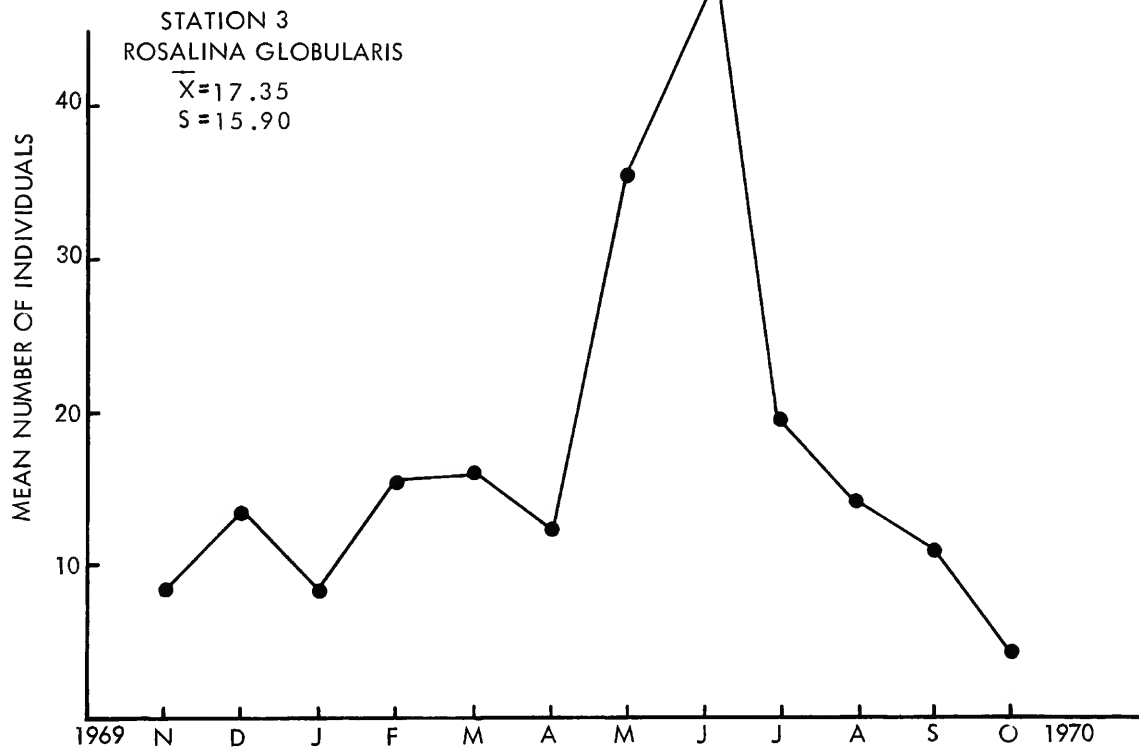| Variability on account of	df	Sum of squares	Mean square	F	p(F)
$\pi/3$ interaction	2	0.33	0.17	0.42	0.66
$\pi/6$ interaction	2	1.95	0.97	2.48	0.09
$\pi/3$ overall periodicity and interaction	4	0.61	0.15	0.39	0.82
$\pi/6$ overall periodicity and interaction	4	3.05	0.76	1.95	0.11
Environmental variables ...	12	3.77	0.31	0.80	0.65
Station differences	1	5.81	5.81	14.81	0.0002
Residual	74	29.05	0.39	--	--
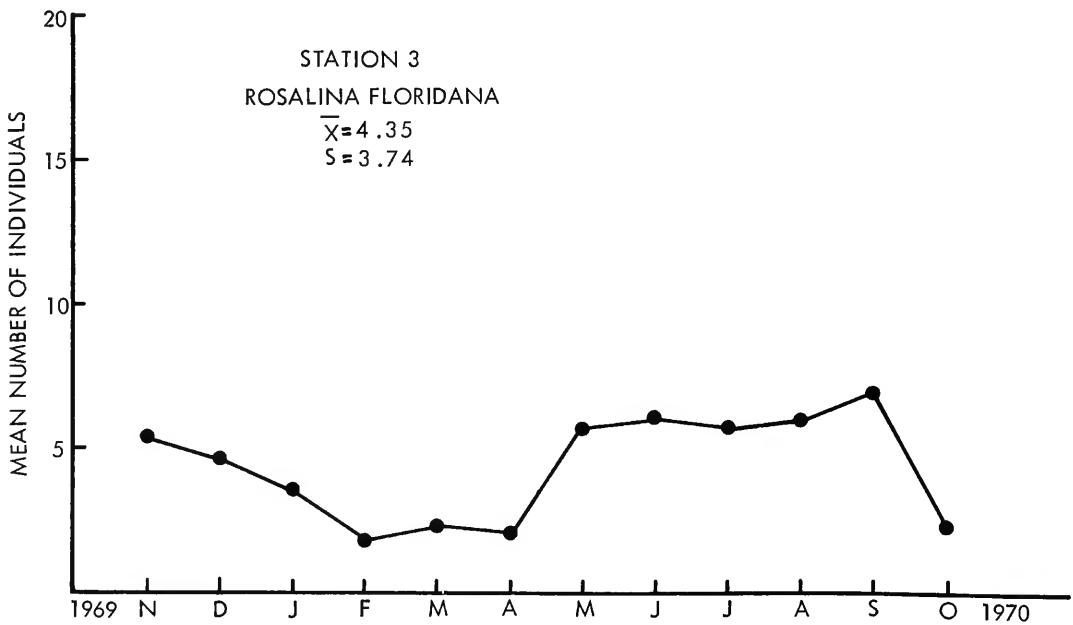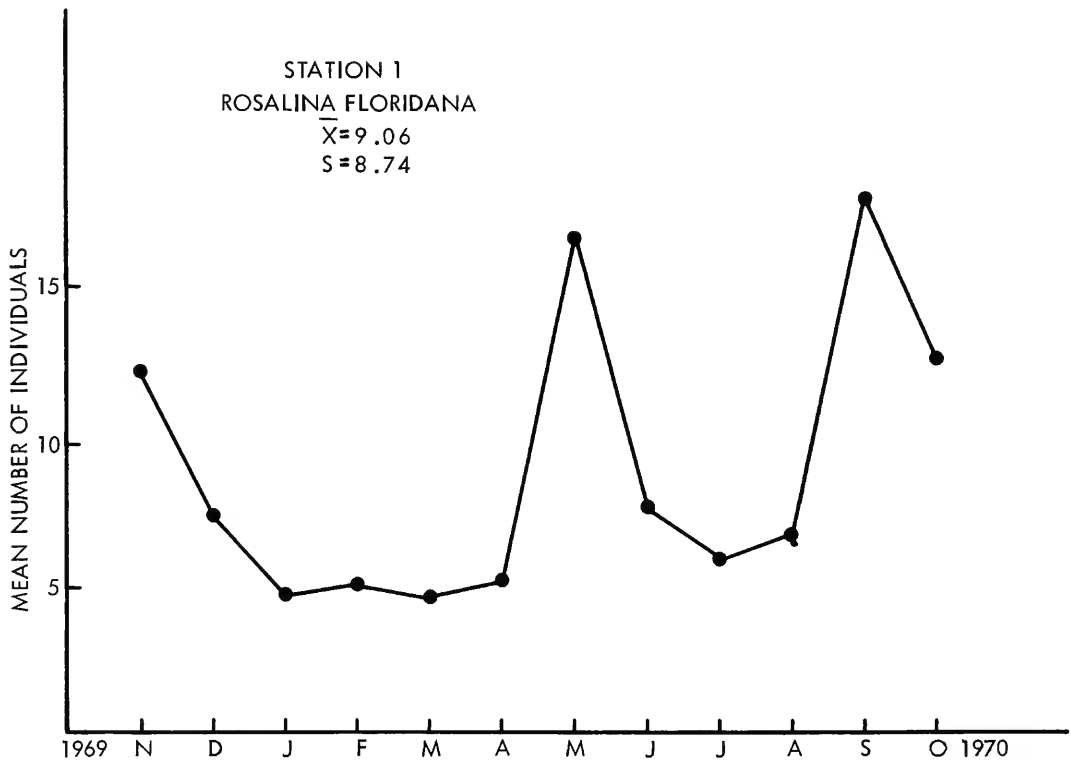
FIGURE 16.—Monthly variations in density of *Rosalina floridana*.
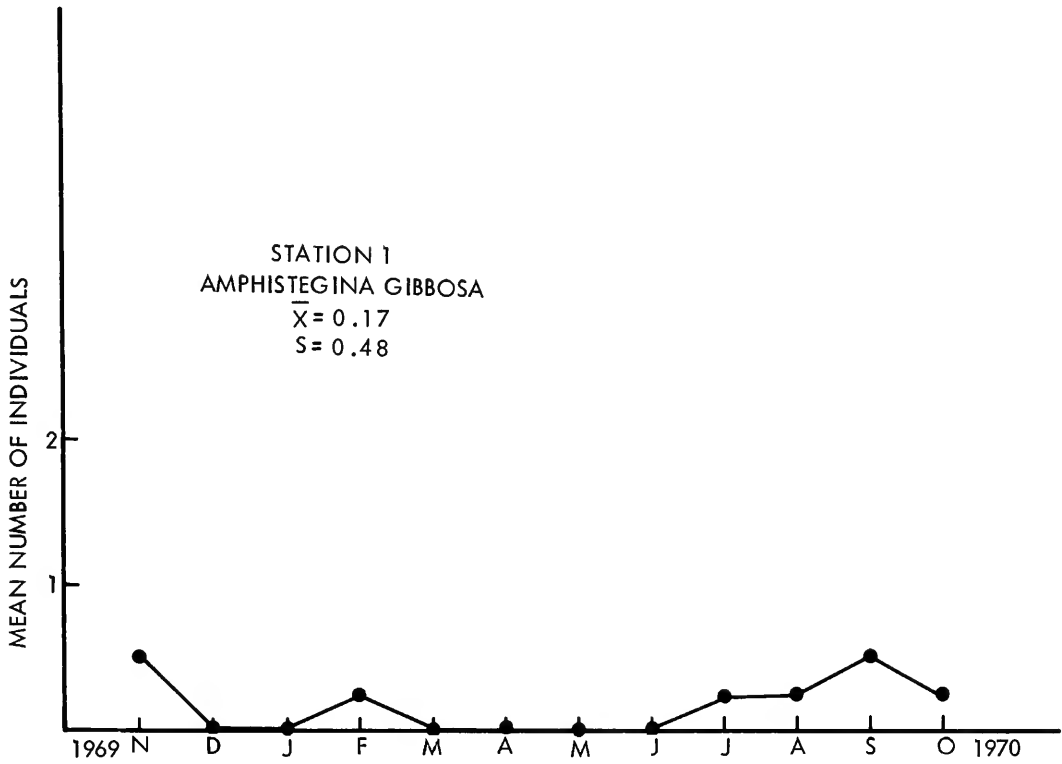
FIGURE 17.—Monthly variations in density of *Amphistegina gibbosa*.
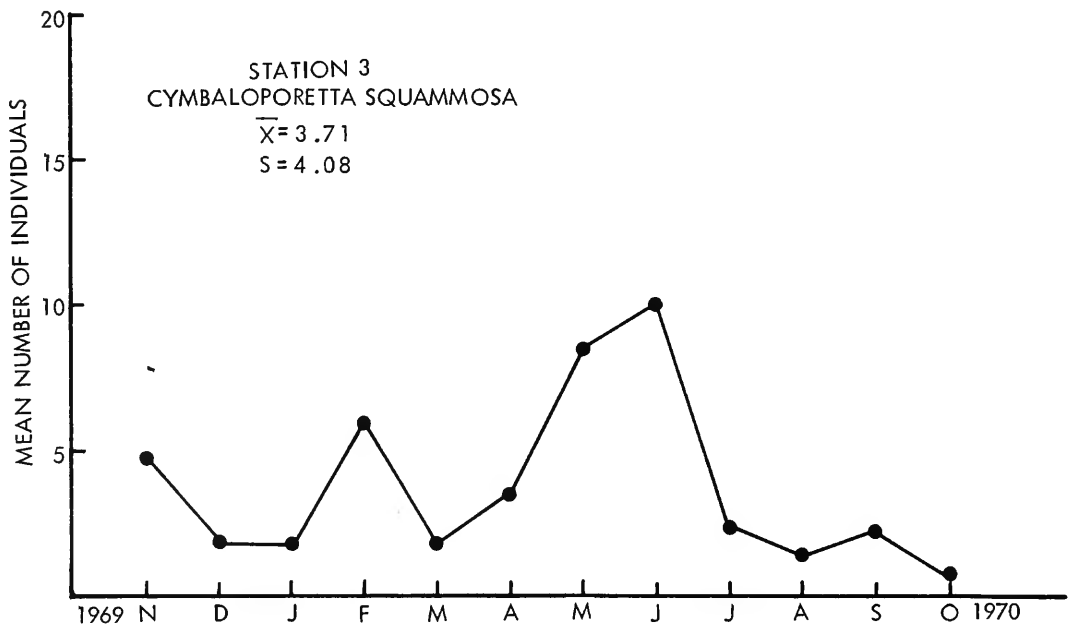
FIGURE 18.—Monthly variations in density of *Cymbaloporetta squammosa*.

TABLE 11.—Statistical analyses for *Cymbaloporetta squammosa*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	6.89	3.44	4.91	0.01
π/6 interaction	2	1.98	0.99	1.41	0.25
π/3 overall periodicity and interaction	4	7.16	1.79	2.55	0.05
π/6 overall periodicity and interaction	4	4.44	1.11	1.58	0.19
Environmental variables ...	12	6.09	0.51	0.72	0.73
Station differences	1	0.06	0.06	0.08	0.78
Residual	74	51.95	0.70	--	--

TABLE 12.—Statistical analyses for *Cymbaloporetta tobagoensis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.19	0.59	1.04	0.36
π/6 interaction	2	1.60	0.80	1.40	0.25
π/3 overall periodicity and interaction	4	2.97	0.74	1.29	0.28
π/6 overall periodicity and interaction	4	2.35	0.59	1.03	0.40
Environmental variables ...	12	11.01	0.92	1.60	0.09
Station differences	1	0.27	0.27	0.47	0.50
Residual	74	42.43	0.57	--	--

Table 11 shows the hypothesis π/3 interaction has a F = 4.91 with p(F) = 0.01, and π/3 overall periodicity and interaction has an F = 2.55 with p(F) = 0.05. The large value for the π/3 interaction hypothesis is borne out by Figure 18, which shows large differences in monthly periodicities between the stations. *Rosalina globularis* is the only other species in this study having a significant interaction of the π/3 type.

Cymbaloporetta tobagoensis has a grand mean of 4.27. Figure 19 shows that at station 1 maxima mean values of 5.00 and 6.25 occur in May and October; minima of 0.75 and 0.50 occur in April and July. In general, the monthly variation at station 1 is small. At station 3 a maximum mean value of 11.00 occurs in November. A mimimum value of 0.25 was recorded in January.

Table 12 shows that none of the hypotheses tested are significant at the 95% level. The hypothesis for environment variables, however, has at F = 1.60 and p(F) = 0.09 and is significant at the 90% level. None of the other hypotheses approach statistical significance. The fact that the environmental variables have a relatively high F value is somwhat puzzling because *C. tobagoensis* does exhibit periodicity of the π/3 or π/6 type, and station differences are not significant.

Cymbaloporetta atlantica has a grand mean of 3.95. Figure 20 shows high mean values at station 1 of 6.50 and 7.50 in May and October. Minima of 0.00 occur in March, June, and September. Station 3 has a maximum mean value of 22.50 in May. Low mean values of 2.00, 2.25, and 2.50 occur in November, December, and January. February through June have the highest mean values at station 3.

Table 13 indicates the hypotheses π/6 interaction and π/6 overall periodicity and interaction have values of F = 4.27 with p(F) = 0.02, and F = 6.06 with p (F) = 0.0003. Figure 20 shows the stations do differ with respect to their periodicity, especially in early autumn. At the same time, both have high mean values in spring, accounting for the highly significant value obtained for the hypotheses π/6 overall periodicity and interaction. The hypothesis station difference has an F = 5.58 and
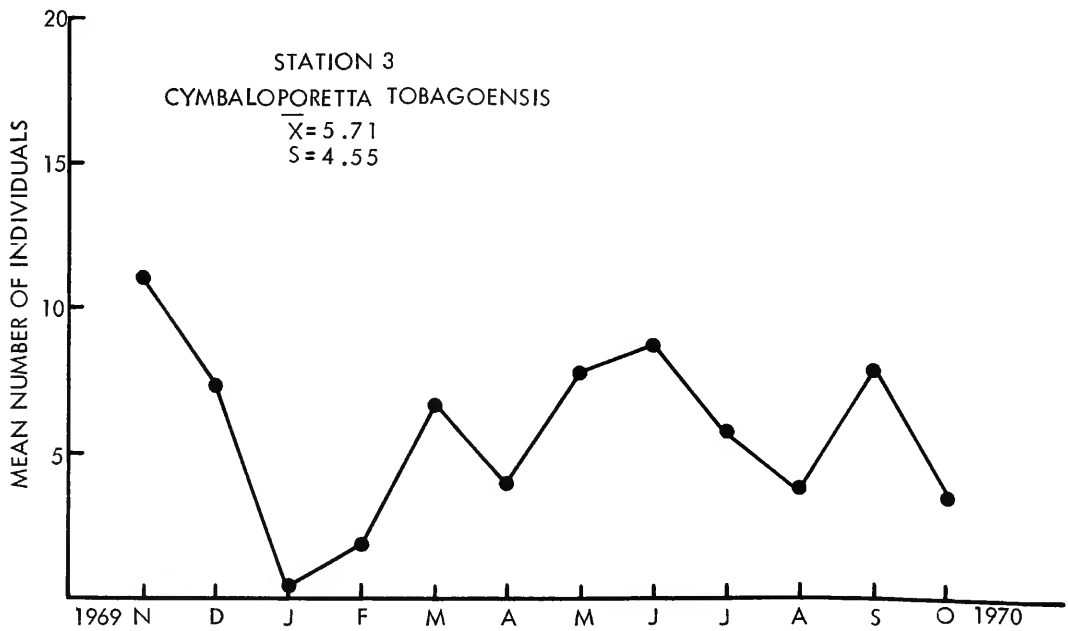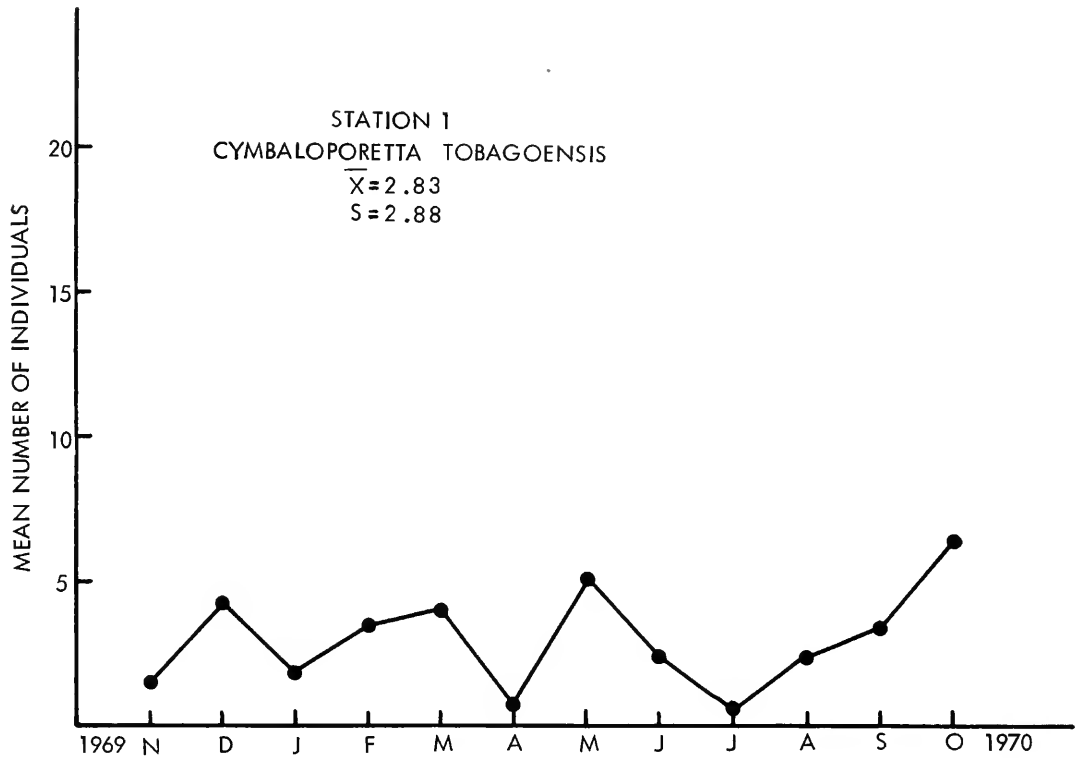
FIGURE 19.—Monthly variations in density of *Cymbaloporetta tobagoensis*.
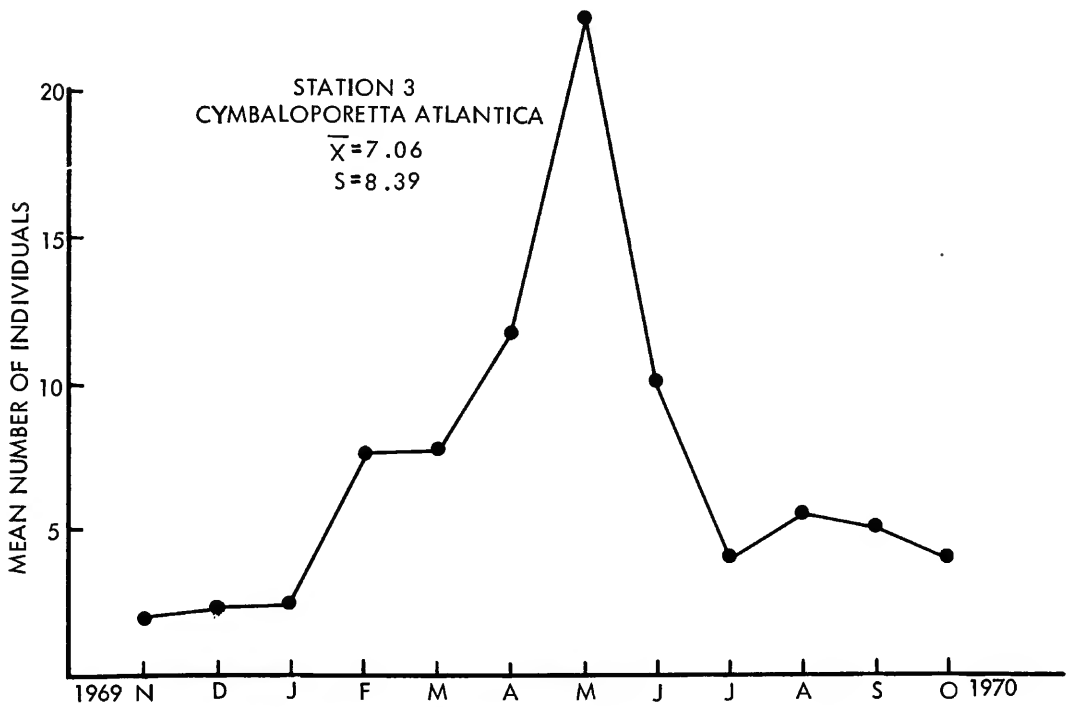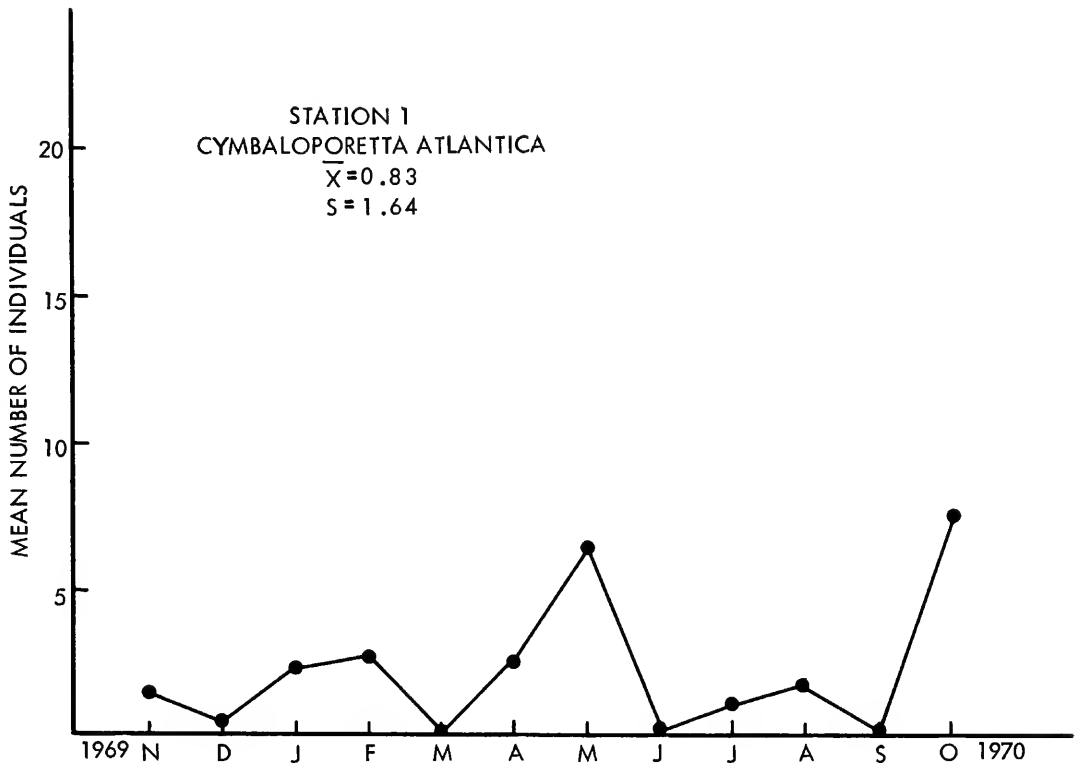
FIGURE 20.—Monthly variations in density of *Cymbaloporetta atlantica*.

TABLE 13.—Statistical analyses for *Cymbaloporetta atlantica*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.31	0.65	1.65	0.20
π/6 interaction	2	3.38	1.69	4.27	0.02
π/3 overall periodicity and interaction	4	3.74	0.93	2.36	0.06
π/6 overall periodicity and interaction	4	9.59	2.40	6.06	0.0003
Environmental variables ...	12	7.21	0.60	1.52	0.12
Station differences	1	2.21	2.21	5.58	0.02
Residual	74	29.27	0.40	--	--

p(F) = 0.02, indicating a significant statistical difference between the overall means of the two stations.

Asterigerina carinata has a grand mean of 3.82. Figure 21 shows that at station 1 maxima mean values of 10.75 and 14.25 occur in September and October. A minimum of 0.25 occurs in April. In general, station 1 shows an increase in the number of individuals observed in the last half of the sampling period. The monthly pattern at station 3 has maxima mean values of 6.00, 7.25, and 6.25 in November, February, and May. The minimum values of 1.50 occur in August and October. The overall pattern at station 3 is quite different from station 1.

Table 14 indicates the hypotheses $\Pi/6$ interaction and $\Pi/6$ overall periodicity and interaction are highly significant. We conclude that *A. carinata* exhibits a monthly periodicity and that this periodicity is different at the two stations (Figure 21).

Bolivina doniezi has a grand mean of 3.73. This species exhibits very little variation from month to month. May, however, has the greatest number of individuals with means of 7.75 and 8.50 at stations 1 and 3, respectively (Figure 22).

Table 15 indicates that none of the hypotheses considered here are even close to being statistically significant for *B. doniezi*.

Planorbulinella acervalis has a grand mean of 3.22. Figure 23 shows that at station 1 maximum mean values of 2.75 occur in May and July. A minimum of 0.25 was recorded in November. Station 1 exhibits an increase in mean monthly abundances during the sampling period. Station 3 has maxima mean values of 8.50 and 8.00 in November and May. Unlike station 1, no simple increase or decrease in mean abundances was observed during the sampling period.

Table 16 indicates that none of the hypotheses considered are significant for *P. acervalis*. The mean square for station differences is the largest reflecting the differences in station means cited above.

Nonionella auricula has a grand mean of 2.34. Figure 24 shows that at station 1 maxima mean values occur in November and October with values of 2.00 and 2.75. Minima mean values of 0.25 occur

TABLE 14.—Statistical analyses for *Asterigerina carinata*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.02	0.51	0.91	0.41
π/6 interaction	2	6.58	3.29	5.86	0.004
π/3 overall periodicity and interaction	4	1.63	0.41	0.73	0.57
π/6 overall periodicity and interaction	4	12.03	3.01	5.36	0.0008
Environmental variables ...	12	8.69	0.72	1.29	0.22
Station differences	1	1.10	1.10	1.95	0.17
Residual	74	41.53	0.56	--	--
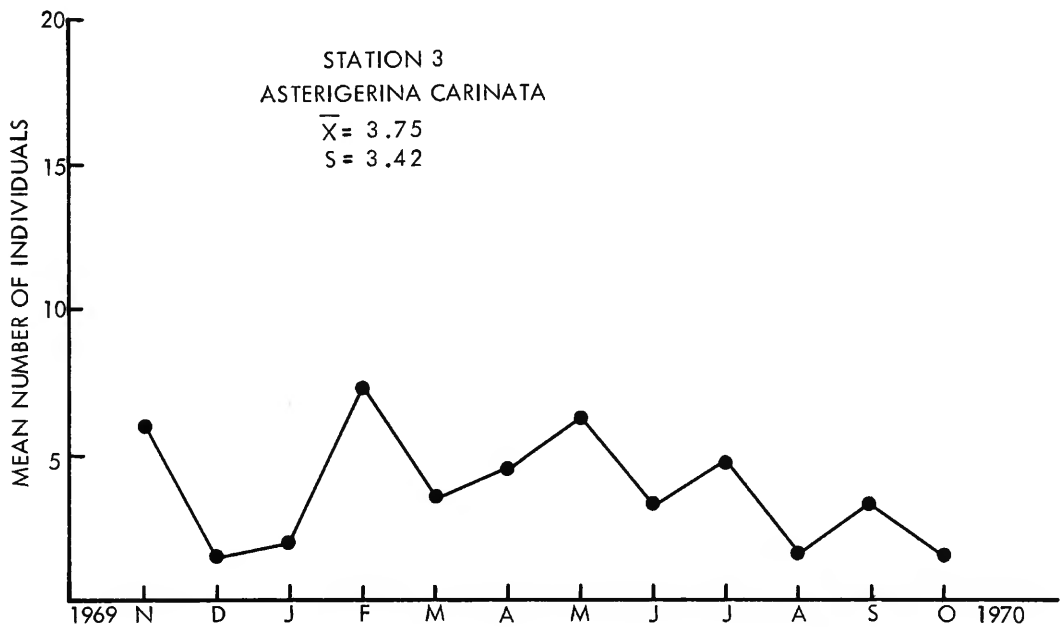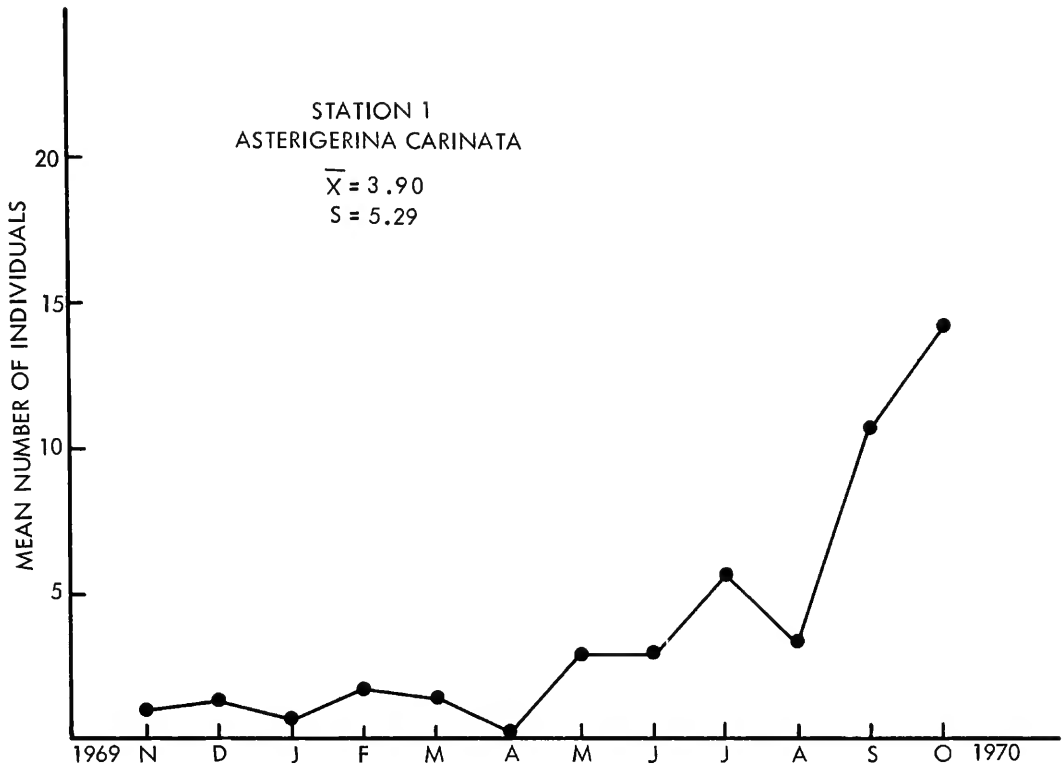
FIGURE 21.—Monthly variations in density of *Asterigerina carinata*.
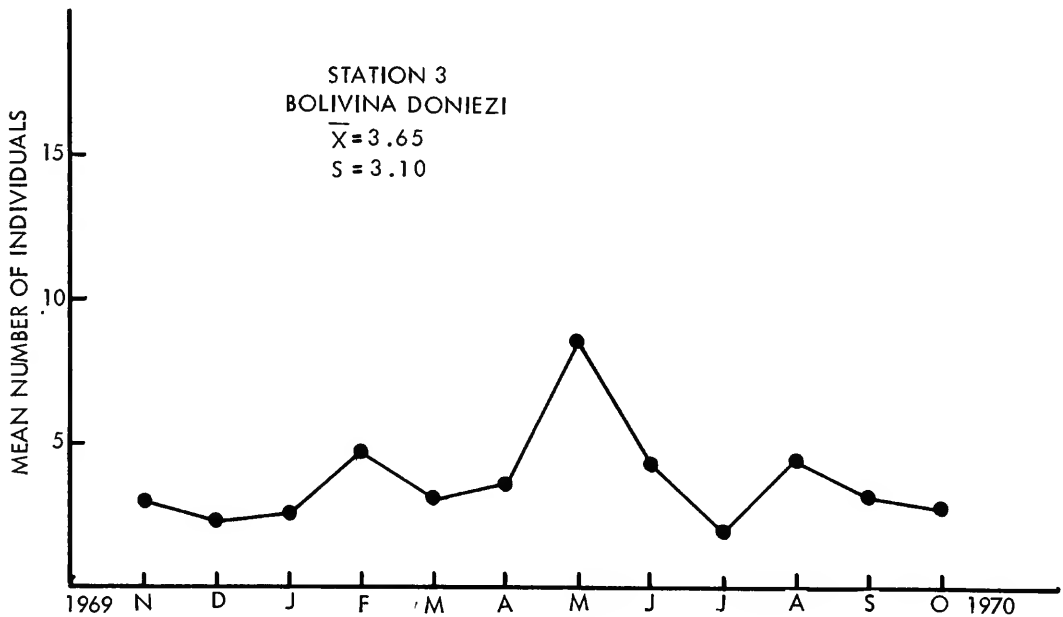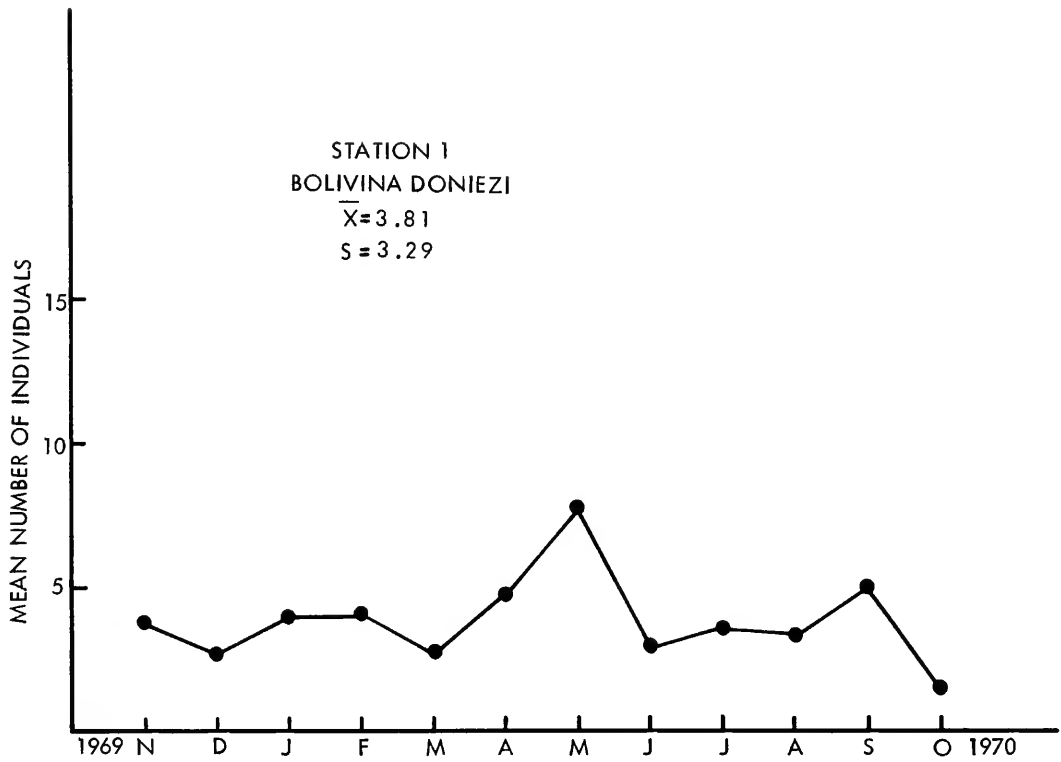
FIGURE 22.—Monthly variations of density of *Bolivina doniezi*.
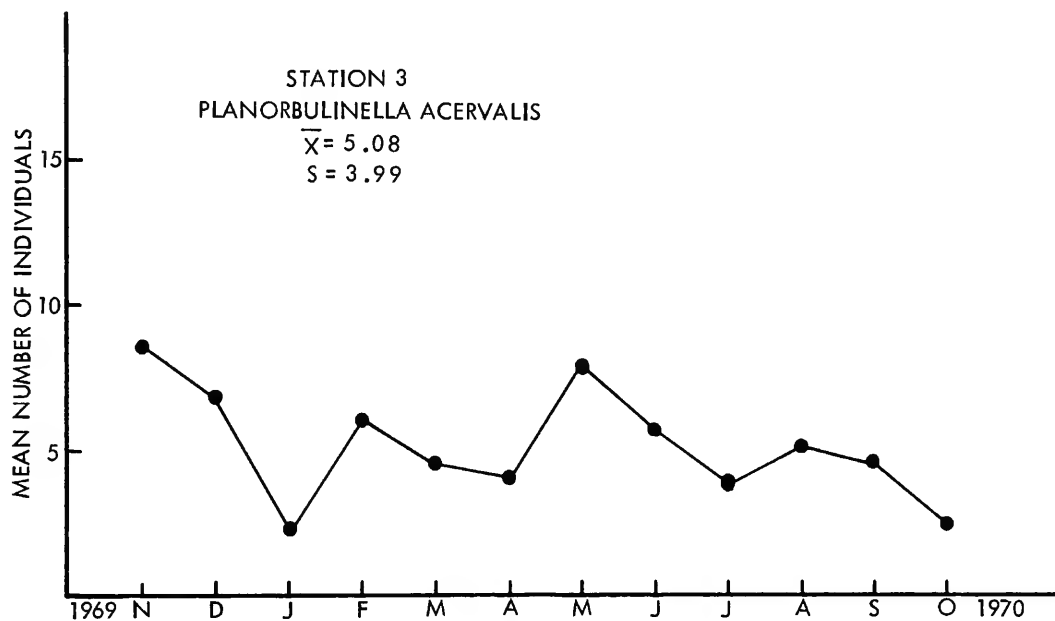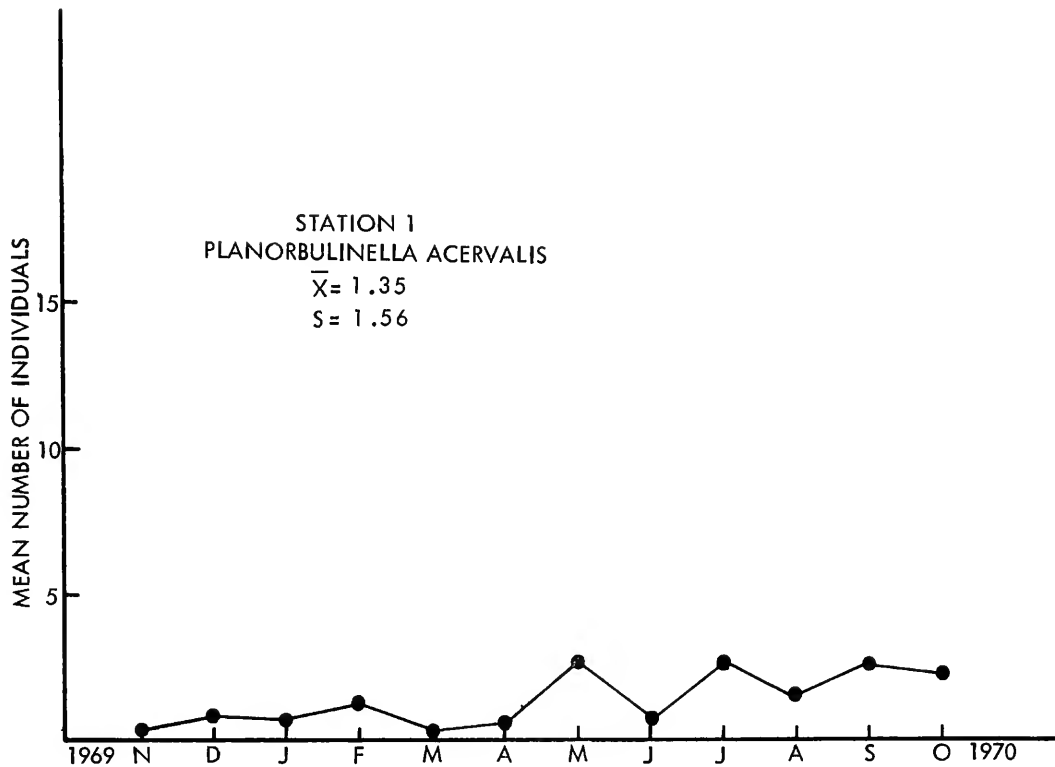
FIGURE 23.—Monthly variations in density of *Planorbulinella acervalis*.
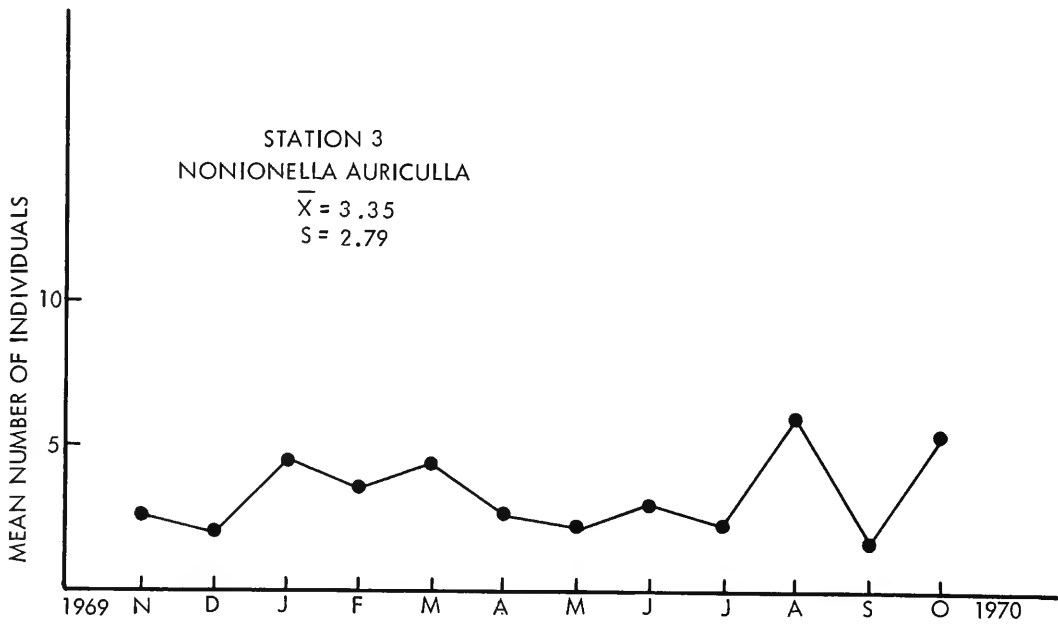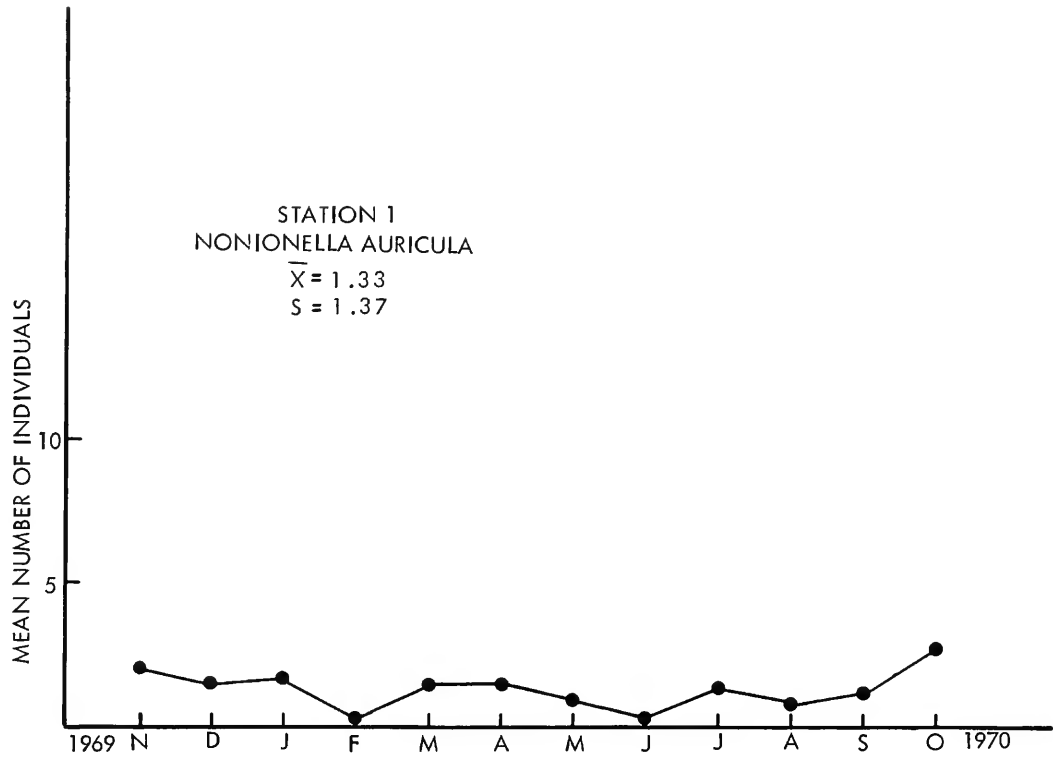
FIGURE 24.—Monthly variations in density of *Nonionella auricula*.

TABLE 15.—Statistical analyses for *Bolivina doniezi*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.01	0.01	0.01	0.99
π/6 interaction	2	0.12	0.06	0.15	0.86
π/3 overall periodicity and interaction	4	0.23	0.06	0.14	0.97
π/6 overall periodicity and interaction	4	0.69	0.17	0.41	0.80
Environmental variables ...	12	4.04	0.34	0.79	0.66
Station differences	1	0.67	0.67	1.58	0.21
Residual	74	31.50	0.42	--	--

TABLE 16.—Statistical analyses for *Planorbulinella acervalis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.48	0.74	1.56	0.22
π/6 interaction	2	0.76	0.38	0.79	0.46
π/3 overall periodicity and interaction	4	2.15	0.54	1.13	0.35
π/6 overall periodicity and interaction	4	0.78	0.19	0.41	0.80
Environmental variables ...	12	6.10	0.51	1.05	0.40
Station differences	1	1.16	1.16	2.43	0.12
Residual	74	35.16	0.46	--	--

TABLE 17.—Statistical analyses for *Nonionella auricula*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.79	0.39	0.92	0.40
π/6 interaction	2	0.17	0.08	0.20	0.82
π/3 overall periodicity and interaction	4	0.89	0.22	0.52	0.72
π/6 overall periodicity and interaction	4	1.69	0.42	0.99	0.42
Environmental variables ...	12	5.35	0.45	1.04	0.41
Station differences	1	1.37	1.37	3.20	0.08
Residual	74	31.75	0.43	--	--

in February and June. At station 3, high means of 6.00 and 5.25 occur in August and October. A minimum of 2.00 occurs in December.

Table 17 indicates that all the mean square values, except for station differences, are relatively low. The hypothesis, station differences, has F = 3.20 and p(F) = 0.08, indicating a significant difference between station means at the 90% level.

Cyclogyra planorbis has a grand mean of 2.33. Figure 25 shows that a high mean value of 22.50 occurs at station 1 in March, while a high of 3.25 occurs at station 3 in February. All other monthly values are relatively low.

At the 95% level of significance none of the hypotheses considered are significant (Table 18). At the 90% level, however, π/6 overall periodicity and interaction is significant, reflecting the high values (especially at station 1) discussed above. Interestingly, although the overall means at the two stations differ considerably, the statistical anal-
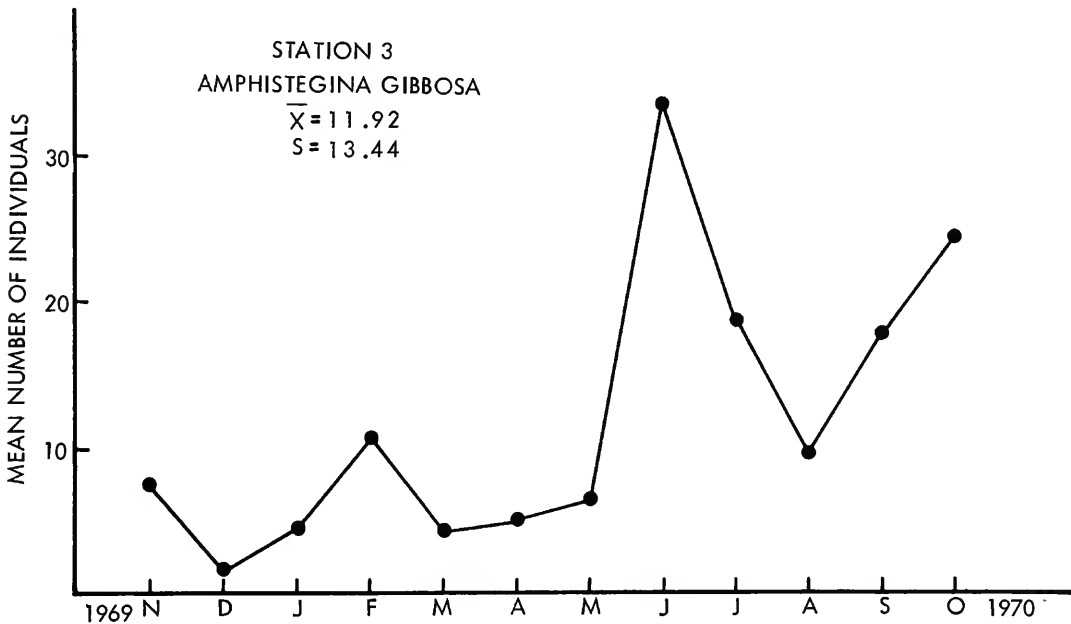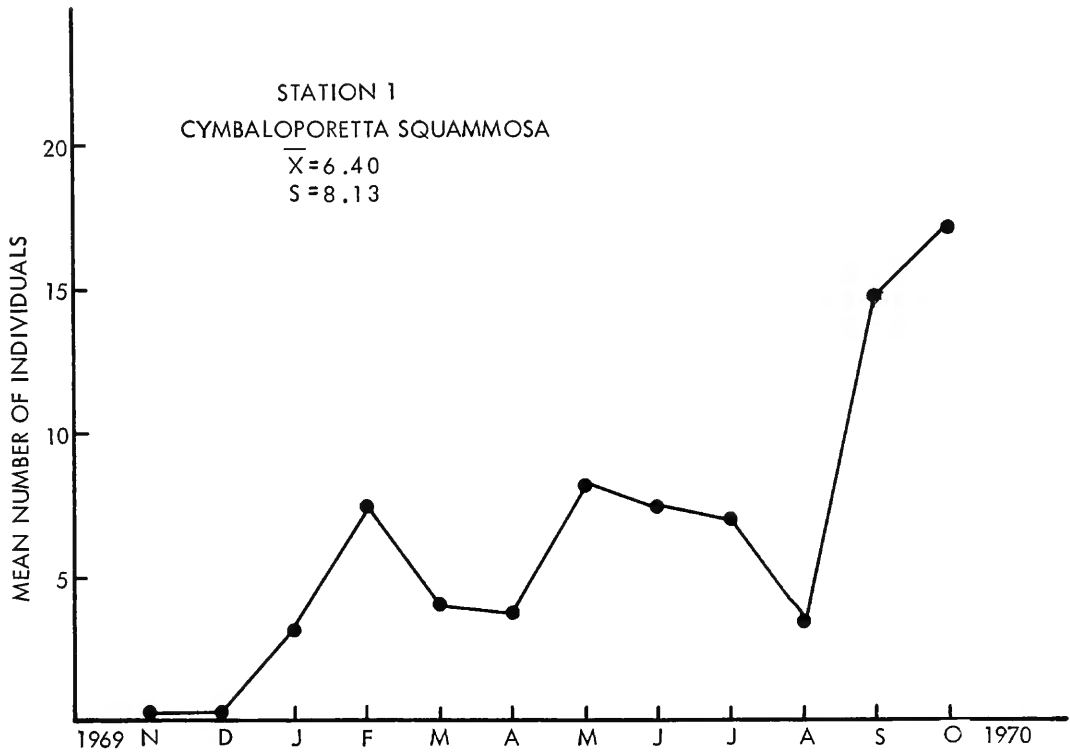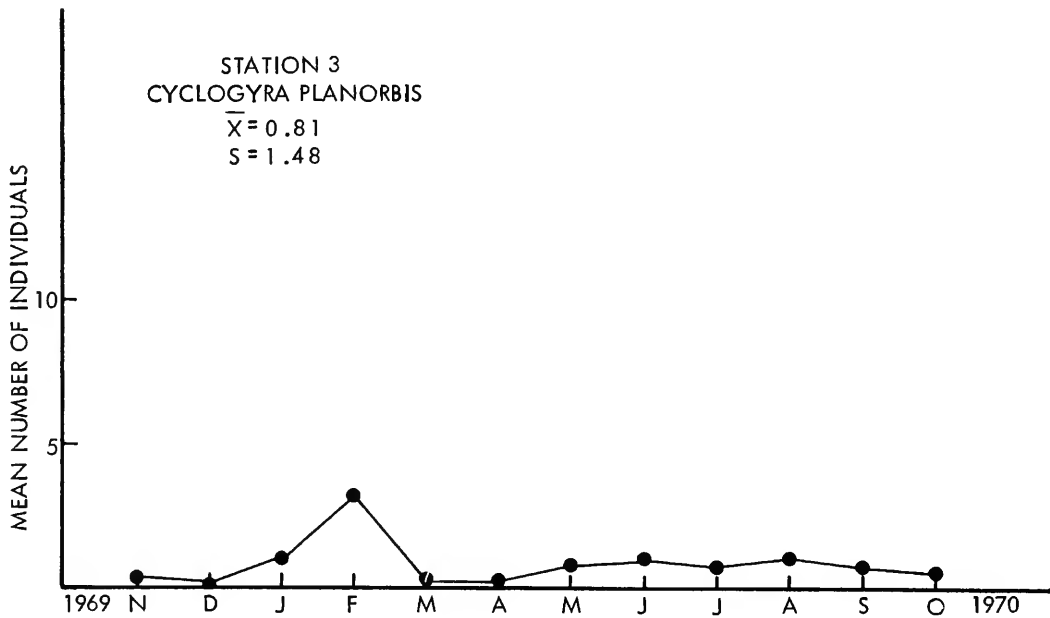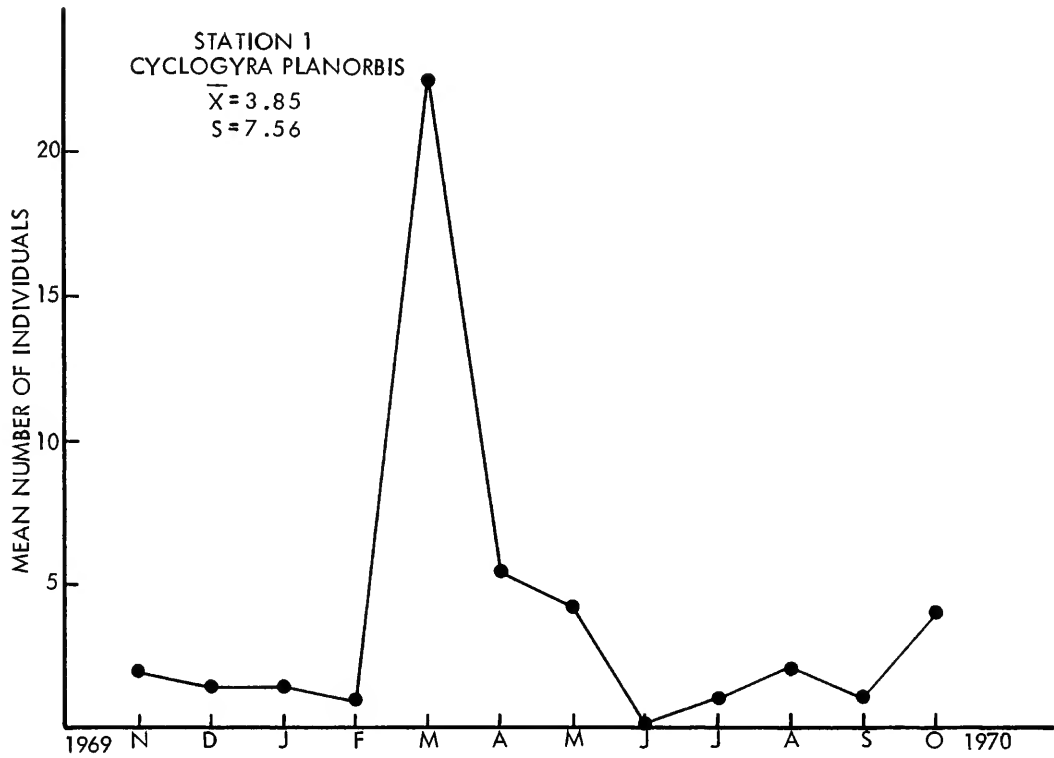
FIGURE 25.—Monthly variations in density of *Cyclogyra planorbis*.

TABLE 18.—Statistical analyses for *Cyclogyra planorbis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.97	0.48	0.90	0.41
π/6 interaction	2	2.07	1.03	1.92	0.15
π/3 overall periodicity and interaction	4	1.12	0.28	0.52	0.72
π/6 overall periodicity and interaction	4	4.36	1.09	2.02	0.10
Environmental variables ...	12	7.33	0.61	1.13	0.34
Station differences	1	0.86	0.86	1.59	0.21
Residual	74	39.89	0.54	--	--

TABLE 19.—Statistical analyses for *Discorbis murrayi*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.94	0.47	1.05	0.36
π/6 interaction	2	0.02	0.01	0.02	0.98
π/3 overall periodicity and interaction	4	0.98	0.24	0.55	0.70
π/6 overall periodicity and interaction	4	0.80	0.20	0.45	0.77
Environmental variables ...	12	7.17	0.60	1.33	0.20
Station differences	1	1.95	1.95	4.35	0.04
Residual	74	33.16	0.45	--	--

yses indicate no significant difference between stations. This is probably so because the higher overall mean value recorded at station 1 is due in large degree to the relatively great number of individuals observed at that station in March.

Discorbis murrayi has a grand mean of 2.08. At station 1 a maximum mean value of 5.25 was observed in May (Figure 26). At station 3, a maximum of 7.75 was observed in November. High mean values of 6.50 and 5.75 were observed in February and April. A low mean value of 0.00 was observed in October. During the sampling year a decrease in the abundance of *D. murrayi* was observed at station 3.

Table 19 indicates that only the hypothesis for station differences is significant for *D. murrayi*, F = 4.35, p(F) = 0.04. The significant difference observed between stations is mainly due to the higher values observed at station 3 during the first 6 months of sampling time (Figure 26).

Fursenkoina pontoni has a grand mean of 2.02. This species is the only one among the abundant species that does not occur at all at one of the stations. At station 3 (Figure 27) *F. pontoni* has a high mean of 21.50 in August. This high value is due almost entirely to a single sample in which 51 individuals were observed.

Table 20 indicates that at the 95% level the hypotheses for II/3 overall periodicity and interaction and station differences are significant. As stated above, the high observed in August is due mainly to a single observation and, consequently, the significance of the periodicity hypothesis may be spurious. The significant value for station differences, however, is clearly in line with the observations.

SUMMARY OF SPECIES ANALYSES.—Table 21 shows p(F) values for the various hypotheses for each species. The species are arranged in decreasing order of abundance. Of the 19 abundant species (mean greater than 2.00), 8 have no significant hypothesis at the 95% level. Three of these are among the most abundant species, and five are among the rarer species. At the 90% level only two species,
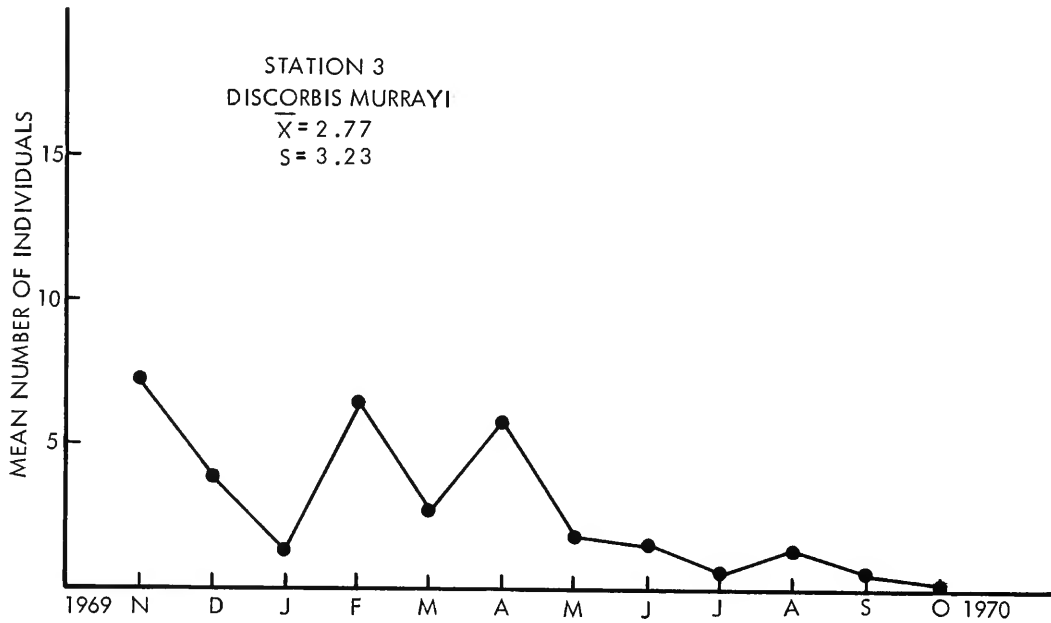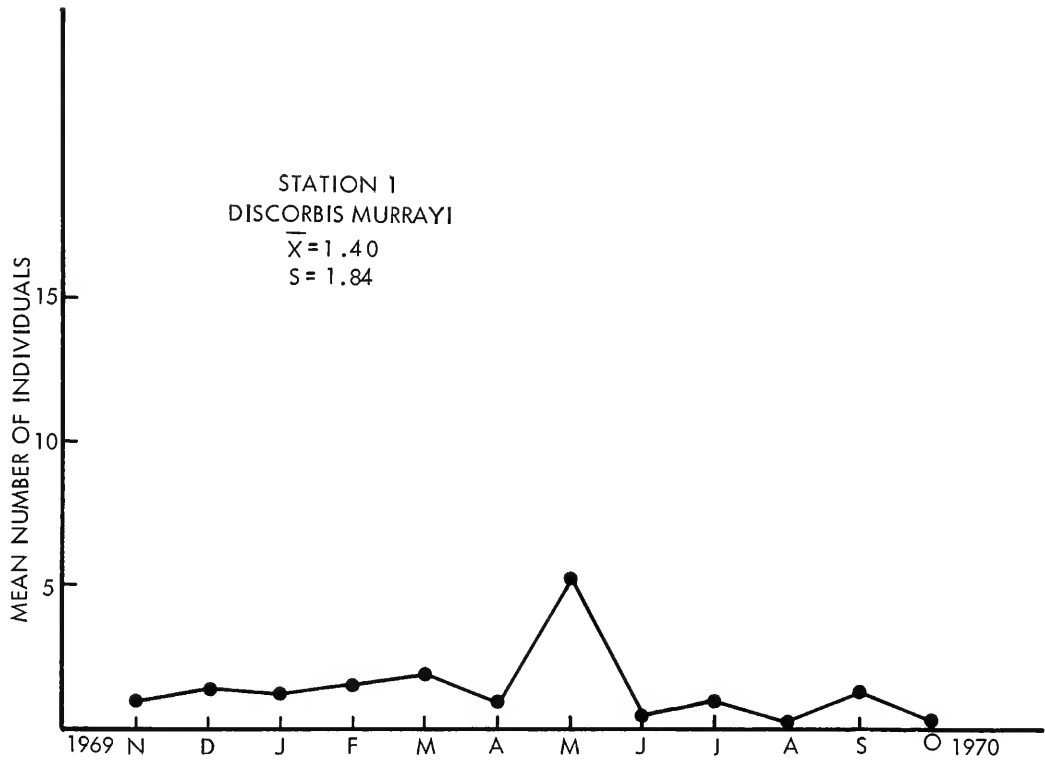
FIGURE 26.—Monthly variations in density of *Discorbis murrayi*.
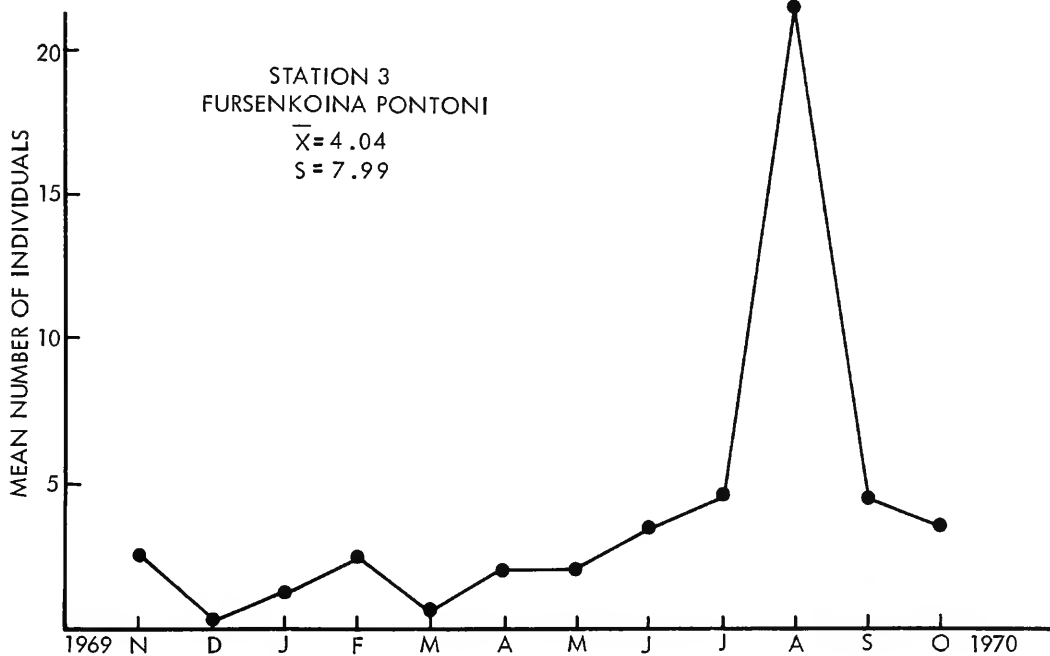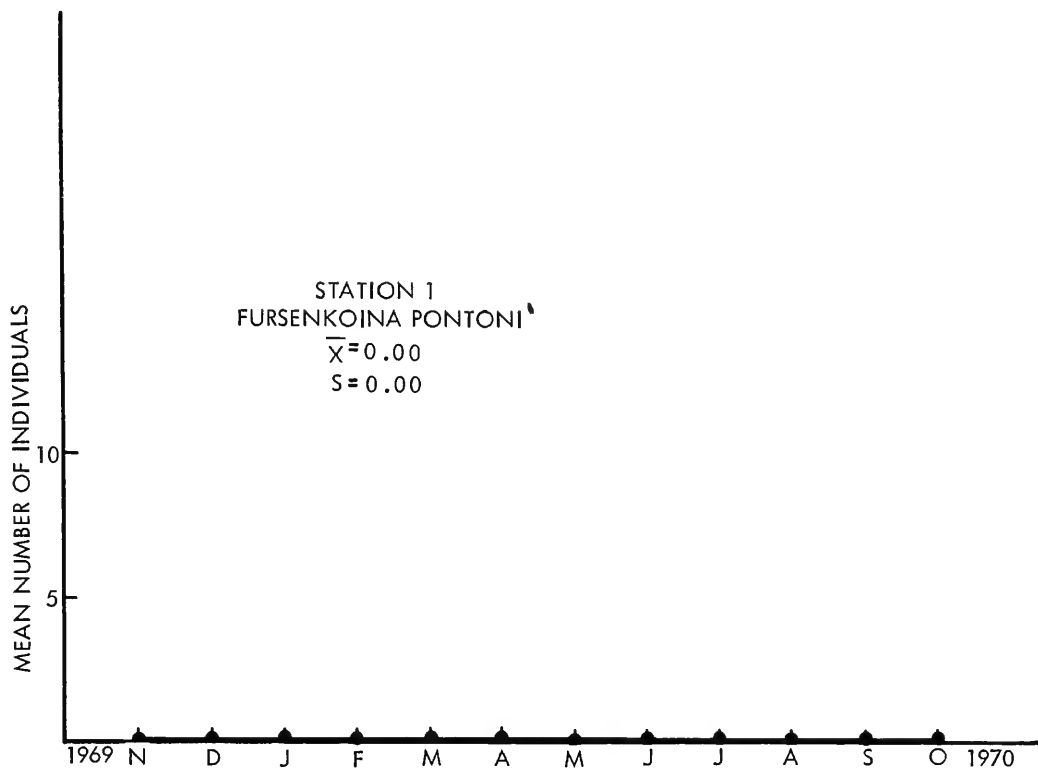
FIGURE 27.—Monthly variations in density of *Fursenkoina pontoni*.

TABLE 20.—Statistical analyses for *Fursenkoina pontoni*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.81	0.90	2.56	0.08
π/6 interaction	2	1.34	0.67	1.90	0.16
π/3 overall periodicity and interaction	4	3.58	0.90	2.53	0.05
π/6 overall periodicity and interaction	4	1.85	0.46	1.31	0.27
Environmental variables ...	12	2.82	0.24	0.67	0.78
Station differences	1	1.91	1.91	5.40	0.02
Residual	74	26.13	0.35	--	--

TABLE 21.—Summary of p(F) values for 19 abundant species

Species	π/3 inter	π/6 inter	π/3 ovrin	π/6 ovrin	Envir var	Sta diff
Bolivina striatula	0.99	0.73	0.73	0.02	0.11	0.54
Bolivina subexcavata	0.29	0.62	0.14	0.07	0.30	0.69
Trifarina occidentalis	0.22	0.78	0.47	0.06	0.16	0.71
Ammonia beccarii	0.33	0.24	0.62	0.09	0.93	0.49
Rosalina globularis	0.02	0.72	0.08	0.001	0.57	0.19
Discorbis mira	0.29	0.08	0.35	0.11	0.33	0.0005
Rosalina subaraucana	0.47	0.03	0.32	0.002	0.69	0.10
Rosalina floridana	0.29	0.31	0.52	0.57	0.40	0.03
Amphistegina gibbosa	0.66	0.09	0.82	0.11	0.65	0.0002
Cymbaloporetta squammosa	0.01	0.25	0.05	0.19	0.73	0.78
Cymbaloporella tobagoensis ...	0.36	0.25	0.28	0.40	0.09	0.50
Cymbaloporetta atlantica	0.20	0.02	0.06	0.0003	0.12	0.02
Asterigerina carinata	0.41	0.004	0.57	0.0008	0.22	0.70
Bolivina doniezi	0.99	0.86	0.97	0.80	0.66	0.21
Planorbulinella acervalis	0.22	0.46	0.35	0.80	0.40	0.12
Nonionella auricula	0.40	0.82	0.72	0.42	0.41	0.08
Cyclogyra planorbis	0.41	0.15	1.72	0.10	0.34	0.21
Discorbis murrayi	0.36	0.98	0.70	0.77	0.20	0.04
Fursenkoina pontoni	0.08	0.16	0.05	0.27	0.78	0.02
TOTALS	2	3	2	5	0	6

Bolivina doniezi and *Planorbulinella acervalis,* have no significant hypothesis. Both of these are relatively rare. Most of the species analyzed individually, then, have one or more significant hypotheses.

The four most abundant species, *Bolivina striatula, B. subexcavata, Trifarina occidentalis,* and *Ammonia beccarii* all have the hypothesis Π/6 overall periodicity and interaction significant at the 90% level. Figures 9 through 11 show that the monthly periodicities for these species are quite similar. All have high densities in May with smaller peaks in November, February, August, or September. The remaining 15 rarer species also show simi-

lar periodicity, although less uniform and more often differing between stations. Figures 12 through 27 show that for most of these species, May is the month with high densities. Often November, February, August, September, or October exhibit high densities. At the 95% level 7 of the 19 abundant species have one or more significant periodicity hypotheses, at the 90% level, 13. We conclude that monthly periodicity is important for most of the species analyzed.

At the 95% level six species have a significant station difference hypothesis. At the same level two of these also have significant periodicity hypotheses. At the 90% level eight species have a significant

station difference hypothesis; of these, five also have significant periodicity hypothesis. For *Discorbis mira, Amphistegina gibbosa, Cymbaloporetta atlantica,* and *Fursenkoina pontoni* the differences in densities between stations is substantial. The latter is the only species among the 19 abundant ones that does not occur at all at one of the stations (station 1).

Table 21 shows that most of the species studied have one or more significant hypotheses. Monthly periodicity and station differences are most important for these species. At the same time, Table 21 shows that the set of 12 environmental variables is not significant for any of the species at the 95% level.

STATISTICAL ANALYSES OF GENERA.—Those genera that contain a number of abundant species were also analyzed as single variates. Table 22 shows the analysis for *Bolivina.* The species added together and treated as a single variate for the analysis are *Bolivina doniezi, B. paula, B. subexcavata, B. striatula, B.* cf. *B. compacta, B. lowmani, B. rhomboid-*

alis, *B.* cf. *B. subexcavata,* and *B.* sp. The mean number of *Bolivina* at station 1 is 62.06, and at station 3, 51.67. Table 22 indicates the only hypothesis with a large mean square is $\pi/6$ overall periodicity and interaction, which has an F = 2.27 and p(F) = 0.07. Thus the analysis for the genus *Bolivina* closely reflects the analysis for its two most abundant species, *B. striatula* and *B. subexcavata* (Tables 2, 3). These species have grand means of 30.55 and 19.57 respectively, while the next most abundant species, *B. doniezi,* has a grand mean of 3.73. The remaining six species all have means of less than 1.

The genus *Elphidium* has seven rare species. Taken together these species, *E. advenum, E. norvangi, E. rugulosum, E. excavatum, E. gunteri, E. kugleri,* and *E.* sp., have a mean of 3.33 at station 1 and 3.64 at station 3. Table 23 indicates an F = 3.39 and p(F) = 0.01 for the hypothesis $\pi/6$ overall periodicity and interaction. The next largest mean square is for $\pi/6$ interaction, which has F = 2.90 and p(F) = 0.06. The genus behaves like many of the abundant species of other genera.

TABLE 22.—Statistical analyses for *Bolivina*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
$\pi/3$ interaction	2	0.46	0.23	0.62	0.54
$\pi/6$ interaction	2	0.31	0.16	0.42	0.66
$\pi/3$ overall periodicity and interaction	4	1.49	0.37	1.00	0.41
$\pi/6$ overall periodicity and interaction	4	3.37	0.84	2.27	0.07
Environmental variables ...	12	5.55	0.46	1.24	0.27
Station differences	1	0.00	0.00	0.01	0.92
Residual	74	27.50	0.37	--	--

TABLE 23.—Statistical analyses for *Elphidium*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
$\pi/3$ interaction	2	1.70	0.85	2.10	0.13
$\pi/6$ interaction	2	2.35	1.18	2.90	0.06
$\pi/3$ overall periodicity and interaction	4	1.97	0.49	1.22	0.31
$\pi/6$ overall periodicity and interaction	4	5.49	1.37	3.39	0.01
Environmental variables ...	12	6.51	0.54	1.34	0.22
Station differences	1	0.03	0.03	0.07	0.79
Residual	74	30.03	0.41		

TABLE 24.—Statistical analyses for *Cymbaloporetta*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	2.05	1.02	2.19	0.12
π/6 interaction	2	4.99	2.50	5.35	0.01
π/3 overall periodicity and interaction	4	4.47	1.12	2.39	0.06
π/6 overall periodicity and interaction	4	9.18	2.30	4.92	0.001
Environmental variables ...	12	6.83	0.57	1.22	0.29
Station differences	1	0.47	0.47	1.00	0.32
Residual	74	34.54	0.47	--	--

The genus *Cymbaloporetta* is represented by *C. atlantica* and *C. squammosa*. This genus has a mean of 7.23 at station 1 and 10.77 at station 3. Table 24 indicates high mean square values for the hypotheses Π/6 interaction and Π/6 overall periodicity and interaction. The former has an F = 5.35 and p(F) = 0.01, while the latter has F = 4.92 and p(F) = 0.001. The values for Π/3 interaction and Π/3 overall periodicity are also relatively large, the latter reaching significance at 90% level. This is in keeping with the individual species analysis because *C. sqaummosa* has significant values of the hypotheses Π/3 interaction and Π/3 overall periodicity and interaction, while *C. atlantica* has significant Π/6 overall periodicity and interaction. The significant difference between stations noted for *C. atlantica* is ameliorated when the two are added together and no significant difference between stations exists for the genus.

The genus *Discorbis* is represented by *D. mira*, *D. murrayi*, and *D. granulosa*. The mean at station 1 is 3.34 and at station 3, 16.91. Table 25 indicates a very large mean square for station differences and

correspondingly high value of F = 12.51 with p(F) = 0.0007. A relatively high mean square with F = 2.89 and p(F) = 0.03 is also present for the hypothesis Π/6 overall periodicity and interaction. The hypothesis for environmental variables also has a relatively high mean square value with an F = 1.80 and p(F) = 0.06. This is a little surprising because the values for this hypothesis are relatively small for the species *D. mira* and *D. murrayi* (Tables 7, 19).

The genus *Rosalina* is represented by *R. concinna*, *R. floridana*, *R. globularis*, *R. subaraucana*, *R. bulbosa*, *R. candeiana*, *R. sp. a*, and *R. sp. b*. The most abundant species are *R. globularis*, *R. subaraucana*, and *R. floridiana*. The mean number of *Rosalina* at station 1 is 17.38 and at station 3, 36.03. Table 26 indicates a high F = 3.85 and p(F) = 0.01 for the hypothesis Π/6 overall periodicity and interaction. The hypotheses Π/6 interaction and Π/3 interaction also have relatively high values. This is in keeping with the analyses for *R. globularis* and *R. subaraucana*. The significant differences between stations observed for

TABLE 25.—Statistical analyses for *Discorbis*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.48	0.74	1.85	0.16
π/6 interaction	2	1.41	0.70	1.76	0.18
π/3 overall periodicity and interaction	4	1.68	0.42	1.05	0.39
π/6 overall periodicity and interaction	4	4.62	1.16	2.89	0.03
Environmental variables ...	12	8.62	0.72	1.80	0.06
Station differences	1	5.01	5.01	12.51	0.0007
Residual	74	29.60	0.40	--	--

TABLE 26.—Statistical analyses for *Rosalina*

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	1.52	0.76	2.36	0.10
π/6 interaction	2	1.74	0.87	2.69	0.07
π/3 overall periodicity and interaction	4	1.60	0.40	1.24	0.30
π/6 overall periodicity and interaction	4	4.97	1.24	3.85	0.01
Environmental variables ...	12	4.10	0.34	1.06	0.41
Station differences	1	0.03	0.03	0.08	0.78
Residual	74	23.91	0.32	--	--

R. subaraucana and *R. floridana,* however, do not appear when the species are added together.

In general, we may conclude that the analyses of genera follow closely the analyses of their most abundant species. The rare species contribute little to the statistical analysis. Consequently, when analyzing a genus, only the more abundant species need be considered for ecological work. Similarly, the inclusion of rare species in the counts of the more abundant species due to misidentification, etc., will probably not affect the outcome.

The total number of living individuals observed (standing crop) in each replicate was also analyzed as a single variate. The mean number of individuals at station 1 is 161.23, and at station 3, 227.54. A plot of the mean number of individuals per month at stations 1 and 3 is shown in Figure 28. The pattern shown in Figure 28 clearly reflects the pattern of the most abundant species (Figures 9–12). At station 1, the five most abundant species make up 58% of the total, and at station 3, 46%.

Table 27 indicates that the hypothesis π/6 overall periodicity and interaction with an F of 4.83

and p(F) = 0.002 is highly significant. This again reflects the influence of the most abundant species for whom this hypothesis has the highest mean square values. The significant station differences observed for the less abundant species are of no importance in the analysis of the total living individuals. Surprisingly, the hypothesis for environmental variables has an F = 1.76 and p(F) = 0.07, which is significant at the 90% level. This is not in keeping with individual analysis of the significance of environmental variables shown in Table 21.

Multivariate Analyses

In the earlier section, we analyzed each of the 19 most abundant species by a general linear model. Now we analyze the entire ensemble of 19 species simultaneously by the same general linear model. In matrix notation, Ω model is written as

$$\Omega: \quad \underset{(96 \times 19)}{X} = \underset{(96 \times 22)}{Z'} \quad \underset{(22 \times 19)}{B} + \underset{(96 \times 19)}{E} \quad (6)$$

where **X** is the matrix of 96 observed abundances,

TABLE 27.—Statistical analyses for total live individuals

Variability on account of	df	Sum of squares	Mean square	F	p(F)
π/3 interaction	2	0.49	0.25	1.45	0.24
π/6 interaction	2	0.67	0.33	1.97	0.15
π/3 overall periodicity and interaction	4	0.50	0.12	0.73	0.57
π/6 overall periodicity and interaction	4	3.27	0.82	4.83	0.002
Environmental variables ...	12	3.57	0.30	1.76	0.07
Station differences	1	0.00	0.00	0.02	0.89
Residual	74	12.53	0.17	--	--
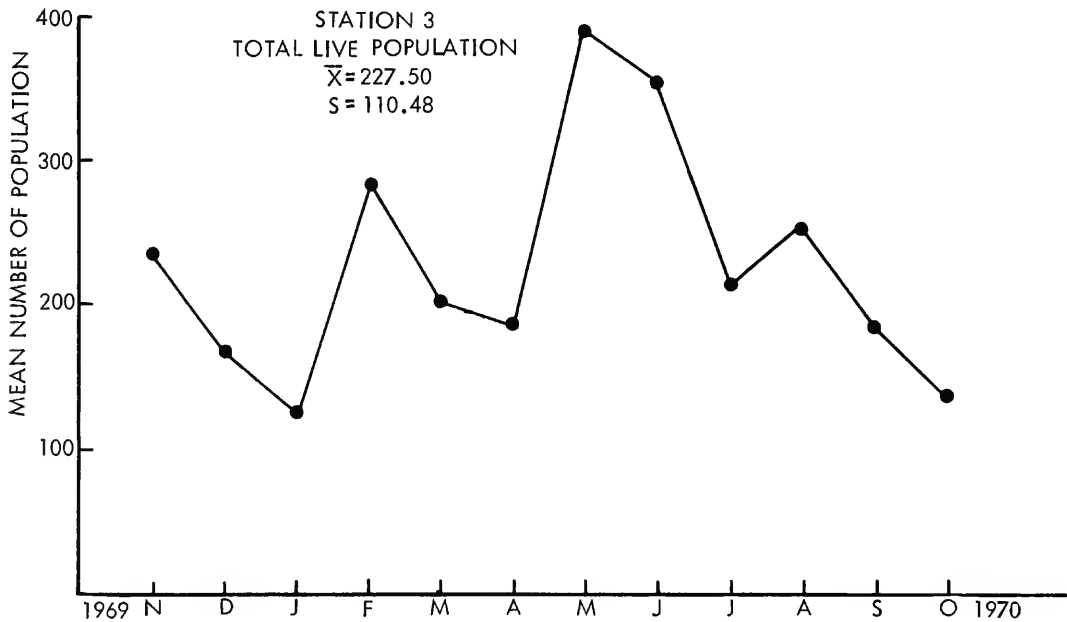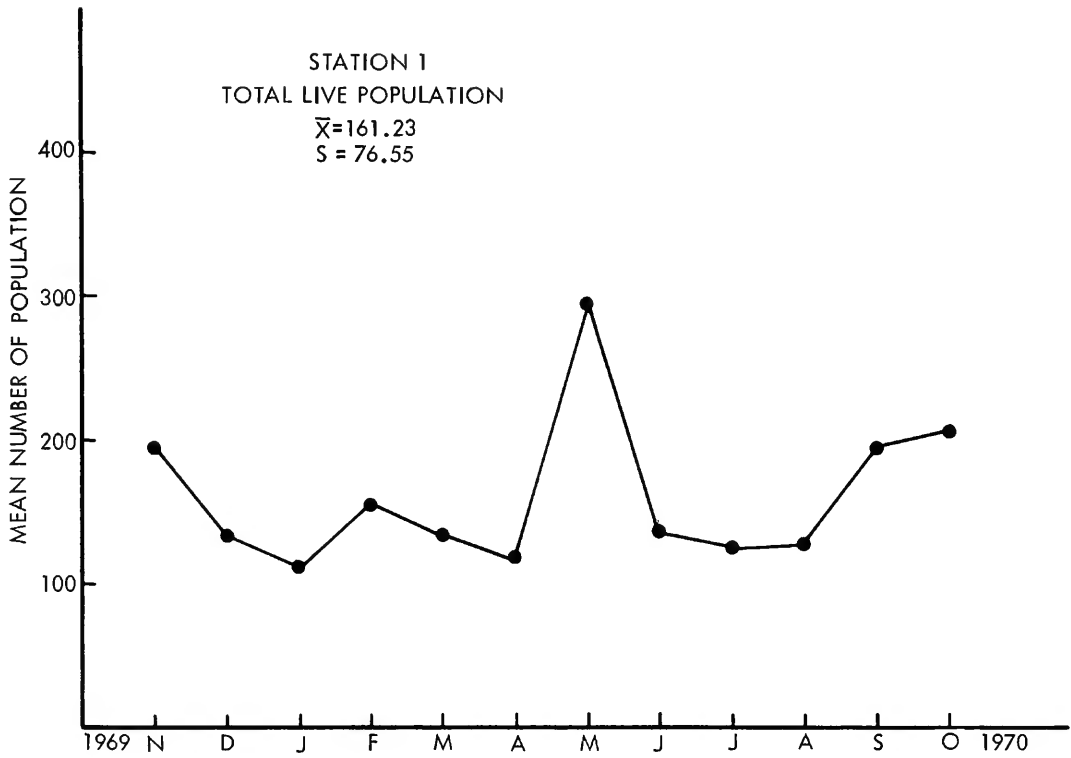
FIGURE 28.—Monthly variations in density of total live population (excluding miliolids).

Z' the same as in the univariate case, $\mathbf{B}$ a matrix of betas (the multivariate analog of the regression coefficients of the univariate model), and $\mathbf{E}$ a matrix of residuals assumed to be distributed as $N(O,\Sigma)$. As in the univarite case the model is solved by matrix transposition, multiplication, and inversion. The solution for $\hat{\mathbf{B}}$ is

$$\hat{\mathbf{B}} = (\mathbf{Z}\ \mathbf{Z}')^{-1}\ \mathbf{Z}\ \mathbf{X} \qquad (7)$$

$$\text{and } \mathbf{E}'\ \mathbf{E} = (N-q)\ \hat{\Sigma}_\Omega = \mathbf{X}'\ \mathbf{X} - \hat{\mathbf{B}}'\ \mathbf{Z}\ \mathbf{Z}'\ \hat{\mathbf{B}}. \qquad (8)$$

The sum of squares of the residual or the variance-covariance matrix so obtained, $(N-q)\ \hat{\Sigma}_\Omega$, is analogous to $ee' = \bar{l}_\Omega = (N-q)\ \sigma^2_\Omega$ of the univariate model.

As in the univarite case six models are hypothesized by deleting columns of the matrix $\mathbf{Z}'$. Their respective variance-covariance matrices $(N-s)\ \hat{\Sigma}_\omega$, are estimated in the same way as for Ω.

A comparison of the Ω model with an ω model is facilitated using the ratio of the determinants of the variance-covariance matrices. This ratio is called a U variate and is written

$$U_{p,q-s,\ N-q} = \frac{|N-q\ \hat{\Sigma}_\Omega|}{|N-s\ \hat{\Sigma}_\omega|} \ . \qquad (9)$$

Seal (1964) indicates that an approximate test for the significance of U is given by

$$X^2_{p\ (q-s)} \simeq [N-q - 0.5\ (p-q+s+1)]\ \ln U_{p,q-s,N-q}. \qquad (10)$$

Table 28 lists the hypotheses and determinants for each of them. In the case of the ω models, the number of parameters in the model is the s of the above notation. For the entire model it is q.

The degrees of freedom, value of chi-square, and the probability of obtaining such value for each of the models is shown in Table 29. The hypotheses $\Pi/6$ overall periodicity and interaction, and station differences are highly significant.

The results of the multivariate analyses closely resemble the univariate analyses. In the individual analyses five species have significant $\Pi/6$ overall periodicity and interaction hypotheses at the 95% level. Similarly, six species recorded significant station differences. In both cases, environmental variables are not significant. The significant difference between stations in the multivariate analyses demonstrates how sensitive the multivariate model is to individual differences even though species vary

TABLE 28.—Determinants of sums of squares of the residual

Effect deleted	Number of parameters in model	Determinant
$\pi/3$ interaction	20	1.21×10^{26}
$\pi/6$ interaction	20	1.27×10^{26}
$\pi/3$ overall periodicity and interaction	18	2.28×10^{26}
$\pi/6$ overall periodicity and interaction	18	3.64×10^{26}
Environmental variables ...	10	1.68×10^{27}
Station differences	21	1.54×10^{26}
No deletion	22	6.09×10^{25}

TABLE 29.—Statistical analyses for 19 abundant species

Variability on account of	df	χ^2	$P(\chi^2)$
$\pi/3$ interaction	38	44.67	0.79
$\pi/6$ interaction	38	31.08	0.22
$\pi/3$ overall periodicity and interaction	76	87.08	0.82
$\pi/6$ overall periodicity and interaction	76	118.12	0.998
Environmental variables	228	232.30	0.59
Station of differences	19	60.00	0.999996

greatly in density. As Table 21 indicates, the five most abundant species do not have significant station differences, and two of the six observed are for the rarest of the abundant species. These results are gratifying because they indicate that the multivariate model will not be greatly dominated by the most abundant species, but instead accurately reflects the entire multivariate population.

Looking at the values within the variance-covariance matrices of the various models, we observe very few negative covariances. Consequently, we computed a correlation matrix for each of the stations. In so doing we are not looking for individual statistical significance, a poor statistical procedure, but rather are interested in the signs of the coefficients. At station 1 of the 152 correlations between the 18 abundant species (*Fursenkoina pontoni* is absent at station 1) only 18 or 12% are negative. Of the 171 correlations between the 19 abundant species at station 3, only 31 or 18% are negative. Both stations have then positive correlations between species and in many cases the species densities are very highly correlated. Consequently, we conclude that for the most part the foraminifera are not undergoing competition during the period of our observations in Jamaica.

Relative Abundance

SPECIES PROPORTIONS.—Foraminiferal researchers commonly express faunal data in terms of species proportions. Species proportions are calculated from the relationship

$$P_i = \frac{a_i}{n}, \qquad (11)$$

where a_i is the number of individuals of species i, and n is the total number of individuals. Usually the proportion is multiplied by 100 expressed as percent and termed relative abundance. While species proportions are simple to calculate, easy to visualize, and accurately represent the relative abundance within a sample, they can be treacherous when comparing between samples. Apparently, authors seldom realize or emphasize that when using relative abundance for comparing areas, the term relative becomes very important. A species may have exactly the same number of individuals at several localities and because the number of species changes (increasing the total number of individuals) and/or

the number of individuals of other species changes, the proportions may differ substantially. Murray (1973) has graphically illustrated the problem. When examining many species distributed among many samples, patterns of species proportions may have little to do with actual changes in densities.

If all species increase and decrease their densities proportionately, a plot of species proportions vs months would be a straight line. Because our measures are estimates, we might expect to find that the relative abundance varies within certain limits about the mean. If individuals are sampled at random, with replacement the standard error of any proportion can be derived from the binomial probability distribution and shown to be

$$\hat{\sigma}_p = \left(\frac{p\,q}{n}\right)^{\frac{1}{2}}, \qquad (12)$$

where p is the proportion of the species, q = 1–p, and n the total number of individuals. This equation indicates that when p is equal to 0.5 the standard error will be the largest. A smaller or larger p will have a smaller standard error. With n = 700 and p = 0.20 the standard error is 0.015, for p = 0.10 it is 0.011 and for p = 0.02, 0.015. Thus a species making up 20% of the fauna can be expected to vary about ±3%, on making up 10% about ±2%, and one having a relative abundance of 2% ± about 1%.

Ujiie (1962) and Dennison and Hay (1967) have used the binomial distribution for estimating the number of individuals required for a desired level of precision. The above authors correctly state that because sampling is made without replacement, the probability distribution to use is actually the hypergeometric. However, because the size of the population being sampled is very large compared to the size of the sample, for all practical purposes the binomial distribution is sufficient. What the authors failed to realize, as do most benthic ecologists, is that even if a biological sample is taken at random, the individuals are not sampled randomly. In benthic ecology we can sample an area or volume at random (or nearly so) but seldom can sample individuals at random. In statistical terminology this kind of sampling is called cluster sampling (Cochran, 1963). The proportion of a species in a sampling unit (single biological sample) is given by

$$p_i = \frac{a_i}{m_i}, \qquad (13)$$

where a_i is the number of indivduals of the ith species, and m_i the total number of individuals in the ith sampling unit. If we have n sampling units the estimate of a species proportion is then given by

$$p = \frac{\sum_{i=1}^{n} a_i}{\sum_{i=1}^{m} m_i}, \qquad (14)$$

and an estimate of the variance of p is obtained from

$$\sigma_p{}^2 = \frac{\sum_{i=1}^{n} m_i{}^2 \; (p_i - p)^2}{n \; \overline{m}^2 \; (n-1)} \qquad (15)$$

(see Cochran, 1963).

To illustrate the differences obtained with the two methods of calculating $\hat{\sigma}_p$, we use the data for November at station 1 for *Bolivina striatula*. In November the counts for *B. striatula* were 35, 51, 53, and 89, while the total number of individuals were 132, 223, 157, and 275, respectively. The standard error of p using the binomial formula is $\hat{\sigma}_p = 0.016$ and using the formula for cluster sampling is $\hat{\sigma}_p = 0.027$. While the differences are relatively small, the confidence limits for the binomial formula are about $\pm 3\%$ and for the cluster formula $\pm 5\%$. Thus we see the confidence placed in estimates of p is not as great as we might suppose from the binomial distribution.

Table 30 gives the percent of the five most abundant species at stations 1 and 3 by months.

Recall that for most species the months February, May, and August or September were times of maxima density. For the species *Bolivina subexcavata* and *Trifarina occidentalis*, changes from month to month are not larger than we might reasonably expect from consideration of standard errors. *Bolivina striatula*, *Ammonia beccarii*, and *Rosalina globularis*, however, do have larger fluctuations.

Figure 29 plots the percent of *Bolivina striatula* by month at stations 1 and 3. Notice that the percent pattern for *B. striatula* does not resemble the density pattern (Figure 9). This is also true for most of the other abundant species. As we have already shown, most species exhibit an overall periodicity that is similar, and, therefore, it would be impossible for individual species percents to resemble the actual changes in densities. For the percent pattern to resemble the actual species densities, the species must behave somewhat independently of the others. *Rosalina globularis* plotted in Figure 30 does so, and the percent pattern shown in Figure 30 closely resembles the density plot shown in Figure 13. As we have shown in the analyses of individual species, *R. globularis* and *Cymbaloporetta squammosa* are unusual in having significant $\pi/3$ periodicities and having monthly patterns rather different from most of the other species. In general, we conclude that the percent pattern is not similar to the density pattern. This is so because, while the abundant species increase their densities during times of overall maxima, such as May, their species proportions are slightly decreased due to the addition of rarer species.

TABLE 30.—Percent of abundant species at stations 1 and 3 by months

Month	B. striatula		B. subexcavata		T. occidentalis		A. beccarii		R. globularis	
	1	3	1	3	1	3	1	3	1	3
Nov........	28.97	9.86	13.09	8.16	7.50	11.24	17.03	6.89	0.64	3.71
Dec........	31.17	10.45	10.58	9.40	11.50	10.75	13.17	4.03	1.30	8.06
Jan........	26.91	12.05	16.14	8.84	11.21	7.23	7.40	8.84	1.12	6.83
Feb........	22.58	11.45	19.03	7.16	9.52	9.30	6.45	14.31	4.36	5.55
Mar........	16.82	11.10	11.09	7.11	9.98	11.97	7.21	8.10	4.44	7.98
Apr........	18.47	13.03	14.65	6.92	9.34	12.10	10.83	8.91	8.49	6.52
May........	16.95	10.19	12.52	8.01	8.77	11.15	14.40	11.28	2.38	9.17
Jun........	21.48	8.18	14.80	7.55	11.19	6.77	11.91	13.61	2.53	14.03
Jul........	20.12	14.45	15.54	8.70	11.16	8.34	8.76	7.76	2.79	9.17
Aug........	20.20	18.01	13.86	8.26	12.67	12.74	9.11	5.08	3.76	5.57
Sep........	17.96	13.96	13.44	6.29	10.21	7.11	8.92	4.24	1.81	5.88
Oct........	16.42	15.43	11.44	3.08	8.64	9.44	8.03	5.44	3.28	2.90
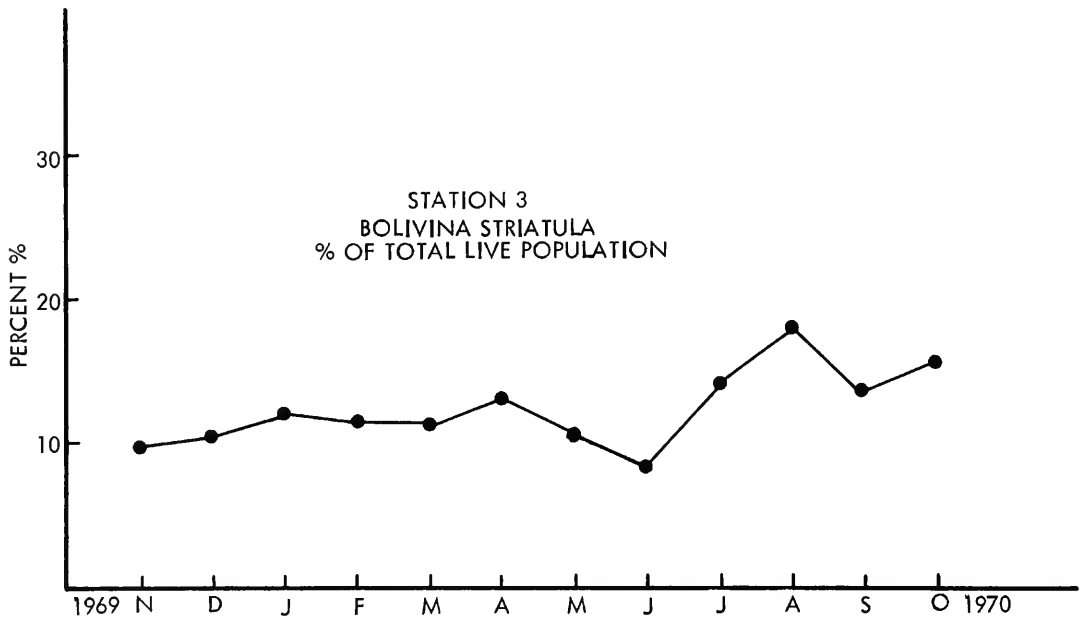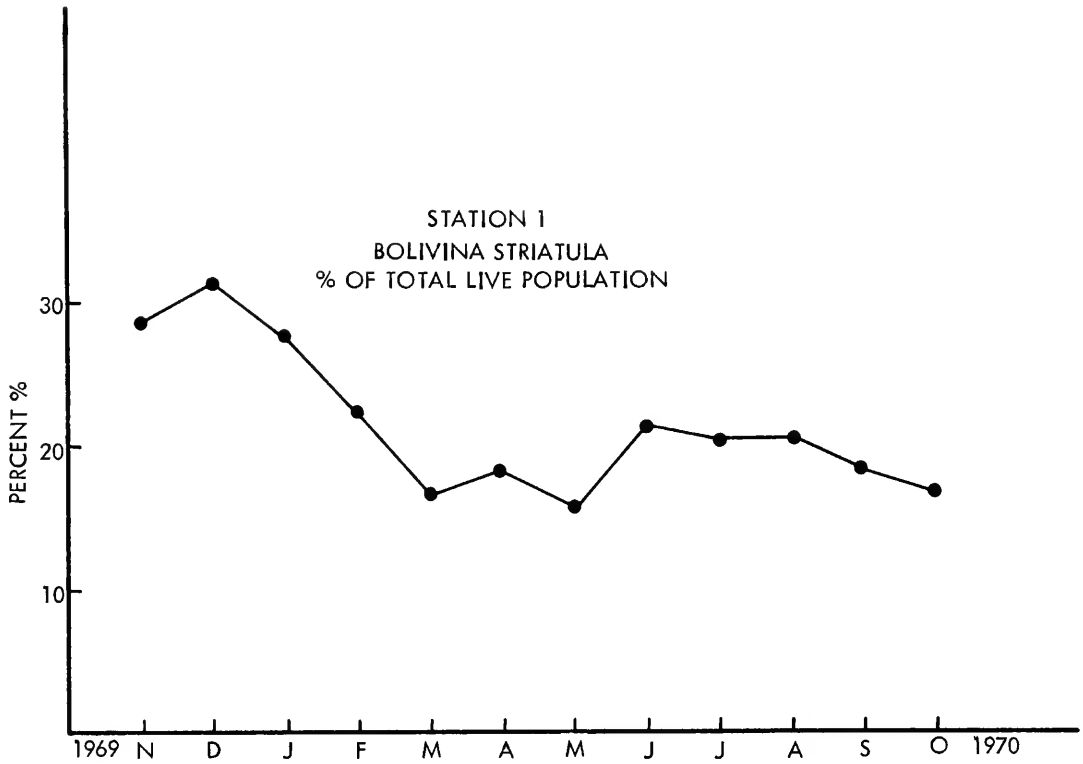
FIGURE 29.—Monthly variations of *Bolivina striatula* in percent of total live population.
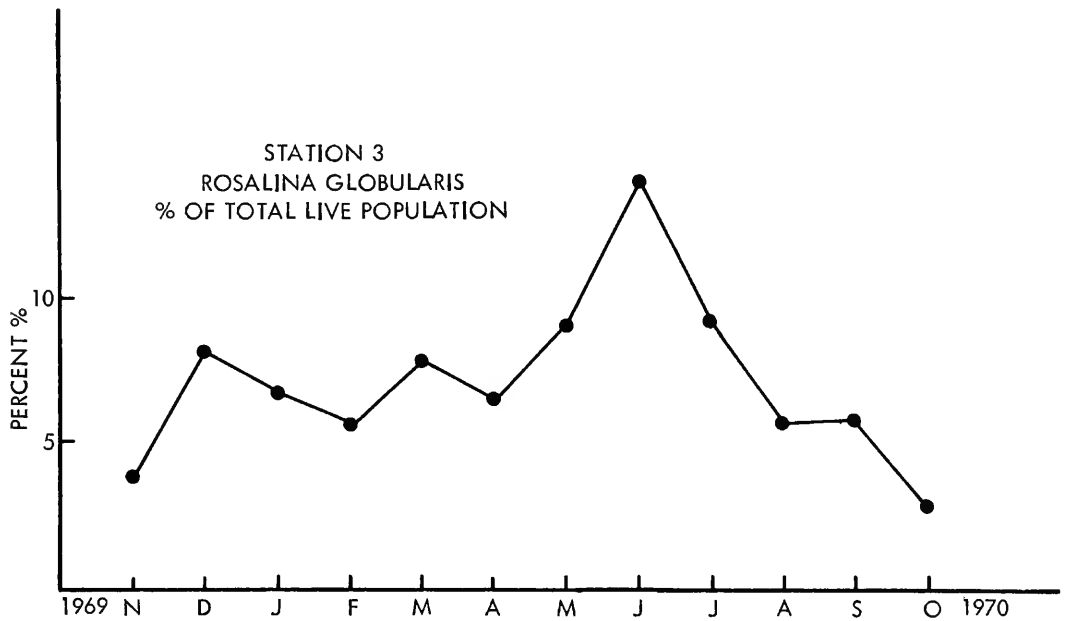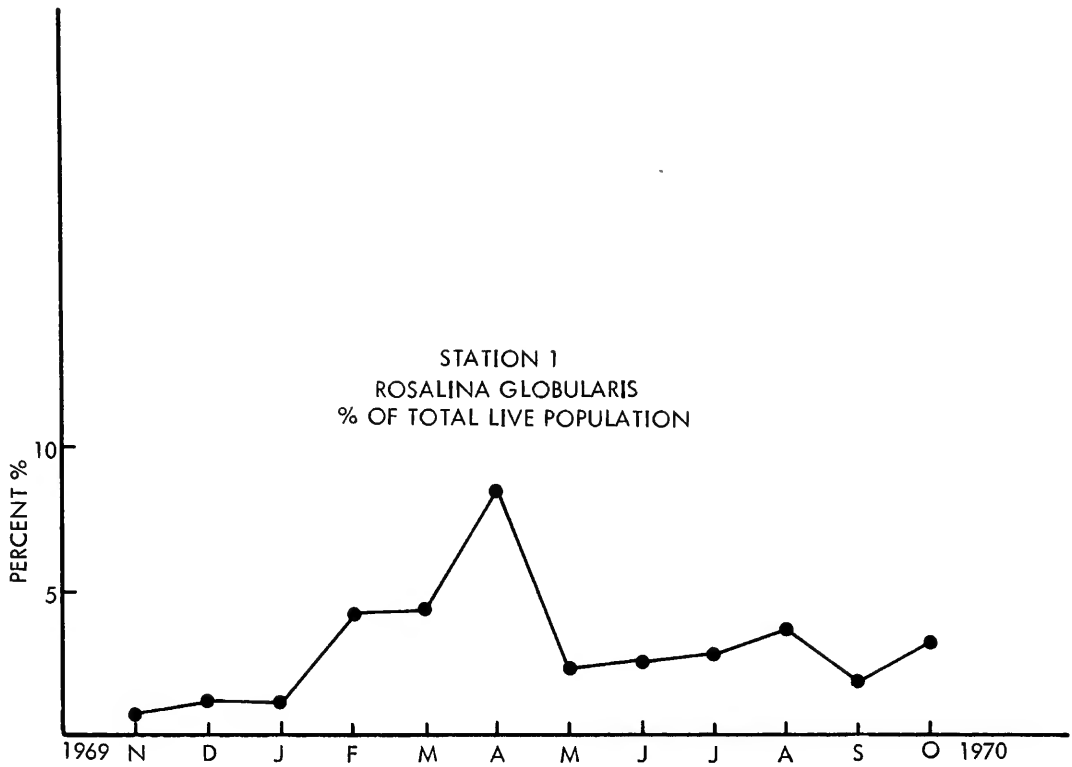
FIGURE 30.—Monthly variations of *Rosalina globularis* in percent of total live population.

DISTRIBUTION OF SPECIES ABUNDANCE.—Naturalists have long been aware that the number of individuals is not evenly distributed among species. Usually a few species are abundant and the remainder very rare. In the present study, at both stations 1 and 3, 95% of the individuals observed belong to a third of the total species observed. In other words two-thirds of the species observed account for only 5% of the individuals. At station 1, 75% of the individuals are accounted for by 10 species, at station 3 by 14 species.

R. A. Fisher (Fisher, Corbet, and Williams, 1943) reasoned that if species had different means, and if the means were distributed as chi-square, the resulting distribution would be the negative binomial. The distribution is completely defined by the mean and k, a positive exponent. When the variance of the negative binomial approaches the mean $k \to \infty$, whereas with great heterogeneity $k \to o$. Fisher observed that on a series of Malayan butterflies the negative binomial fit the data well and the value of k was very small. Fisher, therefore, derived an expression for the expected number of species having n individuals as

$$\frac{\alpha}{n} x^n, \qquad (16)$$

where α is a constant and x a positive number less than 1. The total number of species expected is

$$S = \Sigma \frac{\alpha}{n} x^n = -\ln(1-x). \qquad (17)$$

For a given N, total number of individuals, and S, number of species, Williams (1964, Appendix A) has tabled values of x. After obtaining an approximate value of x, the expression

$$\frac{S}{N} = \frac{1-x}{x} [-\ln(1-x)] \qquad (18)$$

can be used to calculate a more accurate value by successive approximations. Once x is calculated α can be calculated from the expression

$$\alpha = \frac{N(1-x)}{x}. \qquad (19)$$

Because x is near unity, α (the constant in 16, 17) is a number very close to n_1, the expected number of species containing one individual, and has been used extensively as a measure of species diversity (Murray, 1973).

At station 1, S = 115, and N = 7,745. Using (18) successive approximations yield a value of x =

0.9976, α = 18.63, and the expected number of species S = 112.38. The expected number of species, 112, is very close to the observed number 115. Similarly n_1, the expected number of species with one individual, is 18.59, while 23 were observed.

At station 3, the total living population contains N = 10,899 individuals and S = 117 species. The calculated value of x = 0.9983, α = 18.56, and the expected number of species S = 118.36, n_1 = 18.53, while the observed number of species at station 3 with one individual is 27.

Preston (1948, 1962) presented evidence suggesting that the distribution of individuals among species is best described by the log-normal distribution. Although Preston used $\log_2$ in his calculations and illustrations, the more conventional ln is used here. After taking the ln of the number of individuals observed per species, the logarithmic mean, $\hat{\mu}$, and $\hat{\sigma}^2$ variance were calculated. These parameters were then used to calculate the log-normal probability density function by

$$f(x) = \frac{1}{x(2\Pi\sigma^2)^{1/2}} e^{\frac{-1}{2\sigma^2}(\ln x - \mu)^2}. \qquad (20)$$

The expected values of x were calculated up to a value of 121, the remainder were estimated by calculating f(x) at intervals. The error so introduced is small because as x becomes large, f(x) changes little.

Tables 31 and 32 list the observations and expected values for the log series and log-normal distribution. The class intervals chosen are the same as used by Williams (1964). The observations and the expected log series and log-normal curves for station 1 and 3 are plotted in Figure 31. Tables 31 and 32 and Figure 31 indicate the log series gives a better "fit" to the observations than the log normal. Both distributions underestimate the number of rare species observed but the log normal gives a poorer estimate. To evaluate "goodness of fit," a chi-square evaluation was made, grouping the last two classes in each case because of the low expected values. At station 1, the value of chi-square for the log series is 6.62 and for the log normal 18.41. At station 3, chi-square for the log series is 5.72 and for the log normal 29.29. The value of $\chi^2_{(6,95)}$ is 12.59. The chi-square evaluation is, then, in agreement with our visual inspection, and we conclude that Fisher's log series fits the data remarkably well.

TABLE 31.—Number of species observed, predicted log series, and
log-normal distribution at station 1

Individuals per species	Observed	Predicted log series	Predicted log normal
1	23	18.59	11.81
2-4	27	20.04	20.89
5-13	18	20.04	26.42
14-40	21	19.29	23.80
41-121	14	17.17	14.97
122-364	7	12.20	6.92
365-1093	4	4.66	2.71
1094-3280	1	0.39	1.07

TABLE 32.—Number of species observed, predicted log series, and

Individuals per species	Observed	Predicted log series	Predicted log normal
1	27	18.53	10.71
2-4	19	20.01	18.32
5-13	19 ·	20.07	23.73
14-40	15	19.56	23.31
41-121	18	18.00	17.14
122-364	11	14.09	9.94
365-1093	7	7.00	4.81
1094-3280	1	1.10	1.54

SPECIES DIVERSITY.—The simplest measure of species diversity is S, the number of species observed. Another popular measure of species diversity is the Shannon-Wiener information function

$$H = -\Sigma\ p_i \ln p_i, \qquad (21)$$

where p_i is the proportion of the ith species (MacArthur and MacArthur, 1961; Pielou, 1966; and Gibson and Buzas, 1973). The information function has the advantage of not placing much weight on the rarer species, so the chance occurrence of a few individuals representing species not previously collected will not alter the function by much. For example, a species with $p = 0.20$ has a value of p ln p of -0.32, whereas a species with $p = 0.01$ has a value of -0.05. The rarer species contribute an order of magnitude less to the function than the more abundant ones.

While the addition of a few rare species alters the function little, the evenness with which the species are distributed does change the value greatly. For example, five species each with a proportion of 0.20 would have an H value of 1.60, while five species with proportions of 0.90, 0.04, 0.03, 0.02, and 0.01 would have an H = 0.45. Consequently, in evaluating values of H, some measure of evenness or equitability is desirable. The maximum value of H occurs when all species are equally distributed and in this case H = ln S. Therefore, from the definition of logarithms, in this situation $e^H = S$, and $e^H/S = 1$. Any departure from complete evenness will have a value of less than 1 and can be considered a measure of evenness. Buzas and Gibson (1969) suggested the ratio be used for this purpose, and Sheldon (1969) called it E. Other measures have been used (see Pielou, 1966), but for reasons given by Hill (1973),

$$E = \frac{e^H}{S} \qquad (22)$$

appears most appropriate.

To facilitate examination of species diversity, a computer program was written that ranks the species by abundance and calculates the species proportions and cumulative proportions: N = the total number of individuals, S = the number of species, H = the information function, and E = the equitability function. Computer runs were made
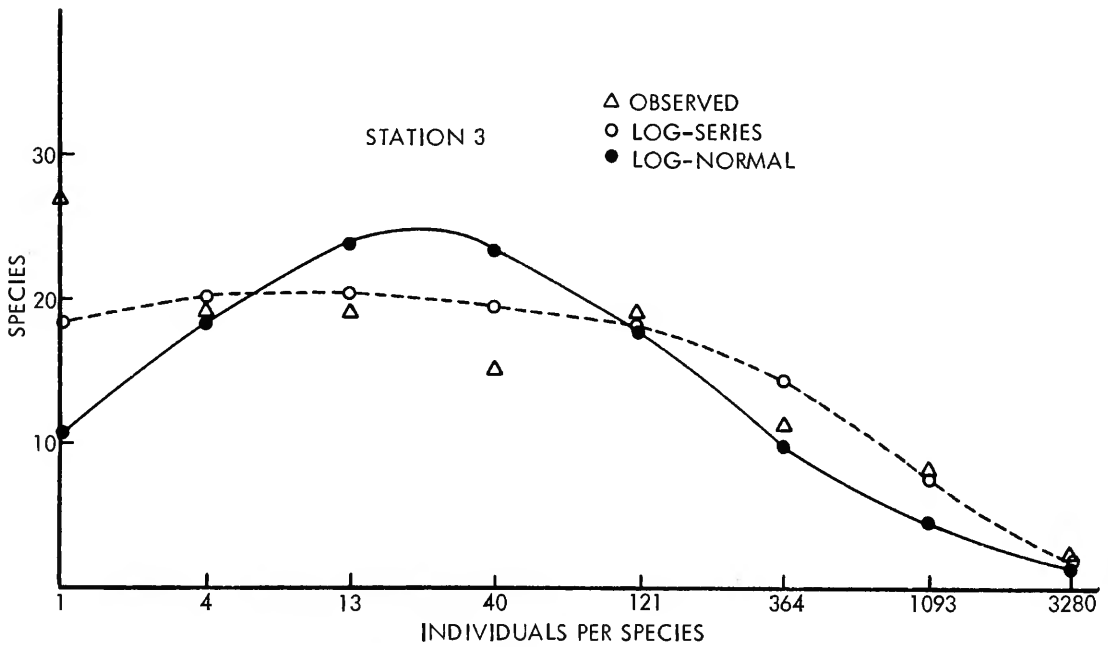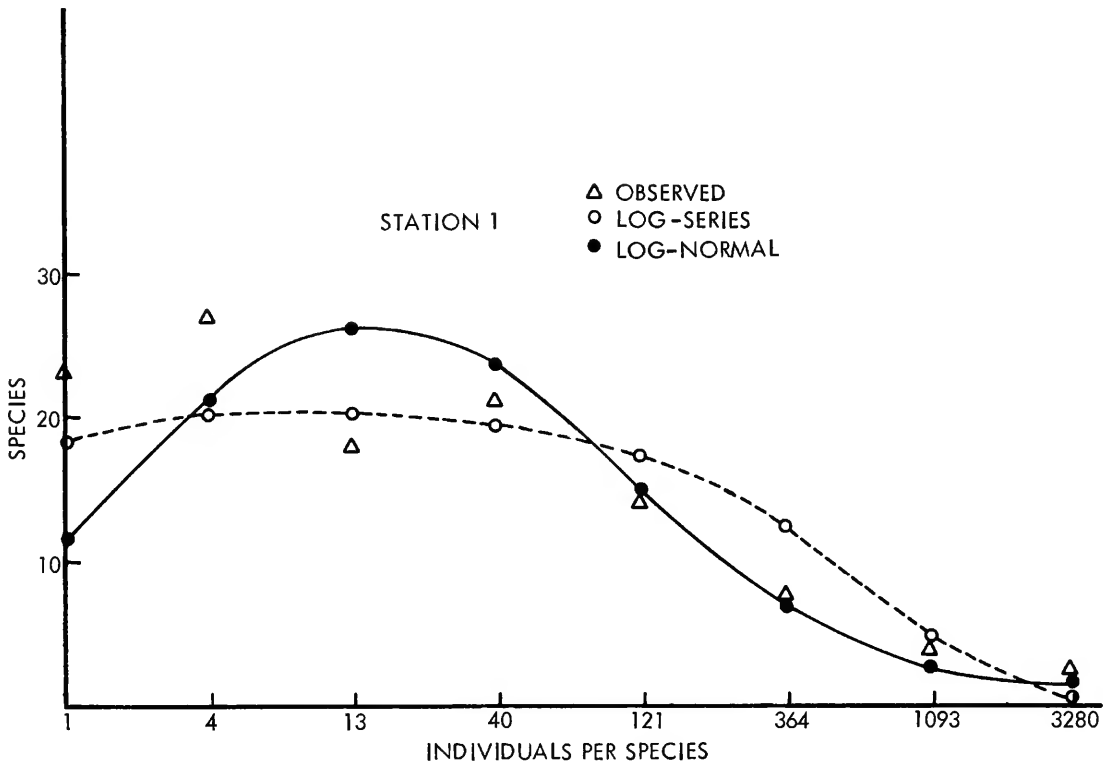
FIGURE 31.— Distribution of numbers of individuals per species.

for each biological sample (20 ml of sediment), each month at each station, and the cumulative individual samples were taken sequentially for the entire year at each station.

The results for S, H, and E by month are plotted in Figure 32. The range of S at station 1 is from 45 to 73 and at station 3 from 49 to 54. Except for November and May, the number of species is always greater at station 3.

The value of H at station 3 is always greater than at station 1. The mean at station 1 is 2.84 and at station 3, 3.21. Figure 32 shows that the value of H at the respective stations varies little from month to month.

Except for the month of August, the value of E is always greater at station 3. The average monthly value for E at station 1 is 0.33 and at station 3, 0.40. The consistently higher value of E at station 3 insures that the value of H at station 3 remains above that of station 1. Thus, in November and May when S is greater at station 1, the value of H remains higher at station 3. E like S shows considerable variation from month to month.

The value of S observed from month to month is dependent on N, the number of individuals observed each month. Figure 33 plots S against N (on a log scale) for each of the 48 biological samples at stations 1 and 3. Spearman's rank correlation coefficient indicates a highly significant positive correlation for N and S at both stations. Note that the lines fitted to the points do not have the same slope. While we expect station 1 to have fewer species when N is less than about 800, when N is greater than 800, station 1 will have more species. The figure illustrates well Hurlbert's (1971) suggestion that values of S should be compared only when values of N are nearly equal. At station 3, the expected S for N = 100 is 24, and for N = 300, 38. In other words a difference of 14 species can be accounted for by the different values of N.

Figure 34 plots H against N (on a log scale). At station 1 Spearman's rank correlation coefficient yields a significant positive value. Note, however, that the slope of the line is small. For N = 100, the expected H is 2.54, while for N = 300, H is 2.75. Station 3 shows no significant increase in H with N.

Figure 35 plots individual sample values of E against N (on a log scale). At both stations Spearman's rank correlation coefficient indicates a

significant negative relationship. The slope of the two lines is nearly equal.

Figures 33, 34, and 35 indicate that for most values of N, S is greater at station 3, but S increases at a greater rate at station 1. Consequently, because the negative slopes of E at both stations are nearly equal, H_1 increases with increasing H, while H_3 does not because the possible increase of S with N is nullified by the decrease in E.

A common way of looking at the relationship of S with increasing N is by looking at cumulative curves. Plant ecologists have long looked at the distribution of S with increasing area. Arrhenius (1921) suggested that species and area are related by a simple power series so that when plotted on a log-log basis, the points fall in a straight line. Gleason (1922) indicated the relationship was semi-log, S plotted arithmetically and A on a log scale.

Note that this is not the same as looking at individual random samples. Instead, we take the first sample, add the second to it, and so on. This is equivalent to starting at some point and measuring outward—clearly not a random procedure. In the present study, the data are further complicated because each set of four biological samples is taken at a different month. Nevertheless to look at the relationship of S and N over a wide range seems worthwhile.

Figure 36 plots cumulative S against N (on a log scale). To simplify the presentation, only the values for every fourth (end of each month) sample are plotted. The lines, however, were calculated from the entire set of 48. As Figure 36 shows, the calculated equations fit the data very well. A simple power series was also calculated for the two stations, $S_1 = 13.44 \, N_1^{.24}$ and $S_3 = 14.37 \, N_3^{.23}$. These lines fit the data equally well. This phenomenon was pointed out by Preston (1962), who indicated that both curves will plot as a straight line unless the range of the abscissa is very large. Although 7,735 individuals were observed at station 1 and 10,899 at station 3, there is no indication that we have found the total number of species present in the area. The rare species are often observed only once; at station 1, 23 species are represented by one individual and at station 3, 27. Obviously, continued collecting will keep turning up rare species until the fatigue of the researcher puts an end to it.

Figure 37 plots cumulative H against N. Station 1 has a slight increase with N, while station 3 is
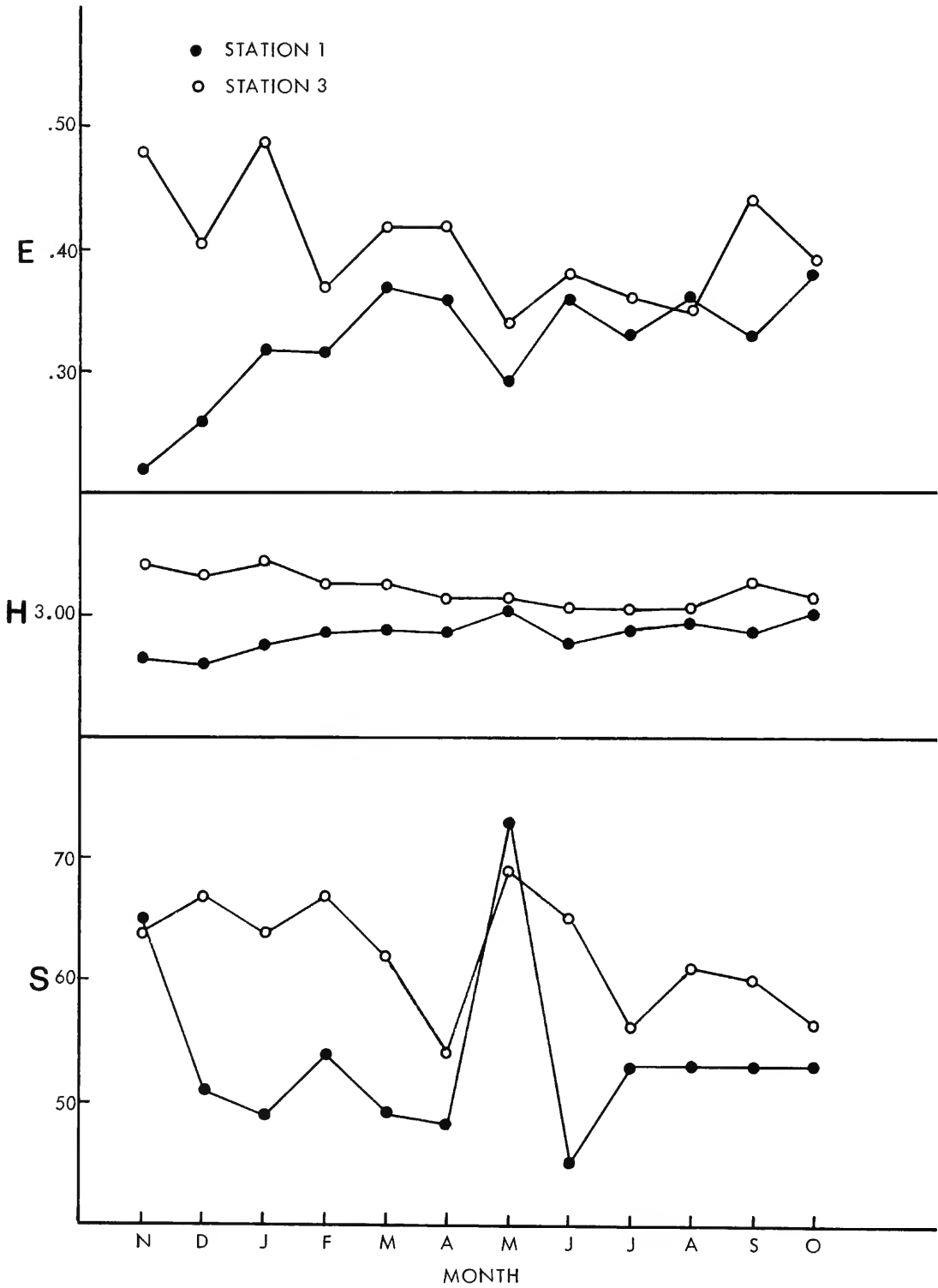
FIGURE 32.—Monthly variations in equitability, information function, and number of species.
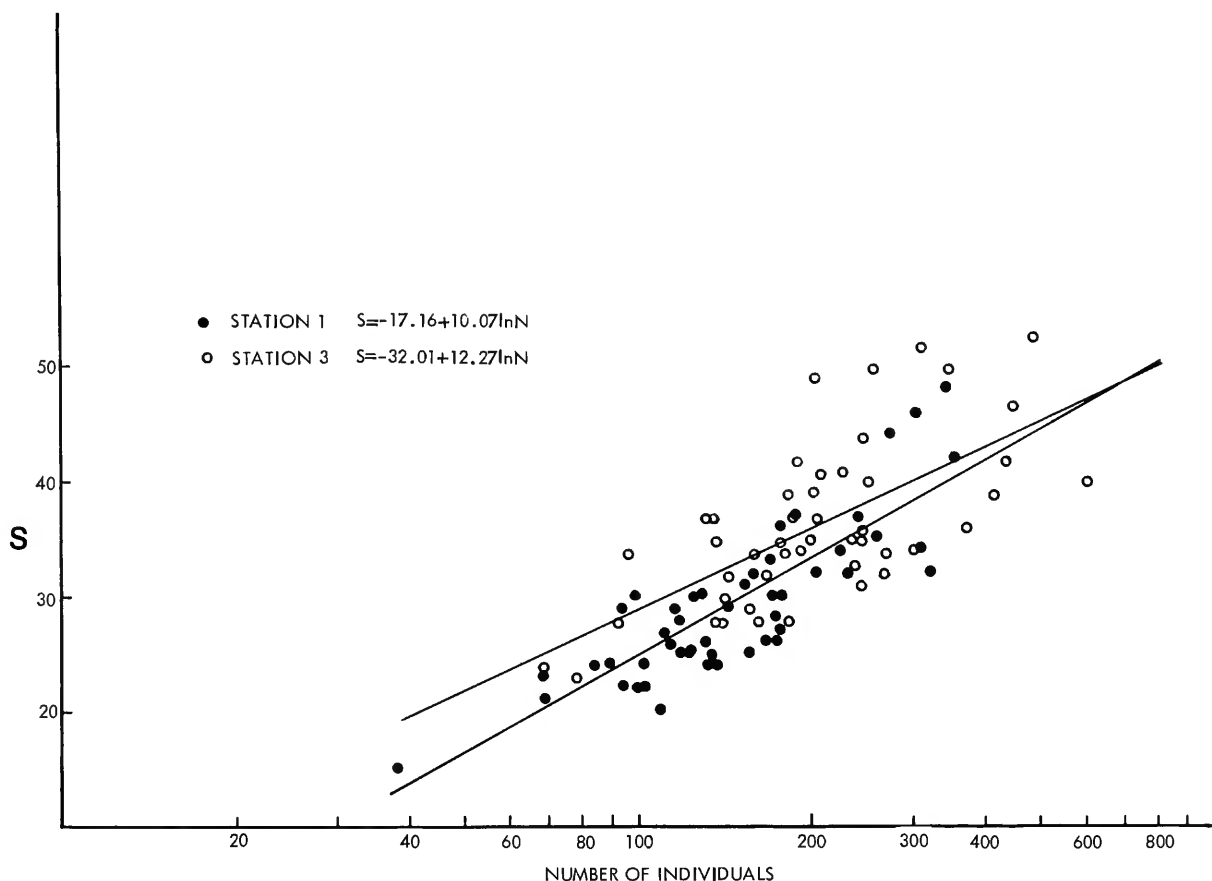
FIGURE 33.—Semilog plot of numbers of individuals vs. species.

nearly horizontal. The values of H remain remarkably stable over the entire observed range. If a single measure of species diversity must be used for data with differing values of N, H is well suited.

Figure 38 plots cumulative E against N. For greater than 1000 individuals E_1 is nearly horizontal. On the other hand, E_3 shows a sharp negative relationship with increasing N, perhaps reaching stabilization at about 8000 individuals. Consideration of Figures 36, 37, and 38 shows that S_1 and S_3 increase continually with N; because E_1 is nearly stable H_1 must increase with N from a consideration of (22). At the same time, if H_3 is stable, and S_3 is increasing, E_3 must decline. An illustration of how this is accomplished will make the relationship clearer. Table 33 shows cumulative samples for the end of February and July at station 1. The table shows the value of H and E for each class of 10

species. The final value of E for each sample is 0.19. Notice that the value of H at the end of class intervals in July is always higher, most notably in the classes 0–10, 10–20, 20–30, 30–40, and 40–50. Correspondingly, at the end of any interval the value of E is higher in July. The addition of another 20 species in the July sample, however, just offsets the increase in H, making the ratio e^H/S the same in both samples. At station 3, the situation is quite different. Table 34 shows that after the first class of 10 species until about 70 species, the cumulative sample for July does not increase as much in its H values as February. Consequently, at 90 species, February has a value of 3.42 and July 3.29. The addition of another 21 species in the July cumulative sample increases the value of H by only 0.02 and the ratio e^H/S is much smaller in the July sample. Examination of computer print-
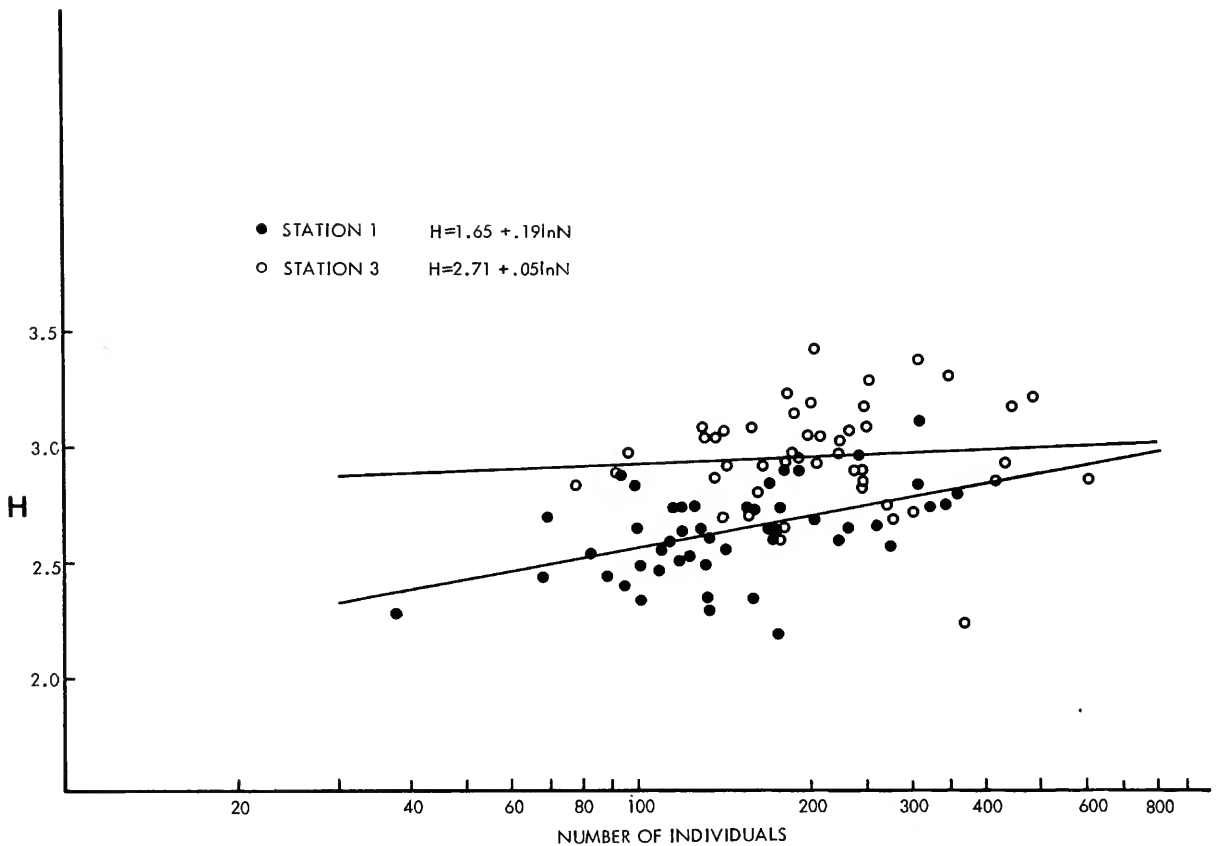
FIGURE 34.—Semilog plot of numbers of individuals vs. information function.

outs indicates that this pattern is a general trend for stations 1 and 3.

The analyses presented here indicate how difficult it is to ask a simple (but imprecise) question. Is species diversity higher at station 1 or 3? No simple answer is possible. The question so stated is too vague.

For values of N (about 100 to 400) occurring in biological samples of 20 ml, usually $S_3 > S_1$, $H_3 > H_1$, and $E_3 > E_1$ (Figures 33, 34, 35). Consideration of cumulative samples indicates that above 800 or 1000 individuals for any given N, we expect $S_1 > S_3$, $H_3 > H_1$, and $E_3 > E_1$ (Figures 36, 37, 38).

In addition we observe that the values of E_1 and E_3 indicate the species are not cumulating in the same way at the two stations (Figure 38, Tables 33, 34).

If we ignore the warnings of Hurlbut (1969) concerning N and look at the totals for the two

stations, we find $S_1 = 115$, and $S_3 = 117$ (for all practical purposes equal). Similarly, Fisher's alpha is $\alpha_1 = 18.63$ and $\alpha_2 = 18.56$. We must keep in mind, however, that $N_1 = 7,745$ and $N_3 = 10,899$, and for a given N above about 800, Figure 36 indicates $S_1 > S_3$.

Biologically, the individual 20 ml samples or perhaps each set of four replicates is most meaningful. They represent random samples of individuals living together at the same time and place. For these samples, S, H, and E are usually higher at station 3, where environmental stress is the lowest.

Discussion

Explaining observed patterns of densities by environmental variables is much more difficult than their recognition. In an earlier study Buzas (1969) demonstrated a highly significant statistical relation-

STATION 1 E=10.2 −.11lnN

STATION 3 E=1.08−.10lnN
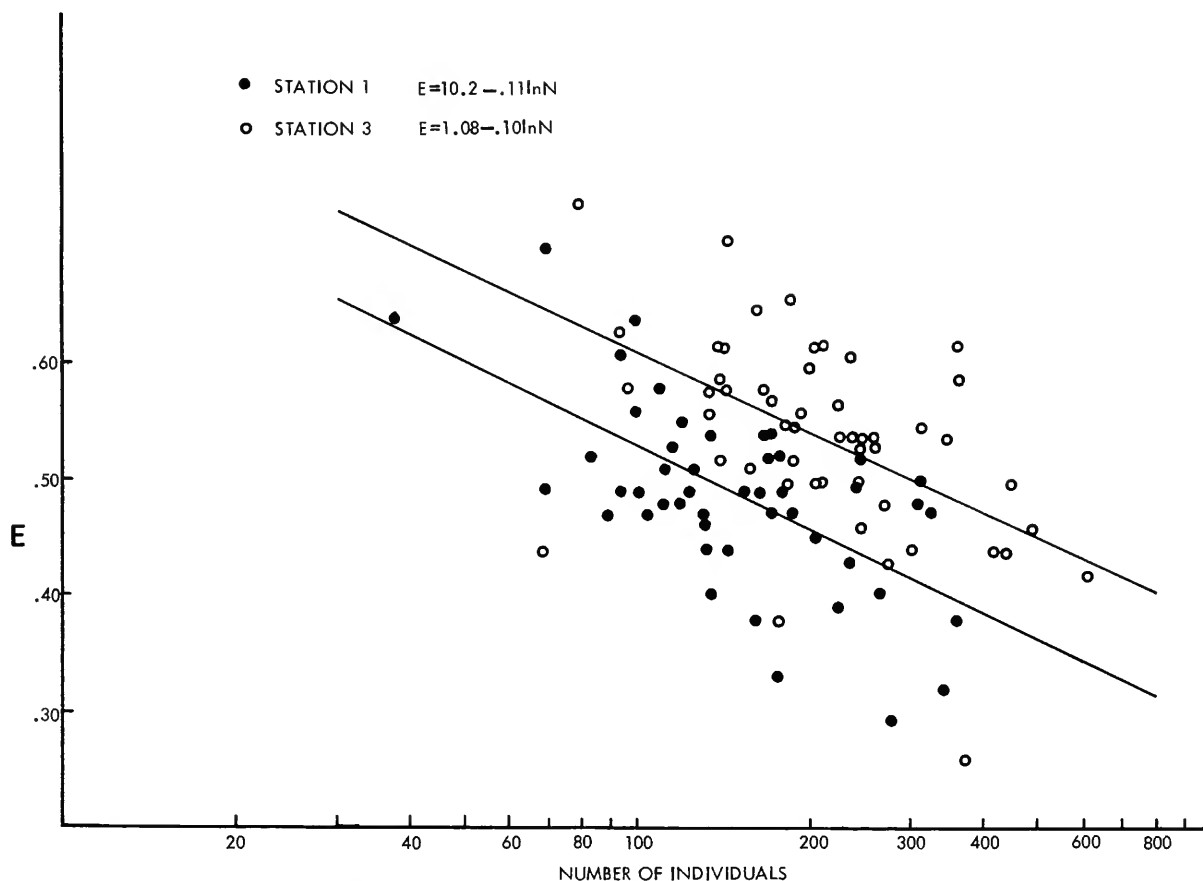
FIGURE 35.—Semilog plot of numbers of individuals vs. equitability.

ship between a set of environmental variables and species densities in a northern temperate estuary. Although the set of environmental variables was highly significant, no single variable could be isolated because the variables are highly correlated and the effect of one cannot be isolated. Lee (1974) made the same point in discussing experiments conducted by Muller (1975). Similarly, Lankford and Phleger (1973) indicated that the zoogeographic distribution of nearshore foraminifera of western North America could not be related to a single environmental variable, but only to properties of coastal-water masses.

In the present study, no significant statistical relationship was found between the densities of the 19 abundant species and the set of environmental variables (Table 21). Even when the 19 species were analyzed simultaneously (multivariate population), no statistical significance was found (Table 29).

Most of the abiotic variables thought to be important in controlling the density of foraminifera were measured (temperature, salinity, oxygen, turbidity, pH, and substrate). It is, of course, likely that some extremes of these variables were not observed, especially at station 1 (back-reef flat). Such extremes, however, would probably affect the entire fauna or most of it, and we see no evidence of such changes. Consequently, we believe abiotic variables do not regulate species densities in these *Thalassia* habitats. Unlike more northern areas, the physical environment is sufficently benign so that biotic variables are most important. This conclusion is in agreement with Sanders (1969), Slobodkin and Sanders (1969), Dayton and Hessler (1972), and Grassle and Sanders (1973), who indicated that tropical and deep-sea environments are similar in that both have high species diversity, environmental stability predictability, and biotic regulation.
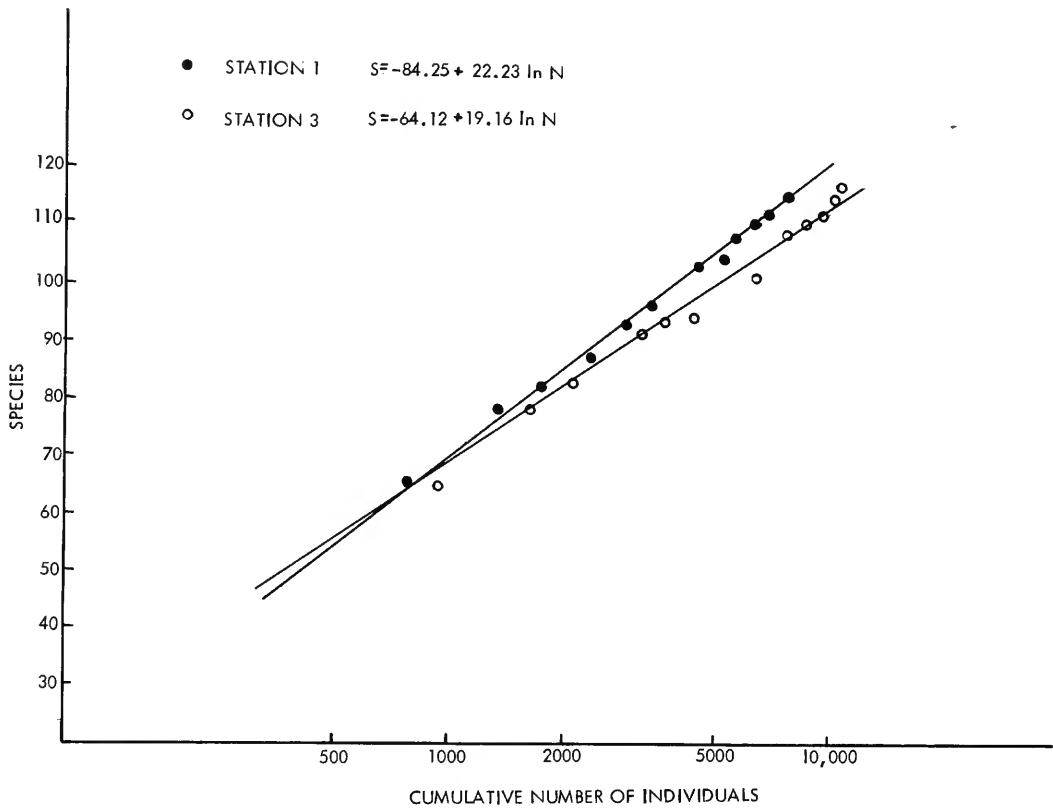
FIGURE 36.—Semilog plot of cumulative number of individuals vs. species.

TABLE 33.—Cumulative values of H and E at 10 species class intervals at station 1 (see text for explanation)

February			July		
S	H	Ė	S	H	Ė
10	1.66	0.53	10	1.71	0.55
20	2.10	0.41	20	2.20	0.45
30	2.38	0.36	30	2.48	0.40
40	2.53	0.31	40	2.68	0.36
50	2.64	0.28	50	2.81	0.33
60	2.71	0.25	60	2.88	0.30
70	2.75	0.22	70	2.92	0.26
80	2.78	0.20	80	2.95	0.24
87	2.80	0.19	90	2.97	0.22
			100	2.99	0.20
			108	3.00	0.19

Competition is sometimes important in regulating species densities (MacArthur, 1972). Shallow-water foraminifera are most likely opportunistic organisms (Buzas, 1968, 1969; Lee et al., 1966; Lee and Muller, 1973); that is, they have the ability to take rapid advantage of changes in the environment, and
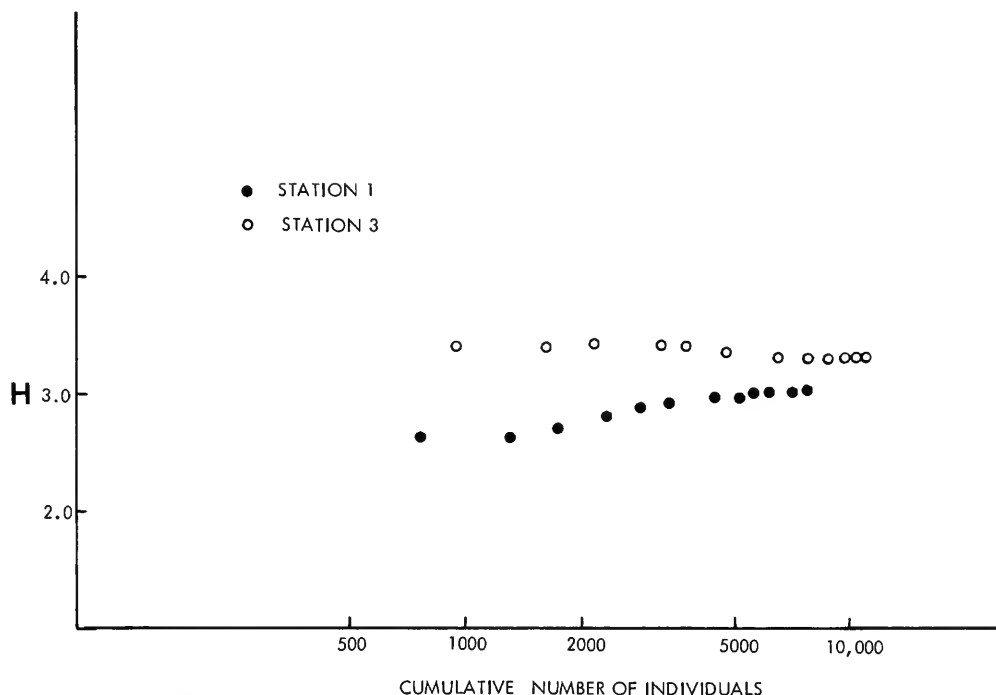
FIGURE 37.—Semilog plot of cumulative number of individuals vs. information function.

reproduce quickly when conditions are favorable. In a Long Island salt marsh, Matera and Lee (1972) found species densities and species composition changed throughout the summer. In Jamaica, species densities are highly positively correlated and species proportions are relatively constant throughout the year (Table 30). This implies necessary resources are present most of the time, otherwise species best adapted to a particular set would dominate and dominance would change with time. Consequently, competition of foraminifera species is not currently important in Jamaica.

According to Grassle and Sanders (1973), in deep-sea and tropical environments "long-term diversity" is accomplished by partitioning the environment through specialization over a long period of time. Not only do the species specialize on food, but also on feeding behavior, biochemical requirements, and microhabitat. As indicated above, species densities are positively correlated at both stations. In any particular replicate when the number of individuals observed is large, it is so for most of the abundant species. Figure 33 shows that the number of individ-

uals and number of species in each replicate is also positively correlated. Thus the evidence indicates no spatial partitioning of the micro habit. Specialization on food, feeding behavior, and biochemical requirements may, of course, be important. Laboratory experiments (Lee and Muller, 1973; Bradshaw, 1955; Lee et al., 1966) indicate that the nutritional requirements of foraminifera are complex. They are selective feeders often requiring more than one species of food for growth and reproduction. Not only the particular species of food, but also its concentration and condition are important. The measurements of food were necessarily indirect in our study (weight of *Thalassia*, particulate organic matter, and weight percent silt plus clay), and we cannot be totally confident that their lack of significance indicates that the complex nutritional requirements of all species are being met. The six significant differences in densities between stations and the five significantly different periodicities between stations (Table 21) might best be explained by specialization to a complex of requirements not measured here. At the same time,

TABLE 34.—Cumulative values of H and E at 10 species class intervals
at station 3 (see text for explanation)

	February			July	
S	H	E	S	H	E
10	1.67	0.53	10	1.77	0.59
20	2.39	0.55	20	2.41	0.56
30	2.79	0.54	30	2.76	0.53
40	3.05	0.53	40	2.97	0.49
50	3.21	0.50	50	3.12	0.45
60	3.30	0.45	60	3.20	0.41
70	3.37	0.42	70	3.25	0.37
80	3.39	0.37	80	3.27	0.33
90	3.42	0.33	90	3.29	0.30
92	3.42	0.33	100	3.30	0.27
			110	3.31	0.25
			111	3.31	0.25
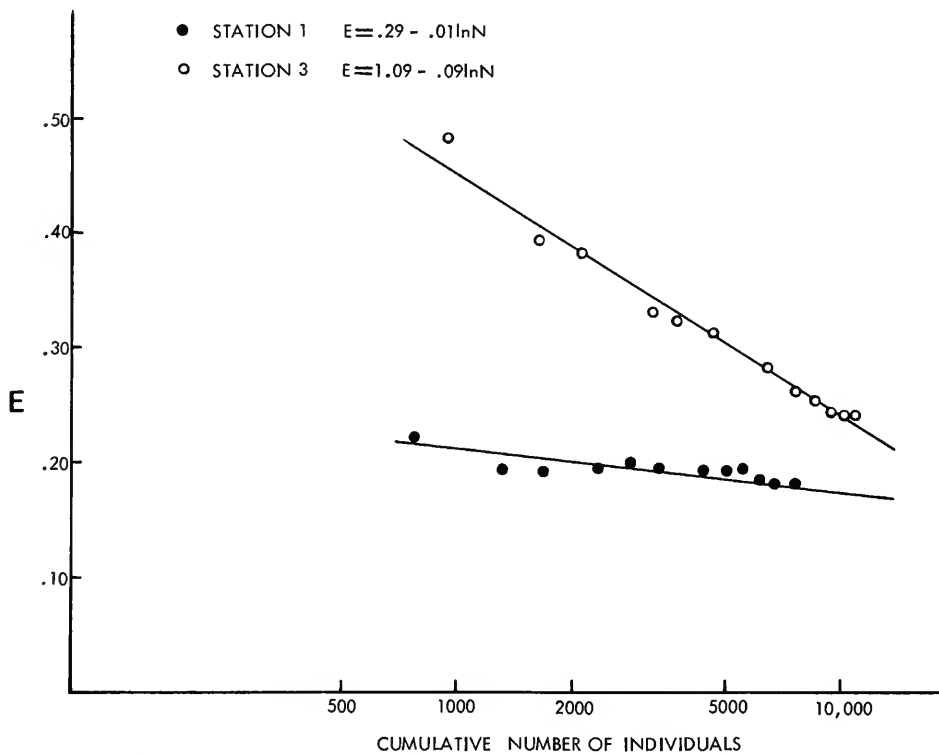
FIGURE 38.—Semilog plot of cumulative number of individuals vs. equitability.

we should realize that if this be so, the complexity of this microenvironment (Lee, 1974) is so fantastic and the variables so highly correlated that we may never be able to unravel it.

On the brighter side, Tables 2–20 and Figures 9–27 show some striking similarities. The hypothesis for $\pi/6$ overall periodicity has high mean square values for many of the species. This overall periodicity is best exemplified by the four most abundant species (Tables 2–5, Figures 9–11). Boltovskoy and Lena (1969) also observed synchronous reproduction in most of the foraminiferal species they studied in Puerto Deseado, Argentina. Such an overall response might be attributed to a single cause. Because foraminiferal nutritional requirements are complex, if they were limiting, the myriad of possible combinations would have to vary simultaneously to explain an overall periodicity at both stations. This seems unlikely.

Field and laboratory observations (Lankford, 1959; Lee 1974) indicate that foraminiferal densities can reach an order of magnitude greater than that observed here. Deposit-feeding organisms do utilize foraminifera as part of their diet (Lipps and Valentine, 1970). We suggest that cropping (Dayton and Hessler, 1972) by nondiscriminate predators reduces foraminiferal densities. When predation eases, the foraminifera quickly increase in density (logarithmic phase of growth), but before competition can ensue, their densities are again substantially reduced. In this way, species maintain similar proportions with time, show no evidence of competition, and maintain similar periodicities.

Jackson (1972) studied the ecology of molluscs from the same stations (and two more) used in this study. At station 1 (back-reef flat), Jackson (1972) found only six species of infaunal and semiinfaunal bivalves while at station 3 (Discovery Bay), he observed 23. In the back-reef flat members of the family, Lucinidae, who are tolerent of environmental variability, dominate the fauna. At Discovery Bay this family no longer dominates, and both eurytopic and stenotopic taxa live together. Jackson (1972) reasoned that the decrease in lucinid density and the maintainence of higher species diversity in Discovery Bay is due to predation. On the average, the 20 ml replicates at station 1 contain 29 foraminiferal species and at station 3, 36. The information function and species equitability (Figures 34, 35) are also larger at station 3, and are, therefore, in accord with what one would expect along a stress gradient. The cumulative number of species at station 1 is 115 and at station 3, 117. More individuals were observed at station 3, however, and as Figure 36 shows, for any N above about 800, station 1 has the greater number of species. In any case, the difference in species diversity between the two habitats is not nearly so dramatic as for the bivalves. The same holds true for species densities. The five most abundant species of foraminifera have no significant difference in density between the habitats, and only six of the 19 most abundant do (Table 21). The bivalves, however, have significant differences for all four of the most abundant species. We conclude that for foraminifera the back-reef flat and Discovery Bay *Thalassia* habitats are similar environments, while for the bivalves they represent distinctive entities.

Systematic Catalog

Herein we follow the systematic structure of the *Treatise of Paleontology* (Loeblich and Tappan, 1964). We do not entirely agree with the *Treatise,* however, either in the placement of particular genera and species or in overall taxonomic philosophy. Overall, we believe the *Treatise* is too inflexible and places undue emphasis on certain morphological features such as wall structure. Consequently, for some genera such as *Elphidium* we have placed species with optically radial and granular walls in the same genus, although according to the classification adopted in the *Treatise* they belong in different superfamilies. Even with these inconsistencies, we believe the systematic arrangement followed here is more "natural" than none at all.

As discussed earlier, the species *Discorbis rosea* and one miliolid were not enumerated in this study due to our inability to identify living specimens with confidence. Miliolaceans are treated in a subsequent paper.

At the end of the remarks for each species, we tabulate the mean number of individuals, standard deviation, and range observed at stations 1 and 3.

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Herouard, 1896

Superfamily AMMODISCACEA Reuss, 1862

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

Genus *Lagenammina* Rhumbler, 1911

Lagenammina? sp.

A few specimens are questionably assigned to this genus. They appear conspecific, but some differ from the generic description given by Loeblich and Tappan (1964:C196, C200) in being less pyriform and more nearly parallel sided, like *Brachysiphon*. All are extremely coarsely arenaceous and roughly finished overall, though some agglutinated grains are much smaller than others on the same individuals. No aperture can be seen. A new species may be represented, but material is inadequate for description.
Hypotype: USNM 211332.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.08	0.35	0–2

Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862

Genus *Ammodiscus* Reuss, 1862

Ammodiscus minimus Höglund

Ammodiscus minimus Höglund, 1947:124, pl. 8: figs. 5, 10; 110, fig. 90; 121, fig. 110.
Involutina minima (Höglund).—Todd and Bronnimann, 1957: 22, pl. 1: fig. 20.

Two finely but clearly arenaceous specimens occur in our material. They are similar to *Ammodiscus minimus,* as well as to *Ammodiscus gullmarensis* Höglund and could belong to that species. Both our material and comparative material are inadequate for certainty.

Hypotype: USNM 211237.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.02	0.14	0–1

Ammodiscus sp.

A single specimen from station 3 is so referred.
Hypotype: USNM 239906.

Genus *Glomospira* Rzehak, 1885

Glomospira glomerata Höglund

Glomospira glomerata Höglund, 1947:130, pl. 3. figs. 8–10; 111, fig. 104.—Todd and Bronnimann, 1957:22, pl. 1: fig. 21.

This species is very rare in our material.
Hypotype: USNM 211326.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.00	0.00	0

Glomospira gordialis (Jones and Parker)

Trochammina squamata Jones and Parker var. *gordialis* Jones and Parker, 1860:304 [type figure not given].
Glomospira gordialis (Jones and Parker).—Todd and Bronnimann, 1957:22, pl. 1: fig. 22.

This species is rare in our material. The form referred to *Glomospira gordialis* (Jones and Parker) by Cushman and Parker (1931:3, pl. 1: fig. 2) and that referred to *Glomospira* cf. *gordialis* (Jones and Parker) by Parker (1954:485, pl. 1: fig. 13) appear to be conspecific and to be more like that referred herein to *Glomospira* sp., as do some from northern localities. Their coiling pattern is closer to *Ammodiscus* than that of the present specimens. An unfigured specimen in the USNM collections referred to *Glomospira gordialis* (Jones and Parker) from Tongue of the Ocean is conspecific with our specimens.
Hypotype: USNM 211327, 211328.

	mean	standard deviation	range
station 1	0.73	0.79	0–3
station 3	0.23	0.59	0–3

Glomospira sp.

A single specimen from station 1 is so referred. Superficially it looks like *Ammodiscus* because all of the later several whorls are planispirally coiled, but in the initial area, the tube is coiled in the glomospirine manner. See the remarks under *Glomospira gordialis* regarding similar forms. These may represent a new species, but available material is insufficient to carry this matter further taxonomically.

Hypotype: USNM 211329.

Subfamily TOLYPAMMININAE Cushman, 1928

Genus *Lituotuba* Rhumbler, 1895

Lituotuba sp.

PLATE 1: FIGURES 1, 2

Rarely occurring specimens appear to belong to this genus. They may represent a new species, but material is insufficient for determination. These specimens appear most similar to *Lituotuba minuta* Collins, but direct comparison has not been made. Specimens are slightly to quite irregularly coiled initially and then develop a rectilinear extension, which appears broken in our individuals. It is clear that the specimens were attached from the flattened character of the underside. They are small for the genus and finely arenaceous.

Figured hypotype: USNM 211212.
Hypotype: USNM 211318.

	mean	standard deviation	range
station 1	0.42	0.85	0–3
station 3	0.02	0.14	0–1

Superfamily LITUOLACEA de Blainville, 1825

Family HORMOSINIDAE Haeckel, 1894

Subfamily HORMOSININAE Haeckel, 1894

Genus *Reophax* Montfort, 1808

Reophax nana Rhumbler

Reophax nana Rhumbler.—Parker, 1952:457, pl. 1: figs. 14, 15.—Parker, Phleger, and Peirson, 1953:13, pl. 1: fig. 11.—

Todd and Bronnimann, 1957:22, pl. 1: fig. 17.—Lankford, 1959, pl. 1: fig. 2.

This species is found in small numbers in many Discovery Bay samples.

Hypotype: USNM 211321.

	mean	standard deviation	range
station 1	1.31	2.53	0–14
station 3	0.60	1.07	0–4

Reophax sp.

Three broken, slightly twisted specimens cannot be identified to species. They are medium size for the genus, have medium sized, agglutinated, subcubic, mineral grains, and have short chambers.

Hypotype: USNM 211320.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.02	0.14	0–1

LITUOLIDAE

Family LITUOLIDAE de Blainville, 1825

Subfamily HAPLOPHRAGMOIDINAE Maync, 1952

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides sp.

A single, small, finely arenaceous, and smoothly finished foraminifer from station 3 is so referred. It has seven chambers in the peripheral whorl and narrow, slightly depressed sutures.

Hypotype: USNM 211330.

Haplophragmoides? sp.

PLATE 1: FIGURES 3, 4

Some arenaceous specimens are so assigned. They are very coarsely agglutinated and roughly finished. They appear involute on both sides. The number of chambers in the peripheral whorl cannot be determined with certainty because the sutures are only very slightly depressed, but there seem to be four or five. The aperture is obscured, as are most

features. Specimens are only slightly compressed and slightly, if at all, umbilicate. The genus is questioned because of the difficulty of determining the characters. It is possible that these specimens are more inflated and enrolled variants of *Ammobaculites exilis* Cushman and Bronnimann, with which they occur, but they seem better questionably placed in *Haplophragmoides*. The characters of both designated taxa are, however, difficult to discern in some cases; their walls look identical, and very few *Ammobaculites exilis* in this material are actually uncoiled.

Figured hypotype: USNM 211211.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 3	0.98	2.26	0–9

Subfamily LITUOLINAE de Blainville, 1825

Genus *Ammobaculites* Cushman, 1910

Ammobaculites exilis Cushman and Bronnimann

PLATE 1: FIGURES 5, 6

Ammobaculites exilis Cushman and Bronnimann, 1948b:39, pl. 7: fig. 9.—Bandy, 1956:192, pl. 30: fig. 3.

The holotype and numerous paratypes have been examined. The present specimens differ from them only in that very few are actually uncoiling. Primary types and present specimens are equally (very) coarsely arenaceous, usually fairly compressed (at least in the coiled portion), and have flush, obscure sutures in the coiled portion. Of the several species of *Ammobaculites* named by Cushman and Bronnimann from coastal Trinidad, our specimens certainly seem best referred to *A. exilis*. Interestingly, more of these species have been recognized in other parts of the Caribbean borders and related waters by different workers, while *A. exilis* apparently has only been recognized by Bandy off the west coast of Florida. Although some doubt has beeen raised by certain workers on the validity of Cushman and Bronnimann's species as distinct, when large populations are considered, their types as well as specimens referred to various of the species by others appear distinct.

Figured hypotypes: USNM 211205.
Hypotypes: USNM 211236.

	mean	standard deviation	range
station 1	2.31	6.02	0–32
station 2	0.81	1.38	0–7

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus *Textularia* Defrance, 1824

Textularia agglutinans d'Orbigny *in* de la Sagra

Textularia agglutinans d'Orbigny *in* de la Sagra, 1839:144, pl. 1: figs. 17, 18, 32–34.—Cushman, 1921:49, 11, fig. 3; 1922a: 22, pl. 1: fig. 6; 1941:1.—Todd and Bronnimann, 1957:24, pl. 2: fig. 13.

As well as the above-synonymized specimens, there are unfigured conspecific specimens in the USNM collections from Puerto Rico and off the southeast coast of the United States. A few specimens were found in the Discovery Bay samples. They are smaller and smoother than characteristic, but seem to belong to the species.

Hypotype: USNM 211219.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.17	0.43	0–2

Textularia? sp.

A single specimen from station 3 is so assigned. It is broken and the base is not present, so it is not possible to tell if it is biserial throughout. It is very small, coarsely arenaceous for its size, has depressed sutures, and has sides that flare only moderately.

Hypotype: USNM 211220.

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus *Trochammina* Parker and Jones, 1859

Trochammina cf. *T. advena* Cushman

A few specimens closely resemble this species, named from the Recent of the Dry Tortugas (Cushman, 1922a:20, pl. 1: figs. 2–4). Those from

Jamaica are, however, usually somewhat more compressed and smaller than the holotype, two paratypes (seen), and other examined specimens of *Trochammina advena,* such as those of Parker and Phleger (1951:9, pl. 4: fig. 15) and Parker (1954:502, pl. 5: figs. 5, 6) from the Gulf of Mexico. They also resemble some specimens referred to *Trochammina laevigata* Cushman and Bronnimann, named from the Recent of Trinidad. For example, they resemble some of those of Todd and Bronnimann (1957:30, pl. 4: figs. 17, 18), but they are much smaller, less smooth, and tend to have fewer chambers than the abundant primary types of *T. laevigata.*

As with some other forms found in this study, a new species may be represented, but material is inadequate for description or adequate comparison with described species. The relatively small size and numbers of these and other Trochamminas and similar forms *(Tiphotrocha* and perhaps *Rotaliammina)* of this collection may indicate that they are juveniles washed in from more congenial environments nearby and that normally do not live at the sampled sites as adults.

Hypotype: USNM 211224, 211225.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 2	0.25	0.56	0–3

Trochammina cf. *T. quadriloba* Höglund

Rarely occuring specimens are very similar to this species and may belong to it. All are quite small, however. They closely resemble the specimens ascribed to this species by Parker (1954:503, pl. 5: figs. 14, 15) from the northeast Gulf of Mexico. The material is inadequate for closer identification.

Hypotype: USNM 211226.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.13	0.39	0–2

Trochammina sp.

A single, distinct, well-preserved individual from station 3 cannot be further identified. It is a trochoid coil with all chambers visible on the spiral side and four on the umbilical. The sutures are depressed around the margin and on the umbilical side and almost flush on the spiral side. It is small and finely arenaceous. The aperture is very distinct, extraumbilical, at the base of the final chamber, semicircular, and with a lip.

Hypotype: USNM 211227.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Genus *Rotaliammina* Cushman, 1924

Rotaliammina aff. *R. mayori* Cushman

A few specimens belong to this genus. They may be conspecific with *Rotaliammina mayori* Cushman (holotype seen) from the Pacific or they may be a new species. Present specimens, however, are too few and poorly preserved (the test is very delicate) to attempt to resolve the problem at this time. The aperture appears nearly circular and umbilical.

Hypotype: 211323, 211324, 211325.

	mean	standard deviation	range
station 1	0.17	0.48	0–2
station 3	0.88	1.32	0–6

Genus *Tiphotrocha* Saunders, 1957

Tiphotrocha cf. *T. comprimata* (Cushman and Bronnimann)

Specimens of this form are too rare and too poorly preserved, especially on the ventral side, to be certain of their identification. They are very similar and may be conspecific with the holotype and 13 paratypes of *Trochammina comprimata* Cushman and Bronnimann (1948b:41, pl. 8: figs. 1–3) and the specimens so referred by Parker, Phleger, and Peirson (1953: p. 14, pl. 3: figs. 3, 4), Todd and Bronnimann (1957:30), and referred to *Tiphotrocha comprimata* (Cushman) by Saunders (1957:11, pl. 4: figs. 1–4; from the east coast of Trinidad), which all clearly are species, sensu stricto. Well preserved individuals from Discovery Bay certainly have the characteristic *Tiphotrocha* aperture of this, the type-species. The present specimens are, however, smaller. They have sometimes

been rather difficult to differentiate from the present *Rotaliammina* cf. *R. mayori* and more difficult to separate from *Trochammina* cf. *T. advena*, when the ventral side is poorly preserved. These and the Trochamminas of this collection may be juveniles.

Hypotype: USNM 211221, 211222.

	mean	standard deviation	range
station 1	0.10	0.37	0–2
station 3	0.27	0.57	0–3

Family ATOXOPHRAGMIIDAE Schwager 1877

Subfamily VERNEUILININAE Cushman, 1911

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina exilis Cushman and Bronnimann

PLATE 1: FIGURES 7, 8

Gaudryina exilis Cushman and Bronnimann, 1948b:40, pl. 7: figs. 15, 16.—Parker, Phleger, and Peirson, 1953:9, pl. 1: figs. 37, 38.—Todd and Bronnimann, 1957:26, pl. 2: figs. 24, 25.—Lankford, 1959, pl. 1: fig. 13.

The holotype and 20 paratypes have been examined, as well as numerous unfigured specimens from Todd and Bronnimann's collection. Low numbers of individuals occur in quite a few Discovery Bay samples.

The present population includes specimens that are more coarsely arenaceous in the early whorls than are most of the primary types, though, among them, grain size does vary also. We believe, however, that these Jamaica foraminifers are conspecific with Cushman and Bronnimann's. There is some degree of variation in the compression of the test and depression of the sutures among the present specimens, comparable to the primary types. There is, herein, some problem of differentiation from the form referred to *Gaudryina* cf. *G. exilis;* it is discussed under that taxon.

Figured hypotype: USNM 211207.

	mean	standard deviation	range
station 1	0.48	1.01	0–5
station 3	0.58	1.28	0–6

Gaudryina cf. *G. exilis* Cushman and Bronnimann

PLATE 1: FIGURES 9, 10

Specimens so assigned occur in low numbers in quite a few Discovery Bay samples. They are somewhat compressed and range in shape from (1) relatively long and thin and somewhat compressed throughout, though flaring from a sharp base, to (2) rapidly flaring from a sharp base to a relatively wide top, giving a subtriangular outline, but at the same time having only a slightly compressed apex, to (3) relatively wide from the base upward, flaring only moderately, and being compressed to about the same degree throughout, which compression is less than that of the first form but more than the apex of the second, and, overall, having a more subquadrate outline than either other form. The wall is coarsely arenaceous, with varying amounts of cement, and is roughly finished. Sutures are moderately depressed but obscured on some specimens, especially in the early portions. In the longer, thinner specimens, there are about four whorls of biserial chambers occupying about two-thirds to three-fourths of the test. Among the short, wide specimens, about two whorls of biserial chambers occupy about three-fourths of the test. The aperture is a slit at the base of the final chamber.

The main difference between this form and *Guadryina exilis* is the much more coarsely arenaceous character of the wall and perhaps the variability in the plan of growth (though more specimens would be needed to determine this with certainty). Among the longer, thinner specimens, however, a transition may almost be discerned with *G. exilis.* This occurs where neatly arranged specimens of *G.* cf. *G. exilis* have begun to agglutinate finer grains than usual in the final one or two chambers and, conversely, where specimens of *G. exilis* are relatively coarsely arenaceous in the earlier chambers (rather common in this population) and only late come to show the relatively fine grain size and fairly smooth finish characteristic of the species. This problem of grain size causes some difficulty in assignment of juveniles when some of the grains are fairly coarse. The present specimens may represent a new species, but material is inadequate for description.

Figured hypotype: USNM 211208.

	mean	standard deviation	range
station 1	0.17	0.52	0–3
station 3	0.56	1.05	0–4

Gaudryina sp.

Three specimens are so assigned; the species cannot be determined. These are subcircular in outline. The upper two-thirds to three-fourths of the test, comprising about the final two whorls, are biserial, while the early portion comprises about three to four whorls of triserial chambers. Sutures are slightly depressed. The aperture is a slit at the base of the final chamber. The wall is medium coarsely to finely arenaceous, with considerable cement, though not very smoothly finished. The cement represents the most significant discernible difference between this form and *Gaudryina?* sp., with the latter being coarsely arenaceous and seeming to contain relatively little cement. *Gaudryina* sp. is less compressed, has less depressed sutures, and seems to tend to be shorter as well as wider, and is more finely arenaceous than *G.* cf. *G. exilis*. It is more inflated and flaring and has less depressed sutures than *G. exilis*.

Hypotype: USNM 211299.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.06	0.24	0–1

Gaudryina? sp.

Two specimens are so assigned. They are subcircular in outline at the apex, rising from slightly compressed early portions. They are biserial in the final chambers and the aperture is a slit along the base of the final chamber. The very coarsely arenaceous and roughly finished character at the wall obscures the sutures and makes uncertain the determination of number of chambers per whorl in the early portion, causing the questionable generic assignment. These specimens are more inflated and have more obscure sutures than *Gaudryina* cf. *G. exilis*. They are more coarsely arenaceous than *Gaudryina* sp.

Hypotype: USNM 211300.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.00	0.00	0

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus *Eggerella* Cushman, 1933

Eggerella cf. *E. advena* (Cushman)

Two specimens resemble this northern species, but are less robust and more finely arenaceous. The sutures are deeply incised and the chambers rounded and clearly visible. The sides are nearly parallel throughout. The tests are orange and very finely arenaceous.

Hypotype: USNM 211229.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.00	0.00	0

Eggerella cf. *E. humboldti* Todd and Bronnimann

PLATE 1: FIGURES 11, 12

These few specimens from Discovery Bay have been compared with numerous primary types of *Eggerella humboldti*. They are very similar and may be conspecific with *Eggerella humboldti* Todd and Bronnimann (1957:26, pl. 2: fig. 26) from the Gulf of Paria. If, however, that is the case, almost all the present individuals are juveniles, as they are smaller than adults of the species and have fewer whorls and chambers. Further, they appear slightly more coarsely arenaceous.

Figured hypotype: USNM 211206.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.23	0.66	0–4

Genus *Karreriella* Cushman, 1933

Karreriella? sp.

Two specimens appear to have the generic characters of *Karreriella* except that they are coarsely arenaceous. They taper rapidly from the pointed base to a subcircular top. They cannot be assigned to a species.

Hypotype: USNM 211331.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.02	0.14	0–1

Subfamily VALVULININAE Berthelin, 1880

Genus *Clavulina* d'Orbigny, 1826

Clavulina tricarinata d'Orbigny

PLATE 1: FIGURES 13, 14

Clavulina tricarinata d'Orbigny, 1839:111, pl. 2: figs. 16–18.—Cushman, 1921:52, pl. 12: fig. 2; 1922a:29, pl. 3: fig. 3; 1922d:89, pl. 17: figs. 3, 4; 1937:23, pl. 3: figs. 2, 3; 1941:2, pl. 1: fig. 1.

This species occurs in low numbers in quite a few Discovery Bay samples; a relatively high percent of these living specimens are juveniles, however, and empty tests of adults are not uncommon. This suggests, as with some other relatively rare forms, that the species mainly lives farther offshore or in another environment and is washed into what is not a particularly hospitable environment.

There is a good deal of variation among the forms referred to this species, but this is in keeping with that seen in populations from other sites. The juveniles could be referred to *Valvulina* if the growth stages were not observed; *Valvulina oviedoiana* d'Orbigny is commonly found in the Caribbean area. Juveniles of *Clavulina tricarinata* could be assigned to this species, or vice versa, though the adults are distinct. This is unlikely in the present material, however, as no adult *Valvulina oviedoiana* have been found. Dead tests of *Clavulina nodosaria* d'Orbigny, which is commonly found with *C. tricarinata,* have been observed in our material, but no living specimens.

Figured hypotype: USNM 211204.

Hypotype: USNM 211343, 211344, 211345, 211346.

	mean	standard deviation	range
station 1	0.52	1.07	0–6
station 3	0.52	0.88	0–3

Suborder MILIONINA Delage and Herouard, 1896

Superfamily MILIOLACEA Ehrenberg, 1839

Family FISCHERINIDAE Millett, 1898

Subfamily CYCLOGYRINAE Loeblich and Tappan, 1961

Genus *Cyclogyra* Wood, 1842

Cyclogyra planorbis (Schultze)

Cornuspira planorbis Schultze, 1854:49, table 6: figs. 16, 17.—Phleger and Parker, 1951:8, pl. 4: figs. 8, 9.—Todd and Bronnimann, 1957:30, pl. 4: fig. 8.
?*Cornuspira involvens* (Reuss).—Cushman, 1921:62; 1922a:58; 1941:7.—Cushman and Parker, 1931:5, pl. 2: fig. 1.

Most samples contain a few specimens of this widespread species. Many conspecific and probably conspecific specimens from the Caribbean and elsewhere have been referred to *Cyclogyra involvens* (Reuss), named from the Tertiary of Germany. If these two specific names represent conspecific forms, *C. involvens* has priority (originally named *Operculina involvens* by Reuss in 1850). The original descriptions, however, suggest that different species are represented and that what has occurred is that many *C. planorbis* have been referred to *C. involvens,* especially in earlier years.

With respect to the above-cited specimens referred to *C. involvens* as well as other unfigured specimens from the localities involved in the above citations and Puerto Rico and Tongue of the Ocean, we question the synonymies. We do so because *C. involvens* is conceived as being larger, with more whorls than *C. planorbis.* This is certainly true of some specimens. This may very well be a gradational difference in any one population, however, and may vary among populations and not constitute a valid specific difference. Populations of specimens from locations involved in the above citations and others would need to be seen to determine the variations and their taxonomic significance. If two species are represented in this Recent material, it seems likely that the large, many-whorled forms referred to *C. involvens* should better be referred to *Cyclogyra incerta* (d'Orbigny), named in 1839 from the Recent of Cuba and Martinique (as *Operculina incerta*). It is interesting

to note that in naming *planorbis,* Schultze questioned its possible synonymy with *C. incerta.*

Hypotype: USNM 211348.

	mean	standard deviation	range
station 1	3.85	7.56	0–41
station 3	0.81	1.48	0–7

Family SORITIDAE Ehrenberg, 1839

Subfamily PENEROPLINAE Schultze, 1854

Genus *Peneroplis* Montfort, 1808

Peneroplis bradyi Cushman

Peneroplis bradyi Cushman, 1930:40, pl. 14: figs. 8–10.

This species differs from *Peneroplis proteus* d'Orbigny mainly in being greatly compressed. Although Cushman indicated this species as being common in the West Indian region, we found only one individual at station 3.

Hypotype: USNM 211294.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Peneroplis pertusus (Forskal)

Nautilus pertusus Forskal, 1775:125 [Brady, 1884, pl. 13: figs. 16, 17, 23].
Peneroplis pertusus (Forskal).—Cushman, 1921:75, pl. 18: figs. 7, 8; 1930:35, pl. 12: figs. 3–6.—Bock, 1971:34, pl. 13: fig. 10.

This species occurs with low abundances in most samples. Size is highly variable, but other characters are not. Only two specimens show any sign of uncoiling. The specimens from our collection are identical to the types deposited in the USNM collections by Cushman and Bock.

Unlike *Peneroplis proteus* d'Orbigny and *Archaias angulatus* (Fichtel and Moll), this species has not been reported from northeastern Gulf of Mexico or off the coast of South Carolina. Perhaps southern Florida is the limit of its northward extension.

Hypotype: USNM 211295.

	mean	standard deviation	range
station 1	1.06	1.63	0–7
station 3	1.44	1.61	0–9

Peneroplis proteus d'Orbigny

Peneroplis proteus d'Orbigny, 1839:60, pl. 7: figs. 7–11.—Cushman, 1921:75, figs. 13–16, pl. 18; figs. 18, 19.—Phleger and Parker, 1951:11, pl. 6: fig. 6.—Todd and Low, 1971:11, pl. 1: fig. 10.—Bock, 1971:34, pl. 13: fig. 11.

This species is abundant and highly variable. In our material most specimens do not exhibit a flaring portion. Perhaps they are juvenile. This, however, is not certain because some of these involute individuals are as large or larger than individuals that flare. Some specimens have an acute periphery and resemble *Peneroplis carinatus* d'Orbigny. All gradations are seen in the individuals, and some specimens with an acute periphery also flare. Descriptions and type specimens in the USNM collections indicate *P. carinatus* does not. Consequently, we have included these individuals under *P. proteus.*

In addition to the specimens synonymized above, specimens in the USNM collections from Charleston, South Carolina closely resemble ours.

This species has a distribution that extends throughout the Caribbean. Bock (1971) indicated it is present in most parts of Florida Bay. Phleger and Parker (1951) and Bandy (1956) recorded this species from the shallow water of the Gulf of Mexico.

Hypotype: USNM 211296.

	mean	standard deviation	range
station 1	0.65	1.00	0–4
station 3	2.23	2.28	0–8

Subfamily ARCHAIASINAE Cushman, 1927

Genus *Archaias* Montfort, 1808

Archaias angulatus (Fichtel and Moll)

Nautilus angulatus Fichtel and Moll, 1803:113, pl. 22: figs. a–e.
Archaias angulatus (Fichtel and Moll).—Cushman, 1930:46, pl. 16: figs. 1–3, pl. 17: figs. 3–5.—Bandy, 1956:192.—Todd and Low, 1971:12, pl. 1: fig. 5.—Bock, 1971:35–36, pl. 14: figs. 1–3.

This species is not very abundant in our material.

Like *Peneroplis proteus,* specimens exhibiting a flaring portion are rare. Most individuals are involute and, except for chamberlets, closely resemble *P. proteus.*

Regarding the specimens cited above, of those illustrated by Cushman, only one specimen (illustrated in pl. 16: fig. 3) was observed in the USNM collection. This specimen is very large and flaring. The specimens deposited by Bandy in the USNM collection range from the involute sorts observed in our material to the large flaring sorts that are usually illustrated. Specimens in the Cushman collection (USNM) also consist of specimens that range from completely involute to large, flaring individuals.

This species has a wide Caribbean distribution. Bandy (1956) reported it as a major constituent of his 41- to 105-foot depth zone in the northeastern Gulf of Mexico. Todd and Low (1971) indicated that *Archaias angulatus* and *Peneroplis proteus* dominate the fauna on the Bahama Bank and Bock (1971) cited *Archaias angulatus* as occurring at 95 of 198 stations in Florida Bay and adjacent waters.

Hypotype: USNM 211283.

	mean	standard deviation	range
station 1	0.15	0.50	0–3
station 3	0.17	0.52	0–3

Suborder ROTALIINA Delage and Hérouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus *Lenticulina* Lamarck, 1804

Lenticulina sp.

A single broken specimen has been identified as a juvenile specimen of *Lenticulina* sp. This specimen is insufficiently diagnostic to allow further classification.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.00	0.00	0

Family GLANDULINIDAE Reuss, 1860

Subfamily GLANDULININAE Reuss, 1860

Genus *Esosyrinx* Loeblish and Tappan, 1953

Esosyrinx? sp.

A single, distinct specimen has been so assigned. It consists of a rather compressed test with rounded margins, having three chambers reminiscent of some elongate *Lenticulina* in arrangement. The sutures are slightly limbate and are flush except where the third chamber meets the second and first chambers on the margin. The slitlike aperture is either not radiate or only slightly so, but has an entoselenian tube. The wall is optically radial, smooth, with small pores, and is translucent up to just below the aperture and along the margins, where it becomes transparent. The entoselenian tube appears to place it in the Glandulinidae, but it is also reminiscent of some of the Nodosariidae, Polymorphinidae, and Pleurostomellidae. With one specimen, which may be juvenile, it is impossible to determine if the plan of growth is biserial in the glandulinid sense or coiled in the nodosariid sense. If the former is the case, *Esosyrinx* appears the best generic reference. Closer identification is impossible.

Hypotype: USNM 211230.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.00	0.00	0

Genus *Laryngosigma* Loeblich and Tappan, 1953

Laryngosigma sp.

A single, distinct specimen from station 3 is so referred. More specimens would be needed to identify it specifically. It is very similar to and may be conspecific with the form identified from the Gulf of Paria as *Laryngosigma williamsoni* (Terquem) by Todd and Bronnimann (1957:32, pl. 5: fig. 24). This individual also is very similar to and may be conspecific with that from Montego Bay, Jamaica, referred to *"Polymorphina* cf. *vitrea* (d'Orbigny)" by Cushman (1921:54, fig. 2, pl. 12: fig. 4). Some other very similar specimens are found in the USNM collections (unfigured) identified as *"Sigmomorphina* cf. *semitecta* (Reuss) var. *terquemi-*

ana (Fornasini)." These are from off the southeast coast of the United States.

Hypotype: USNM 211333.

Subfamily OOLININAE Loeblich and Tappan, 1961

Genus *Fissurina* Reuss, 1850

Fissurina cf. *F. agassizi* Todd and Bronnimann

One specimen occurred in this material. It appears to differ from *Fissurina agassizi* Todd and Bronnimann (1957:36, pl. 9: fig. 14) in being slightly compressed throughout and in having a less lengthy aperture. It differs from *Fissurina goreaui,* new species, in being more pyriform and in having the aperture a more elongate and narrower and more produced slit. It is also similar to *Fissurina compressa* (d'Orbigny), but appears distinct; the margin of that species is different, as described and figured by d'Orbigny. It is, further, similar to *Oolina laevigata* d'Orbigny. D'Orbigny distinguished between "*O. compressa*" and "*O. laevigata*" on the basis that the latter is equally inflated throughout and not at all compressed. He gave no apertural view, but simply stated that the aperture is acuminate. There is no mention of a neck or internal tube. The present form is slightly compressed and has a slit-like aperture. No internal tube is seen. The taxonomic assignment given here is open to question, but insufficient material is present to pursue the matter further.

Hypotype: USNM 211231.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Fissurina cf. *F. milletti* Todd

A few specimens in the Discovery Bay samples most closely resemble this species described from the Marshall Islands. The pores are finer, however, and the neck and keel not so well developed. The Discovery Bay specimens also show a few faint striations rising from the base to about one-fourth to one-third of the way up the test. A new species may be represented here, but the material is inadequate for description.

Hypotype: USNM 211232.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.06	0.24	0–1

Fissurina goreaui, new species

PLATE 1: FIGURES 15–18

Test very small, smooth, occasionally slightly mucronate, rather compressed and equally so throughout, with rounded margin sometimes marked by clear bands of shell material in the otherwise translucent wall; aperture a short, rather wide slit, not protruding, internally containing an entoselenian tube running approximately one-fourth the test length.

Fissurina goreaui differs from *F. agassizi* Todd and Bronnimann in being less pyriform and in having the aperture less elongate, wider and less (not) protruding. The species is named after the late Dr. Thomas F. Goreau, founder of the Discovery Bay Marine Laboratory.

Descriptive statistics of the height, width, and thickness measured in mm for the holotype and four paratypes are:

	mean	standard deviation	range
height	0.138	0.009	0.125–0.150
width	0.097	0.004	0.090–0.100
thickness	0.074	0.014	0.060–0.095

Figured holotype: USNM 211210.
Figured paratype: USNM 211209.

	mean	standard deviation	range
station 1	0.13	0.73	0–5
station 3	0.08	0.28	0–1

Superfamily BULIMINACEA Jones, 1875

Family TURRILINIDAE Cushman, 1927

Subfamily TURRILININAE Cushman, 1927

Genus *Buliminella* Cushman, 1911

Buliminella elegantissima (d'Orbigny)

PLATE 1:FIGURES 19, 20

Bulimina elegantissima d'Orbigny, 1839:51, pl. 7: figs. 13, 14.
Buliminella elegantissima (d'Orbigny).—Cushman and Parker,

1931:13, pl. 3: figs. 12, 13.—Phleger and Parker, 1951:17, pl. 8: figs. 3, 4.—Parker, Phleger, and Peirson, 1953:6, pl. 4: figs. 8, 9.—Bandy, 1956:193.—Todd and Bronnimann, 1957: 32, pl. 8: figs. 1, 2.—Lankford, 1959, pl. 2: fig. 16.

The specimen represented by Figure 13 of Cushman and Parker is missing and thus has not been examined. As well as the above synonymized specimens, many conspecific Recent unfigured specimens in the USNM collections from off the southeast coast of the United States, Antigua (Caribbean), and Rio de Janeiro Harbor have been examined.

This well-known and widespread species is found in low numbers in many of our samples.

Figured hypotype: USNM 211182.

	mean	standard deviation	range
station 1	1.46	1.61	0–6
station 3	0.92	1.24	0–5

Buliminella milletti Cushman

PLATE 1: FIGURES 21, 22

Buliminella milletti Cushman, 1933:78, pl. 8: figs. 5, 6.—Todd and Low, 1971:12, pl. 2: fig. 13.

Rare specimens in this material compare well with primary types (holotype and three paratypes) from Fiji and with other unfigured specimens from Fiji and the Caribbean in the USNM collections—from Montego Bay, Jamaica; Antigua; and the Dry Tortugas (many specimens). Favorable comparison also is made with the figures given by Hofker (1956:44, pl. 4: figs. 3, 4) from off Frederickstad.

Figured hypotype: USNM 211181.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.21	0.50	0–2

Buliminella parallela Cushman and Parker

PLATE 1: FIGURES 23, 24

Buliminella parallela Cushman and Parker, 1931:13, pl. 3: fig. 15.

Rare specimens in the Discovery Bay material compare well with primary types (holotype and one paratype) from Rio de Janeiro Harbor and with other Recent (unfigured) specimens in the USNM collections from shallow water in Rio de Janeiro

Harbor, the Falkland Islands, the Dry Tortugas, and Antigua.

Figured hypotype: USNM 211180.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.27	0.57	0–2

Family BOLIVINITIDAE Cushman, 1927

Genus Bolivina d'Orbigny, 1839

Bolivina cf. B. compacta Sidebottom

As Sliter (1970:157) pointed out, considerable confusion appears to exist in taxonomy among Bolivina compacta Sidebottom, Bolivina variabilis (Williamson), and Bolivina doniezi Cushman and Wickenden, apparently resulting from the fact that these species are quite similar. In the present material, the early portions of some specimens also resemble certain Bolivina subexcavata Cushman and Wickenden in their uneven, grainy appearance, with a thin but rectangular, not sharp, margin. Separation has been difficult in some cases and certain robust specimens could be placed in B. variabilis. Difficulties surrounding the taxonomy of these species have led to the present designation, however. The taxonomic problem is beyond the scope of this study, farther than it has been taken. Tentatively, these specimens appear best referred to B. compacta, although, in general, they differ from the examined topotype sent to the USNM collections by Sidebottom from Delos in being a bit smaller and less flaring, and with a more even pore pattern and smoother walls.

Most specimens in the USNM collections referred to B. compacta are larger, more compressed, have sharper margins than the present specimens and the topotype, and are opaque, with slightly roughened walls. Specimens referred to B. variabilis tend to be less compressed, with rounded margins, more depressed sutures, and a translucent to transparent wall, in which the pores show clearly. It may be that the difference in transparency or opacity has had too strong an influence in assignment of specimens. Bolivina doniezi, as here understood, has a distinct pore pattern, usually with few but large pores usually in lines along and/or parallel to the sutures, often flares quite rapidly, is a quite small

species, with distinct, depressed narrow sutures, and a smooth, translucent wall.

Specimens here referred to *Bolivina* cf. *B. compacta* range from smooth and superficially opaque to smooth and translucent, have a rounded margin, at least in the adult portion, have small to medium, fairly evenly distributed pores, very slightly to fairly depressed, narrow sutures, with depression concomitant with degree of compression of test, which varies slightly, and usually a rather wide final chamber that almost crosses the test, with slit-like aperture rising from the base about two-thirds to three-fourths the way up the chamber. Too few specimens are present to get a good cross section of a population. This also adds to the taxonomic difficulties.

Comparison with other Caribbean specimens in the USNM collections shows that the specimen from the Dry Tortugas identified as *Bolivina compacta* Sidebottom by Cushman (1922a:26, pl. 1: fig. 10) does not appear conspecific with the present and some other specimens referred to *Bolivina compacta,* but preservation may have changed the appearance of the wall. There are three unfigured specimens from Old Providence Island assigned to *Bolivina compacta* by Cushman. Of these, one is a characteristic *Bolivina doniezi,* one transitional between *B. doniezi* and the present *B.* cf. *B. compacta* and one probably conspecific with *B.* cf. *B. subexcavata* of this report. The specimen from the Gulf of Paria figured by Todd and Bronnimann (1957:35, pl. 8: fig. 31) as *Bolivina variabilis* (Williamson) probably is conspecific with the present specimens (which, as mentioned previously, could be *B. variabilis*). Most others designated *B. variabilis* (unfigured) collected by Bronnimann for their study do not appear to be. We would refer some to *Bolivina striatula* and others to other similar species not represented in the present study, such as *Bolivina pseudopunctata* Höglund of Todd and Bronnimann (1957:33, pl. 8: fig. 11). This probably reflects the great taxonomic problems in dealing with Bolivinas of this sort; different populations exhibit different morphologic parameters.

Hypotype: USNM 211238, 211240.

	mean	standard deviation	range
station 1	0.38	0.73	0–3
station 3	0.56	0.82	0–3

Bolivina doniezi Cushman and Wickenden

PLATE 1:FIGURES 25–28

Bolivina doniezi Cushman and Wickenden, 1929:9, pl. 4: fig. 3.—Cushman, 1937:140, pl. 19: fig. 6.

See the comments under *Bolivina* cf. *B. compacta* Sidebottom for further taxonomic comparison. The holotype and 11 paratypes of *Bolivina doniezi* were examined.

This species appears in low numbers but in many samples of this study. Perhaps its most distinguishing characteristic is its pore pattern. The pores are relatively large and at least in the early part of the test are densely concentrated in lines along the bases of the chambers. The wall is smooth and translucent in most individuals. In some cases the early portion shows some secondary thickening. The test shape in lateral view tends to be rapidly flaring, with a rounded apertural end. It is somewhat inflated but narrows toward the margins, with a rounded periphery. The sutures are narrow, straight to arcuate, and slightly depressed. Sutures and chambers are rather irregularly arranged. Chambers increase in relative height in the later one-half to two-thirds of the test. Three specimens were examined for wall structure and found optically radial.

Although specimens generally conform to the above description, some latitude has been allowed in the assignment of individuals to this species. First, some tend to become nearly parallel sided. These almost form a distinct group, but complete gradation to rapid flaring can be seen. These nearly parallel-sided specimens approach some *Bolivina striatula* Cushman, and especially so if the pores are not markedly larger than those of that species. Second, some large specimens with fairly evenly distributed pores in much of the test resemble *Bolivina variabilis* (Williamson) rather closely, though they are thought best retained in *B. doniezi* here. Some specimens superficially resemble smoother specimens of *Bolivina subexcavata* Cushman and Wickenden, though close examination immediately reveals significant differences. The problem of assignment to *B. doniezi* is here complicated because of the small numbers present and, hence, the difficulty of determining the morphologic limits of the population.

Figured hypotypes: USNM 211157, 211158.

Hypotype: USNM 211241, 211242.

	mean	standard deviation	range
station 1	3.81	3.29	0–16
station 3	3.65	3.10	0–16

Bolivina lowmani Phleger and Parker

Bolivina lowmani Phleger and Parker, 1951:13, pl. 6: figs. 20, 21.—Parker, Phleger, and Peirson, 1953:6, pl. 4: fig. 1.—Parker, 1954:515, pl. 7: fig. 21.—Todd and Bronnimann, 1957:33, pl. 8: fig. 18.—Lankford, 1959, pl. 3: fig. 4.

The holotype and one paratype have been examined. A single individual, distinct and clearly belonging to this species, was found at station 3. Hypotype: USNM 211243.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Bolivina paula Cushman and Cahill

PLATE 2: FIGURES 1, 2

Bolivina paula Cushman and Cahill, in Cushman and Ponton 1932:84, pl. 12: fig. 6.—Cushman, 1937:91, pl. 11: fig. 9.—Cushman and McGlamery, 1938:107, pl. 25: figs. 14, 18, 19.—Parker, 1954:516, pl. 7: fig. 26.

The holotype, from the Miocene Yorktown, has been examined. There are many Miocene and Oligocene specimens from the Atlantic Coastal Plain in the USNM collections. Most of these seem conspecific with the present specimens, though some populations include forms similar to smooth Bolivina striatula Cushman (differentiation between these two in the present material has sometimes been hard to make). Some others of these Tertiary specimens resemble Bolivina compacta Sidebottom and, rarely, Bolivina cf. B. subexcavata Cushman and Wickenden of this report, and some other unfamiliar forms.

The specimens, figured and unfigured, collected for Todd and Bronnimann's study of the Gulf of Paria (Trinidad) and named Bolivina sphathulata Williamson (Todd and Bronnimann, 1957:34, pl. 8: figs. 22, 23) are similar to Bolivina paula of this study. Some could be taken as conspecific (as Figure 22), but as a population they are sharper margined and some have short, strong costae on the pro-

loculus. Unfortunately, the present population is too small for good comparison.

Bolivina paula is rare in the present material. Specimens so assigned all have compressed tests, with slightly rounded, smooth, nonlobate, peripheries, fairly rapidly flaring sides that sometimes become subparallel in later parts of relatively long specimens, smooth, shiny, transparent to translucent surfaces, and have very distinctive, quite limbate sutures, neatly arranged, rather arcuate, in early stages especially, which become more limbate or show a sharp curve toward the median line. They have vertically narrow but wide chambers; wall with pores with a marked tendency to be concentrated in lines along the bases of chambers and less dense elsewhere; and aperture a fairly broad slit reaching down from the center or lower on the apertural face to the base, with a tooth plate extending down to the previous chamber. In this material, B. paula has been distinguished from smooth B. striatula by the distinctive sutures, shape of chambers, pore pattern, and usually larger number of chambers in the early part of the test, and smaller proloculus.

Figured hypotype: USNM 211156.
Hypotype: USNM 211244.

	mean	standard deviation	range
station 1	0.27	0.54	0–2
station 3	1.12	1.10	0–4

Bolivina rhomboidalis (Millett)

PLATE 2: FIGURES 3, 4

Textularia rhomboidalis Millett, 1899:559, pl. 7: fig. 4.

The form from the Dry Tortugas referred to Bolivina rhomboidalis (Millett) by Cushman (1922a:28) appears to belong to a species not here represented. Of five unfigured specimens from Old Providence Island identified as Bolivina rhomboidalis (Millett) by Cushman (Cushman, 1941:10), four are certainly best referred to that species, while one is much closer to B. subexcavata of this report. The specimen from Florida Bay figured as Bolivinita rhomboidalis (Millett) by Lynts (1965:69, pl. 7: figs. 5, 6) certainly appears conspecific with Bolivina rhomboidalis of this report, but has not been seen.

The few specimens here referred to Bolivina

rhomboidalis (Millett) intergrade with the abundant *Bolivina subexcavata* Cushman and Wickenden. In other populations the *B. rhomboidalis* form predominates to a greater or lesser degree; evidence suggests that these two represent subspecies. *Bolivina rhomboidalis* may be separated from others by the extreme rhomboidness of the outline and, in some cases, lobation of the longitudinal ridges that form the corners or edges in this form. Interestingly, most Discovery Bay specimens with this morphology were dead, therefore not retained. They probably washed in from deeper water or another nearby environment. Other transitional-appearing specimens have also been included here in *B. rhomboidalis* when their morphology appeared closer to characteristic *B. rhomboidalis* than characteristic *B. subexcavata*.

Figured hypotype: USNM 211155.

	mean	standard deviation	range
station 1	0.81	1.06	0–4
station 3	1.02	1.12	0–4

Bolivina striatula Cushman

PLATE 2: FIGURES 5–10

Bolivina striatula Cushman, 1922a:27, pl. 3: fig. 10; 1941:10.—Cushman and Parker, 1931:16, pl. 3: fig. 21.—Parker, Phleger, and Peirson, 1953:6, pl. 4: figs. 4, 5.—Bandy, 1954: 135, pl. 31: fig. 9; 1956:193.—Todd and Bronnimann, 1957:34, pl. 8: figs. 12–16.—?Lankford, 1959, pl. 3: fig. 6.

The holotype and four paratypes have been examined. All but one paratype are from the Dry Tortugas collection and the other from the Johnson Smithsonian Expedition Station 104. All but one paratype are "microspheres" and show little variation. They are longer than most of our specimens and all have striations, but the conspecificity is clear. (One specimen out of our entire large collection could be assigned to the subspecies *spinata* erected by Cushman, but we have retained it sensu stricto.) The specimen questioned in the synonymy, designated by Lankford, probably is conspecific, but it is quite small and more lobate than characteristic; a population of his specimens would need to be examined for certainty. All specimens (hundreds) designated *Bolivina striatula* Cushman in the USNM collections have been examined. Within certain parameters of variation, they form a very distinct and recognizable species. Of this

group, most are from off Jacksonville, Florida; Canaveral, Florida; Onslow Bay, North Carolina; Charleston, South Carolina; and Eniwetok, Rogerik, and other Marshall Islands. All are Recent. Other localities are Gulf of Paria; Dry Tortugas; Rio de Janeiro Harbor; off Old Providence Island (Caribbean); Vineyard Sound, Massachusetts; and Cochin, South India. One Miocene specimen is from Buff Bay, Jamaica.

The test is medium sized for genus, though varying considerably among specimens. The ratio of length to width is considerably variable, with larger specimens tending to have parallel sides and greater ratios. The test is biserial throughout, with a tendency for the final chamber to approach uniseriality, especially with larger specimens. It is compressed, with flat surfaces and rounded margins. The sides in "megalospheres" (with very large proloculi) are subparallel or only flaring slightly, especially in medium-sized specimens or up to last two or three chambers, which tend to flare more in larger specimens, "microspheres" tend to flare more rapidly from the base, forming triangular small- or medium-sized specimens or flaring initially, then becoming subparallel with medium- to large-sized specimens, with the final two or three chambers flaring again with some large individuals. Some individuals are slightly bent with a slightly curved outline and axis. The periphery is rounded, smooth to slightly lobate, often becoming slightly more lobate with final two or three chambers. The chambers number 10 to 19 and are not inflated to slightly inflated, with a tendency for slight increase in inflation in the final two or three chambers. Early chambers may be narrow and subrectangular to narrow and arcuate or subrounded, the first becoming higher in the latter part of test, with or without other change in basic shape. The change, if occurring, is to subrounded, especially in the final two or three chambers of larger specimens, with other specimens maintaining the subrounded chamber shape throughout. The subrounded chambers have a small lobe near the center of the lower surface, formed by a lobe in the suture below. The chambers are overlapping, from slightly to considerably initially and, if slightly initially, increasing in ontogeny, especially in the last two or three chambers. The proloculus is pronounced, large for genus, especially in "megalopheres," forming a wide, dish-shaped base of test. Sutures

usually are narrow, occasionally limbate in at least part of the test, flush to slightly depressed, may be flush in the early part, becoming slightly depressed, especially between the last two or three chambers, or may be slightly depressed throughout and slightly more so between the last two or three chambers, though giving a nearly straight margin except in the last two or three chambers of some (usually larger) specimens. The suture shape is straight to slightly arcuate to slightly sinuate with a small downward projection or lobe; shape may change in ontogeny or not, commonly with those specimens with straight or arcuate early sutures developing the downward lobe later in ontogeny, especially of large specimens, while some specimens show this lobate suture throughout or through some part (early, mid, or late) of ontogeny with straight or arcuate sutures in other parts. The angle of straight sutures and projected angle of arcuate sutures is usually not greatly downward from the horizontal. Lack of pores at the top of some chambers and median areas gives some sutures a superficial limbate appearance. Striations and wall roughening sometimes obscure sutures, especially in the early part of test. The wall is optically radial, basically thin, transparent to translucent to opaque, variable among specimens and, sometimes, from one part of a specimen to another, it is most commonly transparent at least in the latter part of the test, especially with the final two or three chambers and where pores are absent or not dense. The degree of translucence is usually due to denseness of pores. Opacity is due especially to the presence of abundant thin striations and, with some individuals, slight roughening of the wall surface or simply an opacity of the wall. These opaque characteristics are usually developed in the lower one-third to one-half of the test and seldom extend to the final two or three chambers. The pores range from small to medium large in size. They are clearly visible where the wall is not opaque. They are unevenly distributed and absent on the proloculus, often absent on much of the final chamber, sometimes also on the top parts of the second and third last chambers, especially on larger specimens, and are also absent on some individuals on top thirds to halves of groups of chambers in the lower part of the test and in subcircular patches at the inner margins of chambers, giving transparent walls to those areas and areas where pores are not dense,

translucence often produced where pores are smaller and denser. Pores appear related to striations in some cases, with some appearing lined up in vertical rows parallel to or along which the striations run. These striations usually are very narrow and variable in density and individual length and length of test covered, most commonly dense in the area covered and often accompanied, in the lower part especially, by slight roughening and/or opacity of wall, running in individual length from less than one chamber to numerous chambers, this variable distribution common to most striate specimens. Specimens vary from totally nonstriate to covered with striations, though usually striations are most abundant on the lower one-third to one-half of the test and seldom extend onto the last two or three chambers, especially the final chamber. Of 50 specimens examined for this character, two-thirds were striate. The aperture is slitlike to ovate, reaching from the base to one-half to all the way to the apex of the final chamber, with more slitlike forms tending to be longer. Many specimens have thin, raised, curved apertural rims, with the apertural face slightly depressed (or a depression existing around the aperture) in many specimens, and with a thin, bladelike tooth sometimes occupying the center of the aperture.

Figured hypotypes: USNM 211152, 211153, 211154.

Hypotypes: USNM 211245, 211246, 211247.

	mean	standard deviation	range
station 1	33.94	16.19	10–89
station 3	27.17	14.98	3–73

Bolivina subexcavata Cushman and Wickenden

PLATE 2: FIGURES 11–22

Bolivina subexcavata Cushman and Wickenden, 1929:9, pl. 4: fig. 4.—Todd and Bronnimann, 1957:34, pl. 8: fig. 29.
Bolivina plicatella Cushman.—Cushman and Parker, 1931:15, pl. 3: fig. 19.—Cushman, 1937:89, pl. 16: fig. 21.
Bolivina plicatella Cushman var. *mera* Cushman and Ponton.—Todd and Bronnimann, 1957:33, pl. 8: fig. 30.

There seems strong likelihood that *Bolivina subexcavata* Cushman and Wickenden, *Bolivina plicatella* Cushman, *Bolivina plicatella* Cushman subsp. *mera* Cushman and Ponton, and *Bolivina pseudoplicata* Heron-Allen and Earland may all be the same species. Primary types (holotype and seven

paratypes of *B. subexcavata,* holotype and four paratypes of *B. plicatella,* and holotype and nine paratypes of *B. plicatella* subsp. *mera*) of all but *B. pseudoplicata* have been examined, and, of *B. pseudoplicata,* several types designated by Earland have been examined. The relatively small number of specimens available in each case, the differences in preservation, and the probable geographic variation cause enough uncertainty that synonymy is not clear cut. The fact that *B. plicatella* and *B. plicatella* subsp. *mera* were named from the Miocene, while *B. subexcavata* and *B. pseudoplicata* were named from the Recent could indicate a possibility of evolution or that similar but not conspecific species lived at different times, but by no means necessarily. Though not synonymizing definitely herein, the name *Bolivina subexcavata* has been chosen for the abundant Discovery Bay specimens because it has priority in time. (The relationship to earlier named *Bolivina rhomboidalis* (Millett) is discussed under that species.)

Regarding the above synonymized and possibly synonymous forms, a few comments follow. Todd and Bronnimann's specimens are not well preserved, causing some difficulty. The figured specimen and most of the 14 unfigured from the same Gulf of Paria collection assigned to *Bolivina subexcavata* fall within the present understanding of the species; one, however, clearly is a *B. doniezi.* The figured and one of the two unfigured specimens assigned to *B. plicatella* subsp. *mera* fit well into *B. subexcavata,* while the other unfigured specimen has a more circular plan view than is characteristic, even within the considerable range of variation of *B. subexcavata.* The figured and six unfigured specimens from the Gulf of Paria assigned to *B. pseudoplicata* by Todd and Bronnimann are questionably placed herein in the form designated *B.* cf. *B. subexcavata.* The figured specimen fits best there, but some of the unfigured are more like the species, sensu stricto. In that regard, many of the abundant Recent western Pacific specimens in the unfigured USNM collections ascribed to *B. subexcavata* would be likewise placed therein if found in the present material. They seem to indicate an intraspecific range of variation in the Pacific not really definite at Discovery Bay. Many of these specimens do not have the markedly grainy appearing wall commonly found at Discovery Bay with *B. subexcavata* but

have the wall surface of the present *B.* cf. *B. subexcavata,* though the character is variable. Among all the specimens having that grainy character (that were discussed), it is best developed on the types of *B. pseudoplicata* sent by Earland from Trondheim Fjord. The range and meaning of this character are among the major problems in determining the synonymy of this group of Bolivinas. The range of variation of the plications or ridges is probably the other of the two most important problems.

Regarding specimens assigned originally to *B. plicatella,* that figured by Cushman and Parker is refigured by Cushman in the 1937 reference, so only one specimen is actually involved. Of other specimens examined by Cushman and Parker in their study of foraminifers from some South Atlantic shallow-water localities, there is difficulty in agreeing with their designation of unfigured specimens as conspecific with the figured specimens. The two from Rio Harbor and one from Argentina probably are conspecific, but among the 16 from the Falkland Islands there occur specimens that seem better assigned to *B. inflata, B. doniezi,* and *B.* cf. *B. subexcavata* of this report, and perhaps other species, even considering the possibly different range of variation of a population from the Falklands compared to other localities.

Abundant unfigured USNM specimens from off the southeast coast of the United States ascribed to *B. plicatella* clearly are conspecific with *B. subexcavata* as represented herein.

In an interesting study of some eastern Pacific margin bolivinitids, Sliter (1970:162) made the statement that *"B. pseudoplicata"* differs from *"B. subexcavata"* in having a more gradually tapering, thinner test and more pronounced ornamentation. He also noted (1970:164) that he found little variation in morphology of *"B. subexcavata"* from his sample locations and other geographic areas. Neither of these conclusions is substantiated in the present study although Sliter's work certainly is to be commended. Most of the bolivinitids treated by him and those of the present study constitute a group very difficult of systematic understanding and subject to different interpretation with the data available.

Bolivina subexcavata Cushman and Wickenden, as understood herein, is characterized as follows. The test is biserial throughout, small to medium

sized for the genus, usually slightly compressed, occasionally grading to very compressed, flaring rapidly from the base, giving a wedge-shaped outline. Some tests have axes slightly arched away from the vertical, being slightly arcuate, and/or with the test (chambers) tending to twist around the axis so that the specimens do not lie with their chambers all in the same plane, in extreme cases and along with relatively great compression of part or all of the test, producing a very uncharacteristically twisted and compressed from (Plate 2: fig. 12). In apertural view, the test is usually triangular to subtriangular, depending on the sharpness of the margins and with the margins occasionally so rounded and wide that the test is subrectangular, with nearly equal sides (approaching *B. rhomboidalis*). The greatest thickness usually is centrally located or sometimes along one or two striking, raised, vertically linear features or lines of greatest breadth.

The chambers are often slightly inflated, especially the final one, and usually quite wide with respect to height, increasing quite regularly in size from a fairly sharply pointed base. The chamber outline is narrow subrectangular with straight tops and bottoms, or arcuate, or slightly lobate (resulting from lobes—usually one per suture—in sutures), those lobate chambers usually being higher (versus width) than others. Chambers are sometimes difficult to see because of wall roughness and ornamentation, which may also give them a superficially offset or irregularly arranged appearance.

The aperture is a fairly wide slit in a slight depression and often with a slight lip, reaching from the base toward the apex of the final chamber, usually about halfway.

The sutures mainly are narrow, though sometimes slightly limbate in the early part of the test. They sometimes seem to extend around the chambers on the margin, giving a keeled margin to the test, though this must be optical illusion resulting from marginal narrowing of the test and perhaps the coincidental presence of other wall-surface features. The sutures are nearly flush to commonly somewhat depressed, especially in the later part of the test where spur-shaped final chambers occasionally appear. They are straight, arcuate, or lobate—usually with one fairly sharp, relatively shallow lobe, but sometimes with more and deeper lobes, in association with the longitudinal, linear,

raised features on the test surface, which features, along with test roughness and twisting, can make observation of sutures difficult. Sutures often do not regularly meet medially because of test twisting and ornamentation or irregularity of the surface; this feature often is present throughout the test but sometimes begins after the first few chambers are complete.

The wall is optically radial, thick, translucent, and rarely transparent and nonporate in early chambers, tending to be irregular (not smooth), often giving a grainy appearing surface. The wall often has one or more, with one or two major, sharp, longitudinal ridges that occasionally are actual costae, running from almost the full test length to only on the last few chambers, but not seen to reach the apex of the final chamber. These sometimes are broken slightly at the sutures and occasionally are intersected by rather irregular cross ridges, giving a somewhat irregular reticulate surface to the test. The graininess of the surface often causes the sharp to slightly rounded peripheries to deviate from smooth to slightly irregular, as does suture depression, and to deviate with the occasional presence of such pronounced costalike cross ridges or linear (subvertical) ridges that peripheries appear from slightly to extremely irregular, with from irregular, small subangular protrusions to spurlike lobes. The pores are fairly dense and evenly distributed, though occasionally they are not present in clear bands across the width of early chambers.

Figured hypotypes: USNM 211144, 211145, 211146, 211147, 211148, 211149, 211150, 211151.

Hypotypes: USNM 211248, 211249, 211250, 211251, 211252, 211253, 211254.

	mean	standard deviation	range
station 1	21.96	14.43	3–67
station 3	17.19	12.04	2–57

Bolivina cf. *B. subexcavata* Cushman and Wickenden

PLATE 2: FIGURES 23–26

?*Bolivina pseudoplicata* Heron-Allen and Earland.—Todd and Bronnimann 1957:34, pl. 8: fig. 28.

Todd and Bronnimann's figured specimen is poorly preserved, as are the six unfigured from the

same collection. The figured specimen is most similar to the present *Bolivina* cf. *B. subexcavata,* but some of the unfigured individuals appear more like the species, sensu stricto.

Specimens designated *Bolivina* cf. *B. subexcavata* Cushman and Wickenden therein differ from the species, sensu stricto, as conceived therein in the following ways. Overall, they are less flaring (though not more than all specimens therein adjudged *B. subexcavata*). The sutures are more depressed and the chambers more inflated, especially in the latter part of the test, and generally more neatly arranged. The test is little compressed and the margin quite rounded. The wall is not grainy appearing but, especially in the latter part, shows a well-developed reticulate pattern with small pores in pits, evenly distributed. There are no longitudinal ridges developed parallel to the median suture.

Two slightly different but intergrading sorts of specimens are included herein. They differ in that, along with a slight size differential, the chambers of the smaller specimens (represented by hypotype USNM 211144) are not so neatly arranged as with the larger (hypotype USNM 211145). This smaller form also is slightly more compressed.

Bolivina subexcavata is a very variable species. Yet the specimens here designated *Bolivina* cf. *B. subexcavata* appear to represent a distinct, though very similar form (similar to *B. subexcavata*—see under that species for morphologic variation). In some populations, they may intergrade but appear not to do so in the present sets of specimens, and *B. subexcavata* is very common here.

Figured hypotype: USNM 211144, 211145.

	mean	standard deviation	range
station 1	0.85	1.05	0–5
station 3	0.92	1.22	0–5

Bolivina spp.

The two specimens represented by hypotype USNM 211255 are very similar to *Bolivina doniezi* Cushman and Wickenden in pore pattern especially, and also *Bolivina striatula* Cushman and *Bolivina paula* Cushman and Cahill in plan of growth, but the sutures are rather depressed and the number of chambers is very great for the size.

A single specimen, hypotype USNM 211256, appears distinct here. The test is slightly compressed, with a rounded margin, and is short and rapidly flaring; sutures are narrow and oblique to slightly sinuate and at a fairly low angle, somewhat depressed, giving slightly inflated chambers; the wall is thin, transparent, with evenly spaced, moderately dense, distinct small pores; the aperture is a wide slit from the base up about two-thirds of the way to the apex of the final chamber. The specimen resembles *Bolivina doniezi* and *Bolivina inflata* Heron-Allen Earland but does not appear conspecific.

Hypotype: USNM 211255, 211256.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.02	0.14	0–1

Bolivina? spp.

Three specimens from station 3 and two from station 1 (represented by hypotypes USNM 211257, 211258) are so referred. They conclude with at least three series of biserial chambers occupying two-thirds to three-fourths of the test. The early portion may not be biserial, however. Tests are somewhat compressed, with rounded margins. The early portions appear unusually thick for a biserial form and the median sutures run slightly diagonally upward, suggesting a triserial or even coiled base. It has been impossible to determine the form of this portion with certainty, however. The apertures rise as wide slits from the bases nearly to the center of the final chambers and have tooth plates. The walls are fairly thin, translucent, smooth, and shiny. The pores are medium sized and of fairly even distribution. The hypotype is not as twisted and is more transparent and smooth than the others and its wall can be seen clearly to be radial.

A single specimen from station 1 (hypotype USNM 211259) is tentatively assigned to *Bolivina.* Apparently juvenile, it is very small and has seven or eight chambers. The final four chambers form two biserial pairs, with an open, slitlike aperture rising from the base a short distance up the final chamber. The growth pattern of the initial part is, however, difficult to determine. There is either a bulbous proloculus followed by two similar chambers in biserial arrangement and all tilted "forward" and upward slightly, or there is a very small

proloculus followed by three chambers in trocho-spiral arrangement. The wall is opaque and rather granular appearing, not smooth, with small, regularly spaced pores. The test is only slightly compressed, has rounded margins, narrow and depressed sutures, and rather inflated chambers.

Hypotype: USNM 211257, 211258, 211259.

	mean	standard deviation	range
station 1	0.10	0.31	0–1
station 3	0.00	0.00	0

Genus *Rectobolivina* Cushman, 1927

Rectobolivina raphana? (Parker and Jones)

PLATE 3: FIGURES 1, 2

?Siphogenerina raphanus (Parker and Jones).—Cushman, 1922a:35, pl. 5: fig. 5.

Rectobolivina raphana (Parker and Jones).—Loeblich and Tappan, 1964:C553, fig. 438: 9–11.

Rare live individuals occur in the present material, though empty tests also are found in sufficient numbers to suggest that they live nearby and are washed in, as with *Siphogenerina costata*. As to the taxonomic relationships and placement of *S. costata* and *Rectobolivina raphana*, see the remarks under the former. (The question here is not of the specific identity relating to other specimens but of the validity of the generic and specific breakdown.) Cushman's figured specimen, cited above, appears to actually belong to *R. raphana*, though some question exists between the two species.

Figured hypotype: USNM 211214.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.08	0.28	0–1

Family BULIMINIDAE Jones, 1875

Subfamily PAVONININAE Eimer and Fickert, 1899

Genus *Reussella* Galloway, 1933

Reussella atlantica Cushman

Verneuilina spinulosa Reuss.—Cushman, 1921:51; 1922a:28, pl. 3: fig. 11.

Reussella spinulosa (Reuss) var. *atlantica* Cushman, 1947:91, pl. 20: figs. 6, 7.

Reussella atlantica Cushman.—Phleger and Parker, 1951:18, pl. 8: figs. 8, 9.—Parker, Phleger, and Peirson, 1953:13, pl. 4: figs. 12, 13.—Parker, 1954:519, pl. 7: fig. 28.—Bandy, 1954:138, pl. 31: fig. 7; 1956:197.—Lankford, 1959, pl. 3: fig. 9.

The holotype and seven paratypes from the Recent off Canaveral, Florida and abundant unfigured "topotypic" specimens from off the southeast coast of the United States also in the USNM collections have been seen.

The present specimens seem to be a bit smaller and more delicate and have slightly better developed spines than the primary types, but too few Discovery Bay specimens occur to be certain. As Hofker himself has stated (1956:52: figs. 1, 4–7), his *Reussella mortenseni*, from the southern Caribbean, may be conspecific with *Reussella atlantica*, but we have seen no specimens so attributed and hesitate to synonymize.

Hypotype: USNM 211322.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.52	0.80	0–4

Genus *Chrysalidinella* Schubert, 1908

Chrysalidinella aff. *C. miocenica* Cushman

A single specimen is so referred. It resembles the holotype of *Chrysalidinella miocenica* and some of the specimens in the USNM collections so referred. The holotype of *C. miocenica* is, however, shorter and wider. The present specimen also resembles two paratypes of *Chrysalidinella popei* Andersen. Those specimens, from the Recent of South Pass, have, however, sharper keels that rise on each chamber from raised limbate sutures. The Discovery Bay specimen has a keel arising in the same fashion, but the sutures and keel are not as protruding and the keel does not become as sharp. The specimens in the collections (USNM) from off Onslow Bay, North Carolina referred to *C. miocenica* appear to be conspecific with *C. popei* paratypes. The scope of the present study does not allow solution of whether or not *C. miocenica* and *C. popei* are distinct species or of the problem that some specimens in the collections referred to *Chrysalidinella*

dimorpha (H. B. Brady) are very similar to the present specimen.

Hypotype: USNM 211342.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Subfamily BULIMININAE Jones, 1875

Genus *Sagrina* d'Orbigny, 1839

Sagrina pulchella d'Orbigny *in* de la Sagra

PLATE 3: FIGURES 3–6

Sagrina pulchella d'Orbigny, 1839:150, pl. 1: figs. 23, 24.
Bolivina pulchella (d'Orbigny).—Cushman, 1922d:41, pl. 7: fig. 4; 1922a:25, pl. 1: figs. 8, 9; 1937:151, pl. 15: figs. 10, 11; 1941:10.—Cushman and Parker, 1931:15, pl. 3: fig. 20.

Hofker (1956:49, pl. 4: figs. 21–36) reports this form as *Bitubulogenerina pulchella* from the southern Caribbean. As *Bolivina pulchella,* as well as the above-cited reference, unfigured conspecific specimens in the USNM collections come from Montego Bay, Jamaica, and (abundant specimens) from off the southeast coast of the United States.

Figured hypotypes: USNM 211178, 211179.

	mean	standard deviation	range
station 1	0.85	0.92	0–3
station 3	1.35	1.59	0–6

Sagrina pulchella d'Orbigny *in* de la Sagra subsp. *primativa* (Cushman)

Bolivina pulchella (d'Orbigny) var. *primativa* Cushman, 1930: 47, pl. 8: fig. 12; 1937:90, pl. 12: fig. 6.—Phleger and Parker, 1951:14, pl. 7: fig. 3.—Bandy, 1956:193.—Todd and Bronnimann, 1957:34, pl. 8: figs. 9, 10.
Bolivina pulchella primativa Cushman.—Parker, Phleger, and Peirson, 1953:6, pl. 4: figs. 2, 3.—Parker, 1954:516, pl. 7: fig. 36.—Lankford, 1959:3: fig. 7.

Some specimens from the Discovery Bay material are placed in this subspecies instead of the species, sensu stricto. (The holotype has been examined.) Whether or not two subspecifically different populations are represented, however, is a question. A transition appears to occur and some specimens have been arbitrarily designated. A larger popula-

tion would be needed in the present material to resolve this question.

The large unfigured Recent USNM collection from off the southeast coast of the United States referred to the species, sensu stricto, shows a complete and common range of variation in the character (length of the biserial part) given by Cushman to differentiate the subspecies. Probably this would be the case for at least some other Recent (at least) populations too, but in most cases available for some observation, there are only one to a few "characteristic" specimens from given locations included in synonymy and remarks. Therefore, though quite possibly all specimens could be included in the species, sensu stricto, a morphologic breakdown into species and subspecies has been retained herein.

	mean	standard deviation	range
station 1	0.23	0.59	0–3
station 3	0.52	0.74	0–3

Family UVIGERINIDAE Haeckel, 1894

Genus *Siphogenerina* Schlumberger, 1882

Siphogenerina costata Schlumberger

Siphogenerina cf. *raphanus* (Parker and Jones).—Cushman and Parker, 1931:17, pl. 3: figs. 25, 26.
Siphogenerina raphana (Parker and Jones).—Todd and Bronnimann, 1957:36, pl. 9: fig. 7.
Siphogenerina costata Schlumberger.—Loeblich and Tappan, 1964:C569, fig. 449: 1–4.

Following Loeblich and Tappan (1964), these specimens are placed in *Siphogenerina costata* rather than *"Siphogenerina" raphana,* though they are conspecific with specimens referred to *"S." raphana.* Much taxonomic confusion arose regarding these two species, which now appears to be resolved by Loeblich and Tappan (1964:C553, C569). It does seem possible, however, as has been argued, that *S. costata* and *Rectobolivina raphana* are not only congeneric but conspecific, as some appear very similar. The specimen referred to *"Siphogenerina raphanus* (Parker and Jones)" by Cushman (1922a:35, pl. 5: fig. 5) and herein questionably referred to *Rectobolivina raphana* is closer to *R. raphana* than *Siphogenerina costata,* as typified, but suggests a transition between the two forms.

Other unfigured specimens in the USNM collections from Rio de Janeiro Harbor referred to "*Siphogenerina raphanus* (Parker and Jones)" are *Siphogenerina costata* of the present usage, and those figured and unfigured from Rio de Janeiro Harbor and the Gulf of Paria clearly are conspecific. Eight unfigured "*Siphogenerina raphanus*" from Puerto Rico may be *Siphogenerina costata* or *Rectobolivina raphana,* or may further indicate by their transitional appearance that one species only is represented. Examination of larger populations probably could resolve this question. Both forms occur in small numbers in the Discovery Bay samples.

Holotype: USNM 211339.

	mean	standard deviation	range
station 1	0.56	0.85	0–3
station 3	0.25	0.44	0–1

Genus *Trifarina* Cushman, 1923

Trifarina occidentalis (Cushman)

PLATE 3: FIGURES 7–10

Uvigerina angulosa Cushman [not Williamson], 1922a:34, pl. 5: figs. 3, 4.
Angulogerina occidentalis (Cushman).—Cushman and Parker, 1931:17.—Todd and Bronnimann, 1957:36, pl. 9: figs. 5, 6.

Numerous unfigured specimens in the USNM collections from off the southeast coast of the United States are assigned to "*Angulogerina occidentalis* (Cushman)" and are conspecific with the present specimens.

The figured specimen ascribed to "*Angulogerina jamaicensis* Cushman and Todd" by Parker (1954: 521, pl. 8: fig. 8) from the northeast Gulf of Mexico is very similar to *Trifarina occidentalis,* but shows the spines of *T. jamaicensis* on the early chambers.

Considerable intraspecific variation exists in this species in the number of costae and angularity of test, especially in the upper part, where it may be typically triangular or rounded with lobate chambers. A large population is represented in the Discovery Bay samples.

Figured hypotypes: USNM 211174, 211175.
Hypotype: USNM 211223.

	mean	standard deviation	range
station 1	15.90	8.38	2–37
station 3	22.46	14.10	0–72

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838

Subfamily DISCORBINAE Ehrenberg, 1838

Genus *Discorbis* Lamarck, 1804

Discorbis granulosa (Heron-Allen and Earland)

PLATE 3: FIGURES 11, 12, 13

Discorbina valvulata (d'Orbigny), var. *granulosa* Heron-Allen and Earland, 1915:695, pl. 52: figs. 1–6.
Discorbis valvulata (d'Orbigny) var. *granulosa* (Heron-Allen and Earland).—Todd, 1957, pl. 90: fig. 6.

This distinctive species has a thick test wall that is coarsely perforate on the spiral side, imperforate on the umbilical side. The periphery is broadly rounded, lobate. The chambers are inflated, arranged in two to two and a half whorls, with seven to eight chambers in the peripheral whorl. The sutures are radial, limbate, and deeply incised. The umbilicus is covered by overlapping imperforate triangular flaps extending from the bases of the chambers. The aperture is a narrow opening beneath the chamber flap, remaining open in previous chambers.

This species easily recognized by its extremely thick wall, the very coarse pores on the spiral side, and globose outline.

Figured hypotype: USNM 211196.

	mean	standard deviation	range
station 1	0.50	1.27	0–8
station 3	0.06	0.32	0–2

Discorbis mira Cushman

PLATE 3: FIGURES 14, 15, 16

Discorbis mira Cushman, 1922a:39, pl. 6: figs. 10, 11; 1931:25, pl. 5: figs. 5, 6; 1941:11, pl. 2: figs. 4–6.

This species is common throughout the present samples. It may be recognized by its biconvex test, and acute, entire periphery which bears a narrow imperforate keel.

Figured hypotype: USNM 211195.

	mean	standard deviation	range
station 1	1.44	2.35	0–13
station 3	14.08	11.06	0–60

Discorbis murrayi (Heron-Allen and Earland)

Rotalia murrayi Heron-Allen and Earland, 1915:722, pl. 53: figs. 27–34.

This small species has an unequally biconvex test with a finely imperforate, hispid wall. The periphery is subangular, lobate. The chambers are globose, arranged in one and one-half to two whorls, with five to seven chambers in the peripheral whorl. All chambers are visible on the flattened spiral side; only those of the peripheral whorl are visible on the strongly convex umbilical side. The sutures are radial and deeply depressed. The umbilicus is filled by an umbilical plug that is in turn covered by umbilical flaps extended from the bases of the chambers. The aperture is a narrow slit beneath the umbilical flap of the final chamber.

The hispid surface of this species is quite distinctive, somewhat resembling that of some planktonic species. This surface texture is sufficiently characteristic to allow identification of pathologic specimens on this basis alone.

Figured hypotype: USNM 211190.

	mean	standard deviation	range
station 1	1.40	1.84	0–8
station 3	2.77	3.23	0–12

Discorbis rosea (d'Orbigny)

Rotalia rosea d'Orbigny, 1826:272, Modèle no. 35.
Rotalina (Rotalina) rosea (d'Orbigny).—d'Orbigny, 1839:72, pl. 3, figs. 9–11.
Truncatulina rosea (d'Orbigny).—Cushman, 1921:56, pl. 13: figs. 2, 3; 1922a:6, pl. 14: figs. 3–5.

This species has not been included in the statistics of this study because it has a thick rose-colored test that matches the color of the stain (Rose Bengal) used in sample preparation to determine living protoplasm, and therefore the number of living specimens cannot be determined. The test is large, coarsely perforate, unequally biconvex. The periphery is acute, lobate in juveniles, entire in mature specimens, with a keel consisting of a row of closely spaced short spines. The spiral side is covered by a scattering of short, stubby spines, which are not present on the umbilical side. Juvenile specimens have a strongly convex umbilical side and a flattened spiral side; during development the spiral side becomes strongly convex and the umbilical side less so. There are about two and one-half whorls visible on the spiral side of mature specimens, with eight to nine chambers in the peripheral whorl. The sutures are tangential, flush to raised on the spiral side, depressed on the umbilical side. The umbilicus is filled by a large umbilical plug. The umbilical ends of the chambers are extended into short, flat umbilical flaps. The aperture is an interiomarginal, umbilical-extraumbilical slit that is open under the chamber flaps, and open in previous chambers.

Genus *Bronnimannia* Bermúdez, 1952

Bronnimannia caribaea (Cushman)

Planulina caribaea Cushman, 1931:112, pl. 20: fig. 1.

Two living specimens of *Bronnimannia caribaea* were found in the present material. This compressed species was originally described from Montego Bay, Jamaica.

Hypotype: USNM 211368.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.00	0.00	0

Genus *Discorbinella* Cushman and Martin, 1935

Discorbinella minuta, new species

Test small, trochoid, strongly compressed, concavoconvex; slightly convex spiral side moderately perforate, slightly concave umbilical side very finely perforate; periphery entire to somewhat lobate, with thick imperforate keel; chambers falciform, arranged in one and one-half to two whorls, seven to eight chambers in peripheral whorl, gradually increasing in size as added; chambers partially involute on both sides, only chamber flaps of previous whorl visible on umbilical side; sutures limbate, strongly curved, raised to slightly depressed on spiral side, depressed on umbilical side; proximal ends of chambers on umbilical side bearing short imperforate flaps that approach small central umbilical plug; aperture narrow umbilical slit

between chamber flaps and plug, remaining open in previous chambers.

This small species is a fairly common component of the population at station 3, but only a few specimens occur at station 1. It is somewhat difficult to separate from juvenile specimens of *Cymbaloporetta atlantica,* due principally to the small size and flattened conical shape of both. Upon close examination, however, the strongly curved sutures that are depressed on the umbilical side and the finely punctate umbilical-side wall distinguish this species. Descriptive statistics of the maximum diameter, minimum diameter, and thickness measured in mm for the holotype and three paratypes are:

	mean	standard deviation	range
maximum diameter	0.173	0.022	0.150–0.200
minimum diameter	0.145	0.019	0.130–0.170
thickness	0.051	0.013	0.040–0.070

Figured holotype: USNM 211163.
Figured paratype: USNM 211167.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 3	0.92	1.27	0–7

Discorbinella sp.

A single broken specimen of *Discorbinella* is insufficiently diagnostic to allow further identification, although it exhibits sufficient characteristics to place it in *Discorbinella.* The test is concavo-convex. The low convex spiral side is thickened and finely perforate; the concave umbilical side is thin walled and coarsely perforate. The periphery is acute, entire, with a thin keel. The chambers are falciform, not inflated, arranged in one and one-half whorls, with six chambers in the peripheral whorl, chambers increasing rapidly in size as added. The sutures are arcuate, flush on spiral side, depressed on umbilical side. Although the final chambers are not preserved, previous chambers possess umbilical interiomarginal slit apertures.

Hypotype: USNM 211267.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.02	0.14	0–1

Genus *Eoeponidella* Wickenden, 1949

Eoeponidella pacifica (Uchio)

Asterigerinata pacifica Uchio, 1960:67, pl. 10: figs. 26–31.
Eoeponidella delicatula Seiglie, 1965:511, pl. 5, fig. 11.

This tiny species occurs infrequently throughout the present suite of samples. The present specimens have been compared with the type material and appear to be conspecific.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.13	0.33	0–1

Genus *Epistominella* Husezima and Maruhasi, 1944

Epistominella? sp.

A single broken specimen questionably referable to *Epistominella* was found at station 3, but was lost during study. It was minute, bioconvex, and with about eight chambers in the peripheral whorl. The sutures were somewhat depressed on the umbilical side. Since the final chamber was broken, the character of the aperture could not be determined. The periphery was rounded and lobate.

Genus *Helenina* Saunders, 1961

Helenina anderseni (Warren)

Pseudoeponides anderseni Warren, 1957:39, pl. 4: figs. 12–15.—Parker and Athern, 1959:341, pl. 50: figs. 28–31.
Helenina anderseni (Warren).—Saunders, 1957:374, figs. 1, 2.—Todd and Low, 1971:18, fig. 2.
Helenina anderseni (Warren).—Todd and Low, 1971:15, pl. 3: fig. 1.

This species occurs often at station 1 but only once at station 3.

Hypotype: USNM 211357.

	mean	standard deviation	range
station 1	0.46	1.13	0–7
station 3	0.02	0.14	0–1

Genus *Neoconorbina* Hofker, 1951

Neoconorbina terquemi (Rzehak)

Rosalina orbicularis Terquem [not d'Orbigny, 1850], 1875:75, pl. 9: fig. 4.

Discorbina terquemi Rzehak, 1888:228.

Neoconorbina terquemi (Rzehak).—Parker, 1958:267, pl. 3: figs. 26, 27.

Discorbis orbicularis (Terquem).—Cushman, 1922a:38, pl. 5: fig. 10; 1931:27, pl. 6: fig. 3.

Conorbina orbicularis (Terquem).—Parker, 1954:522, pl. 8: figs. 13, 14.

This species occurs in small numbers in several of the present samples.

Hypotype: USNM 211372.

	mean	standard deviation	range
station 1	0.23	0.66	0–3
station 3	0.44	0.99	0–4

Genus *Patellinella* Cushman, 1928

Patellinella sp.

This form, with a low conical spire, superficially closely resembles *Patellina corrugata* Williamson and may have been mistaken for it in some instances. It has, however, the generic characters of *Patellinella*. Only one specimen was found at station 1, but, unfortunately, we lost it.

Genus *Rosalina* d'Orbigny, 1826

Rosalina bulbosa (Parker)

"*Discorbis*" *bulbosa* Parker, 1954:523, pl. 8: figs. 10–12.

This species appears in small numbers in many of the present samples. These specimens are identical to the holotype, but appear quite different from the illustration of "*Rosalina bulbosa* (Parker)" given by Akers and Dorman (1964:51, pl. 9: figs. 14, 15), which they collected from the Gulf Coast Pleistocene. This species has all the characteristics imputed to *Rosalina* (Loeblich and Tappan, 1964:C584), with the exception of the umbilical chamber flaps. The aperture of the present species is an interiomarginal arch extending from the large, open umbilicus to the rounded periphery. A narrow apertural lip is present. Although this species lacks the rosalinid chamber flap, it seems unwarranted to erect yet another genus to include only this species.

Hypotype: USNM 211358.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.54	0.85	0–4

Rosalina candeiana d'Orbigny

PLATE 4: FIGURES 1–3

Rosalina candeiana d'Orbigny, 1839:97, pl. 8: figs. 2–4.

Truncatulina candeiana (d'Orbigny).—Cushman, 1921:57, pl. 13: fig. 5; 1922a:47, pl. 6: figs. 7–9.

Truncatulina cora (d'Orbigny).—Cushman, 1922a:48, pl. 7: figs. 3–5.

Specimens from the present samples appear conspecific with d'Orbigny's figured specimens from beach sands of Cuba. The test is planoconvex, low trochospiral, with a coarsely perforate wall. The periphery is subacute and lobate. The chambers are inflated on the spiral side, flattened on the umbilical side, arranged in about three whorls, with six chambers in the peripheral whorl. The sutures are straight, radial, and depressed. The umbilicus is rather small and open, partially covered by wide, imperforate, overlapping umbilical flaps extending from the base of each chamber, leaving a stellate umbilical opening as illustrated by d'Orbigny. The aperture is a low interiomarginal extraumbilical-umbilical arch bordered above by a prominent apertural lip, remaining open in earlier formed chambers.

Figured hypotype: USNM 211186.

Hypotype: USNM 211359.

	mean	standard deviation	range
station 1	0.17	0.56	0–3
station 3	0.06	0.24	0–1

Rosalina concinna (Brady)

PLATE 4: FIGURES 4–6

Discorbina concinna Brady, 1884:646, pl. 90, figs. 7, 8.

Discorbis concinnus (Brady).—Bandy, 1956:193, pl. 31: fig. 4.

This species is fairly abundant in the present suite of samples, especially at station 3. On casual observation, it may be confused with large flattened specimens of *Rosalina globularis,* from which it differs in having flush sutures and a thickening of the test over the earlier whorls on the spiral side, and in lacking the pronounced chamber flaps on

the umbilical side. It differs from *Neoconorbina terquemi* in having a rounded, nonkeeled periphery, in having an extremely finely perforate to imperforate umbilical side, and in lacking the pronounced chamber flaps of *N. terquemi,* the chamber flap of this species being a wide, short, rounded extension of the base of the chamber.

Figured hypotype: USNM 211187.

	mean	standard deviation	range
station 1	0.65	1.06	0–4
station 3	2.69	2.66	0–8

Rosalina floridana (Cushman)

PLATE 4: FIGURES 7–9

Discorbis floridana Cushman, 1922a:39, pl. 5: figs. 11, 12; 1931:21, pl. 4: figs. 7, 8.—Cushman and Parker, 1931:18, pl. 4: fig. 5.
Discorbis micens Cushman.—Todd, 1957:290, pl. 90: fig. 7.

This species appears in considerable numbers throughout the present samples. Study of the types and of the present specimens shows that this is a variable species, but it exhibits definite characteristics. The test is a low trochospiral coil, with a wall that is moderately perforate on the spiral side, finely perforate to imperforate on the umbilical side. The area above the umbilicus is imperforate in most specimens. The periphery is broadly rounded, lobate. The chambers are inflated, arranged in two to two and a half whorls, with five to seven chambers in the peripheral whorl, the chambers increasing rather rapidly in size as added. Early sutures are limbate and flush, becoming simple and somewhat depressed on the spiral side; all sutures are deeply incised on the umbilical side. The umbilicus is large and partially covered by very large triangular chamber flaps. Characteristic of the species is a deep furrow at the proximal edge of the flap on each chamber. The aperture is a low interiomarginal extraumbilical-umbilical arch with lip.

Many different forms have been referred to this species, probably because of the poor and misleading original illustration, and because the final chamber of the holotype is broken. The paratype and topotypic specimens, however, give a clear picture of the characters and variation of this species.

Figured hyptoype: USNM 211185.

Hypotype: USNM 211360.

	mean	standard deviation	range
station 1	9.06	8.74	0–52
station 3	4.35	3.74	0–17

Rosalina globularis d'Orbigny

PLATE 4: FIGURES 10–12

Rosalina globularis d'Orbigny, 1826:271, pl. 13: figs. 1–4.
Discorbis columbiensis Cushman, 1925:43, pl. 6: fig. 13.
Tretomphalus bulloides (d'Orbigny).—Cushman, 1934:86, pl. 11: fig. 2.
Tretomphalus myersi Cushman, 1943:26, pl. 6: figs. 4–6.

This, the type-species of *Rosalina,* is probably the most variable and misidentified species of the genus. The diagnostic characteristics of *R. globularis* have been clearly set forth by Douglas and Sliter (1965). They found considerable variation in laboratory-cultured specimens, including specimens of the type-species of *Tretomphalus, T. bulloides* (d'Orbigny), thus placing that genus in synonymy with *Rosalina,* as has been discussed under *Cymbaloporetta atlantica.* Many specimens throughout the present suite of samples fall within the range of variation reported by Douglas and Sliter, and have been so identified.

Figured hypotype: USNM 211184.
Hypotype: USNM 211361.

	mean	standard deviation	range
station 1	4.67	4.27	0–15
station 3	17.35	15.90	2–83

Rosalina subaraucana (Cushman)

PLATE 4: FIGURES 13–15

Discorbis subaraucana Cushman, 1922a:41, pl. 7: figs. 1, 2; 1931:32, pl. 7: fig. 2.
Discorbis floridana Cushman.—Phleger and Parker, 1951:20, pl. 10: fig. 4.—Parker, Phleger, and Peirson, 1953:7, pl. 4: figs. 18, 19.
Discorbis floridanus Cushman.—Bandy, 1954:136, pl. 31, fig. 1.

This species occurs in considerable numbers in samples collected from this study. It is readily identified by its low trochospiral, nearly planoconvex test that is finely perforate on both sides, the fairly rapid increase in chamber size as added, the limbate, curved flush to slightly depressed sutures, and the small umbilicus and correspondingly small chamber flaps.

Figured hypotype: USNM 211173.

	mean	standard deviation	range
station 1	2.77	2.60	0–14
station 3	10.98	8.97	1–38

Rosalina sp.

Test biconvex, low trochospiral coil, globose; wall moderately to coarsely perforate; periphery rounded, lobate; chambers inflated, arranged in about three whorls, with eight chambers in the peripheral whorl; sutures strongly curved, nearly tangential, deeply incised; umbilicus large, open, partially covered by overlapping triangular chamber flaps; aperture an interiomarginal extraumbilical-umbilical slit, remaining open in chambers previous to the final.

Three specimens of this species were found in the present samples, all from station 3. Because of the scarcity of specimens, no study of the wall structure has been undertaken, but the appearance of the wall, the open umbilicus, and the chamber flaps all suggest placement in Rosalina.

Hypotype: USNM 211363.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.06	0.24	0–1

Rosalina? sp.

A single broken and deformed specimen from station 1 is tentatively classified as a Rosalina. The test is a low trochoid coil. The chambers are strongly inflated, arranged in about two and one-half whorls, with six chambers in the final whorl. The last few chambers are eccentric, unrolling away from the axis of coiling. The periphery is rounded, lobate. The sutures are radial, depressed. The umbilicus is rather large, partially closed by chamber flaps extending from the base of each chamber. The nature of the aperture is uncertain because of the apertural face of the final chamber is broken.

Genus Stetsonia Parker, 1954

Stetsonia minuta Parker

Stetsonia minuta Parker, 1954:534, pl. 10: figs. 27, 29

The specimens from Jamaica closely resemble Parker's types. Parker (1954) stated that occasionally chambers of the second whorl are visible on the dorsal side. None of our specimens exhibit this feature, but otherwise are identical.

Hypotype: USNM 211297.

	mean	standard deviation	range
station 1	0.17	0.48	0–2
station 3	0.06	0.24	0–1

Subfamily BAGGININAE Cushman, 1927

Genus Baggina Cushman, 1926

Baggina aff. B. philippinensis (Cushman)

PLATE 4: FIGURES 16–18

Occasional specimens comparable to Baggina philippinensis (Cushman) occur in samples from station 3. These specimens have inflated, coarsely perforate tests, only the area over the aperture lacking pores. The chambers are arranged in one and one-half to two whorls, with five chambers in the peripheral whorl, increasing rapidly in size as added. Sutures are slightly curved, simple, strongly depressed on the umbilical side, and slightly depressed on the spiral side. The aperture is a low interiomarginal extraumbilical-umbilical arch.

These specimens are smaller than the holotype of "Pulvinulina philippinensis," and differ somewhat from that specimen in the shape of the chambers and the size of the aperture. They do, however, appear conspecific with small specimens referred to Baggina philippinensis in the USNM reference collection.

Figured hypotype: USNM 211172.
Hypotype: USNM 211354.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.13	0.39	0–2

Genus Cancris de Montfort, 1808

Cancris sagra (d'Orbigny)

Rotalina (Rotalina) sagra d'Orbigny, 1839:77, pl. 5: figs. 13–18.

Cancris sagra (d'Orbigny).—Cushman, 1931:74, pl. 15: fig. 2.—Cushman and Todd, 1942:77, pl. 19: figs. 4–7.—Bandy,

1954:136, pl. 30: fig. 9.—Parker, 1954:532, pl. 10: figs. 15, 21.—Todd and Bronnimann, 1957:37, pl. 11: fig. 4.

Living specimens of this species are quite rare in the present material. These specimens vary somewhat in biconvexity and chamber shape, but fall within the range of variation reported for this species by Cushman and Todd (1942), and exhibited by specimens of *Cancris sagra* in the USNM reference collection.

Hypotype: USNM 211369.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 3	0.06	0.24	0–1

Family GLABRATELLIDAE Loeblich and Tappan, 1964

Genus *Glabratella* Dorreen, 1948

Glabratella altispira, new species

PLATE 4: FIGURES 19–24

Test minute, high trochospiral, about as high as wide, finely perforate on spiral side, imperforate on umbilical side, periphery rounded, lobate, chambers globose, about one and one-half times longer than wide, arranged in three to four whorls, with four chambers in each whorl, chambers increase gradually in size as added; sutures deeply incised, somewhat curved on spiral side, radial on umbilical side; umbilicus large, open; aperture arched umbilical opening, remaining open in previous chambers, umbilical striae indistinct or lacking.

This species is fairly common in the present samples, occurring more often at station 1 than at station 3. Of the previously described species of *Glabratella,* it seems most like *G. erecta* (Sidebottom) in general shape, differing in being smooth rather than coarsely rugose on the spiral side, and in having less oblique sutures than *G. erecta.* Descriptive statistics of the maximum diameter, minimum diameter, and thickness measured in mm for the holotype and three apartypes are:

	mean	standard deviation	range
maximum diameter	0.095	0.041	0.090–0.100
minimum diameter	0.089	0.002	0.085–0.090
thickness	0.109	0.002	0.105–0.110

Figured holotype: USNM 211165.
Figured paratype: USNM 211160.
Paratypes: USNM 211276, 211277.

	mean	standard deviation	range
station 1	0.50	1.38	0–8
station 3	0.17	0.52	0–2

Glabratella braziliensis Boltovskoy

Glabratella braziliensis Boltovskoy, 1959:90, pl. 14: figs. 8–11.

This rather large species of *Glabratella* is found in several samples in this study. It is readily identified by its hemispherical shape, roughened convex spiral side with tangential, flush sutures, and depressed umbilical side with radiating rows of granules and depressed radial sutures.

Hypotype: USNM 239905.

	mean	standard deviation	range
station 1	0.08	0.35	0–2
station 3	0.02	0.14	0–1

Glabratella cf. *G. carinata* Seiglie and Bermudez

PLATE 5: FIGURES 1–3

A few specimens of *Glabratella* have been found at station 3 that are referred to *Glabratella* cf. *G. carinata* Seiglie and Bermudez. These specimens differ from the illustrations and description of that species in having an open umbilicus rather than having the umbilicus filled with granular material. The aperture appears to open into the rather large umbilicus. Because the amount of variation within species of *Glabratella* is not yet understood, it seems preferable to compare these specimens with *G. carinata* rather than erect a new species.

Figured hypotype: USNM 211193.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.08	0.35	0–2

Glabratella compressa, new species

PLATE 5: FIGURES 4–6, 10–12

Test minute, compressed, concavoconvex, finely perforate, transparent; periphery rounded, lobate;

chambers about twice as long as wide, arcuate, somewhat inflated, arranged in about two whorls with four chambers in peripheral whorl; sutures curved, tangential, slightly depressed on spiral side, radial, straight, moderately depressed on umbilical side; umbilicus large, open; aperture basal umbilical opening, remaining open in previous chambers; radial umbilical striae indistinct or lacking.

This is a common species of *Glabratella* in our samples, occurring in six samples from station 3 and 17 samples from station 1. The tiny transparent, strongly compressed test with wide umbilical opening clearly sets this species apart from other described species of this genus. Descriptive statistics of the maximum diameter, minimum diameter, and thickness measured in mm for the holotype and three paratypes are:

	mean	standard deviation	range
maximum diameter	0.108	0.021	0.085–0.135
minimum diameter	0.094	0.021	0.070–0.120
thickness	0.048	0.012	0.035–0.060

Figured holotype: USNM 211166.
Figured paratype: USNM 211161.
Paratypes: USNM 211278, 211282.

	mean	standard deviation	range
station 1	0.44	0.68	0–3
station 3	0.52	2.89	0–20

Glabratella hexacamerata Seiglie and Bermudez

PLATE 5: FIGURES 7–9

Glabratella hexacamerata Seiglie and Bermudez, 1965:31, pl. 1: figs. 6, 7.

This is the most common species of *Glabratella* in the present suite of samples. It is easily recognized by its possession of six globular chambers per whorl. The low convex spiral side is roughened; the umbilical side is smooth. The umbilicus is large and open.

Figured hypotype: USNM 211194.
Hypotype: USNM 211264.

	mean	standard deviation	range
station 1	0.31	0.69	0–3
station 3	0.79	1.15	0–5

Glabratella testigoensis Seiglie and Bermudez

Glabratella testigoensis Seiglie and Bermudez, 1965:37, pl. 2: figs. 4–7; pl. 4: figs. 4–6.

A single specimen of *Glabratella* occurring at station 3 appears to be conspecific with topotypic specimens of *G. testigoensis* in the USNM collections. Although the present specimen is less rugose on the spiral side than most specimens on the topotypic slide, it appears to fall within the range of variation represented on that slide. The specimen was lost during study.

Glabratella spp.

PLATE 5: FIGURES 13–21

Description of the form represented by hypotype USNM 211189 and treated ecologically as *Glabratella* sp. A follows. Test small, moderately highly trochospiral; wall finely perforate and roughened on the spiral side, imperforate but covered by rows of granules on umbilical side; periphery rounded, lobate; chambers strongly inflated, arranged in two to two and one-half whorls with five chambers in the peripheral whorl, increasing rapidly in size as added, a thin vertical costa on entire umbilical side of each covered by radiating rows of granules, distal end of each chamber, with exception of final chamber, protruded as a spine on the peripheral edge of spiral side of each chamber, then extending toward center of test along spiral side of chamber to chamber of previous whorl, final chamber bearing only rudimentary costa along spiral side; sutures deeply incised, radial; umbilicus moderately large, filled with granules; aperture not seen.

Only two specimens of this form were observed, but the morphologic characteristics appear to be unique, quite unlike any other species present in this study, any species of *Glabratella* in the USNM collections, or any species in the literature.

Figured hypotype: USNM 211189.

Description of the form represented by hypotype USNM 211168 and treated ecologically as *Glabratella* sp. B follows. Test small, low trochospiral; wall finely perforate on spiral side, imperforate on umbilical side; periphery rounded, lobate; chambers inflated, somewhat longer than high, arranged in two whorls, six in final whorl, increasing gradually in size as added; sutures arcuate, strongly

depressed on spiral side, nearly flush on umbilical side; umbilicus large, open; ornamentation on chambers of final whorl fine striae radiating from umbilicus and extending about halfway to periphery; aperture interiomarginal umbilical arch, previous apertures remaining open.

In general morphology, this species closely resembles minute specimens of *Rosalina floridana* (Cushman), differing mainly in possession of fine radiating umbilical striae and in lacking the characteristic rosalinid interiomarginal arched aperture. Indeed, Douglas and Sliter (1965) have suggested that *R. floridana* may belong in the genus *Glabratella* on the basis of reported plastogamic reproduction and the open pustulose aperture. Juvenile specimens of *Rosalina floridana* with rosalinid apertures and no umbilical striae, however, are numerous throughout the present suite of samples. It is possible that characteristic specimens of *R. floridana* represent the "microspheric" stage of this species and that the present specimens represent the "megalospheric" reproductive stage, but this cannot now be demonstrated. Lee et al. (1963) observed the life cycle of *R. floridana* and reported only slight morphologic differences between the two generations; however, they found no significant differences in relative size of either proloculus or mature test, finally resorting to coiling direction statistics as the best method of discerning the type of generation. Although all three specimens of this group of *Glabratella* spp. represented by hypotype USNM 211168 exhibit sinistral coiling as reported by Lee et al., for the megalospheric generation, specimens of *Rosalina floridana* in the present samples are about equally left and right coiled. Therefore, it seems probable that a new species is represented here, although insufficient material is present to erect a new species at this time.

Figured hypotype: USNM 211168.

Description of the form represented by hypotype USNM 211191 and treated ecologically as *Glabratella* sp. C follows. Test minute, low trochospiral, wall very finely perforate; periphery rounded, lobate; chambers strongly inflated, appearing somewhat longer than high on spiral side, triangular, about as high as wide on umbilical side, arranged in about two whorls, with six in peripheral whorl; sutures arcuate on spiral side, radial and nearly straight on umbilical side, deeply depressed on both sides; umbilicus small, open; umbilical area lacking granules or striae; aperture minute umbilical opening.

Although the characteristics of this species appear unlike those of any described species, an insufficient number of specimens is present to make a new name.

Figured hypotype: USNM 211191.

Glabratella sp. A

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.02	0.14	0–1

Glabratella sp. B

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.04	0.20	0–1

Glabratella sp. C

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.04	0.20	0–1

Genus *Glabratellina* Seiglie and Bermúdez, 1965

Glabratellina sp.

PLATE 5: FIGURES 22–24

Test small, moderately high trochospiral, coarsely perforate and rugose on spiral side, imperforate and covered by granules on umbilical side; periphery rounded, lobate; chambers moderately inflated, slightly longer than high, arranged in two and one-half to three whorls, five to six chambers in peripheral whorl, chambers increasing gradually in size as added; sutures arcuate, depressed on both sides; granules on umbilical side arranged in numerous radiating rows, covering umbilicus and extending to periphery; aperture a narrow extraumbilical-umbilical slit along base of linguiform umbilical extension of final chamber.

Of the previously described species, *Glabratellina* sp. seems to be most like *G. duclozi* Seiglie and Bermúdez, from the Miocene of Cuba, differing in having a more compressed test, less inflated chambers, and lacking the strong costae on the spiral side. *Glabratellina* sp. is a rare species throughout the present suite of samples, occurring in three

samples from station 1 and five samples from station 3.

Figured hypotype: USNM 211159.

Hypotype: USNM 211280.

	mean	standard deviation	range
station 1	0.08	0.35	0–2
station 3	0.15	0.50	0–3

Glabratellina sagrai (Todd and Bronnimann)

PLATE 5: FIGURES 25–27

Rosalina sagrai Todd and Bronnimann, 1957:37, pl. 9: fig. 22.

Two small specimens conspecific with the holotype of *"Rosalina"* sagrai Todd and Bronnimann have been found in the present material. This species is best placed in the genus *Glabratellina*, based on the characteristics exhibited on the umbilical side of the test. This species has a small planoconvex test. The moderately high-spired spiral side is finely perforate, the flattened umbilical side is imperforate. The periphery is subacute and slightly lobate. The chambers are arranged in three whorls, with six to seven chambers in the peripheral whorl. Sutures are limbate, slightly depressed, curved and oblique on the spiral side, depressed and radial, but indistinct on the umbilical side. The umbilical area is covered by granules that extend toward the periphery along the sutures and obscure the sutures. The chambers bear fine radiating striae on the umbilical side where not obscured by granules. The final chamber bears a linguiform umbilical extension or flap that is characteristic of the genus *Glabratellina*, and beneath which lies the aperture that extends about two-thirds of the distance from the umbilicus to the periphery.

Figured hypotype: USNM 211192.

	mean	standard deviation	range
station 1	0.06	0.32	0–2
station 3	0.00	0.00	0

Genus Angulodiscorbis Uchio, 1953

Angulodiscorbis corrugata (Millett)

PLATE 6: FIGURES 1–3

Discorbina corrugata Millett, 1903:700, pl. 7: fig. 5.

Discorbis corrugata (Millett).—Bermúdez, 1949:237, pl. 15. figs. 7–9.

Numerous specimens that appear to belong to this species occur in the present suite of samples. This small species has a high trochospiral test, the moderately inflated chambers of which are arranged three to three and a half whorls, with five chambers per whorl. The sutures are flush in early whorls, but depressed in the peripheral whorl. The rather small umbilicus is generally filled with granular material. The aperture is a narrow interiomarginal slit, extending from the umbilicus about halfway to the periphery. The umbilical side of the test is covered by radial rows of granules, and the spiral side is dominated by five strong costae that extend along the centers of the chambers from the proloculus to the somewhat angular periphery. This species closely resembles the illustration of *Glabratellina duclozi* of Seiglie and Bermúdez (1965), but lacks the linguiform umbilical extension characteristic of that genus and, by inference, of that species.

This species differs from *Angulodiscorbis pyramidalis* (Heron-Allen and Earland, 1924) in having five chambers in each whorl instead of the four characteristic of that species. Seiglie and Bermúdez (1965) attributed five chamber-per-whorl specimens to *A. pyramidalis*, although the original description and figures specify four chambers per whorl. Two specimens in the USNM collections labeled *Angulodiscorbis "pyramidata"* (Heron-Allen and Earland) from Fiji were inspected and found to have four chambers per whorl as originally described.

The specimens identified by Bermúdez (1949) as *Discorbis corrugata* (Millett) from the upper Oligocene of the Dominican Republic have been closely inspected and appear conspecific with the present suite of specimens, indicating a range for the species of Oligocene to Recent.

Although Seiglie and Bermúdez (1965) placed this species in *Glabratella*, it is more reasonably placed in *Angulodiscorbis*, following the generic criteria presented by Loeblich and Tappan in the *Treatise* (1964).

Figured hypotype: USNM 211201.

	mean	standard deviation	range
station 1	0.52	1.11	0–6
station 3	2.04	3.48	0–18

Family SIPHONINIDAE Cushman, 1927

Genus *Siphonina* Reuss, 1850

Siphonina pulchra Cushman

Siphonina pulchra Cushman, 1919:42, pl. 14: fig. 7, 1922a:49, pl. 7: figs. 11, 12; 1931:69, pl. 14: figs. 2, 3.—Phleger and Parker, 1951:24, pl. 12: fig. 15.—Parker, 1954:532, pl. 10: figs. 10, 11.

The species occurs rarely only at station 1. All specimens but one are juveniles, but appear to be conspecific with Cushman's specimens from the Miocene of Cuba.

Hypotype: USNM 211364.

	mean	standard deviation	range
station 1	0.15	0.36	0–1
station 3	0.00	0.00	0

Genus *Siphoninella* Cushman, 1927

Siphoninella? sp.

A single specimen occurring at station 1 is so referred. It fits the generic description given by Loeblich and Tappan (1964:C591), but does not have the fimbriate keel so common in the family Siphoninidae. It is rather small, with a single whorl, coiled early stage, followed by two biserial chambers and a uniserial final chamber ending in a large, flaring, open aperture with a phialine lip. The specimen is compressed and fairly flat surfaced, with a rounded margin. The pores are medium sized, fairly dense, and evenly distributed in the translucent wall. The sutures are narrow and quite depressed. It is not possible to identify this form more closely at this time. Conceivably, it may be a juvenile specimen whose plan of growth would change further, but this seems unlikely.

Hypotype: USNM 211340.

Family ASTERIGERINIDAE d'Orbigny, 1839

Genus *Asterigerina* d'Orbigny, 1839

Asterigerina carinata d'Orbigny

Asterigerina carinata d'Orbigny, 1839:118, pl. 5: fig. 25; pl. 6: figs. 1, 2.—Cushman, 1921:60, pl. 14: figs. 7, 8; 1922a:54, figs. 4–6; 1931:77, pl. 15: figs. 4, 5.—Phleger and Parker,

1951:26, pl. 14: fig. 2.—Bandy, 1954:135, pl. 31: fig. 5.—Parker, 1954:532, pl. 10: figs. 16, 17.—Todd and Low, 1971:15, pl. 3: fig. 3.

This abundant species occurs at both stations 1 and 3. This is the characteristic species of *Asterigerina* in the Caribbean, originally described by d'Orbigny from the beach sands of Cuba and Jamaica.

Hypotype: USNM 211356.

	mean	standard deviation	range
station 1	3.90	5.83	0–26
station 3	3.75	3.42	0–13

Asterigerina sp.

A single, broken but living specimen of *Asterigerina* was found in a sample from station 1. Although this specimen is clearly different from *A. carinata,* it is insufficiently well preserved to allow specific identification.

Hypotype: USNM 211239.

Family EPISTOMARIIDAE Hofker, 1954

Genus *Epistomaroides* Uchio, 1952

Epistomaroides? sp.

A single, small, broken specimen from station 3 has been questionably referred to *Epistomaroides* on the basis of probable small secondary chambers on the umbilical side of the test and apparent slight retral processes over the sutures, as are characteristic of the genus. Because of the small size and fragility of the specimen, more positive identification cannot be made. Specimen was lost during study.

Genus *Eponidella* Cushman and Hedberg, 1935

Eponidella sp.

A single broken specimen of an apparently unreported species has been found in the present suite of samples at station 1. This specimen has a biconvex, low trochospiral, coarsely perforate test. The periphery is rounded and entire. The chambers are somewhat inflated, arranged in one and one-half whorls, each subdivided into small chamberlets vis-

ible on the umbilical side. There are nine chambers in the peripheral whorl. The sutures are limbate, slightly curved, and flush. The umbilicus is filled by a large umbilical plug. The final chamber is broken so that the aperture is not preserved, but the aperture of the penultimate chamber is a single-lipped, oval areal opening. Specimen was lost during study.

Superfamily SPIRILLINACEA Reuss, 1862

Family SPIRILLINIDAE Reuss, 1862

Subfamily SPIRILLININAE Reuss, 1862

Genus *Spirillina* Ehrenberg, 1843

Spirillina vivipara Ehrenberg

PLATE 6: FIGURES 4–6

Spirillina vivipara Ehrenberg, 1843:323, 422, pl. 3(VII): fig. 41.—Cushman, 1922a:37, pl. 5: fig. 7; 1931:3, pl. 1: figs. 2–4; 1941:11.—Phleger and Parker, 1951:25, pl. 13: figs. 3, 4.— Parker, 1954:522, pl. 8: figs. 15, 16.

Other synonymous specimens are found so referred in the unfigured USNM collections from the Dry Tortugas, Puerto Rico, Tongue of the Ocean, and Bermuda. In the Discovery Bay material specimens are rare and with one exception occur only at station 3.

Figured hypotypes: USNM 187958.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.38	0.87	0–4

Genus *Mychostomina* Berthelin, 1881

Mychostomina revertens (Rhumbler)

PLATE 6: FIGURES 7–12

Sprillina vivipara Ehrenberg var. *densepunctata* Cushman.— Cushman and Parker, 1931:18, pl. 4: fig. 1.
?*Conicospirillina atlantica* Cushman, 1947:91, pl. 20: fig. 8.
Mychostomina revertens (Rhumbler).—Smith and Isham 1974:66, pl. 1: figs. 1–3, 7–9.

A few specimens of this species occur in quite a few Discovery Bay samples. The specimen figured by Cushman and Parker is conspecific; however,

three unfigured specimens from their collection referred as above are *Spirillina vivipara*. The synonymy of "*Conicospirillina atlantica*" is questioned only for the reason that the specimens so referred from off the southeast coast of the United States are generally larger than *Mychostomina revertens* of the present report and conspecific specimens from the West and South Pacific. They certainly are congeneric.

Figured hypotypes: USNM 187956, 187957.

Hypotypes: USNM 211309, 211310, 211311, 211312, 211313, 211314, 211315, 211316, 211317.

	mean	standard deviation	range
station 1	0.77	1.29	0–7
station 3	1.98	2.42	0–9

Subfamily PATELLININAE Rhumbler, 1906

Genus *Patellina* Williamson, 1858

Patellina advena Cushman

Patellina advena Cushman, 1922c:135, pl. 31: fig. 9.— Cushman and Parker, 1931:18, pl. 4: fig. 3.
Patellina corrugata Williamson.—Cushman, 1941:10.

This species is very rare in our material and occurs only at station 3. The similarity between this species and *Patellina corrugata* Williamson is great. In the two cases where populations of specimens have been seen, however, they seem distinct. All the many unfigured specimens from the Arctic in the USNM collections referred to *P. corrugata* seem correctly so. Several unfigured specimens from off the southeast coast of the United States are referred to *P. corrugata*, but appear to fall into both species, with little suggestion of gradation.

The holotype (the only primary type available) of *P. advena* is from the Oligocene of Mississippi. It would be very helpful to see populations of specimens from a stratigraphic continuum and more geographic areas in the Recent to observe more fully the distinctness of the two species. As it stands, the species appear distinct, but a minor uncertainty exists.

Among Recent specimens, Cushman and Parker (1931:18) remarked that *P. corrugata* is a cold-water form and *P. advena* a warm-water form. The latter has been identified from the Recent of the South and Southwest Pacific; Juan Fernandez Islands,

Chile; and Rio de Janeiro Harbor. Unfigured specimens in the USNM collections from Bermuda and Jamaica identified as *P. corrugata* appear to be *P. advena*. Cushman and Parker's (1951:23, pl. 17: fig. 4) specimen identified as *P. corrugata* (from 128 m in the Gulf of Mexico) certainly appears to be *P. corrugata*.

Hypotype: USNM 211319.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.10	0.59	0–4

Superfamily ROTALIACEA Ehrenberg, 1839

Family ROTALIIDAE Ehrenberg, 1839

Subfamily ROTALIINAE Ehrenberg, 1839

Genus *Ammonia* Brünnich, 1772

Ammonia beccarii (Linné)

Nautilus beccarii Linné, 1758:710.
Rotalia beccarii (Linné).—Cushman, 1922a:52, pl. 8: figs. 7–9; 1928:104, pl. 15: figs. 1–7; 1931:58, pl. 13: figs. 1, 2; 1944:35, pl. 4: fig. 22.—Said, 1949:37, pl. 4: fig. 5.—Post, 1951:176.—Parker, 1952:457, pl. 5: fig. 5.—Parker, Phleger, and Peirson, 1953:13, pl. 4: figs. 20–22, 25–30.
"*Rotalia*" *beccarii* (Linné) variants.—Phleger, Parker, and Peirson, 1953:42, pl. 9: figs. 14, 15.—Parker, 1954:531, pl. 10: figs. 1, 2, 5, 6.
Ammonia beccarii (Linné).—Phleger, 1964:379, pl. 2: figs. 22–25.—Buzas, 1965:62, pl. 4: fig. 1.
Rosalina parkinsonia d'Orbigny, 1839:99, pl. 4: figs. 25–27.
Rotalia beccarri (Linné), var. *parkinsonia* (d'Orbigny).—Phleger and Parker, 1951:23, pl. 12: fig. 6.
Rotalia beccarii (Linné) var. *tepida* Cushman, 1926:79, pl. 1; 1931:61, pl. 13: fig. 3.—Phleger and Parker, 1951:23, pl. 12: fig. 7.—Post, 1951:176.—Parker, 1952:457, pl. 5: fig. 8.
Rotalia cf. *R. beccarii* (Linné) var. *parkinsonia* (d'Orbigny).—Cushman, Todd, and Post 1954:360, pl. 89: fig. 22.
Rotalia beccarii (Linné) var. *sobrina* Shupack, 1934:6, fig. 4.—Post, 1951:176.—Parker, 1952:457, pl. 5: fig. 8.

Living specimens of this widespread shallow-water species occur throughout these samples, often in large numbers. Only one of the present samples was found to be devoid of living specimens of *Ammonia beccarii*. The morphology of the test appears to vary with the environment, so that in certain samples so-called "varieties" dominate. None of the present specimens approach the large size exhibited by typical material from the sands of Rim-

ini, but they closely resemble small specimens from that area. In this regard, it is interesting to note that the only large specimens in the USNM collections are from the Rimini area, and that these are the only specimens that show the complex channeling on the umbilical side of the test that is considered "typical" for this species.

Hypotype: USNM 211352.

	mean	standard deviation	range
station 1	17.25	15.36	3–99
station 3	20.31	31.40	0–158

Ammonia jacksoni, new species

PLATE 6: FIGURES 13–18

Test small, strongly convex on spiral side, slightly convex on umbilical side; wall finely perforate on spiral side, imperforate near umbilicus on umbilical side; periphery narrowly rounded, slightly lobate to entire; chambers inflated, arranged in two to three whorls, six to ten chambers in peripheral whorl, increasing gradually in size as added; all chambers visible on spiral side, only those of peripheral whorl visible on umbilical side; sutures limbate, gently curved, slightly depressed on umbilical side, becoming open near umbilicus, nearly tangential, slightly depressed to flush on spiral side; umbilicus moderately large, filled by numerous closely spaced pillars that extend to proloculus; umbilical ends of chambers thickened, covered by papillae or granules, as are sutures near umbilicus, giving entire umbilical area granulate appearance; aperture interiomarginal slit (closed in some specimens) on umbilical side of final chamber.

This small species is fairly common in many samples from station 1, but only two specimens have been found in samples from station 3. It is morphologically quite distinct from *Ammonia beccarii* (Linné), possessing more numerous chambers per whorl and more strongly tangential sutures on the spiral side, as well as a densely papillate umbilical area. *Glabratellina sagrai* (Todd and Bronnimann) is somewhat similar in appearance, but differs in having a subacute periphery, a flattened umbilical side, fewer chambers per whorl, and completely closed sutures on the umbilical side.

This species is named in honor of J. B. C. Jackson, who collected the samples and aided this study in many ways.

Descriptive statistics of the maximum diameter, minimum diameter, and thickness measured in mm for the holotype and three paratypes are:

	mean	standard deviation	range
maximum diameter	0.164	0.045	0.120–0.205
minimum diameter	0.144	0.037	0.105–0.180
thickness	0.104	0.036	0.070–0.140

Figured holotype: USNM 211164.
Figured paratype: USNM 211162.
Paratypes: USNM 211271, 211272.

	mean	standard deviation	range
station 1	0.98	1.50	0–6
station 3	0.04	0.20	0–1

Family ELPHIDIIDAE Galloway, 1933

Subfamily ELPHIDIINAE Galloway, 1933

Genus *Elphidium* Montfort, 1808

Elphidium advenum (Cushman)

Polystomella advena Cushman, 1922a:56–57, pl. 9: figs. 11, 12.
Elphidium advenum (Cushman).—Todd and Bronnimann, 1957:39, pl. 6: figs. 5–7.—Parker, Phleger, and Peirson, 1953:7, pl. 3: fig. 11.—Bandy, 1956:193, pl. 30: fig. 18.

Some of our specimens do not have a carina, but clearly are within the range of variation of the species. Specimens closely resembling the holotype and paratype are more inflated and have more limbate sutures and better development of septal bridges than the carinaless specimens. The latter resemble *Elphidium rugulosum* (Cushman and Wickenden), but are easily distinguished by their raised umbilicus. All specimens of *Elphidium advenum* examined (including the holotype and paratype) have an optically granular wall structure. For this reason, and because other characters, such as pores on the apertural face, are not consistent, we choose a conservative view of the genus *Elphidium* in opposition to the multigenera proposed by Loeblich and Tappan (1964) and many other authors.
Hypotype: USNM 211284.

	mean	standard deviation	range
station 1	0.42	0.87	0–3
station 3	1.10	1.43	0–6

Elphidium excavatum (Terquem)

Polystomella excavata Terquem, 1875:25, pl. 2: fig. 2.
Elphidium incertun var. *clavatum* Cushman, 1930:18–19, pl. 7: figs. 8, 9.
Elphidium clavatum Cushman.—Loeblich and Tappan, 1953:98, pl. 19: figs. 8–10.—Buzas, 1965:58, pl. 2: figs. 6, 7, pl. 3: figs. 1, 2; 1966:591, pl. 71: figs. 1–8.—Todd and Bronnimann, 1957:39, pl. 6: fig. 10.

This widespread common northern species occurs rarely. As Lutze (1965) and Feyling-Hanssen (1972) have convincingly pointed out, the species called *Elphidium clavatum* Cushman by most American workers is a junior synonym of *E. excavatum* (Terquem). The individuals from Jamaica are smaller than *E. excavatum* from colder waters and do not have the brownish color that is so characteristic of this species. Nevertheless, the umbilical bosses, variable septal bridges, and sutural pattern are characteristic of *E. excavatum*. Todd and Bronnimann found this species in the Gulf of Paria, but it has rarely been reported from the tropics.
Hypotype: USNM 211287.

	mean	standard deviation	range
station 1	0.21	0.65	0–3
station 3	0.02	0.14	0–1

Elphidium gunteri Cole

Elphidium gunteri Cole, 1931:34, pl. 4: figs. 9, 10.—Parker, 1954:508, pl. 6: fig. 16.—Bandy, 1956:194, pl. 30: fig. 19.—Lankford, 1959:2098, pl. 2: fig. 7.

This species occurs rarely at station 1. Specimens have fewer chambers (eight to ten) than the specimens deposited in the USNM collections, but in other respects are identical.
Hypotype: USNM 211285.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.00	0.00	0

Elphidium kugleri (Cushman and Bronnimann)

Cribroelphidium kugleri Cushman and Bronnimann, 1948:18–19, pl. 4: fig. 4.

The specimens in this study as well as two of Cushman and Bronnimann's paratypes are optically radial in wall structure. The specimens are very

distinctly perforate and compare well with Cushman and Bronnimann's specimens, although some of ours have as many as nine chambers instead of the six described by Cushman and Bronnimann. Some of the specimens appear brownish in color. All lack umblical bosses.

Hypotype: USNM 211286.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 3	0.54	1.17	0–6

Eliphidium norvangi, new species

PLATE 7: FIGURES 1–4

Test small, planispiral, involute; periphery rounded, slightly lobate; chambers seven to eleven in final whorl, initial and final chambers bearing many spike-shaped papillae; sutures distinct, slightly limbate; sutural pores a single row extending to umbilical area; septal bridges short, distinct, on all sutures; wall calcareous, finely perforate, optically radial, transparent to translucent; umbilicus slightly depressed, containing many spike-shaped papillae; aperture and lower half of apertural face bearing many spike-shaped papillae.

This species is quite distinctive because of the numerous relatively large spike-shaped papillae. All specimens in our material have these papillae. No named species of *Elphidium* appears to resemble it. Moreover, examination of all primary types of 94 species in the USNM collection bears out that the species described here is unique. Small size probably contributed to its obscurity.

We have named this species in honor of the late Dr. Aksel Norvang of the Zoological Museum, Copenhagen, who made outstanding contributions to our knowledge of foraminifera.

Descriptive statistics of the maximum diameter, minimum diameter, and thickness measured in mm for the holotype and six paratypes are:

	mean	standard deviation	range
maximum diameter	0.126	0.023	0.090–0.160
minimum diameter	0.104	0.011	0.090–0.120
thickness	0.073	0.020	0.050–0.100

Figured holotype: USNM 211216.
Figured paratype: USNM 211217.
Paratypes: USNM 211288, 211289, 211290, 211291, 211292.

	mean	standard deviation	range
station 1	1.46	2.66	0–14
station 3	0.13	0.33	0–1

Elphidium rugulosum (Cushman and Wickenden)

PLATE 7: FIGURES 5, 6

Elphidium articulatum d'Orbigny var. *rugulosum* Cushman and Wickenden, 1929:7, pl. 3: fig. 8.
Elphidium rugulosum (Cushman and Wickenden).—Bandy, 1956:194, pl. 30: fig. 21.

Specimens closely resemble Cushman and Wickenden's holotype and paratypes and Bandy's hypotypes. On most specimens septal bridges are poorly developed and characteristically, rugose material fills in the sutures and umbilical area. Individuals from our study and Cushman and Wickenden's paratypes were found to have a granular wall structure.

The type-locality of this species is Cumberland Bay, Juan Fernandez Islands, Chile. Bandy reported it from the Gulf of Mexico, but it is not reported by other authors. This species probably does have a wide distribution in the Caribbean because some of the specimens in the USNM collection that are identified as *Elphidium matagordanum* (Kornfeld) and *E. mexicanum* Kornfeld probably belong to this species.

Figured hypotype: USNM 211215.

	mean	standard deviation	range
station 1	0.85	0.99	0–4
station 3	1.77	2.19	0–9

Elphidium spp.

Specimens represented by hypotype USNM 239849 are very small juveniles and do not have the characters by which species can be distinguished. They may belong to either *Elphidium advenum* (Cushman) or *E. rugulosum* (Cushman and Wickenden).

Specimens represented by hypotype USNM 239850 are larger and "coarse" in appearance with numerous irregular septal bridges. They may represent aberrant forms of *E. excavatum* (Terquem) or *E. gunteri* Cole.

Hypotypes: USNM 239849, 239850.

	mean	standard deviation	range
station 1	0.25	0.44	0–1
station 3	0.08	0.35	0–2

	mean	standard deviation	range
station 1	0.06	0.32	0–2
station 3	0.00	0.00	0

Superfamily GLOBIGERINACEA Carpenter, Parker, and Jones, 1862

Family HANTKENINDAE Cushman, 1927

Subfamily HASTIGERININAE Bolli, Loeblich, and Tappan, 1957

Genus *Globigerinella* Cushman, 1927

Globigerinella aequilateralis (Brady)

Globigerinella aequilateralis (H. B. Brady).—Phleger and Parker, 1951:35, pl. 19: fig. 14.
Globigerinella aequilateralis (Brady).—Todd and Bronnimann, 1957:40, pl. 12: fig. 7.—Cifelli and Smith, 1970:35, pl. 4: figs. 2–4.

One specimen of this planktonic species was found at station 1. One must assume that some planktonic specimens washed ashore while still living and that we captured a few before they died. There is nothing morphologically peculiar about most to suggest any other history (such as the morphologic differences observed between "water-column" and "bottom" populations of the same planktonic species).

Whether or not this genus is a junior synonym of *Hastigerina* Thomson, with this species the type, is beyond the scope of this study.

Hypotype: USNM 211302.

Family GLOBOROTALIIDAE Cushman, 1927

Subfamily GLOBOROTALIINAE Cushman, 1927

Genus *Globorotalia* Cushman, 1927

Globorotalia inflata (d'Orbigny)

Globigerina inflata d'Orbigny.—Phleger and Parker, 1951:34, pl. 19: figs. 10, 11.—Cifelli and Smith, 1970:28, pl. 2: figs. 4, 5.

Three living specimens of this common planktonic species were found at station 1.

Hypotype: USNM 211306.

Globorotalia menardii (d'Orbigny)

Pulvinulina menardii (d'Orbigny).—Cushman, 1922a:50, pl. 8: figs. 3, 4.
Globorotalia menardii (d'Orbigny).—Phleger and Parker, 1951:36, pl. 20: figs. 1, 2.—Bandy, 1956:194.—Cifelli and Smith, 1970:40.

Four living and characteristic specimens of this planktonic species were found at station 1 in the Discovery Bay material.

Hypotype: USNM 211307.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.00	0.00	0

Family GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862

Subfamily GLOBIGERININAE Carpenter, Parker, and Jones, 1862

Genus *Globigerina* d'Orbigny, 1826

Globigerina quinqueloba Natland

Globigerina cf. *G. quinqueloba* Natland.—Todd and Bronnimann, 1957:40, pl. 12: figs. 2, 3.

A single living specimen of this common planktonic species was found at station 1. It falls within the limits of the species, sensu stricto, though it could be placed in *Globigerina quinqueloba* Natland subspecies *egelida* Cifelli and Smith. A relatively much larger population would be needed to determine this more certainly; therefore, it seems best simply to leave it at the species level.

Hypotype: USNM 211301.

Globigerina rubescens Hofker, 1956

Globigerina rubescens Hofker, 1956:234, pl. 32: fig. 26, pl. 35: figs. 18–21.

A single individual belonging to this species was observed at station 1.

Hypotype: USNM 211308.

Genus *Globigerinoides* Cushman, 1927

Globigerinoides conglobatus (Brady)

Globigerinoides conglobata (H. B. Brady).—Phleger and
Parker, 1951:35, pl. 19: fig. 15.—Bandy, 1956:194.
Globigerinoides conglobatus (Brady).—Cifelli and Smith,
1970:37, pl. 5: figs. 2–5.

A single somewhat immature individual was
found living at station 1.
Hypotype: USNM 211304.

Globigerinoides ruber (d'Orbigny)

Globigerina rubra d'Orbigny.—Cushman, 1921:55, pl. 12, fig.
6; 1922a:36, pl. 14: figs. 1, 2.
Globigerinoides rubra (d'Orbigny).—Phleger and Parker,
1951:35, pl. 19: fig. 16.—Bandy, 1954:136, pl. 31: fig. 6;
1956:194.—Todd and Bronnimann, 1957:40, pl. 12: fig. 5.
Globigernoides ruber (d'Orbigny).—Cifelli and Smith, 1970:38,
pl. 5: fig. 6.

Rare living individuals of this very common
planktonic species are found at station 1 in the pres-
ent material. Presumably they were collected shortly
after being washed into very shallow water. They
appear to be water-column species; some, however,
have white rather than red tests.
Hypotype: USNM 211305.

	mean	standard deviation	range
station 1	0.10	0.37	0–2
station 3	0.00	0.00	0

Subfamily CATAPSYDRACINAE Bolli, Loeblich, and Tappan, 1957

Genus *Globigerinita* Bronnimann, 1951

Globigerinita glutinata (Egger)

Globigerinita glutinata (Egger).—Cifelli and Smith, 1970:35,
pl. 4: fig. 5.

Two specimens were found living at station 1.
The species is widespread and locally common in
water-column plankton in the Caribbean.
Hypotype: USNM 211303.

	mean	standard deviation	range
station 1	0.06	0.24	0–1
station 3	0.00	0.00	0

Superfamily ORBITOIDACEA Schwager, 1876

Family EPONIDIDAE Hofker, 1951

Genus *Eponides* de Montfort, 1808

Eponides? sp.

PLATE 7: FIGURES 7–9

A single small specimen from station 3 is ques-
tionably assigned to *Eponides*. It has a biconvex
trochospiral test that is coarsely perforate on the
spiral side, imperforate near the umblicus and on
the apertural face. The chambers are arranged in
about two whorls, with six chambers in the periph-
eral whorl. The periphery is rounded, lobate. The
sutures are limbate, depressed, sigmoid on the um-
bilical side, tangential on the spiral side. The aper-
ture is a wide interiomarginal extraumbilical-
umbilical arch.

This species differs from Loeblich and Tappan's
(1964:C678) definition of *Eponides* in having a
coarsely perforate spiral side and in having a
rounded periphery. Because only a single specimen
is present, no study of the internal structure has
been attempted.
Figured hypotype: USNM 211169.

Genus *Neoeponides* Reiss, 1960

Neoeponides antillarum (d'Orbigny)

Rotalina (Rotalina) antillarum d'Orbigny, 1839:75, pl. 5: figs.
4–6.
Truncatulina antillarum (d'Orbigny).—Cushman, 1921:57, pl.
13: figs. 7, 8.
Eponides antillarum (d'Orbigny).—Cushman, 1931:42, pl. 9:
fig. 2.—Phleger and Parker, 1951:20, pl. 10: figs. 9, 10.—
Bandy, 1954:136, pl. 30: fig. 8.—Parker, 1954:528, pl. 9:
figs. 14, 15.
Pulvinulina incerta Cushman, 1922a:51, pl. 9: figs. 1–3.

This species is fairly common at station 3, but
only one specimen has been found at station 1.
These specimens seem to be smaller than average
specimens from the USNM collections.
Hypotype: USNM 211349.

	mean	standard deviation	range
station 1	0.02	0.14	0–1
station 3	0.33	0.60	0–2

Family AMPHISTEGINIDAE Cushman, 1927

Genus *Amphistegina* d'Orbigny, 1826

Amphistegina gibbosa d'Orbigny

PLATE 7: FIGURES 10–12

Amphistegina gibbosa d'Orbigny, 1839:120, pl. 8: figs. 1–3.
Amphistegina lessonii d'Orbigny.—Cushman, 1931:79, pl. 16: figs. 1–3.—Phleger and Parker, 1951:26, pl. 13: figs. 13, 14, pl. 14: fig. 1.—Bandy, 1956:192.

This is the shallow-water species of *Amphistegina* in the Caribbean area. Numerous specimens have been found in samples from station 3, but only occasional specimens appear in material from station 1.

The taxonomic problem posed by this species is a particularly difficult one. *A. gibbosa* was named by d'Orbigny in 1839, with the comment that this species approaches only *A. "quoyii"* in its characteristics, differing principally in the shape of the chambers and in lacking medial partitions on the "rosette" side of the test.

Among the species of *Amphistegina* listed in d'Orbigny's *Tableau méthodique de la classe des Céphalopodes* (1826), *A. quoyii* was the first, indicated as living at Rawack, in Australia. No description of the species was given, however, and no illustration was listed in the text. Nevertheless, in the captions to the illustrations, plate 17, figures 1–4 are listed as *"A. quoyii."* In the same publication, d'Orbigny listed as the third species of *Amphistegina*, *A. lessonii* from Mauritius in the Indian Ocean. For *A. lessonii*, he gave no description, but listed figures 1–4 of plate 17 as illustrations of his species, plus his plaster model no. 98. According to the plate captions, however, *A. lessonii* was not figured. Comparison of the illustrations on plate 17 with the model of *A. lessonii* suggests that two separate species of *Amphistegina* are represented; the illustrations are of a lenticular compressed species, the model is of a strongly biconvex, much less compressed species. The most logical conclusion to be drawn is that the reference to the illustrations in the text is incorrect, that the illustrations are of *A. quoyii*, and that this is the name that should be applied to the Pacific species, which is similar, but not identical to the Caribbean species as noted by d'Orbigny (1839). The name *A. lessonii*, which has generally been applied to the current species,

should be used for the inflated forms from the Indian Ocean characterized by d'Orbigny's model. Figured hypotype: USNM 211202.

	mean	standard deviation	range
station 1	0.17	0.48	0–2
station 3	11.92	13.44	0–64

Family CIBICIDIDAE Cushman, 1927

Subfamily CIBICIDINAE Cushman, 1927

Genus *Cibicides* de Montfort, 1808

Cibicides mayori (Cushman)

Truncatulina mayori Cushman, 1924:39, pl. 12: figs. 3, 4.
Cibicides mayori (Cushman).—Cushman, Todd, and Post, 1954:371, pl. 91: figs. 29, 30.—Todd, 1957, pl. 92: fig. 10; 1965:53, pl. 22: fig. 7.

A few specimens that appear conspecific with the holotype and paratypes of this species occur at station 3 in the present samples. These specimens are planoconvex, with inflated chambers and depressed sutures. The periphery is lobate, with a thin serrate keel. The interiomarginal slit aperture extends along the umbilical side from the slightly depressed umbilicus to the periphery. A supplementary sutural aperture is present on the spiral side at the posterior corner of the final chamber, remaining open in previous chambers.

Hypotype: USNM 211265.

	mean	standard deviation	range
station 1	0.00	0.00	0–0
station 3	0.10	0.31	0–1

Cibicides pseudoungerianus (Cushman)

PLATE 7: FIGURES 13–15

Truncatulina pseudoungeriana Cushman, 1922b:97, pl. 20: fig. 9.
Cibicides pseudoungerianus (Cushman).—Bandy, 1956:193, pl. 31: fig. 8.

The present suite of specimens has been compared with the holotype of *"Truncatulina pseudoungeriana"* Cushman, from the Oligocene of Mississippi, and appears conspecific. This small species has a plano-convex to slightly biconvex test,

with an entire to somewhat lobate periphery that bears a narrow, imperforate keel. There are eight to ten chambers in the peripheral whorl, with carved, limbate sutures that are depressed on the umbilical side, flush to slightly raised on the spiral side. Early chambers on the spiral side are obscured by a thickening of the wall over the previous whorls. The aperture extends from the umbilicus across the periphery and along the bases of the final few chambers on the spiral side.

Most of the reported occurrences of *Cibicides pseudoungerianus* from Recent sediments are actually of other species of *Cibicides* and other genera. Bandy's specimens, however, and some unfigured specimens in the USNM collections from shallow Atlantic water off the southeast United States appear to belong to this species.

Figured hypotype: USNM 211200.

	mean	standard deviation	range
station 1	1.98	2.61	0–11
station 3	1.92	2.84	0–17

Cibicides sp.

Two small, probably immature specimens of *Cibicides* from station 3 are insufficiently diagnostic to allow specific identification.

Hypotype: USNM 211266.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.04	0.20	0–1

Family PLANORBULINIDAE Schwager, 1877

Genus *Planorbulina* d'Orbigny, 1826

Planorbulina mediterranensis d'Orbigny

Planorbulina mediterranensis d'Orbigny, 1826:280, pl. 14: figs. 4–6, 6 bis.—Cushman, 1922a:45, pl. 6: figs. 1, 2; 1931:129, pl. 24: figs. 5–8.—Bandy, 1954:137, pl. 31: fig. 3.—Parker, 1954:545, pl. 13: fig. 9.

Two individuals from station 3 appear to belong to this widely distributed species. These specimens may be distinguished from the more abundant *Planorbulinella acervalis* (Brady) by having chambers that are much wider than high, with broadly rounded peripheries, and that are not arranged in the alternating annular series characteristic of *Planorbulinella*.

Hypotype: USNM 211353.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.04	0.20	0–1

Family ACERVULINIDAE Schultze, 1854

Genus *Acervulina* Schultze, 1854

Acervulina sp.

PLATE 7: FIGURES 16–18

This species has an attached test, with a low trochospiral juvenile stage, later adding irregularly shaped inflated chambers in an apparently random pattern. The periphery is rounded to subacute. The wall is moderately perforate. The sutures are depressed. There is no apparent primary aperture, which distinguishes this form from broken or juvenile specimens of *Planorbulinella acervalis* (Brady).

The present specimens appear conspecific with specimens in the USNM collection labeled "*Acervulina inhaerens* Schultze." Included with the latter are intermixed specimens of *Planorbulinella acervalis* (Brady), *Planorbulina mediterranensis* d'Orbigny, and other rather nondescript encrusting forms. This species lacks, however, the coarse, funnel-shaped pores that appear to be the diagnostic feature of *Acervulina inhaerens* as figured and described by Schultze.

Although numerous specimens of this species are to be found in the present samples, the various species appear to be so poorly defined that erection of yet another species of *Acervulina* at this time seems ill advised.

Figured hypotype: USNM 211203.

	mean	standard deviation	range
station 1	0.17	0.48	0–2
station 3	0.85	1.66	0–9

Genus *Planorbulinella* Cushman, 1927

Planorbulinella acervalis (Brady)

PLATE 7: FIGURES 19–21

Planorbulina acervalis Brady, 1884:657, pl. 92: fig. 4.—

Cushman, 1921:55, pl. 12: fig. 8; 1922a:45, pl. 6: fig. 3; 1931:130, pl. 25: fig. 1; 1941:13, pl. 2: figs. 7, 8.

Planorbulina mediterranensis d'Orbigny.—Cushman, 1915:28, pl. 12: fig. 1; 1941:13, pl. 2: fig. 9.

This variable attached species has a juvenile trochospiral stage that is difficult to distinguish from small specimens of *Cibicides pseudoungarianus* (Cushman), differing in having a subacute periphery, a lesser number of chambers per whorl, and in having slightly to strongly depressed sutures on the umbilical side. The umbilical side is strongly convex; the spiral side is planar to concave.

Mature specimens have new chambers added in annular alternating series; the chambers are about as wide as they are high. Mature chambers do not reach to the umbilicus, as do those of the juvenile stage. Chambers are flattened to concave on the spiral side, and convex, somewhat inflated on the umbilical side. Marginal apertures with narrow lips are present at the base of the apertural face of the final chamber and at the suture with the preceding chamber, the posterior aperture remaining open in earlier chambers. The periphery is acute in the mature stage, generally with a thin, irregular, imperforate keel.

Some large trochoid specimens from the present samples have been included in this species because they exhibit apertures similar in shape and placement to those of mature specimens of this species, although they do not develop the annular alternating chambers but retain the juvenile trochoid type of development.

Figured hypotype: USNM 211188.
Hypotype: USNM 211350, 211351.

	mean	standard deviation	range
station 1	1.35	1.56	0–8
station 3	5.08	3.99	0–18

Family CYMBALOPORIDAE Cushman, 1928

Genus *Cymbaloporetta* Cushman, 1928

Cymbaloporetta atlantica (Cushman)

PLATE 7: FIGURES 22–24

Tretomphalus atlanticus Cushman, 1934:86, pl. 11: fig. 3, pl. 12: fig. 7.

Juveniles of this species closely resemble small specimens of *Rosalina globularis* d'Orbigny, lacking only the well-developed umbilical chamber flaps of that species. Chambers are added in a low trochospiral coil until the one and one-half whorl stage, when the characteristic alternating annular chambers are added, generally four to a whorl. Some large individuals eventually add a single large float chamber to form a "typical" tretomphaloid chamber arrangement.

Because the type-species of *Tretomphalus* (*T. bulloides*) is conspecific with the type-species of *Rosalina* (*R. globularis*), the various species assigned to *Tretomphalus* must be reassigned to other genera (for more information, see Douglas and Sliter, 1965). Because this species has a characteristically cymbaloporettid stage in its ontogeny, Douglas and Sliter suggest placement in *Cymbaloporetta*. This assignment seems reasonable and is followed in the present study.

Figured hypotype: USNM 211199.
Hypotype: USNM 211268.

	mean	standard deviation	range
station 1	0.83	1.64	0–7
station 3	7.06	8.39	0–54

Cymbaloporetta squammosa (d'Orbigny)

PLATE 8: FIGURES 1–3

Rosalina squammosa d'Orbigny, 1839:91, pl. 3: figs. 12–14.
Cymbalopora squammosa (d'Orbigny).—Cushman, 1922a:41, pl. 6: figs. 4–6.
Cymbaloporetta squammosa (d'Orbigny).—Cushman, 1931:83, pl. 16: fig. 4.
Cymbalopora poeyi (d'Orbigny).—Cushman, 1931:83, pl. 16: fig. 4.

This species has a juvenile trochospiral stage, later developing alternating annular chambers, generally six in each whorl. The juvenile stage somewhat resembles that of *Rosalina globularis*, differing in lacking the chamber flaps and the depressed sutures on the umbilical side that are characteristic of that species, and in possessing a large umbilical plug and a much thicker test wall. This species has a much thicker and more opaque test than that of *Cymbaloporetta atlantica,* and has six annular chambers in the mature stage compared to four chambers of *C. atlantica*. Also, *C. squammosa* lacks the final tretomphaloid float chamber found in some large specimens of *C. atlantica*.

Figured hypotype: USNM 211198.

Hypotype: USNM 211270.

	mean	standard deviation	range
station 1	6.40	8.13	0–47
station 3	3.71	4.08	0–17

Cymbaloporetta tobagoensis (Bronnimann)

PLATE 8: FIGURES 4–6

Cymbalopora tobagoensis Bronnimann, 1949:183, figs. a, b.

Cymbaloporetta bradyi (Cushman).—Todd and Bronnimann, 1957:37, pl. 11: fig. 9.

In this species, the annular mature chambers characteristic of *Cymbaloporetta* are added in a less tightly organized fashion than those of *C. atlantica* and *C. squammosa*, resulting in a low, flattened irregularly conical test. The wall is moderately to coarsely perforate on the spiral side, intermediate between the thickened, coarsely perforate wall of *C. squammosa* and the thin, finely perforate wall of *C. atlantica*. The juvenile stage differs from those of the other two species in possessing depressed sutures on both spiral and umbilical sides, and in having pores on the umbilical side. The juvenile stage differs from *Rosalina globularis* in lacking chamber flaps, and in possessing a large umbilical plug.

Figured hypotype: USNM 211197.

Hypotype: USNM 211269.

	mean	standard deviation	range
station 1	2.83	2.88	0–13
station 3	5.71	4.55	0–15

Superfamily CASSIDULINACEA d'Orbigny, 1839

Family CAUCASINIDAE Bykova, 1959

Subfamily FURSENKOININAE Loeblich and Tappan, 1961

Genus *Fursenkoina* Loeblich and Tappan, 1961

Fursenkoina pontoni (Cushma)

PLATE 8: FIGURES 7, 8

Virgulina pontoni Cushman, 1932:80, pl. 12: figs. 10, 11; 1937:19, pl. 2: fig. 27.—Phleger and Parker, 1951:19, pl.

9: figs. 9, 10.—Parker, Phleger, and Peirson, 1953:5, pl. 4: figs. 14, 15.—Parker, 1954:513, pl. 7: fig. 9.—Lankford, 1959, pl. 2: fig. 17.

Virgulina punctata d'Orbigny.—Cushman and Parker, 1931:15.—Cushman, 1941:9.—Todd and Bronnimann, 1957:33, pl. 8: fig. 8.

Virgulina schreibersiana Czjzek.—Bandy, 1954:139, pl. 31, fig. 10.

The holotype and a paratype have been examined. Three Discovery Bay specimens were examined for wall structure and found to be clearly optically granular. The species is fairly well represented at station 3. Some of the abundant unfigured specimens referred to *"Virgulina punctata"* from the southeast coast of the United States and the Dry Tortugas (especially the former) in the USNM collections are *Fursenkoina pontoni*, though the majority are *F. punctata*. Of other USNM unfigured specimens referred to *F. punctata*, the following judgments are made: of the seven from Bermuda, both *F. punctata* and *F. pontoni* are represented; the one from Montego Bay, Jamaica is *F. punctata*; the one from Puerto Rico is *F. pontoni*; the two from off Tobago probably are *F. pontoni*; and the two from off Guadaloupe are *F. pontoni*.

Though *Fursenkoina pontoni* was named from Miocene sediments, the above-cited Recent forms certainly appear conspecific. Perhaps the Miocene age of type *F. pontoni* has led to some of the confusion of Recent specimens with *F. punctata*, which was named by d'Orbigny from the Recent of Cuba; *F. punctata* is much more compressed and tends more toward biseriality than *F. pontoni*, and tends to be larger.

Figured hypotype: USNM 211183.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	4.04	7.99	0–51

Fursenkoina punctata (d'Orbigny)

Virgulina punctata d'Orbigny, 1839:139, pl. 1: figs. 35, 36.—Cushman, 1921:52, pl. 11: fig. 15; 1922a:31, pl. 3: fig. 9; 1937:23, pl. 3: fig. 27.—Parker, 1954:513, pl. 7: fig. 11.

Virgulina schreibersiana Czjzek.—Bandy, 1956:198.

Only a single living specimen of this species was found at station 3 in the Discovery Bay material.

Hypotype: USNM 211298.

Genus *Sigmavirgulina* Loeblich and Tappan, 1957

Sigmavirgulina tortuosa (Brady)

PLATE 8: FIGURES 9–12

Bolivina tortuosa H. B. Brady.—Cushman and Parker, 1931: 16, pl. 3: fig. 22.—Cushman, 1937:133, pl. 17: figs. 11–19; 1941:10.—Todd and Bronnimann, 1957:34, pl. 8: fig. 24.

Todd and Bronnimann's figured specimen is weathered and superficially resembles the thin, twisted form of *Bolivina subexcavata* discussed herein; it is, however, *Sigmavirgulina tortuosa*. Of two specifically referred unfigured specimens collected by Bronnimann in the same study, one is *S. tortuosa* and the other is a thin, twisted *Bolivina subexcavata*. Of three unfigured specimens in the USNM collections from off Onslow Bay, North Carolina and referred to *Sigmavirgulina tortuosa,* two are *S. tortuosa* and one is a fairly characteristic *Bolivina subexcavata*.

It has been difficult to determine the variability and exact morphology of this species in the Discovery Bay material as few specimens occur in any one sample and there is a disproportionate number of juveniles. This later situation is the case with many of the rarer species here and is believed to indicate that the species live more abundantly nearby in deeper water or otherwise different environments and tend mainly to be washed in accidentally. The fact that the number of individuals here is greater, though still rare, at the deeper station (3) supports this.

Comparison with large populations of *Sigmavirgulina tortuosa* from other localities has assisted greatly in understanding the plan of growth and variability of these present specimens and of the species and genus themselves. The major taxonomic problem arises out of understanding the coiling in the early part of the test. The fact that Loeblich and Tappan (1964:C733) noted a very early axial twisting, leading them to conclude that the first two series of chambers were coiled in a sigmoiline fashion and that the examined specimens had a granular rather than radial wall led them to separate this, the type-species from *Bolivina,* to which it had been assigned. It is also compared with *Fursenkoina,* with which it is thought to be closely related. Specimens in the present study examined for wall structure showed *Fursenkoina* to be optically granular and *Bolivina* optically radial. Like-

wise, numerous specimens of *Sigmavirgulina tortuosa* have been examined; they are not "beautifully" radial, but do show numerous calcite crosses. These examined specimens then perhaps should be referred to the genus *Compresserigerina,* radial, but they differ morphologically in having large pores and not tending to become unserial and have a neck, and they certainly appear to belong to the species *tortuosa*. The entire problem of radial versus granular wall is in doubt. Leaving that aside, there appears to be sufficient morphologic distinction to the species *tortuosa* to place it in a distinct genus, and if that is to be, *Sigmavirgulina tortuosa* is correctly the type-species. The higher taxonomic placement, dependent on assumed wall structure, as described by Loeblich and Tappan (1964) leaves many problems. As with the others encountered herein, we mainly follow the placement of Loeblich and Tappan fairly closely for convenience, in spite of this problem.

Recognizing *Sigmavirgulina tortuosa* as distinct from *Bolivina,* leaving aside the problem of wall structure, brings up other problems. There is a considerable degree of variation in the amount of axial twisting at the base and the descriptive terms of this twisting must be understood. Specimens range from what would usually be called slightly twisted (perhaps 15°) basally, but clearly biserial throughout, to forms with such a basal twist (approaching 720°) that a problem arises as to how to "term" this twist. It could be called a sigmoiline coil or spire or it could be defined as a series of biserial chambers with a very rapidly rotating axis of coiling. Unfortunately, those specimens tending toward this last situation have a bulbous base with a thick wall (probably a result of maintaining the continuity of chambers being offset so rapidly) that makes seeing the exact positions and relations of the chambers difficult. The precise arrangement of early chambers showed by Loeblich and Tappan (1964, fig. 601: 1a) has not been seen in the present study. Their etched basal view (1964, fig. 601: 2) showing "twisted biserial early chamber arrangement" has been seen and better illustrates the problem of description and understanding. From the exterior (as with 1a), only less twisted biserial arrangements have been clearly seen herein, the wall thickness being a deterrent with specimens twisted more than approximately 180°.

The variation in twisting and concomitant wall

and test thickness, along with some other variations within the species, make juveniles difficult to recognize as belonging to the same species and initial difficulty in recognizing the species as a single taxonomic unit.

All mature specimens show considerable flaring. They become more regularly biserial, though continuing to twist, after the initial twisting. The surface is smooth and translucent except often in the early twisted part. There, ornamentation may consist of up to a few short costae in addition to the keel, which superficially may look like a costa at this point. There may also or instead be some very short spines that appear to be related to the pores and perhaps project from or around them— this occurring on large-pored specimens. In such cases, the pores may be seen as linear projections back into the thick wall. These lines are the pores and are located in the early part of the test, but not always in association with spines.

Most specimens are only somewhat compressed in the adult chambers, but this varies somewhat and, varying, may be markedly thickest along the median and go to sharp and/or keeled margins. That is the more usual case; they may otherwise only become less thick toward a rounded margin. The majority of specimens are keeled, either throughout or become keeled in the last few to pair of chambers. Some specimens show a keel as an extension of the limbate sutures. The sutures often are not distinct or depressed in the early, twisted portion, but usually become so. They may be thickened or narrow, or go from thickened to narrow. The depression of the sutures often hardly indents the margin when it is sharp or keeled, even though depression may (or may not) be reasonably marked in the body of the test.

The pores on most specimens are relatively few and large, but pore pattern is variable. Pore size may be small or medium throughout or decrease markedly in the last one or two chambers, sometimes disappearing at the top of the rather bulbous final chambers of rather juvenile specimens. Pores may be relatively evenly distributed or may be concentrated along the bases of chambers or become so in adult chambers, or may be or become concentrated (as above) in rows parallel to the bases of chambers and, occasionally, also along the margins.

A strange feature of some large pores is that in the early, twisted, and immediately following part of the test, the pores appear to be located as pits in centers of small, sharp pustules; these pustules may be slightly extended to be the spines mentioned above. Also, as mentioned, such pores, either in association with spines or not, are often linear-appearing from being seen extending through the thick but translucent wall.

The aperture in adults usually extends as a slit from the base some distance upward toward the apex of the final chamber, on keeled (most) specimens surrounded by the keel, which forms a lip, but with a lip if not keeled. Occasionally, the aperture begins above the base of the final chamber and is more terminal. A tooth plate can be seen. In juveniles there is more apertural variability; the less twisted forms have the adult-type aperture, though a bit more oval, while the more bulbous and twisted forms have a more open, ovate slit located basally on the side of the depression formed by the join of two chambers. This depressed location is very seldom found in adults because of the rising and smooth overlap of chambers.

With most specimens, there is little difficulty distinguishing them from other species. A few small specimens, with little twist and pores along the bases of the chambers, resemble a form of *Bolivina doniezi* Cushman and Wickenden, but that species does not twist. In some cases, the compressed and twisted form here included in *Bolivina subexcavata* Cushman and Wickenden and clearly transitional with characteristic specimens of that species has either been taken for or included with *Sigmavirgulina tortuosa*. The resemblance is, however, superficial. *Sigmavirgulina tortuosa* twists earlier and usually more profoundly and has a smooth wall, usually with large pores, while the *Bolivina* has a grainy appearing wall, small pores, and a lesser but longer continuing twist.

Figured hypotype: USNM 211176, 211177.

Hypotype: USNM 211334, 211335, 211336, 211337, 211338.

	mean	standard deviation	range
station 1	0.50	0.82	0–4
station 3	2.50	1.66	0–6

Genus *Coryphostoma* Loeblich and Tappan, 1962

Coryphostoma? limbata (Brady) subsp. *costulata* (Cushman)

PLATE 8: FIGURES 13, 14

Bolivina limbata H. B. Brady var. *costulata* Cushman, 1922a: 26, pl. 3: fig. 8; 1937:187, pl. 21: fig. 30.
Loxostomum mayori (Cushman).—Cushman and Parker, 1931:16, pl. 3: fig. 24.—Cushman, 1941:11 [part].—Todd and Bronnimann, 1957:35, pl. 8: fig. 38.—Bandy, 1956:295. [part, not p. 31: fig. 11].

The holotype of *"Bolivina limbata* H. B. Brady var. *costulata* Cushman"* and the holotype and five paratypes of *"Bolivina mayori* Cushman"* have been examined. (Both were described from off Florida by Cushman, 1929.) So have numerous other specimens of both taxa from essentially the "type" areas and other areas. Examination strongly suggests that two taxa are represented, but that original descriptions have led to some confusion in differentiating these similar forms. Overall, *"Loxostomum mayori"* has a more delicate test, tends to have rounder margins, and has from none to numerous striae or fine costae of varying length and position, as opposed to the few strong basal costae of *"Loxostomum limbatum costulatum."* Bandy's figured specimen appears to belong to *L. mayori,* while, of the other two unfigured specimens deposited with it, one could be either species, while one clearly is *"L. limbatum costulatum."* Unfigured specimens included in Cushman and Parker's material from Rio de Janeiro Harbor and the unfigured specimens treated by Cushman in 1941 (from Old Providence Island) appear to belong to both taxa. *"Loxostomum* cf. *mayori* (Cushman)"* of Phleger and Parker from the Gulf of Mexico (1951:17, pl. 8: fig. 5) appear to belong to *L. mayori.*

Relatively rare, mainly juvenile specimens were found living in this study. More common, empty (dead) tests found probably indicate that the species lives nearby, adjusted to another environment.

The present specimens are characterized by a few, strong costae over the large, usually bulbous, proloculus and sometimes first few following chambers. A few striations or finer costae are present on the later chambers of some larger specimens. Also characteristic are the sutures, which are very limbate toward the median line of the test, which, with the chamber overlap, forms a zigzag pattern

of clear subtriangles in the biserial part of the test. Early, the sutures are arcuate, though they may become straight and oblique later. Early, they are either flush or slightly depressed. In larger specimens they may become narrow and slightly depressed (if they were not depressed early) in the later part. Some larger tests are twisted. The margins are usually rounded, but sometimes carinate in part, or occasionally all, of the test. The pores are of medium size, not very dense, and of fairly even distribution, except that in a few cases there are concentrations along suture edges. The pores are very distinct because the walls are so clear. The aperture is large—long with a fairly wide slit and a thick lip. There is an internal process that reaches the aperture to form a tooth plate in the final chamber of some specimens, but in others seems not to extend all the way up to the aperture nor all the way down from the apex to the base.

The generic placement of this species is questionable in some morphologic features, but, more basically, we question the limits and wall structures of the genus *Coryphostoma* as given by Loeblich and Tappan (1964:C733). The first remarks given with their original generic description (1962:111) allow for somewhat broader limits than does the description itself and the direct comparisons with other genera. The significant remark states that because of the revision of *Loxostomum,* many species previously so referred were left nameless and the name *Coryphostoma* is proposed for them. This, then, leaves the present taxon only differing from characteristic *Coryphostoma* (except in wall structure) in not being rounded in cross section, but rather flattened, but usually with rounded margins (as opposed to *Loxostomum's* quadrate, double-keeled outline and sometimes denticulate aperture with no internal toothplate). Both *Coryphostoma* and *Loxostomum* are stated to have granular walls. Several specimens of the present taxon have been examined and found to have optically radial walls. The wall is not "beautifully" radial, but many calcite crosses can be found. We also found this with *Sigmavirgulina tortuosa,* and we feel that the original descriptions of the walls as granular, with no exceptions, are in error. We cannot say that this is so for all species of *Sigmavirgulina* and *Coryphostoma,* but it is for the two species here discussed (and *S. tortuosa* is the type-species of *Sigmavirgulina*). The present *Loxosto-*

mum-like specimens certainly do not belong to *Loxostomoides* or to *Rectobolivina* ("radial") on the basis of considerable morphologic differences. We are unable to resolve the taxonomic problem further than to raise these questions. We have, therefore, tentatively placed the form *"Loxostomum limbatum costulatum"* in *Coryphostoma*. It appears best placed there if one disregards the "radial-granular" wall question, which is subject, at best, to considerable interpretation.

Figured hypotype: USNM 211213.

	mean	standard deviation	range
station 1	0.31	0.62	0–2
station 3	1.00	1.30	0–5

Coryphostoma? sp.

Two specimens, one from each station, are so referred. They closely resemble the type-species of the genus, *Coryphostoma plaita* (Carsey), except they are smaller and the apertures appear larger. The aperture also appears to be in a terminal pit, with a higher "back" side, reminiscent of some of the Pleurostomellidae. It may, however, simply be a large slit. No apertural teeth nor connecting tubes between chambers can be seen. The wall is optically radial. It is because of the problems of toothplate, aperture, and wall structure that the genus is questioned. The only pleurostommellid-like form it resembles at all closely is *"Pleurostomella vicksburgensis* Howe," which is similarly bi-serial, but that form differs in the aperture, which is not similarly sunken, in having larger pores, and in being larger. The material is too scanty for further determination.

Hypotype: USNM 211347.

Family CASSIDULINIDAE d'Orbigny, 1839

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina cf. *C. subglobosa* Brady

Cassidulina subglobosa Brady.—Phleger and Parker, 1951:27, pl. 14: fig. 13 [not figs. 11, 12].—?Parker, 1954:536, pl. 11: fig. 6 [not figs. 4, 5, 7–9].—Lankford, 1959, pl. 3: fig. 15.
Cassidulina sp. A. Todd and Bronnimann, 1957:37, pl. 11: fig. 10.

Only 12 specimens have been obtained, from station 3, in the present material. Therefore, synonymy is particularly difficult in questionable cases. In the case of Phleger and Parker and that of Parker, the specimens questionably synonymized are very similar to our specimens, but not identical, and belong to populations that they state include large, characteristic specimens also (as those figures cited as not conspecific with the present specimens). This may also be the case with Lankford's material, but no comments are made and the figured specimen appears conspecific. Phleger and Parker's citation is as *Cassidulina subglobosa* in the text but as *Cassidulina* cf. *subglobosa* on the plate description and on the slide containing the specimen. Parker's (1954) specimen is described as a "small compressed variant." Our specimens are too few to identify more closely, but they are not characteristic *C. subglobosa,* being much too compressed and small. They are also similar to *Cassidulina barbara* Buzas, but more globose, with less depressed sutures, a slightly different aperture, and are somewhat smaller. A new species may be represented or perhaps all are juvenile or variant *C. subglobosa.* Among the many unfigured specimens in the USNM collections from off the southeast coast of the United States are many very similar specimens included with the larger and more characteristic *C. subglobosa.* The taxonomic problem is beyond the scope of this report.

The present specimens are very small, smooth, transparent to translucent, and optically granular in wall structure, with small pores. They show about six or seven chambers in the peripheral whorl (four complete viewed from the apertural side). They have slightly limbate, flush to very slightly depressed sutures. Specimens are subglobose in shape, with a rounded margin. The apertural face stands up parallel to the axial plane of the test, clearly showing the aperture. It is small, subtriangular, with a slight V-shaped projection of the wall into the aperture near the base on one side; though the wall is slightly thickened around the aperture, no internal processes have been seen.

Hypotype: USNM 211341.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.23	0.47	0–2

Family NONIONIDAE Schultze, 1854

Subfamily NONIONINAE Schultze, 1854

Genus *Nonionella* Cushman, 1926

Nonionella auricula Heron-Allen and Earland

Nonionella auricula Heron-Allen and Earland, 1930:192, pl. 5: figs. 68–70.—Todd and Bronnimann, 1957:32, pl. 5: fig. 32.

Specimens from Jamaica most closely resemble individuals in the Cushman collection collected by P. Bronnimann from the Gulf of Paria, Trinidad. Some individuals resemble the paratypes of *Nonionella atlantica* Cushman, but the latter are generally more inflated and characteristically contain pustules in the umbilical area.

Hypotype: USNM 211293.

	mean	standard deviation	range
station 1	1.33	1.37	0–6
station 3	1.98	2.42	0–9

Family ALABAMINIDAE Hofker, 1951

Genus *Trichohyalus* Loeblich and Tappan, 1953

Trichohyalus aguayoi (Bermúdez)

Discorbis aguayoi Bermúdez, 1935:204, pl. 15: figs. 10–14.—Todd and Bronnimann, 1957:37, pl. 9: fig. 24.
Discorinopsis aguayoi (Bermúdez).—Parker, Phleger, and Peirson, 1953:7, pl. 4: figs. 23, 24.—Phleger and Ewing, 1962: 178, pl. 5: figs. 5, 6.

This species occurs in samples from station 1 only.

Hypotype: USNM 211365.

	mean	standard deviation	range
station 1	0.17	0.48	0–2
station 3	0.00	0.00	0

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE, 1927

Genus *Anomalina* d'Orbigny, 1826

Anomalina glabrata Cushman

PLATE 8: FIGURES 15–17

Anomalina glabrata Cushman, 1924:39, pl. 12: figs. 5–7.—Cushman, Todd, and Post, 1954:370, pl. 91: fig. 23.

This rather small species occurs in several samples, mostly from station 1. It has a low trochoid test, with about one and one-half whorls visible on the flattened spiral side of the largest individuals. The chambers are somewhat inflated on the umbilical side. The periphery is broadly rounded. There are eight to nine chambers in the ultimate whorl. Sutures are limbate, flush to slightly depressed. The umbilicus is small but open, with the umbilical corner of each chamber thickened and imperforate. The aperture is an interiomarginal extraumbilical-umbilical slit extending to the periphery.

Figured hypotype: USNM 211171.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.02	0.14	0–1

Anomalina? reniformis (Heron-Allen and Earland)

PLATE 8: FIGURES 18–20

Discorbina reniformis Heron-Allen and Earland, 1915:696, pl. 52: figs. 7–14.
Anomalina? maculosa Todd, 1957:296, pl. 92: fig. 12.

The generic assignment of this species is uncertain because it exhibits characteristics that preclude its inclusion in any described genus. It has a small, slightly trochospirally coiled test that is moderately to coarsely perforate except at the sutures and on the apertural face. The chambers are inflated and the sutures are flush, resulting in a globular test. The test wall is extremely thick, obscuring the details of chamber arrangement. The periphery is rounded, entire. There are usually six to nine chambers in the peripheral whorl, early chambers increasing rapidly in size as added, later chambers increasing in size more slowly. The umbilicus is closed. The apertural face of the last chamber appears to be covered by an imperforate callus, the bottom edge of which is free, resulting in a low slitlike interiomarginal aperture varying in length, ranging from the umbilicus to the periphery in some specimens to a very short peripheral slit in others.

Because only a small number of specimens are present in these samples, no attempt at wall-

structure study has been attempted, and no placement in the *Treatise* (Loeblich and Tappan, 1964) classification is possible. For convenience, the questionable assignment to *Anomalina* by Todd (1957) has been followed, because it does exhibit many characteristics of that poorly defined genus. The assignment to *Discorbina* by the original authors is less acceptable, because *Discorbina* has been placed in synonymy with *Discorbis* in the *Treatise* (Loeblich and Tappan, 1964), and the present specimens clearly do not exhibit the characteristics of that genus.

Figured hypotype: USNM 211170.

Hypotype: USNM 211262, 211366, 211367.

	mean	standard deviation	range
station 1	0.08	0.28	0–1
station 3	0.02	0.14	0–1

Superfamily ROBERTINACEA Reuss, 1850

Family CERATOBULIMINIDAE Cushman, 1927

Subfamily CERATOBULIMININAE Cushman, 1927

Genus *Lamarckina* Berthelin, 1881

Lamarckina sp.

Test small, planoconvex, auriculate, about two times higher than wide; wall finely perforate, translucent; periphery acute with a thick, narrow keel, lobate; chambers inflated, arranged in a single whorl, eight chambers in largest specimen, chambers increasing rapidly in size as added; sutures limbate, slightly depressed on flat spiral side, deeply incised on convex umbilical side; umbilicus large, depressed, partially covered by large plate extending from lower part of final chamber to prolocular area and first few chambers; aperture an arch beneath the chamber flap on proximal side of the flap.

Although the distinctive features of these specimens appear unlike those of any previously reported species, an insufficient number is present to permit formal naming of a new species.

Hypotype: USNM 211371.

	mean	standard deviation	range
station 1	0.04	0.20	0–1
station 3	0.08	0.28	0–1

Family ROBERTINIDAE Reuss, 1850

Genus *Cerobertina* Finlay, 1939

Cerobertina sp.

Two extremely small specimens of *Cerobertina* have been found at station 3. These specimens are compressed, concavo-convex, about twice as high as they are wide. The wall is translucent, finely perforate. The periphery is narrowly rounded, entire in early development, becoming somewhat lobate. About seven to eight flattened chambers are visible from either side. The chambers increase rapidly in size as added. The sutures are radial, slightly curved, flush. The chamberlets on the umbilical side are very small and indistinct. The aperture is a low silt along the umbilical side of the depressed apertural face of the final chamber. These specimens are unlike other described species of this genus, but too small a sampling is present to allow erection in another species.

Hypotype: USNM 211370.

	mean	standard deviation	range
station 1	0.00	0.00	0
station 3	0.04	0.20	0–1

Genus *Ungulatella* Cushman, 1931

Ungulatella? sp.

Three very distinct specimens have been found at station 1. They appear to belong to *Ungulatella* (and may represent a new species). They differ from the generic description given by Loeblich and Tappan (1964:C782), however, in that they have a smooth, not rough, wall and they have more overlap of chambers than Loeblich and Tappan describe as seen on the side from which the aperture is visible. They are most similar to *Ungulatella gracilis* Seiglie from shallow water off Venezuela (which also is smooth) but show more chamber overlap and have a more rounded, rather than sharp, rim around the depression in the final chamber that contains the largest part of the aperture.

In the present specimens also, the aperture is more comma shaped than loop shaped and superficially looks like a circle. The material is insufficient to be more certain of the taxonomic designation.

Hypotype: USNM 211228.

	mean	standard deviation	range
station 1	0.06	0.32	0–2
station 3	0.00	0.00	0

Appendix

Number of Individuals Observed in 20 ml Replicate Samples

Table A.—Station 1

SPECIES	NOV 1969				DEC				JAN 1970				FEB				MAR			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Acervalis sp.					1															
Ammobaculites exilis		2	2	1			5		4	4					6		1			
Ammodiscus minimus																				
Ammodiscus sp.																				
Ammonia becarii	27	52	30	25	30	10	15	16	11	5	8	9	17	11	9	3	12	10	6	11
Ammonia jacksoni	1	6	6	3	1	1		2				1	2	1	2		3			
Amphistegina gibbosa				2									1							
Angulodiscorbis corrugata					1			2			1				2	1		1	2	2
Anomalina glabrata				1					1											
Anomalina (?) reniformis							1							1						
Archaias angulatus																				
Asterigerina carinata	1	1		2	3	1	1	1	1			2	5		1	1	2		2	2
Asterigerina sp.																				
Baggina aff. B. philippinensis																				
Bolivina doniezi	4	4	1	6	1	1	3	6	3	2	9	2		2	9	5	3	3	3	2
Bolivina lowmani																				
Bolivina paula				1		1					2								1	
Bolivina rhomboidalis	1								1			1			2					
Bolivina striatula	35	51	53	89	27	36	31	74	21	24	45	30	22	35	52	31	23	31	10	27
Bolivina subexcavata	19	20	18	46	12	9	7	29	9	18	32	13	6	12	67	33	13	21	6	20
Bolivina spp.																	1			
Bolivina (?) spp.		1	1			1						1								
Bolivina cf. B. compacta		1		1	1						1									
Bolivina cf. B. subexcavata		3	1	2	1		1	1	1		1	1		1	3	1	1	1	1	
Bronnimannia caribaea				1																
Buliminella elegantissima		3	5	4		3		1		1	1	1	1	2	2			1	3	
Buliminella milletti				1																
Buliminella parallela																				
Cancris sagra		1																		
Cassidulina cf. C. subglobosa																				
Cerobertina sp.																				
Chrysalidinella aff. C. miocenica																				
Cibicides mayori																				
Cibicides pseudoungerianus		3		4		1	4	2	1	2			2	2	2		1	1		
Cibicides sp.																				
Clavulina tricarinata	2							1		1	2				1				2	6
Coryphostoma (?) limbata costulata		2							1				1		2		1	2		
Coryphostoma (?) sp.																				
Cyclogyra planorbis		2		6			3	3	3		3		1		3		17	2	41	30
Cymbaloporetta atlantica	2		1		2					2		2	2							
Cymbaloporetta squammosa			1					1		8	3	2	20	1	5	4	5	5	5	1
Cymbaloporetta tobagoensis		2		4	4	5	4	4	5	2	1		2	4	5	3	1	3	2	4
Discorbinella minuta				1																
Discorbin ella sp.																				
Discorbis granulosa		1					1						1							1
Discorbis mira							2		1	1	2	1	3	1					2	
Discorbis murrayi		2		2	4		2		2		2	1		1	2	3	5	1	2	
Eggerella cf. E. advena				1							1									
Eggerella cf. E. humbolti				1																
Elphidium advenum				2										3						1
Elphidium excavatum																		1	2	2
Elphidium gunteri															1					
Elphidium kugleri													1							
Elphidium norvangi	1	1									1								4	2
Elphidium rugulosum		3	2						1					1	1	2			2	1
Elphidium spp.	1	1																	1	
Eoeponidella pacifica				1											1					
Epistomaroides (?) sp.																				
Epistominella (?) sp.																				
Eponidella sp.																				
Eponides (?) sp.																				
Esosyrinx (?) sp.																				
Fissurina cf. F. agassizi																				
Fissurina cf. F. milletti							1													
Fissurina goreaui																				5
Fursenkoina pontoni																				
Fursenkoina punctata																				

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APR 1	APR 2	APR 3	APR 4	MAY 1	MAY 2	MAY 3	MAY 4	JUN 1	JUN 2	JUN 3	JUN 4	JUL 1	JUL 2	JUL 3	JUL 4	AUG 1	AUG 2	AUG 3	AUG 4	SEP 1	SEP 2	SEP 3	SEP 4	OCT 1	OCT 2	OCT 3	OCT 4
			2				2					1											2	1	1		
				13	2	32	25			1	1		1					2							1	5	1
						1																					
13	5	17	16	21	29	20	99	14	7	11	34	13	15	5	11	8	12	11	15	14	7	17	31	25	12	25	4
	2						1	1		1	1		1				4							4	1		
					6	3	2						1					1					2	1			
												1				1						1	1				
		1														1			1		1		3	26	23	6	2
		1		2	7	1	2	1	4	1	6	7	11	3	2	3	5	5		2	13	7	21				
												1															
7	1	4	7	4	7	16	4	3	3	2	3	8	4	1	1	2	2	9		3	1	3	13	2	1	1	2
		1	1		1		2			1	1								1		1	2	3	2		1	2
		1	2		3	1	1	2	1	1	2		2			4			2								
24	12	32	19	27	48	73	51	16	33	27	43	20	33	26	22	16	32	31	23	36	19	40	44	49	35	40	11
12	3	23	31	19	36	66	26	13	9	22	38	43	22	7	6	10	21	26	13	27	7	31	39	29	35	23	7
1							1																				
			1	1	3	3		1		1	1	1	1					1			1		5	1	2		
		1		3	3			2		2	1	1				4	2	1	1	3	1			6	2	2	1
			1		3	5	2	3			1				1	1				1							1
		1									1					1				1							1
2		1	2		5	7	4			1	3	5	1	1		1		2	1				8	9	6	11	
						1	1	2				1		1	1		1			2	1	2					
																						1					
1	5	8	8			7	10						2	1	1	3	5			2	1	1		5	8	2	1
	1		7	6								1			1			1						5		3	4
4	2	3	6	6	13	11	3	4	5	15	6	8	13	6	1	3	5	4	1	9	19	9	22	47	14	6	1
	1		2		12	7	1		2		7			2				3	6	4	4	1	4	5	4	13	3
	1						1					1								1							
	1		4	1	13	1	1		2		3	1					1	1		2	5	2	2		1	8	
2		1	1	3	8	2	8	2				2	1		1			1				2	3	5	1	8	1
		2		2			2		1	2												1		1			1
							3			2																	
										1		1			1			2					1		1		
		9	1	14	1	3	2	1	1	1	6	2	1					1	1	3	1	4	3	1	1		
			2		2	2	1			1	1	1	1	1		1				1	1		1	2	1	1	1
		.				1	1					1								1					1		
			1																					1			
																1											
							1																			1	

TABLE A.—Continued

SPECIES	NOV 1969				DEC				JAN 1970				FEB				MAR			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Gaudryina exilis	3	3		1	2	1		1	1	1	1		2							
Gaudryina sp.																				
Gaudryina (?) sp.	1			1																
Gaudryina cf. G. exilis					1		1													
Glabratella altispira													2	1	3		3		4	8
Glabratella braziliensis																				1
Glabratella compressa		1		1	1									1		1			1	3
Glabratella hexacamerata			2								1				3					
Glabratella testigoensis																				
Glabratella sp. A			1																	
Glabratella sp. B																				
Glabratella sp. C																				
Glabratella cf. G. carinata																				
Glabratellina sagrai																				
Glabratellina sp.															1	2				
Globigerina quinqueloba																				
Globigerina rubescens																			1	
Globigerinella aequilateralis									1											
Globigerinita glutimata							1													
Globigerinoides conglobatus																				
Globigerinoides ruber										1			1							
Globorotalia inflata									1											
Globorotalia menardii				1																1
Glomospira glomerata					1															
Glomospira gordialis	1			3	1		1	1	1	2		1			1					
Glomospira sp.																				
Haplophragmoides sp.																				
Haplophragmoides (?) sp.	1							1	1											
Helenina anderseni													1	3			1		1	
Karreriella (?) sp.																				
Lagenammina (?) sp.																				
Lamarckina sp.																				
Laryngosigma sp.																				
Lenticulina sp.																				
Lituotuba sp.						1														
Mychostomina revertens		7	3		2	1			1	1			1		3		1	1		1
Neoconorbina terquemi				1																
Neoeponides antillarum				1																
Nonionella auricula	2	3	2	1	2		1	3	4			3			1		2		3	1
Patellina advena																				
Patellinella sp.																				
Peneroplis bradyi																				
Peneroplis pertusus	1												2				1	1		
Peneroplis proteus		1		1	1	1						2								
Planorbulina acervalis	1				1	1	1		1		2		1	1	2	1				1
Planorbulina mediterranensis																			1	
Rectobolivina raphana (?)																				
Reophax nana	4	8	3		3	4	3	3	3	3	3			2	14	4		1		
Reophax sp.		1	1																	
Reussella atlantica																				
Rosalina bulbosa						1										1				
Rosalina candeiana																		2		
Rosalina concinna				1	1				1	3						1		1	1	3
Rosalina floridana	3	20	10	17	17	8	3	2	3	4	5	7	1	7	9	3	4	8	2	5
Rosalina globularis	1	2		2	1	4	2			1	2	2	5	3	10	9	2	8	6	8
Rosalina subaraucana	4			3				2	1	1	1	2	3	1	4	3		2		3
Rosalina sp.																				
Rosalina (?) sp.																				
Rotaliammina aff. R. mayori			1																	
Sagrina pulchella		1	1	1	1			3		2		1		2	2	2		1	2	
Sagrina pulchella primativa			1					3		1						1				
Sigmavirgulina tortuosa		1		4		1				1		2	1			1	1			
Siphogenerina costata		1			1	2			1				2	1	1		1			
Siphonina pulcra					1							1								
Siphoninella (?)												1								
Spirillina vivipara												1								
Stetsonia minuta	2	1		1														1		
Textularia agglutinans								1												
Textularia (?) sp.																				
Tiphotrocha cf. T. comprimata																				
Trichohyalus aguayoi																				
Trifarina occidentalis	14	12	9	24	19	10	23	10	12	21	4	13	6	9	31	13	14	13	5	22
Trochammina cf. T. advena		1																		
Trochammina cf. T. quadriloba																				
Trochammina sp.																				
Ungulatella (?) sp.				2																

APR				MAY				JUN				JUL				AUG				SEP				OCT			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
						1	5																1				
		1	1				1																	1	1		
							2															1				2		
1		2	1	1			1				1					1	2					1	1			1		1
			1		2											1		1	2								
												1															
	2					1												1									
											1				1			1									
					1													1									
1					2													2								1	
							1								1				1								
				1	2	2	1			1	1		2		1		2	1	1	1	1	2	2			1	1
																										1	
		1			1				1	1	1				1	2	1	1		1		1				7	
				1			1												1								
						1	1																1				
	1				1	3		2		2		1		1			1	3		1				3	1		
1						1			2	3	2			1	3		1	2		2							
					1													3	1							1	
2		2	2		2	1	1					1	2	3		1		1	1		1		4	6	3	2	
					1																						
2		1			4	2	1		1		7	6	4	2		3	3	2		4	3	6	2	2		1	
		1	1		3		2	1			1	4	3		1	1	2	3		4		4	6	1		1	
1			1	1	4	2	4	1	1	1		5	4	1	1	1	1	2	2	2	2	3	3	8	1		
																						1					
			1		2	1	1																				
					1																						
					1							1						2				1	2	1	3		
3	1	5	12	22	8	29	10	7	4	6	14	12	8	3	1	9	5	13		4	7	8	52	18	9	13	11
15		15	10	2	8	9	9		1	1	12	8	4	1	1	1	2	9	7	4		4	6	13		8	6
1	1	2	3	1	7	5	5	9	1	3	2	3	4	1	2	2	2	4	1	3	3	4	5	7	4	14	4
								1																			
				1	2								1				2	1								1	
1	1	1		1	3	3	2				1		1	1		1		1		2	1					2	
			1	1			2														1					1	
			1		2				2	1			1	2	2	1		1				2	1			3	
						1	2	3							1	1		1		1		1					
					2	1																					
												1								2	1	2	1	1		2	1
13	2	9	20	12	37	24	30	10	11	14	27	17	22	11	6	11	16	31	6	14	13	19	33	18	24	25	4
						1					1																1
																				1							

TABLE B.—Station 3

SPECIES	NOV 1969				DEC				JAN 1970				FEB				MAR			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Acervalis sp.	1		2	6		1						1	1	1		2	3			1
Ammobaculites exilis	2	3		3	1			1	3											1
Ammodiscus minimus																				
Ammodiscus sp.																				
Ammonia beccarii	9	11	38	7	10	3	3	11	10	6	10	18	92	8	54	6	7	35	11	12
Ammonia jacksoni	1																			
Amphistegina gibbosa	3	6	15	5	1	3	3		5	2	3	8	8		31	4	1	6	7	3
Angulodiscorbis corrugata	12	2	3		1	3			2		2			1	18	8	8	1	3	4
Anomalina glabrata																				
Anomalina (?) reniformis																				
Archaias angulatus													1		3					
Asterigerina carinata	5	6	7	6	1	1	1	2	4	3	1		12	4	13		2	7	1	4
Asterigerina sp.																				
Baggina aff. B. philippinensis					2	1						1								
Bolivina doniezi	2	3	4	3	4	4	1		6	1	3		3	5	5	6	3	1	5	3
Bolivina lowmani																				
Bolivina paula	2	3		1	1		1		1	1	1		2	1	1	1		3	1	3
Bolivina rhomboidalis	3	1		1		1	1			1	1		1				1	2		
Bolivina striatula	36	14	20	23	10	21	19	20	15	19	23	3	28	55	29	16	8	18	31	32
Bolivina subexcavata	26	14	16	21	27	20	7	9	24	10	6	4	7	15	34	24	12	7	20	18
Bolivina spp.											1									
Bolivina (?) spp.																				
Bolivina cf. B. compacta			2		1						1	1					3	2	1	1
Bolivina cf. B. subexcavata	2		1		1							1		2	3		1	1	1	2
Bronnimannia caribaea																				
Buliminella elegantissima	5		2	3	3	4	1			1	2		3	2		1		1		3
Buliminella milletti	2				2					1					1					
Buliminella parallela		1	1				1											1		
Cancris sagra				1																
Cassidulina cf. C. subglobosa					1				1				1		2					
Cerobertina sp.																1	1			
Chrysalidinella aff. C. miocenica			1																	
Cibicides mayori									1											
Cibicides pseudoungerianus	5	2			2	2	2		3	1	1	1	4	2		1	4	3		3
Cibicides sp.																				
Clavulina tricarinata		2	1	1	2	1	2							3	2		2		1	
Coryphostoma (?) limbata costulata	1								1		1				2		1	1	1	1
Coryphostoma (?) sp.				1																
Cyclogyra planorbis		1							4				7		5	1				1
Cymbaloporetta atlantica			4	4	4	2		3	3	1	3	3	12		13	5	14	4	4	9
Cymbaloporetta squammosa	5	5	4	5	3		3	1			6	1		5	17	2	3	4		
Cymbaloporetta tobagoensis	12	14	7	11	15	9		5		1			3	2	2		4	6	5	12
Discorbinella minuta	2		1			1		2	2	1			1		3		1	1		1
Discorbinella sp.																				
Discorbis granulosa																				
Discorbis mira	24	24	3	12	19	25	7	17	5	9	7	3	29	10	19	11	11	12	10	12
Discorbis murrayi	10	6	9	6	8	4	1	2	3	1	1		3	12	8	3	2	2	4	3
Eggerella cf. E. advena																				
Eggerella cf. E. humboldti	1	1	1		4				1									1		
Elphidium advenum	3			1		1			2						1	2				2
Elphidium excavatum																				
Elphidium gunteri																				
Elphidium kugleri	1								1	1			3					1		4
Elphidium norvangi															1					
Elphidium rugulosum	1					1	2	3	9	2	4		3			2	2	6	2	
Elphidium spp.					1										2					1
Eoeponidella pacifica	1																			
Epistomaroides (?) sp.																				
Epistominella (?) sp.																				
Eponidella sp.																				
Eponides (?) sp.																				
Esosyrinx (?) sp.																				
Fissurina cf. F. agassizi																1				
Fissurina cf. F. milletti	1													1					1	
Fissurina goreaui																1	1			
Fursenkoina pontoni	3		1	6	1				1	1	2	1	2	6	1	1			1	1
Fursenkoina punctata							1													

APR 1	APR 2	APR 3	APR 4	MAY 1	MAY 2	MAY 3	MAY 4	JUN 1	JUN 2	JUN 3	JUN 4	JUL 1	JUL 2	JUL 3	JUL 4	AUG 1	AUG 2	AUG 3	AUG 4	SEP 1	SEP 2	SEP 3	SEP 4	OCT 1	OCT 2	OCT 3	OCT 4
		1	1				9	2	3	2								1	1			2					
				4	1	7											2	2		1	1	2	1		1	2	1
								1																			
14	21	28	4	8	139	25	4	16	14	158	5	5	46	7	8	17	8	9	17	12	5	6	8	0	7	2	21
								1																			
7	1	8	3	4	14	4	3	28	45	46	16	12	34	11	17	20	9	4	4	20	30	13	8	11	10	12	64
2			1	5	3	4					3					3			5	4							
														1													
					1					1										1							
2	1	4	11	5	13	5	2		7	4	2	2	6	6	5	5	1			5	5	3		1			1
																										1	5
5	2	6	1	2	10	16	6	5	7		4	4	2	1	1	12	1	2	3	4	1			3	1	4	3
												1											7			1	
	1	3	1	1	3	4	3	2	2	1	2			2		2	2	1		1						2	
	3	1		1	3	2	4	4	2	1	3	1			1			1		1	1	1	2				
20	28	44	6	39	38	48	34	26	61	8	21	25	38	32	28	73	42	21	45	29	22	10	41	47	8	22	8
16	12	16	8	21	32	33	39	19	57	5	26	18	24	18	14	54	12	7	10	5	13	7	21	4	3	8	2
2	1					2	2					1		1	1	1	1		3		1					1	
1		1		3	5	2	3	1			1	1	2		1	3							4				1
	1			1	1		3	1			1			1			1		1	1		1					
2						2			1			1				1	1		1		1		1				
		1						1	1							1		1				1					
		1																									
					1																						
2	1	4	1		17	7		1				1								4		2	2	5		2	
								3	5	1														1			
1	2							3			1	2						1		1		1	1	1		1	1
						2	4	3	2			1											1			1	1
		1		2		1			2		1	1	3	2		2										2	
10	11	7	19	12	54	15	9	17	12	7	4	3	8	2	3	4	3	3	12	10	3	5	2	5	2	5	4
7	2		5	3	10	13	8	8	5	14	13	3	5		1	2	2	1		1	4	2	2				3
12	1	1	2	3	15	10	3	8	12	11	4	5	2	12	4	5		4	6	4	9	9	10	2		6	6
2		1	1		3	1		3						1	2		1		1	7			2	1		1	
					1				2										1								
18		31	5	14	60	27	15	10	26	41	5	13	20	11	13	10	9	11	15		5	18	11	10	7	2	
3	12	5	3		3			2	4				1			1		3	2			2					
								1																			1
2	1	3	5	1	2	4	2	6			1	2			3	1		2	1				1				
																						1					
1	2						1					1				2								6	1	1	
								1	1									1									
1		2	1	3	4			8	3	1	7	1	3			2	3	1		1			1	1		1	1
		1			1			1	1					1													
								1																			
									1																		
		1																				1				1	
2	1	4	1				8	13	1			11	1		6	51	18	5	12	5	3	3	7	6	1	7	

TABLE B.—Continued

SPECIES	NOV 1969				DEC				JAN 1970				FEB				MAR			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Gaudryina exilis	3	6			5				1				2	1	1					1
Gaudryina sp.		1			1															
Gaudryina (?) sp.																				
Gaudryina cf. G. exilis	4		1	3	1	2		1	3						3	1			1	
Glabratella altispira			2	2		1										1				
Glabratella braziliensis																				
Glabratella compressa														1						
Glabratella hexacamerata	4	2		1	2	1			1		3					1		1	1	2
Glabratella testigoensis														1						
Glabratella sp. A																				
Glabratella sp. B																1				
Glabratella sp. C									1											1
Glabratella cf. G. carinata	1					1						2								
Glabratellina sagrai																				
Glabratellina sp.																				
Globigerina quinqueloba																				
Globigerina rubescens																				
Globigerinella aequilateralis																				
Globigerinita glutinata																				
Globigerinoides conglobatus																				
Globigerinoides ruber																				
Globorotalia inflata																				
Globorotalia menardii																				
Glomospira glomerata																				
Glomospira gordialis	1	1							1				1				2			1
Glomospira sp.																				
Haplophragmoides sp.																				
Haplophragmoides (?) sp.	8		6		1				3		2				8					1
Helenina anderseni																				
Karreriella (?) sp.																				
Lagenammina (?) sp.									1								1	2		
Lamarckina sp.																				
Laryngosigma sp.																				
Lenticulina sp.																				
Lituotuba sp.					1															
Mychostomina revertens	7	2	2	4	8		5	3	4						5	2		3	1	
Neoconorbina terquemi					3							1							1	
Neoeponides antillarum	1		1												2	1			1	
Nonionella auricula	1	3	2	4	4	1		3	5	1	11	1	3	5	0	6	3		5	9
Patellina advena													1							
Patellinella sp.																				
Peneroplis bradyi																				
Peneroplis pertusus	1	1				2		2		1	2	2	3		9				2	2
Peneroplis proteus			8	1	1			1	4	1	2	1	7		3	2			2	2
Planorbulina acervalis	18	3	7	6	10	9	3	5	8	1			7		12	5	5	2	4	7
Planorbulina mediterranensis																				
Rectobolivina raphana (?)							1				1			1			1			
Reophax nana	4	1	4	1	1			1	2	1	1	1			1			1	3	
Reophax sp.							1													
Reussella atlantica	4	2			2	1			1		1								1	1
Rosalina bulbosa	1	1		2	2			2	1	1	1				2	1			1	2
Rosalina candeiana																				
Rosalina concinna	4	5	3	4	5	6	3	5	4	2		4	6	1	8	8	1	4		7
Rosalina floridana	8	5	5	3	15	3	1		5	4		5		5	2		4	1	1	3
Rosalina globularis	17	7	4	7	23	5	6	20	18	7	7	2	10	4	32	16	19	17	22	6
Rosalina subaraucana	3	3	15	4	9	7	1	6	6	2	1	2	12	1	38	10	10	8	16	22
Rosalina sp.																				
Rosalina (?) sp.								1												
Rotaliammina aff. R. mayori									3		1				2	1		1	3	
Sagrina pulchella	3	3	3	2		5			2	1	2			4	3	1			1	5
Sagrina pulchella primativa	1	2	2		1	2		1		1	1					1				
Sigmavirgulina tortuosa	4	3	3	1	1	1	1	3	2	2	1			6	3	4		5	4	1
Siphogenerina costata				1				1	1	1		1			1					
Siphonina pulcra																				
Siphoninella (?)																				
Spirillina vivipara							3		1				1			1				
Stetsonia minuta																			1	
Textularia agglutinans					1										1	1	1			1
Textularia (?) sp.																				
Tiphotrocha cf. T. comprimata	1	1			1															
Trichohyalus aguayoi																				
Trifarina occidentalis	29	11	39	27	28	28	11	5	16	6	14		21	20	40	23	16	22	24	34
Trochammina cf. T. advena						1			1											
Trochammina cf. T. quadriloba					1				2			1								
Trochammina sp.					1															
Ungulatella (?) sp.																				

	APR				MAY				JUN				JUL				AUG				SEP				OCT		
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
			1			2								1				3					1				
1																											
		1			3	2		2	1																		
				1																							
1	1			2																							
					5	3	2	1	2		1	1	1			1			1		1			1			
							1																				
																1										
							1			3	1			1							1						
								3	1																		
				3		9		4	1							1											
																	1										
						1																1					
												1			1					1						1	
																							1				
				1	2	1		3	2	2			1	5	3	8	2			9	1		5	1	1	1	1
						2		4	4					2		1		1			1	1					1
						2	2				1													1			
4	4	1	1	3			7	5	3	2	2	2	5	2	1	10	6	5	3	4	3			10	6	4	1
																							4				
								1																			
2	2	2	1		4			4		1	2	1	2	1		3	3		2	3			2	2	2	1	2
4			1	5	5		1	4	1	5		3	7	2	3	8	3		1	2		4	2	5	4		2
10	1	2	3	4	9	15	4	7	2	3	10			8	7	8	3	2	7	4	6	5	3	5			4
										1																	1
						3																		2		2	
1			2	1	1	3	2		1				2					1	6	2		1		1		1	1
	2					1	1	4	3	1		2				1		1		3	1	3	6				3
5	1	5	2	3	4		2	2	2	1	3	1			3	1	5	2	6	1		1	2	2	2	3	2
1				1				1				2	3	3				1	1				1				1
						1		3	5	2	4					1	3	1		1			4		1		1
					1																			1			1
	1	1				2		1	1		3								1		1		1	1			
		2	7	1	7	7								1	1	3			1	3	6	6	0		1	1	1
6		2		2	5	11	5	8	8	6	2	3	4	6	10	10	4	6	4	1	7	3	17		3	3	3
31	7	7	4	45	34	51	13	46	44	26	83	19	19	31	9	21	9	16	10	7	10	6	20	5	2	2	7
12	4	10	9	5	36	31	18	20	13	8	20	5	15	30	12	19	3	5	12	19	7	9	9	2	5	5	8
22	13	35	21	14	49	72	39	29	47	5	15	23	11	24	13	54	33	21	20	20	14	12	6	13	7	20	12
				1		3					1						1						1	1		1	
						1																				1	

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PLATES

PLATE 1

Lituotuba sp., hypotype, USNM 211212, × 140: 1, Side view; 2, side view.

Haplophragmoides? sp., hypotype, USNM 211211, × 160: 3, Side view; 4, edge view.

Ammobaculites exilis (Cushman and Bronnimann), hypotype, USNM 211205, × 100: 5, Side view; 6, edge view.

Gaudryina exilis (Cushman and Bronnimann), hypotype, USNM 211207, × 140: 7, Apertural view; 8, side view.

Gaudryina cf. *G. exilis* (Cushman and Bronnimann), hypotype, USNM 211208, × 140: 9, Apertural view; 10, side view.

Eggerella cf. *E. humboldti* (Todd and Bronnimann), hypotype, USNM 211206, × 300: 11, Side view; 12, edge view.

Clavulina tricarinata (d'Orbigny), hypotype, USNM 211204, × 160: 13, Apertural view; 14, side view.

Fissurina goreaui, new species, paratype, USNM 211209, × 200: 15, Apertural view; 16, side view.

Fissurina goreaui, new species, holotype, USNM 211210, × 200: 17, Apertural view; 18, side view.

Buliminella elegantissima (d'Orbigny), hypotype, USNM 211182; × 160: 19, Apertural view; 20, side view.

Buliminella milletti (Cushman), hypotype, USNM 211181; × 160: 21, Apertural view; 22, side view.

Buliminella parallela (Cushman and Parker), hypotype, USNM 211180, × 160: 23, Apertural view; 24, side view.

Bolivina doniezi (Cushman and Wickenden), hypotype, USNM 211158, × 200: 25, Apertural view, 26, side view.

*Bolivina doniezi* (Cushman and Wickenden), hypotype, USNM 211157, × 200: 27, Apertural view; 28, side view.
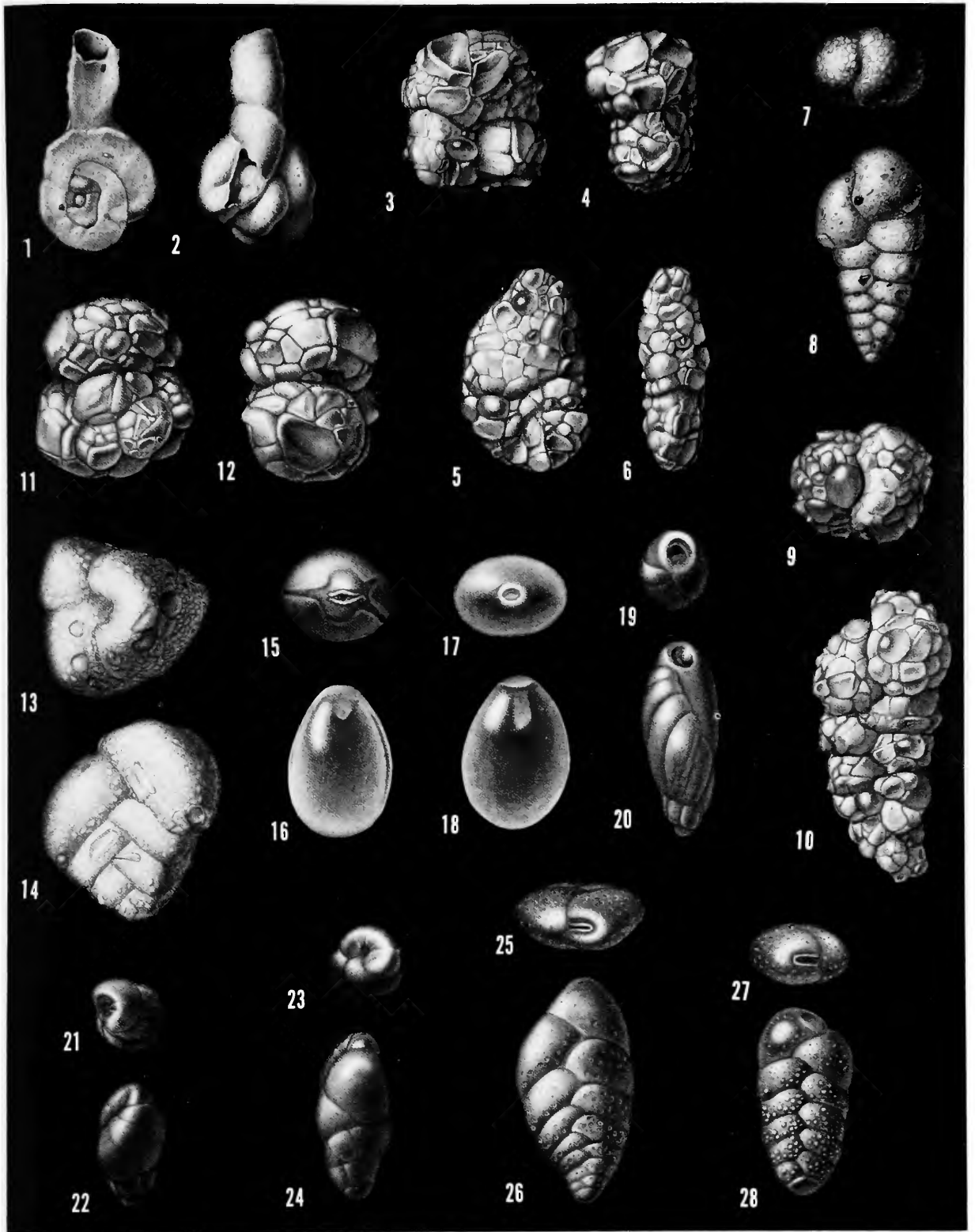
PLATE 2

Bolivina paula (Cushman and Cahill), hypotype, USNM 211156, × 160: 1, Apertural view; 2, side view.

Bolivina rhomboidalis (Millett), hypotype, USNM 211155, × 140: 3, Apertural view; 4, side view.

Bolivina striatula, (Cushman), hypotype, USNM 211154, × 160: 5, Apertural view; 6, side view.

Bolivina striatula (Cushman), hypotype, USNM 211153, × 160: 7, Apertural view; 8, side view.

Bolivina striatula (Cushman), hypotype, USNM 211152, × 160: 9, Apertural view; 10, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211146, × 200: 11, Apertural view; 12, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211148, × 200: 13, Apertural view; 14, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211147, × 200: 15, Apertural view; 16, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211150, × 200: 17, Apertural view; 18, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211149, × 200: 19, Apertural view; 20, side view.

Bolivina subexcavata (Cushman and Wickenden), hypotype, USNM 211151, × 200: 21, Apertural view; 22, side view.

Bolivina cf. *B. subexcavata* (Cushman and Wickenden), hypotype, USNM 211144, × 200: 23, Apertural view; 24, side view.

Bolivina cf. *B. Subexcavata* (Cushman and Wickenden), hypotype, USNM 211145, × 200: 25, Apertural view; 26, side view.
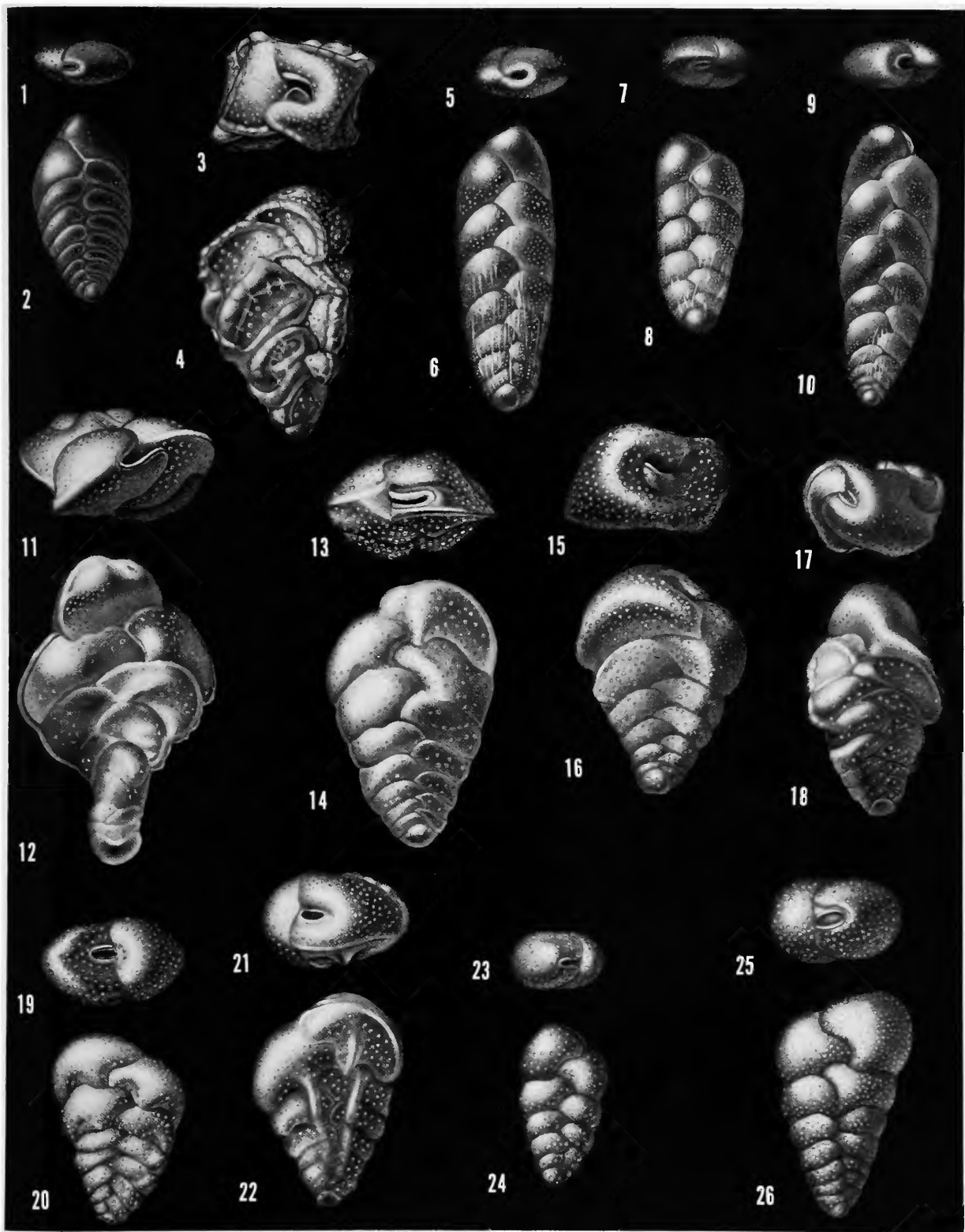
PLATE 3

Rectobolivina raphana (Parker and Jones), hypotype, USNM 211214, × 50: 1, Apertural view; 2, side view.

Sagrina pulchella d'Orbigny, hypotype, USNM 211179, × 160: 3, Apertural view; 4, side view.

Sagrina pulchella d'Orbigny, hypotype, USNM 211178, × 160: 5, Apertural view; 6, side view.

Trifarina occidentalis (Cushman), hypotype, USNM 211174, × 160: 7, Apertural view; 8, side view.

Trifarina occidentalis (Cushman), hypotype, USNM 211175, × 160: 9, Apertural view; 10, side view.

Discorbis granulosa (Heron-Allen and Earland), hypotype, USNM 211196, × 80: 11, Side view; 12, edge view; 13, side view.

Discorbis mira (Cushman), hypotype, USNM 211195, × 80: 14, Side view; 15, edge view; 16, side view.

Discorbis murrayi (Heron-Allen and Earland), hypotype, USNM 211290, × 160: 17, Side view; 18, edge view; 19, side view.

Discorbinella minuta, new species, holotype, USNM 211163, × 200: 20, Side view; 21, edge view; 22, side view.

Discorbinella minuta, new species, paratype, USNM 211167, × 200: 23, Side view; 24, edge view; 25, side view.
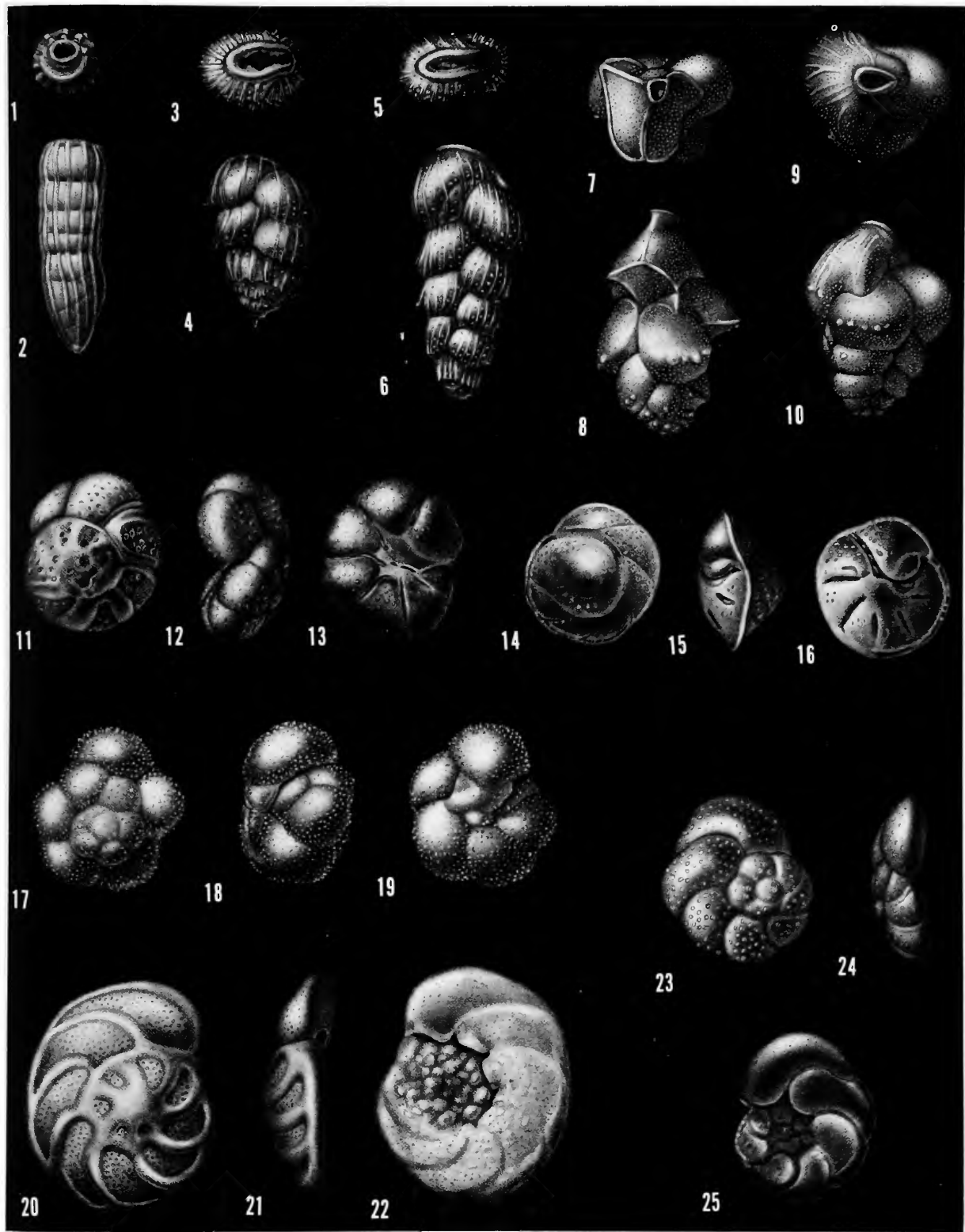
PLATE 4

Rosalina candeiana (d'Orbigny), hypotype, USNM 211186, × 90: 1, Side view; 2 edge view; 3, side view.

Rosalina concinna (Brady), hypotype, USNM 211187, × 100: 4, Side view; 5, edge view; 6, side view.

Rosalina floridana (d'Orbigny), hypotype, USNM 211185, × 100: 7, Side view; 8, edge view; 9, side view.

Rosalina globularis (d'Orbigny), hypotype, USNM 211184, × 100: 10, Side view; 11, edge view; 12, side view.

Rosalina subaraucana (Cushman), hypotype, USNM 211173, × 140: 13, Side view; 14, edge view; 15, side view.

Baggina aff. *B. philippinensis* (Cushman), hypotype, USNM 211172, × 140: 16, Side view; 17, edge view; 18, side view.

Glabratella altispira, new species, paratype, USNM 211160, × 300: 19, Side view; 20, edge view; 21, side view.

Glabratella altispira, new species, holotype, USNM 211165, × 300: 22, Side view; 23, edge view; 24, side view.
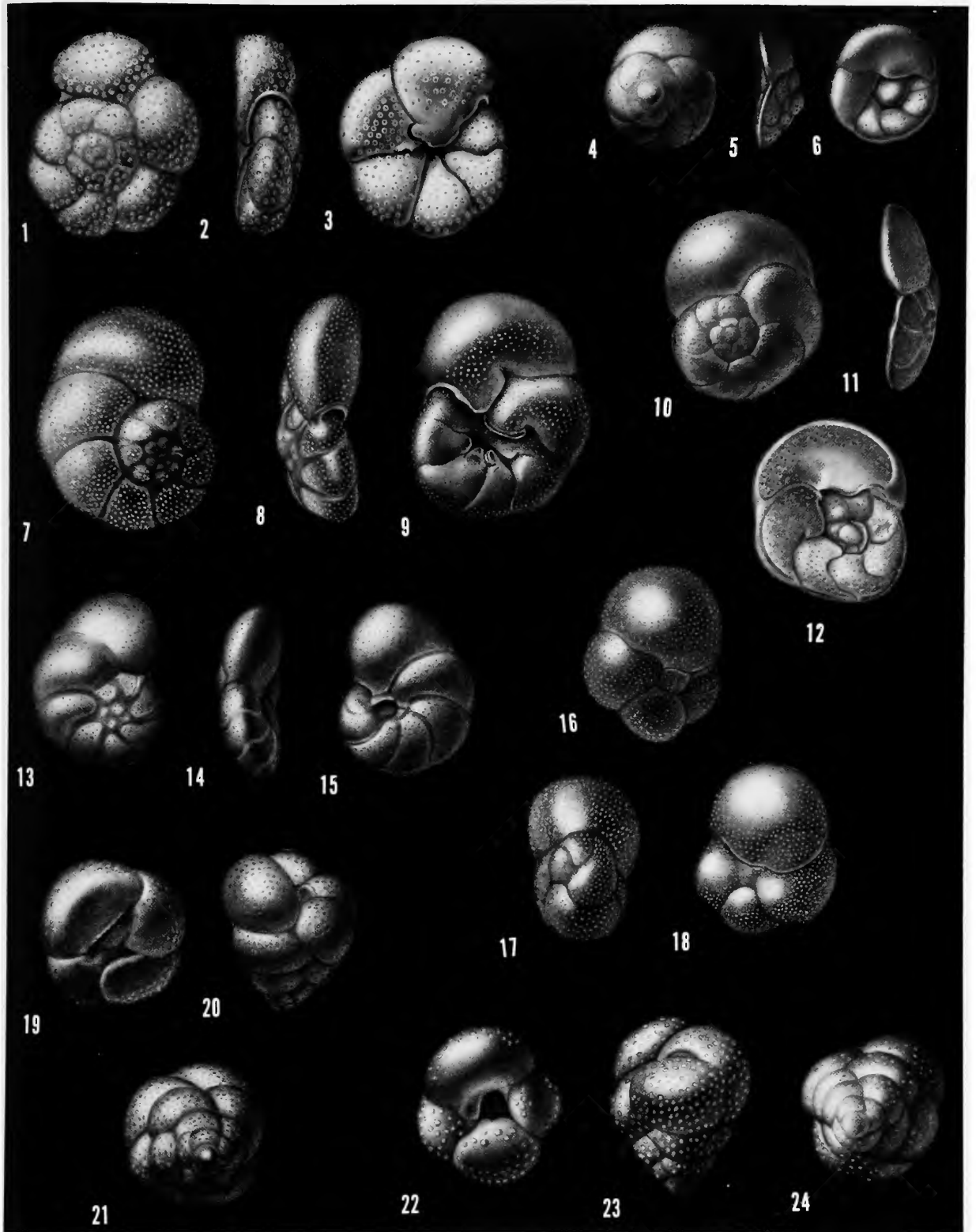
PLATE 5

Glabratella cf. *G. carinata* (Seiglie and Bermudez), hypotype, USNM 211193, × 300: 1, Side view; 2, edge view; 3, side view.

Glabratella compressa, new species, paratype, USNM 211166, × 230: 4, Side view; 5, edge view; 6, side view.

Glabratella hexacamerata (Seiglie and Bermudez), hypotype, USNM 211194, × 300: 7, Side view; 8, edge view; 9, side view.

Glabratella compressa, new species, holotype, USNM 211161, × 230: 10, Side view; 11, edge view; 12, side view.

Glabratella spp., hypotype, USNM 211189, × 300: 13, Side view; 14, edge view; 15, side view.

Glabratella spp., hypotype, USNM 211168, × 300: 16, Side view; 17, edge view; 18, side view.

Glabratella spp., hypotype, USNM 211191, × 300: 19, Side view; 20, edge view; 21, side view.

Glabratellina sp., hypotype, USNM 211159, × 200: 22, Side view; 23, edge view; 24, side view.

Glabratellina sagrai (Todd and Bronnimann), hypotype, USNM 211192, × 200: 25, Side view; 26, edge view; 27, side view.
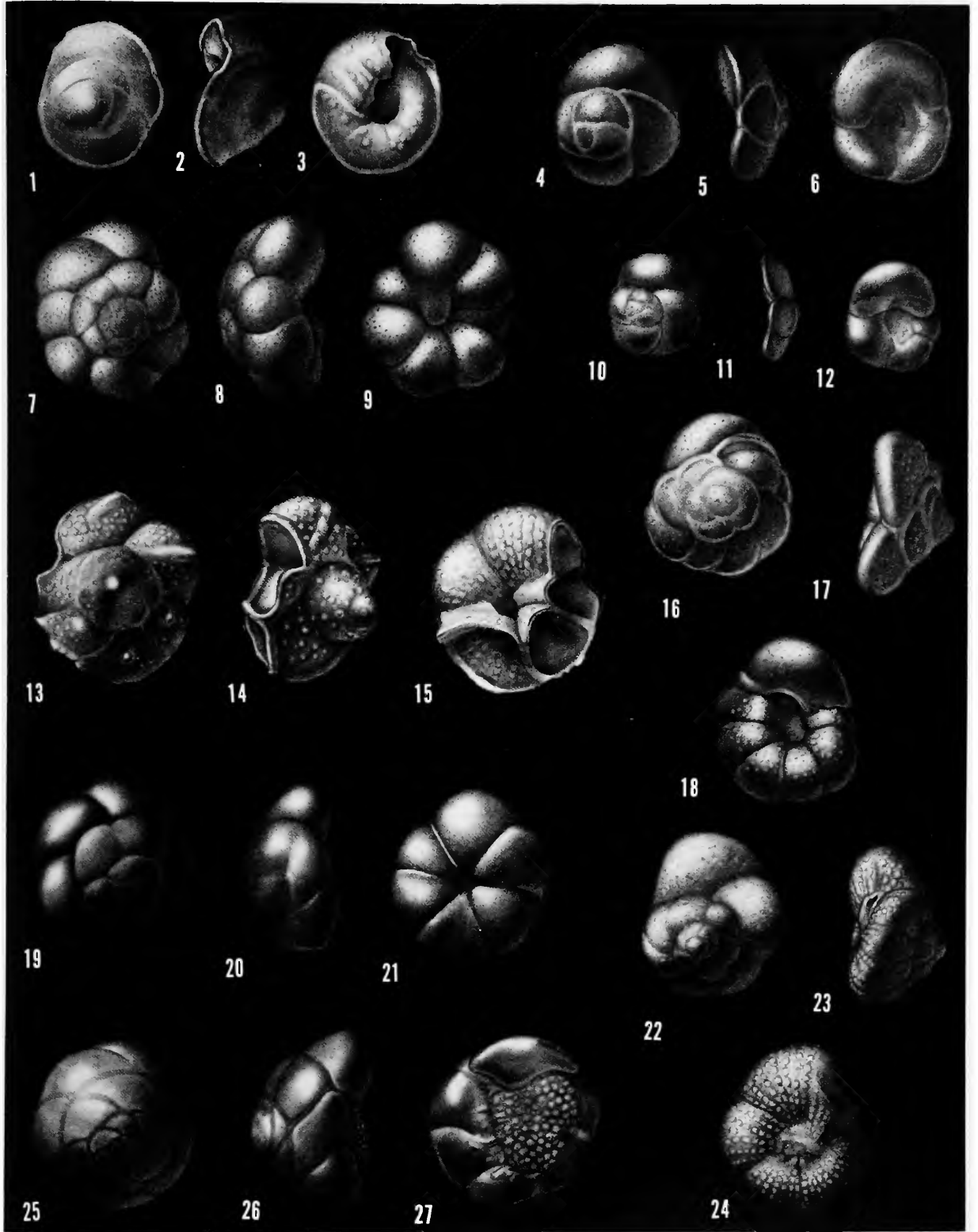
PLATE 6

Angulodiscorbis corrugata (Millett), hypotype, USNM 211201, × 200: 1, Side view; 2, edge view; 3, side view.

Spirilina vivipara (Ehrenberg), hypotype, USNM 187958, × 160: 4, Side view, 5, edge view; 6, side view.

Mychostomina revertens (Rhumbler), hypotype, USNM 187956, × 300: 7, Side view; 8, edge view; 9, side view.

Mychostomina revertens (Rhumbler), hypotype, 187957, × 300: 10, Side view; 11, edge view; 12, side view.

Ammonia jacksoni, new species, paratype, USNM 211162, × 200: 13, Side view; 14, edge view; 15, side view.

Ammonia jacksoni, new species, holotype, USNM 211164, × 200: 16, Side view; 17, edge view; 18, side view.
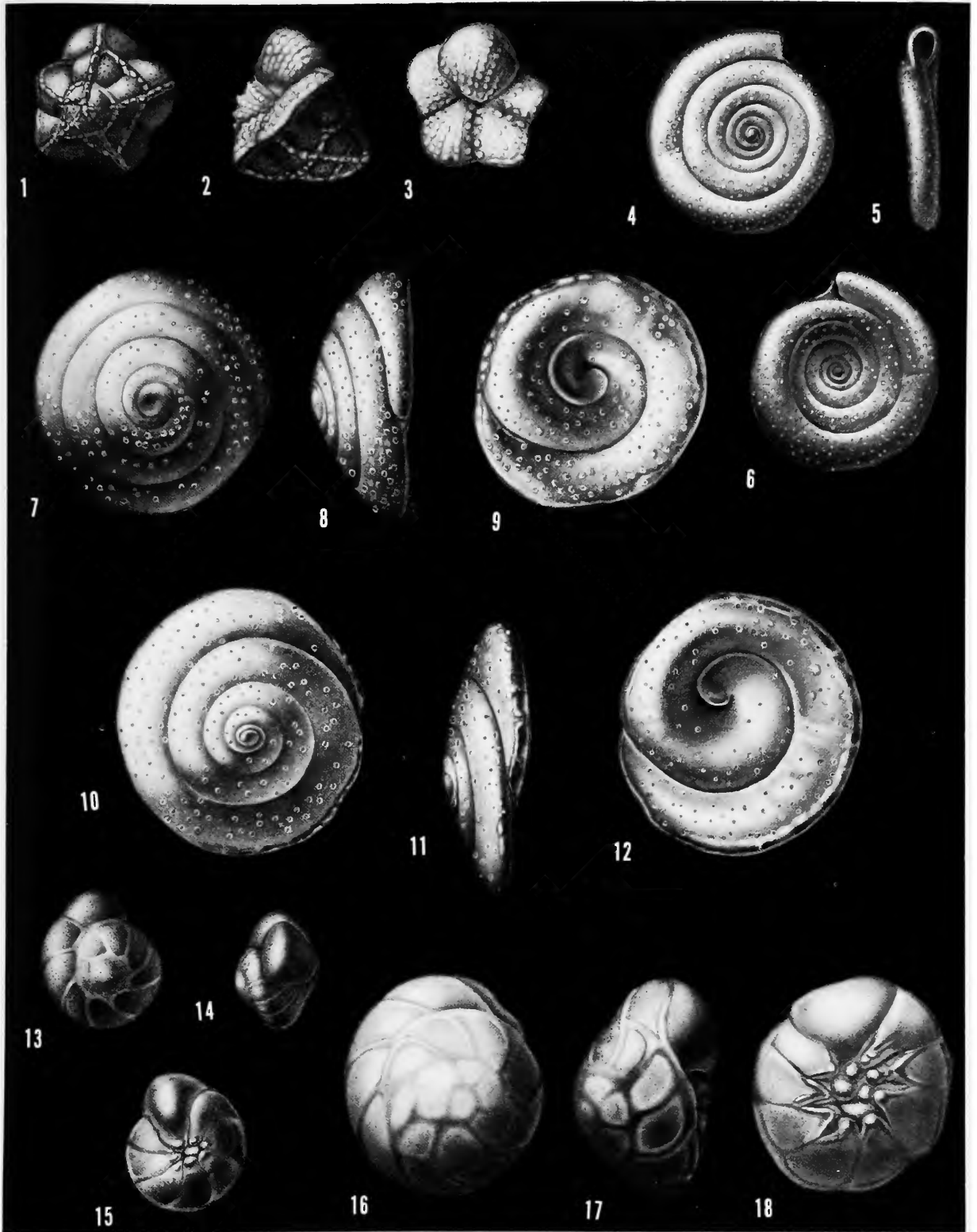
PLATE 7

Elphidium norvangi, new species, holotype, USNM 211216, × 200: 1, Apertural view; 2, side view.

Elphidium norvangi, new species, paratype, USNM 211217, ×200: 3, Apertural view; 4, side view.

Elphidium rugulosum (Cushman and Wickenden), hypotype, USNM 211215, × 200: 5, Side view; 6, edge view.

Eponides sp., hypotype, USNM 211169, × 160: 7, Side view; 8, edge view; 9, side view.

Amphistegina gibbosa (d'Orbigny), hypotype, USNM 211202, × 80: 10, Side view; 11, edge view; 12, side view.

Cibicides pseudoungerianus (Cushman), hypotype, USNM 211200, × 100: 13, Side view; 14, edge view; 15, side view.

Acervulina sp., hypotype, USNM 211203, × 100: 16, Side view; 17, edge view; 18, side view.

Planorbulinella acervalis (Brady), hypotype, USNM 211188, × 80: 19, Side view; 20, edge view; 21, side view.

Cymbaloporetta atlantica (Cushman), hypotype, USNM 211199, × 200: 22, Side view; 23, edge view; 24, side view.
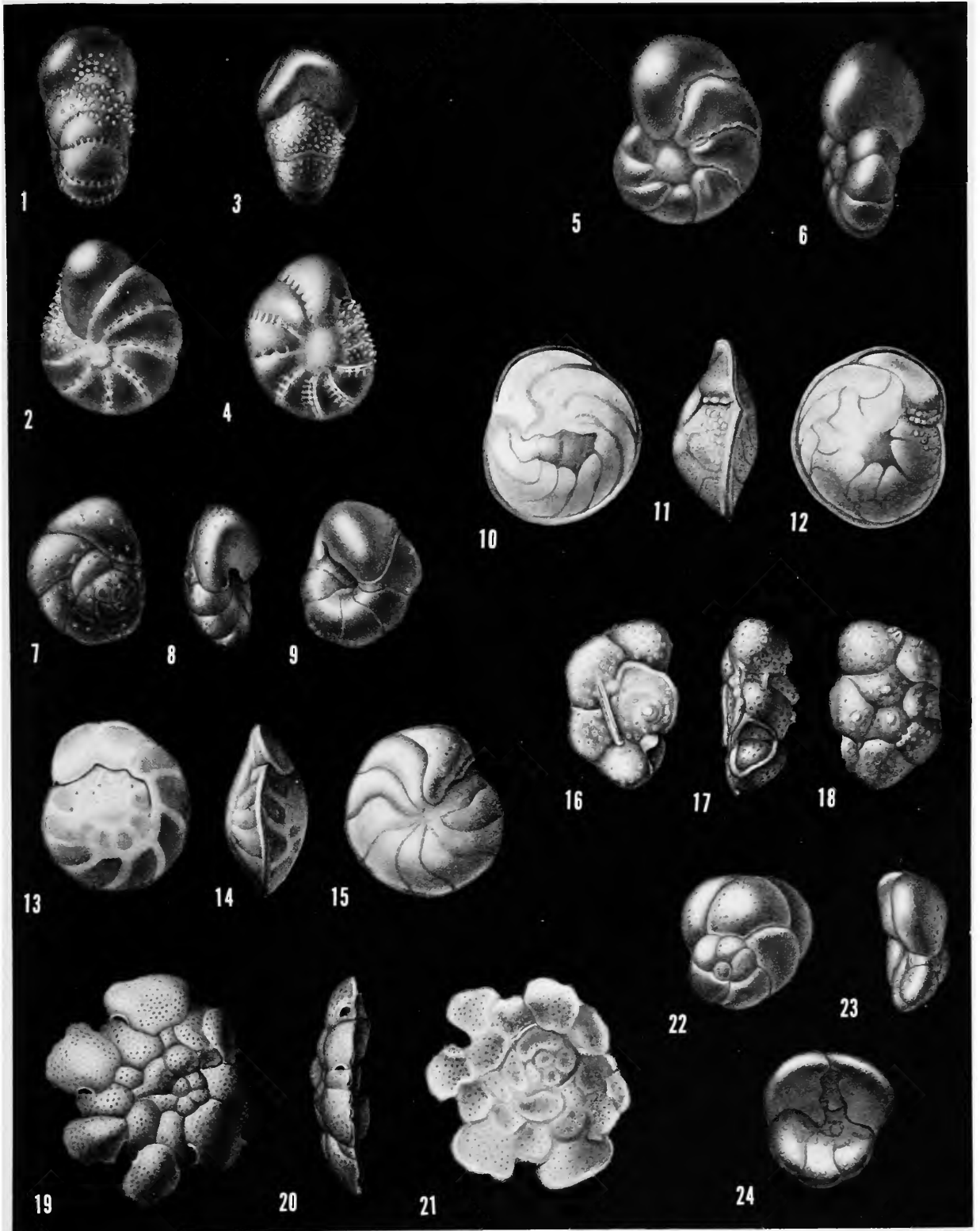
PLATE 8

Cymbaloporetta squammosa (d'Orbigny), hypotype, USNM 211198, × 80: 1, Side view; 2, edge view; 3, side view.

Cymbaloporetta tobagoensis (Bronnimann), hypotype, USNM 211197, × 140: 4, Side View; 5, edge view; 6, side view.

Fursenkoina pontoni (Cushman), hypotype, USNM 211183, × 80: 7, Apertural view; 8, side view.

Sigmavirgulina tortuosa (Brady), hypotype, USNM 211177, × 160: 9, Apertural view; 10, side view.

Sigmavirgulina tortuosa (Brady), hypotype, USNM 211176, × 160: 11, Apertural view; 12, side view.

Coryphostoma? limbata (Brady) subspecies *costulata* (Cushman) hypotype, USNM 211213, × 100: 13, Apertural view; 14, side view.

Anomalina glabrata (Cushman) hypotype, USNM 211171, × 140: 15, Side view; 16, edge view; 17, side view.

Anomalina? reniformis (Heron-Allen and Earland), hypotype, USNM 211170, × 140: 18, Side view; 19, edge view; 20, side view.
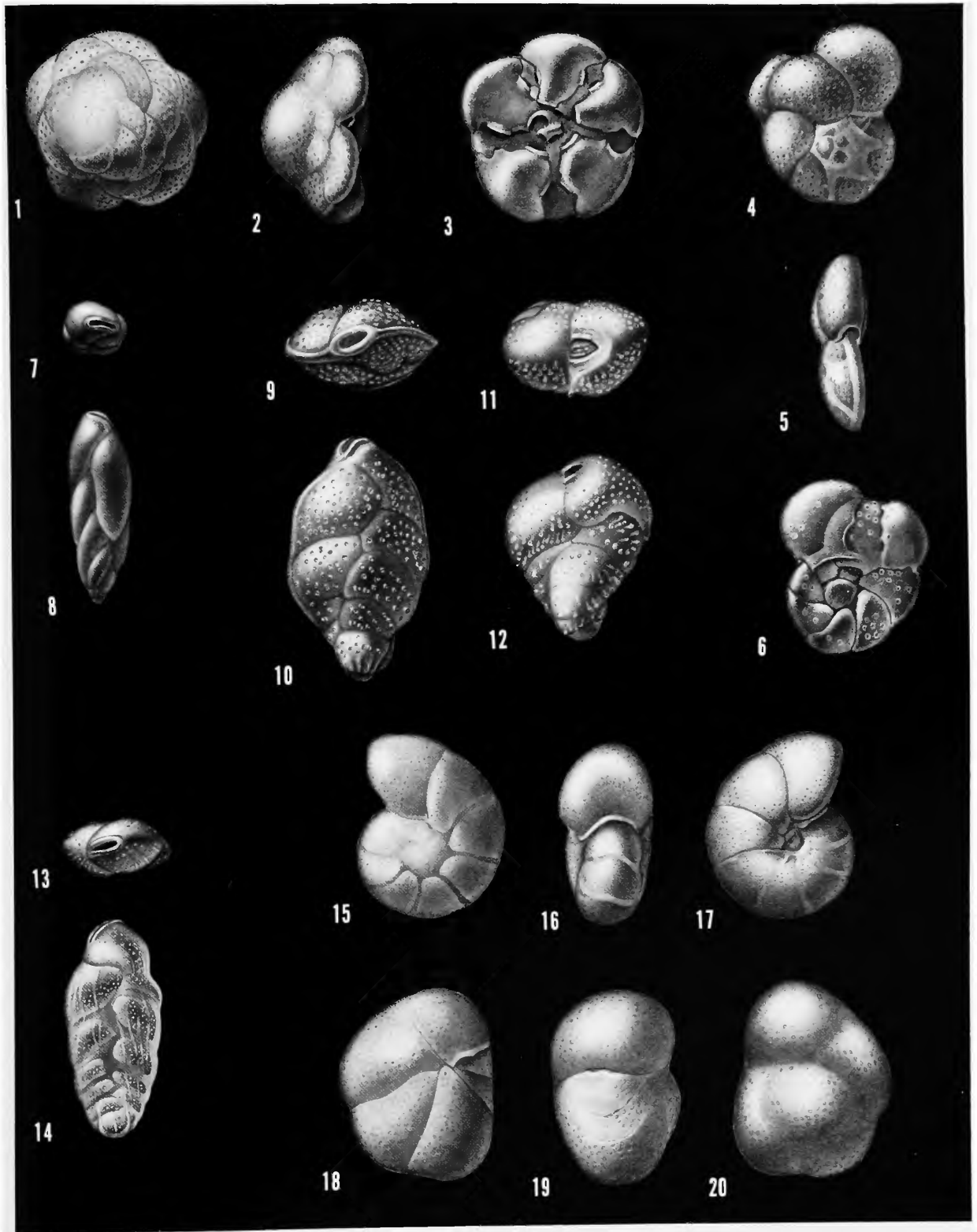
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