THE SHALLOW-WATER FORAMINIFERA

of

BERMUDA

by

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1933

Signature Redacted

Certification by the DEPARTMENT of

Professor in Charge of Research

Chairman of Departmental Committee on Graduate Students

Head of Department

Signature Redacted
"The Shallow-Water Foraminifera of Bermuda" is the report of an investigation covering those marine protozoans, the foraminifera, which are living today in the water off Bermuda. The report is confined to those genera and species living in shallow water, at a depth not exceeding ten fathoms. A detailed description of all the genera and species comprises the main body of the report. Of the 112 species and varieties found at Bermuda, 14 are new. One new genus is described. Fifty-three dredging samples from all sides of the island and submarine platform provided material for this study. The Recent foraminiferal fauna of Bermuda is very similar to that of the West Indies, but is smaller in number of species which is to be expected of an isolated island well-removed from the mainland. The sedimentary and biological environment in which different species are found is discussed with special attention given to those species whose distribution is restricted by ecological conditions.

A report upon 23 sedimentary rock samples from a deep well drilled in Bermuda also accompanies the description of the Recent fauna. Foraminifera of assured Miocene age and dubious Eocene age are found in these well samples. All of the fossils are much eroded and broken suggesting that they have been reworked out of some other sedimentary formation. Thus the age of the Bermuda sediments in which they are now found cannot be positively established, but it is concluded that this Miocene and possibly Eocene fauna lived in the near vicinity of Bermuda if not on the platform of the present Bermuda.
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I. INTRODUCTION

The coral reefs, bottom-fauna, physiography and structure of the Bermuda platform have been receiving attention from biologists, geologists, and traveling naturalists since 1667 or before. Names as famous as Lyell, Dana and Agassiz are found in any bibliography of the literature on Bermuda. That such a small place should claim so much attention seems, at first consideration, unwarranted. However, the very existence of a small group of islands, isolated in the ocean and remote from the mainland, has always aroused the geologists' interest. A tropical to sub-tropical flora and fauna in latitudes as far north as Bermuda interested the pioneer biologists to produce adequate explanations for their presence. Both geologists and biologists have found the existence of shallow-water marine life in the midst of deep water an engrossing problem. Furthermore, any thoroughly isolated spot is of scientific interest.

Bermuda is of more than ordinary interest because geological and biological data may be co-ordinated with more than mere scientific speculation, thanks to the well samples from a very deep boring made in the island proper. From these well samples, the material and depth below sea-level of the igneous basement is definitely known. From the present investigation, the character of the sediments above the igneous rock, and their contained foraminiferal fauna, is known through the well log. Since there are more foraminifera than other organic remains in these sedimentary samples, the problem is especially suited to research along foraminiferal lines. The interpretation of a Tertiary
fossil fauna is best achieved through a comparison with the Recent fauna. For this purpose a detailed study has been made of the Recent fauna at Bermuda.

The Recent foraminiferal fauna of Bermuda has hitherto received very little attention. Brady’s 1884 Challenger Reports record a fair number of species described and figured by him from "off Bermuda". Woodward, who apparently knew very little about the foraminifera, published in 1885 a list of foraminifera from Bermuda, which seems to be a compilation of Brady’s specific names and a few others based on Woodward’s observations. No descriptions or illustrations accompanied Woodward’s list, and the obsolete nomenclature he used leaves much doubt as to just what material he had at hand. Cushman made an excellent collection of the foraminifera from Bermuda. He has referred in various publications to some of the species from Bermuda, but he made no attempt to give his collection a thorough survey or the species detailed study.

The present investigation covers four purposes. First, it describes for the first time the foraminiferal fauna from an isolated and biologically interesting region. With this description is given as much information of ecological value as is available to the author. Second, it sets forth limitations and variations of many of the species in that most variable family, the Miliolidae. Third, this investigation has traced back to the original sources much of the disputed nomenclature, and has thus untangled many taxonomic snarls. Fourth, it gives for the first time data on the geological age of the sediments at Bermuda.
For the detailed study of the Recent foraminiferal fauna over fifty dredging samples have been used. Nearly all of these samples are large in volume of sand and organic remains. The foraminiferal tests are those of living animals or animals very recently dead, as the dredging apparatus did not dig down far into the sandy bottom as do some of the core-taking dredges. No tow-net samples were available. Hence this investigation covers only the benthonic fauna, but it is logical to assume that all pelagic forms are included, as the tests of pelagic micro-organisms settle to the bottom after the death of the animal. The dredging stations were located on all sides of the main island of Bermuda, and include every kind of sedimentary environment to be found there. Some of them were taken in the shoal waters off the main island and near the center of the Bermuda platform. All of the samples came from depths varying between one-half and ten fathoms. At no place on the Bermuda platform is the depth estimated to be over ten fathoms, and all of the available dredging samples come from the main platform.

The treatment of the samples was very simple. The sand was washed, dried, and put into carbon tetrachloride. The specific gravity of this liquid is such that the tests of foraminifera will float on the surface while corals, sand and heavier organic fragments sink through the liquid to the bottom. A station by station examination of the fauna was then pursued.

The fact that the Bermuda fauna is isolated from contamination by other faunas and the fact that each dredging contained hundreds of foraminifera, made it advisable to study intensely the variation
of some of the species. The large number of individuals of some species affords an excellent opportunity to set the limits within which each species may vary. Recommendations have been made at times for research on living individuals of some of the most highly variable species, and it is hoped that such work will be carried out at the Marine Biological Station in Bermuda. As stated previously, fifty-three different samples have been examined. In each sample were nearly one hundred individuals of some of the commoner species. Such material provides adequate basis for conclusions in regard to variations. Old age variations have been distinguished from individual variations only after very many individuals had been arranged in suites graduated on size.

The author is very grateful to Dr. Cushman for making available the facilities of his private laboratory and for the use of his remarkably complete library on the foraminifera. His help in preparing the illustrations and his suggestions in connection with the research have been of great aid. To Dr. Shimer, of the Massachusetts Institute of Technology, thanks are due for many helpful suggestions and criticisms during the pursuit of the investigation. Harvard University has kindly lent its collection of Bermuda dredging samples and its core samples. Miss Margaret Moore's painstaking work on the original drawings, photographs of which are here presented, has been appreciated by the author.
The bottom conditions at the shallow-water dredging stations about Bermuda vary to some extent. Three general types of stations have been used in collecting the material considered in this paper. Most of the bottom samples were taken from protected localities between the reefs and heads of corals where the bottom sand is fairly coarse and composed of shells and coral fragments. At these stations the foraminifera are unbroken, handsomely developed, and contribute materially to the volume of the bottom sand. Such stations are typical of the tropics and subtropics, hence the Bermuda stations are comparable to the Tortugas, Hawaiian, and Samoan stations. The best of such samples were collected by Dr. Cushman. Another type of station is the rough-water or "current" station, away from the corals, where the waves or tide currents disturb the bottom. At the rough-water stations the sand is fine and the foraminifera are broken, while at the "current" stations the sand is coarse because the tide currents sweep away the finer material. The best examples of rough-water stations are those at Brackish Pond Flats and Three Hills Shoals, both coral reefs, situated on the main Bermuda Platform but away from the island proper. All of these samples were collected under the auspices of Harvard University. The third type of station is at mud-bottomed localities near land where the eel grass and mangroves grow far out into the shallow water and where corals are absent. All of these samples were collected by the author.

All of these types of stations are of considerable interest at Bermuda, because of the isolated situation of the island and the
consequent absence of overlapping of environments or mingling of faunas. The fauna found off the northeast coast of the United States is excluded from Bermuda by the deep water intervening. The deep-water fauna which is found on the slopes of the Bermuda Platform cannot mingle with that found on top of the platform because the water there is too shallow and consequently provides too warm an environment.

The least restricted environment, where the bottom conditions are the least specialized, of course, offers the most diversified fauna. Such stations as those in the middle of Castle Harbor, at the north side of Castle Harbor, along Hogfish Gut, and in the middle of Long Bay, have yielded the largest number of genera and species. At these places there is adequate and unhampered gentle circulation of the water, food is abundant, and coral reefs are not numerous.

The protected waters between coral heads furnish an excellent fauna of Quinqueloculinas, Triloculinas, Miliolinellas, and Articulinas, all of which are represented in large numbers. The arenaceous genera are not abundant in the samples collected by Dr. Cushman from very protected places, and the only explanation that can be offered for this fact is that the water is too quiet and the food supply inadequate.

The rough-water stations which are unprotected from the waves carry a very poor and broken fauna. In most cases these stations have received only cursory study. Most of the species found there are represented by very young specimens which are not identifiable. Many young Bolivinas are found in the fine sand at such stations and it is questionable whether they and the other young individuals are indigenous to these stations or are swept into them by the waves and currents.
The "current" stations carry a very limited fauna. The heavy species with large tests, such as *Arohaias angulatus*, *Dentostomina bermudiana*, *Quinqueloculina agglutinans*, and *Clavulina tricarinata* are found in abundance at these stations, while the lighter species are absent. The adjustment is obvious; the smaller species are swept away by the tide currents, and at the same time plenty of food is available for those species which are heavy enough to remain on the bottom.

The mud-bottomed type of station affords a very restricted environment. These places are very shallow protected bays, or the extreme heads of harbors, where there is no circulation of the water except with the tide. Dolly's Bay, Mullet Bay, and Crow Lane at the end of Hamilton Harbor are stations of this type. Clumps of large mangroves grow far out into the water, and are so thick that a rowboat can barely be pushed between them. Eel grass and other forms of vegetation also thrive there. The bottom mud is full of partially decayed vegetable matter. At low tide the stations are typical swamps, and afford an excellent example of marine swamps in the process of land building and encroaching upon the ocean. While no chemical data is at hand for the water at such stations, it is estimated that the water must be high in carbonic acid on account of the decaying vegetation. Such stations cannot be called brackish in the true sense of the word, because there are no rivers in Bermuda to empty into these estuaries and thus contribute fresh water.

At these acid, mud-bottomed stations are found the only truly siliceous foraminifera in the Bermuda fauna. *Trochammina inflata*, the only species at Bermuda to produce an entirely siliceous test,
is confined to these stations. *Ammobaculites reophaciformis var. parvum* is almost entirely siliceous and is also confined to these stations. The species with a chitinous inner wall and partially siliceous external wall such as *Reophax communis*, *Spiroplectammina delicatula*, *Ammobaculites reophaciformis*, and *Clavulina nodosaria* are largely restricted to these stations, being rare at all others. Cushman has already established the fact that certain genera and species of arenaceous foraminifera live in the more acid waters at great depths or at cold latitudes, and this recording of some others in shallow, tropical waters where the vegetation furnishes carbonic acid is of further interest. *Bolivina* and *Siphogenerina* also thrive here, existing in greater numbers than at other stations. The same is true of *Quinqueloculina subpoeysana* and *Massilina arenata*, both of which are common at all stations about Bermuda, but especially abundant at the mud-bottomed stations. The last-mentioned four genera are typically calcareous, but their presence at an acid-water station may indicate that these are primitive or degenerate species of those genera. All other calcareous genera and species are either absent at these stations or scarce and very much dwarfed and deformed, with very thin-walled tests. Certainly this environment does not favor the growth of those species which secrete a calcareous test, and does favor the development of a chitinous or siliceous test.

The samples collected by the author in Harrington Sound present a puzzling problem. Harrington Sound is a fairly large body of water, landlocked, and communicating with the ocean through subterranean passages to the east, and through a very narrow inlet to the west. The tide rips in and out of this inlet with great force at all times,
as there are only a few minutes at the turn of the tide when the water
is not rushing through it with the speed of a mountain torrent. Thus
a natural migration of bentronic forms into this body cannot be ex-
pected. The only reasonable assumption is that young individuals are
swept in by the tide. In such a case, a normal fauna would be anti-
cipated. On the contrary, a very queer fauna is found there.
Triloculina cuvieriana, Pyrgo subsphaerica, P. denticulata, and
Articulina cassis var. mucronata comprise the major part of the fauna, with
other genera and species rare or absent. A normal representation
of species of Quinqueloculina is conspicuously missing. No satis-
factory explanation of these facts can be offered.

A more detailed survey of ecological conditions cannot be given
for lack of data. The samples of the Harvard Collection comprise about
one-half of the material studied, and for most of them there is no
depth given and no data on bottom conditions, merely the latitude and
longitude of the dredging. Hence it is considered wisest to draw only
general conclusions from the ecological data contributed by Dr.
Cushman and the author.
III. KEY TO STATION DATA

<table>
<thead>
<tr>
<th>Collector's No.</th>
<th>Location</th>
<th>Lat. and Long.</th>
<th>Depth and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>*H.C.#440</td>
<td>Off St. Catherine's Point</td>
<td>64° 39' 50&quot; W. 32° 23' 00&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#1409</td>
<td>St. George's Channel</td>
<td>64° 38' 57&quot; W. 32° 21' 56&quot; N.</td>
<td>4 fath.</td>
</tr>
<tr>
<td>K.C.C.#7</td>
<td>Middle of Dolly's Bay</td>
<td>64° 32' 50' W. 32° 21' 56&quot; N.</td>
<td>4 fath. fine yellow mud</td>
</tr>
<tr>
<td>K.C.C.#6</td>
<td>Middle of St. George's</td>
<td>64° 32' 50' W. 32° 21' 56&quot; N.</td>
<td>5 fath. fine white mud</td>
</tr>
<tr>
<td></td>
<td>Harbor</td>
<td>64° 32' 50' W. 32° 21' 56&quot; N.</td>
<td>5 fath. fine white mud</td>
</tr>
<tr>
<td>H.C.#355</td>
<td>Middle of Mullet Bay</td>
<td>64° 41' 05&quot; W. 32° 22' 05&quot; N.</td>
<td>6 fath. fine white mud</td>
</tr>
<tr>
<td>K.C.C.#3</td>
<td>Head of Mullet Bay</td>
<td>64° 41' 05&quot; W. 32° 22' 05&quot; N.</td>
<td>1 fath. grassy bottom, fine gray mud</td>
</tr>
<tr>
<td>H.C.#454</td>
<td>N. side Castle Harbor</td>
<td>64° 40' 20&quot; W. 32° 21' 28&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#1412</td>
<td>Middle Castle Harbor</td>
<td>64° 40' 20&quot; W. 32° 20' 55&quot; N.</td>
<td></td>
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<tr>
<td>H.C.#311</td>
<td>N. of Goat Island</td>
<td>64° 39' 25&quot; W. 32° 21' 06&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#451</td>
<td>Nonsuch Scaur</td>
<td>64° 39' 12&quot; W.</td>
<td>32° 20' 30&quot; N.</td>
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<tr>
<td>H.C.#408</td>
<td>Nonsuch Scaur</td>
<td>64° 39' 08&quot; W.</td>
<td>32° 20' 28&quot; N.</td>
</tr>
<tr>
<td>H.C.#409</td>
<td>Castle Roads</td>
<td>64° 39' 40&quot; W.</td>
<td>32° 20' 00&quot; N.</td>
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<tr>
<td>H.C.#430</td>
<td>Hogfish Cut</td>
<td>64° 52' 20&quot; W.</td>
<td>32° 15' 08&quot; N.</td>
</tr>
<tr>
<td>H.C.#431</td>
<td>Hogfish Cut</td>
<td>64° 52' 18&quot; W.</td>
<td>32° 15' 12&quot; N.</td>
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<tr>
<td>H.C.#434</td>
<td>Hogfish Cut</td>
<td>64° 52' 18&quot; W.</td>
<td>32° 15' 16&quot; N.</td>
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<tr>
<td>J.A.C.#8</td>
<td>Outside Ely's Harbor</td>
<td></td>
<td>1 fath. in reef, coarse sandy bottom</td>
</tr>
<tr>
<td>J.A.C.#9</td>
<td>Ely's Harbor S. end of Wreck House</td>
<td></td>
<td>4 fath. blue mud</td>
</tr>
<tr>
<td>J.A.C.#10</td>
<td>Ely's Harbor just inside S.E. entrance</td>
<td></td>
<td>7 fath.</td>
</tr>
<tr>
<td>J.A.C.#11</td>
<td>Ely's Harbor just outside N.E. entrance</td>
<td></td>
<td>4 fath.</td>
</tr>
<tr>
<td>J.A.C.#12</td>
<td>Off Ely's Harbor</td>
<td></td>
<td>6½ fath. between reefs, white sandy mud</td>
</tr>
<tr>
<td>J.A.C.#13</td>
<td>Long Bay</td>
<td></td>
<td>2 fath. between reefs</td>
</tr>
<tr>
<td>Collector's No.</td>
<td>Location</td>
<td>Lat. and Long.</td>
<td>Depth and Remarks</td>
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</tr>
<tr>
<td>J.A.C.#1</td>
<td>Mangrove Bay S. of rocks off King's Point</td>
<td>64° 51' 06&quot; W. 32° 15' 30&quot; N.</td>
<td>5 fath. sandy mud</td>
</tr>
<tr>
<td>J.A.C.#2</td>
<td>Somerset end of bridge over entrance to Mangrove Bay</td>
<td>64° 50' 12&quot; W. 32° 15' 17&quot; N.</td>
<td>4½ fath., sandy</td>
</tr>
<tr>
<td>J.A.C.#3</td>
<td>Mangrove Bay off King's Point House</td>
<td>64° 49' 55&quot; W. 32° 16' 05&quot; N.</td>
<td>3 fath., fine sand</td>
</tr>
<tr>
<td>J.A.C.#4</td>
<td>Mangrove Bay inside line between Boaz Island and Somerset</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
<td>3 fath., sandy</td>
</tr>
<tr>
<td>J.A.C.#5</td>
<td>Head of Mangrove Bay</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
<td>2½ fath., sandy mud</td>
</tr>
<tr>
<td>J.A.C.#6</td>
<td>Pool between rocks Head of Mangrove Bay</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
<td>1 fath., sandy</td>
</tr>
<tr>
<td>J.A.C.#7</td>
<td>Mangrove Bay between rocks off King's Point and bridge</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
<td>6 fath., fine sandy mud</td>
</tr>
<tr>
<td>H.C.#364</td>
<td>East of Monkey Hole</td>
<td>64° 51' 06&quot; W. 32° 15' 30&quot; N.</td>
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<tr>
<td>H.C.#366</td>
<td>Little Sound</td>
<td>64° 50' 12&quot; W. 32° 15' 17&quot; N.</td>
<td>9 fath.</td>
</tr>
<tr>
<td>H.C.#456</td>
<td>Between Burt Island and Darrell Island</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
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<tr>
<td>H.C.#420</td>
<td>N. side of Long Island</td>
<td>64° 48' 35&quot; W. 32° 16' 52&quot; N.</td>
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<tr>
<td>H.C.#</td>
<td>Location</td>
<td>Coordinates</td>
<td>Description</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>#421</td>
<td>Two Rock Passage</td>
<td>64° 48' 10&quot; W. 32° 17' 05&quot; N.</td>
<td>2 fath., fine sandy bottom</td>
</tr>
<tr>
<td>#10</td>
<td>Mouth Crow Lane and end of Hamilton Harbor</td>
<td></td>
<td>1 ½ fath., black muddy bottom, vegetable matter and coal</td>
</tr>
<tr>
<td>#1</td>
<td>Middle of Crow Lane</td>
<td></td>
<td>Black muddy bottom, mangrove swamp, 1 fath.</td>
</tr>
<tr>
<td>#3</td>
<td>Head of Crow Lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#423</td>
<td>Cobbler's Cut</td>
<td>64° 48' 32&quot; W. 32° 18' 03&quot; N.</td>
<td>3 fath., yellow sandy bottom</td>
</tr>
<tr>
<td>#5</td>
<td>Harrington Sound M.E. of Aquarium</td>
<td></td>
<td>1 ½ fath., gray sandy bottom; very protected place</td>
</tr>
<tr>
<td>#4</td>
<td>Harrington Sound, Green Bay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>Harrington Sound, Trunk Island Bay</td>
<td></td>
<td>1 fath., white sandy bottom, most of this material taken from small white mounds made by the &quot;fireworm&quot; Between Trunk Id. and the mainland, not near any subterranean passages</td>
</tr>
<tr>
<td>Collector's No.</td>
<td>Location</td>
<td>Lat. and Long.</td>
<td>Depth and Remarks</td>
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<td>H.C.#1505</td>
<td>Burchall Cove</td>
<td>64° 43' 43&quot; W.</td>
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<td></td>
<td>32° 19' 50&quot; N.</td>
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<tr>
<td>H.C.#411</td>
<td>Near Pigeon Rocks</td>
<td>64° 43' 20&quot; W.</td>
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<td></td>
<td>32° 20' 28&quot; N.</td>
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</tr>
<tr>
<td>H.C.#317</td>
<td>Mouth of Bailey's Bay</td>
<td>64° 43' 03&quot; W.</td>
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<td>32° 20' 30&quot; N.</td>
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<tr>
<td>H.C.#402</td>
<td>West entrance to Ferry Reach</td>
<td>64° 42' 15&quot; W.</td>
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</tr>
<tr>
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<td></td>
<td>32° 21' 13&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#429</td>
<td>West of Three Hill Shoals</td>
<td>64° 45' 10&quot; W.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>32° 25' 20&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#324</td>
<td>Three Hill Shoals</td>
<td>64° 43' 50&quot; W.</td>
<td>8 1/2 fath.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32° 25' 15&quot; N.</td>
<td></td>
</tr>
<tr>
<td>H.C.#377</td>
<td>Reefs N.W. of Bailey's Bay Flats</td>
<td>64° 47' 40&quot; W.</td>
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<td></td>
<td></td>
<td>32° 24' 10&quot; N.</td>
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<tr>
<td>H.C.#1417</td>
<td>South side of Murray Anchorage</td>
<td>64° 43' 16&quot; W.</td>
<td>8 fath.</td>
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<td>32° 22' 11&quot; N.</td>
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<tr>
<td>H.C.#1418</td>
<td>South side of Murray Anchorage</td>
<td>64° 42' 18&quot; W.</td>
<td>8 fath.</td>
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<td>32° 22' 38&quot; N.</td>
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<tr>
<td>H.C.#360</td>
<td>In reefs East of Brackish Pond Flats</td>
<td>64° 45' 40&quot; W.</td>
<td></td>
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<tr>
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<td></td>
<td>32° 21' 35&quot; N.</td>
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<tr>
<td>H.C.#361</td>
<td>Brackish Pond Flats</td>
<td>64° 48' 20&quot; W.</td>
<td>32° 21' 35&quot; N.</td>
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<tr>
<td>H.C.#359</td>
<td>Brackish Pond Flats</td>
<td>64° 46' 10&quot; W.</td>
<td>32° 21' 10&quot; N.</td>
</tr>
<tr>
<td>H.C.#1416</td>
<td>Ship Channel near Crawl Flats</td>
<td>64° 44' 00&quot; W.</td>
<td>32° 21' 10&quot; N.</td>
</tr>
</tbody>
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*J.A.C.* - Jos. A. Cushman Collection  
*K.C.C.* - Katharine Carman Collection  
*H.C.* - Harvard Collection
Map of Bermuda Plateau, based on British Admiralty Chart. Latitude and longitude ruled to minutes. One-hundred-fathom line in dots; Ship Channel in dashes; soundings in fathoms.

REFERENCE MAP WITH LATITUDE AND LONGITUDE FOR LOCATING DREDGING STATIONS
IV. SYSTEMATIC DESCRIPTION

of

RECENT GENERA and SPECIES
Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

REOPHAX COMMUNIS Lacroix

Pl. 1, figs. 5, 6.

Reophax communis Lacroix, Bull. Inst. Oceanographique, No. 549, 1930, p. 4, figs. 5-7 (in text).

Description: Test minute, elongate, tapering, cylindrical, composed of 6 to 10 chambers in rectilinear series, with very slight constrictions between chambers, rarely arcuate, generally straight; chambers appressed, gradually increasing in size as added; sutures straight and at right angles to the long axis of the test, not distinct; wall fragile, with a chitinous inner lining which is not destroyed by weak acids, with large calcareous and siliceous grains roughly cemented by a small amount of cement; aperture simple, central, circular, terminal, and with a distinct neck in well-developed adults; color yellow to light brown.

Length, 0.52 mm.; thickness 0.16 mm.

This is a very tiny delicate species which may easily be overlooked or broken in washing. The coarse texture and indistinct sutures render the structure obscure, hence the relation of the chambers cannot be seen well unless the test is immersed in glycerin and examined with transmitted light. Its wall is very brittle when dry and a few specimens are flexible when wet. In the choice of sand particles with which to build its test, Reophax communis is one of the few Bermuda species to use truly siliceous sand. It does not show the high selectivity displayed by its associate Spiroplectammina delicatula which is very fine-grained and uses wholly siliceous material.

The specimens here figured are typical of the Bermuda material.
Some of the Bermuda specimens show the last two adult chambers inflated and well separated by pronounced constrictions, with the last chamber tapering toward the aperture which has a decided neck. These individuals are more slender and longer than the average, and have narrow high chambers; they are probably the microspheric form. Lacroix describes a thick form and a longer slender form in his original description of the species.

The distribution of this species in Bermuda is very restricted. At the head of Hamilton Harbor and in its shallow, brackish, mud-bottomed continuation, Crow Lane, this species is very common. It is rare at two other stations both of which have mud bottoms, and it is not found at all others. *Reophax communis* is generally found associated with *Spiroplectammina delicatula* at all the Bermuda stations examined, and the two resemble each other in size and general appearance being the only two minute arenaceous forms present.

Lacroix has described this species from the coast of Monaco. Sidebottom records\(^1\) a species which he calls *Reophax arctica* Brady, from the Island of Delos in the Mediterranean. His figures show broken specimens which are laterally compressed and with elliptical apertures, but his figures are very poor. In all probability, Sidebottom's species is *R. communis* Lacroix, as *R. arctica* is typical of cold water and is recorded only from very deep water or cold arctic regions. The uniserial form from off the coast of Peru which Cushman and Kellett described\(^2\) as

Bisenerina delicatula is, in the wholly uniserial forms, Reophax communis.

REOPHAX cf. SCOTTII Chaster

Pl. 1, fig. 4.


Description: Test minute, elongate, composed of several chambers in a rectilinear series; chambers well separated, globose, somewhat pyriform, abruptly truncated below, enlarging very little as added, proloculum large; sutures distinct, much depressed; wall delicate, translucent, of thin chitinous membrane with very few fine sand grains adherent, very flexible when wet, fragile when dry; aperture circular, terminal; color light yellow.

Length, 0.59 mm.; thickness, 0.19 mm.

There is only one specimen of this species in the material examined, although there may have been others which were broken in washing. It is from a shallow-water, mud-bottom station which appears to be its habitat in regions outside of Bermuda. It agrees with the descriptions and figures cited above except that there are no mica flakes observable on the wall.

This species is not recorded from the West Indies, but is common
about the British Isles and is recorded from several localities in the Mediterranean.

**REOPHAX sp?**

There is one very small representative of this genus from Dolly's Bay. It is slender, almost without tapering as the initial chamber is large, is composed of 5 chambers in all, and has an elongated last chamber with a produced neck and circular aperture. More material is needed before identification can be made.

**Family LITUOLIDAE**

**Genus AMMORACULITES Cushman, 1910**

**AMMORACULITES REOPHACIFORMIS Cushman**

Pl. 1, figs. 1, a, b.


Description: Test elongate, the early portion planispirally coiled with 3 to 5 chambers to a whorl, umbilical area depressed, the later portion uncoiled in a rectilinear series of chambers; periphery rounded; adult chambers inflated, circular in transverse-section, becoming larger as added, the last chamber bluntly pointed and tapering toward the aperture; sutures depressed; wall thick, composed of a heavy chitinous.
inner wall and outer wall of very coarse calcareous grains poorly cemented with calcareous cement; aperture high on the apertural face in the coiled portion, terminal, central, and circular in the uncoiled portion.

Length, 2 mm.; breadth, initial end, 0.70 mm., last chamber 0.66 mm.

*Ammobaculites reophaciformis* occurs abundantly at only two stations and is present at twelve. It is poorly developed at most stations. Young forms still in the coiled stage are more common than adults with long rectilinear series, and seldom does the rectilinear portion form more than half the test. It is a very fragile species, breaking easily when wet. However, fragments of it are not found at many stations as would be expected if it were common though fragile. This species is found in the Pacific as well as the Atlantic, recorded from Tortugas, the West Indies, the Philippine region, and Hawaiian Islands in coral reef sands, as well as from the coast of Florida in warm, shallow waters.

*Ammobaculites reophaciformis* Cushman, var. *PARVUM* Garman, n.var.

Pl. 1, figs. 2 a-c; 3.

Description: Test small, planispirally coiled in early stages, later developing a few chambers in rectilinear series, coiled stages much compressed and with angled periphery, uncoiled portion slightly compressed and with rounded periphery, umbilical area not depressed; chambers not inflated, the final chamber elongated and tapering toward the aperture; sutures indistinct, not depressed, lower on the side corresponding to the apertural face in the young and tending to become
horizontal as chambers are added; wall thin, chitinous, with outer wall of fine calcareous grains firmly cemented with calcareous cement; aperture in the coiled portion at the peripheral angle of the apertural face, in the uncoiled portion shifting to the outer angle of the test as chambers are added, round, with a distinct neck.

Length of holotype, 1.42 mm.; breadth of initial end, 0.52 mm.; breadth of last chamber, 0.62 mm.; thickness, 0.42 mm.

This is a smaller finer-grained form than *A. raphephaliformis*. Its sloping sutures and angled periphery also distinguish it. This variety is found at one station only, the middle of Crow Lane, a long arm of water which becomes swimpier and more acid headward, with a black mud bottom and mangroves growing in the shallower places. The typical *A. raphephaliformis* is present here also, but somewhat dwarfed. The new variety is included in this paper for its ecological value.

**Family TEXTULARIIDAE**

**Genus SPIROPLECTAMMINA Cushman, 1927**

**SPIROPLECTAMMINA DELICATULA** (Cushman and Kellett)

Pl. 1, figs. 7a, 3c.

**Bisnusma delicatula** Cushman and Kellett, *Proc. U. S. Nat. Mus.*, vol.75, art.25, 1929, p.3, pl.1, figs.3a,b.

**Description:** Test minute, elongate, tapering, often twisted, early stages planispirally coiled about a large proloculum, later portion biserial, periphery rounded; chambers numerous, distinct, somewhat inflated, increasing uniformly in size as added; sutures depressed, making
an angle of nearly 90 degrees with long axis of test; wall thin, siliceous, with fine sand grains smoothly cemented, easily broken when wet; aperture an arched slit at the base of the inner margin of the last-formed chamber; color reddish-brown.

Length, 0.77 mm.; breadth, 0.24 mm.; thickness, 0.24 mm.

The Bermuda specimens have been compared with Cushman and Kellett's types from the Pacific off the coast of Peru. The small biserial form figured by Cushman and Kellett is identical with the small biserial form from Bermuda. A careful examination of the Pacific and Bermuda material was made by Dr. Cushman and the author, with the specimens immersed in glycerin to show the true relation of the chambers. In both cases the biserial forms were found to be wholly biserial except for an initial stage composed of a large proloculum with 3 to 5 smaller chambers planispirally coiled about it. Thus the genera of the Bermuda and Pacific biserial form is limited to Spiroplectammina. The uniserial forms from the Pacific were found to be wholly uniserial, and correspond to Raophax communis found at Bermuda accompanying Spiroplectammina.

Spiroplectammina delicatula is one of the few wholly siliceous examples of the arenaceous foraminifera found at Bermuda. Its test is unaffected by acid, proving that the inner wall and cemented material are made of siliceous sand grains. It is remarkable that such selectivity can be shown by a foraminifer, as siliceous sand is very rare in the waters of the Bermuda platform. This is not a common species, occurring at only 3 stations, two of which have fine muddy

2. Ibid. pl. 1, figs. 5a, b.
bottoms and the third has a fine sand and mud bottom and is adjacent to one of the mud bottom stations. All three stations are in very protected waters and near the main Bermuda harbors. Possibly the sand grains are harbor debris, glass, anchor mud, etc., material not indigenous to Bermuda.

**Genus TEXTULARIA Defrance, 1824**

**TEXTULARIA AGGLUTINANS** d'Orbigny

*Pl. 1, figs. 10 a, b; 11 a-c.*


**Description:** Test large, elongate, biserial, composed of a compressed initial portion which tapers abruptly to a blunt point, and a later portion which does not taper and in which the sides of the test are parallel, narrow and straight-sided from edge view, periphery rounded; chambers in the early portion compressed and enlarging as added, in the later portion somewhat inflated and of uniform size; sutures depressed, distinct, at right angles to the long axis of the test; wall moderately rough, composed of calcareous cement and calcareous fragments; aperture an elongated slit at the base of the inner side of the last chamber; color white.

Length, 2.72 mm.; breadth, 1.21 mm.; thickness, 0.79 mm.

The Bermuda species corresponds to d'Orbigny's original figures and description from Cuba. D'Orbigny's figures are copied here, (pl. 1, figs. 11 a-c), for the sake of comparison, and as a substitute for a complete synonymy. The literature on **Textularia agglutinans**
is very confused, likewise the actual specimens catalogued under this name, hence the records of its distribution are dubious. Many rough tapering Textularias of differing appearance and from widely varying ecological conditions have been called by this name by authors unfamiliar with d'Orbigny's types and figures. Thus it seems justifiable to present herewith figures of both the Bermuda and the d'Orbigny Cuba species, and identify the Bermuda specimens as the same as the West Indian species. Much of the Bermuda material is too poor to use as it is broken or of indefinite character, and for that reason the species is not recorded from as many stations as it might be. It is probably more common than this paper implies.

The chief distinction between Textularia agglutinans and Textularia candeiiana can be made when the specimens are viewed from the edge. *T. agglutinans* has a convex aspect to its tapering portion, is narrow and with parallel sides in the adult portion, only a small part of the base of the test is tapering, and the aperture is a simple slit which does not extend from side to side of the test. *T. candeiiana*, on the other hand, has a concave aspect from the edge view; tapers strongly from the inflated apertural end to the long, pointed initial end; the chambers increase in size as added even to the last adult chambers; and the aperture is long, extending nearly from one side of the chamber to the other, and in good specimens has enlarged lobes at either end of the slit.
TEXTULARIA CANDESIANA d'Orbigny

Pl. 1, figs. 8a-c; 9a, b.


Description: Test large, elongate, biserial, strongly tapering from a very broad, swollen, apertural end to a long, sharply-pointed, compressed initial end, strongly wedge-shaped from side or peripheral view, periphery rounded; chambers numerous, compressed in early portion of test, much inflated in later portion; sutures slightly depressed, distinct except in early part of test; wall heavy, wholly calcareous, completely destroyed by weak acid; aperture at the inner base of the last chamber, elongate, narrow, curved, with enlarged, lobate terminations at each end; color white.

Length, 1.83 mm.; breadth, 1.05 mm.; thickness, 1.17 mm.

The synonymy for Textularia candesiana is here omitted on account of its confusion, and copies of d'Orbigny's original figures are offered, (pl. 1, figs. 8a-c), in lieu of many references to works of other authors. The specimen from Bermuda here illustrated resembles d'Orbigny's figures more closely than most of the Bermuda specimens do. However, only these individuals which were definitely similar to d'Orbigny's figure were classified as T. candesiana. The rest were
discarded as too indefinite to allow a positive identification. The 
illustrated specimen, which is probably a well-developed adult of the 
microspheric form, shows lobate terminations of the aperture, although 
the aperture is filled with foreign cement. There are holes in the 
cement. These holes are not in the wall of the test, but in the ex-
traneous material which has collected in the aperture. Many of the 
large adults have this filling in the aperture. All well-developed 
specimens show the lobate enlargements at both ends of the aperture, 
but younger specimens do not. That this is an adult characteristic is 
borne out by the fact that several large, broken individuals in the 
collection exhibit simple slot-like apertures in all chambers except 
the last three.

This species is widely distributed in the Bermuda waters, and is 
fairly common at the stations where it is found. If young and indis-
tinct specimens could be identified, this species would doubtless prove 
to be more common. The distinctions between T. candeiana and T. 
agglutinans are given with the description of the latter.
TEXTULARIA CONICA d'Orbigny

Pl. 2, figs. 1a-c; 2a, b.


Description: Test small, short, very wide, generally wider than long, early portion sharply tapering to a blunt point, later portion flaring laterally, and thickened in central area, upper surface of apertural end flattened, periphery roundly angled; chambers very low and wide, rapidly increasing in width and thickness as added, but not in height, not inflated; sutures slightly depressed, indistinct; wall rough and heavy, of calcareous cement and calcareous grains, wholly destroyed by weak acid; aperture a short, wide slit in a depressed area at the base of the inner margin of the last-formed chamber; color white.

Length, 0.67 mm.; breadth, 0.88 mm.; thickness, 0.52 mm.

The synonymy for T. conica is here omitted because of the confusion in descriptions, figures, and distribution. Copies of d'Orbigny's figures are given, (pl. 2, figs.2a,b), for comparison with the Bermuda species, which seem to the author to correspond very closely.

This species shows wide distribution in Bermuda as it is found at scattered stations on all sides of the island, but it is not abundant at any one station. Depth and bottom conditions are not known for the stations where it occurs. It is easily distinguished from the other species of Textularia in this region by its shortness, its very low, wide chambers, and its flaring, flattened, apertural end.
TEXTULARIA FLORIDANA Cushman

Pl. 2, figs. 3 a, b.


**Textularia floridana** Cushman, Carnegie Inst. Washington, Publ. 511, 1922, p. 24, pl. 1, fig. 7; U. S. Nat. Mus., Bull. 104, pt. 5, 1922, p. 18, pl. 2, figs. 11, 12.

**Description:** Test small, elongate, much compressed, thick in the median portion, thin and narrowing toward the outer margin of the test, initial end a small blunt point, major portion of the test wider, and with edges nearly parallel, upper surface of the apertural end nearly flat; chambers numerous, with tubular projections along the periphery, often broken, producing hollow spots on the periphery, last adult chambers much higher than the preceding ones; sutures raised, thick, and opaque with concentrated cement material; wall thin, translucent, almost wholly of calcareous cement, a few calcareous grains on apertural face; aperture a high short opening at the base of the inner margin of the last chamber.

Length, 1.66 mm.; breadth, 0.90 mm.; thickness, 0.40 mm.

This species is rare at Bermuda. It corresponds with specimens from the type locality, which are in the Cushman Laboratory, in every way except that it is less arenaceous than the Florida specimens, a fact which would be expected in Bermuda where siliceous sand is almost unknown.
Family VERNEILLINIDAE
Genus CLAVULINA d'Orbigny, 1826

CLAVULINA TRICARINATA d'Orbigny

Pl. 2, figs. 5a, b; c.


Description: Test large, elongate, triangular in transverse-section, early portion triserial and sharply tapering, forming a short, blunt point, later portion uniserial and making up the major part of the test, slightly constricted at the base of the uniserial part; chambers numerous, inflated, thus giving the whole test a lobate appearance, the angles of each chamber extending back over the preceding chamber; sutures distinct, much depressed; wall strong and thick, composed of much calcareous cement and coarse grains of calcareous material with a negligible percent of siliceous particles; aperture central, terminal, circular, with a large valvular tooth projecting above the aperture; color white.

Length, 3.02 mm.; thickness, 0.75 mm.

There are distinct megaspheric and microspheric forms. In the megaspheric form, which is somewhat smaller than the microspheric, the angles of the test are rounded, the sides between the angles are flat to convex, the chambers in the uniserial portion are few, high and inflated, and the last adult chambers lose their triangular transverse-section and become circular, higher and more inflated than their
predecessors. In the microspheric form the contrasting characteristics are: a larger size, sharper angles of the test, concave sides between the angles, many closely appressed low chambers in the uniserial portion, and last adult chambers triangular in transverse-section.

This is the same species which is common in the West Indies and at Tortugas. It agrees with d’Orbigny’s original figure from Cuba. Several transverse sections of this species were made in order to substantiate the differences between the megalospheric and microspheric forms. Throughout the whole of the genus *Clavulina*, Cushman finds that the megalospheric form discards the youthful stages more rapidly than does the microspheric, and the Bermuda example bears out this statement. Much of the confusion in the literature on *Clavulina tricarinata* is probably due to the lack of distinction between these two forms, on the part of such older writers as Brady, Woodward, and Goets.

At Bermuda this is a very common species at most of the stations. The material of the wall was tested with acetic acid before the above statement was made in regard to its calcareous composition.

**CLAVULINA NODOSARIA** d’Orbigny

Pl. 2, figs. 7, 8.

*Clavulina nodosaria* d’Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères", p.110, pl.2, figs.19,20.-----

**Description:** Test small, elongate, early portion triserial, pointed and triangular in transverse-section, later portion uniserial with a circular transverse-section, occasionally an intervening biserial stage;
chambers in the early portion not distinct, in the later portion distinct and somewhat inflated; sutures distinct, depressed, and at right angles to the long axis of the uniserial portion; wall composed of a chitinous inner layer and calcareous grains roughly cemented by calcareous cement; aperture round, terminal, central, with a valvular tooth, large for so small a test; color light yellowish-brown to white.

Length, 2.61 mm.; thickness, 0.51 mm.

This species is not common at Bermuda, as it is found in abundance at only one station, is common at one other, and is rare in others. It is such a small species and so fragile that it may be preserved only in quiet waters, as is borne out by the fact that the two stations where it is common were in very protected locations. The only other records of Clavulina nodosaria are from the West Indian region and Tortugas. Cushman has described a variety novangliae from off the coast of New England.

A comparison of Clavulina nodosaria and Clavulina tricarinata is here given. Clavulina nodosaria is very small and delicate, has a roughly circular transverse-section in the whole of the uniserial stage, has no chambers which overlap on the preceding ones, has a partly chitinous wall, and a brownish color. On the other hand, Clavulina tricarinata is large and robust, triangular in transverse-section in the uniserial part with the exception of the last one or two adult chambers of the megalospheric form, has all of its chambers overlapping at the angles of the test, has a wholly calcareous wall, and is white in color.
Family VALVULINIDAE

Genus VALVULINA d'Orbigny, 1826

VALVULINA OVIEDOIANA d'Orbigny

Pl. 2, figs. 9, 10.


Description: Test large, triserial, triangular in transverse-section, rapidly increasing in size from a small initial end to a much inflated apertural end, test as wide or wider than long, periphery roundly angled; chambers distinct, inflated, triangular in transverse-section in the early stages, becoming nearly square in the adult stages; sutures distinct, curving, with convexity in the direction of the apertural end; wall heavy, rough, wholly calcareous; aperture a large depressed area at the junction of the last three chambers, in the center of the apertural end, with a heavy, overhanging valvular flap which frequently joins the flap of the preceding chamber; color white.

Length, 1.85 mm.; breadth, 1.85 mm.

Valvulina oviedoiiana is one of the commonest of the arenaceous species at Bermuda. It is found in abundance at many stations where the bottom is sandy and the water shallow, and broken fragments of it are common at nearly every station. This species is known only from the West Indies, Florida and the Gulf of Mexico, where it is a characteristic member of the fauna. Its presence in Bermuda provides
another example of the close relation between the fauna of Bermuda and that of the West Indies.

**VALVULINA LAEVIS** Carman, n.sp.

Pl. 2, figs. 11, 12.

*Description:* Test large, triserial, elongate, nearly twice as long as wide, evenly tapering from a somewhat inflated apertural end to a pointed initial end, triangular in transverse-section; chambers numerous, increasing uniformly in size as added, somewhat inflated in adult stages; sutures depressed, distinct, straight, making an angle of 45 degrees with the long axis of the test; wall moderately smooth, fine-grained, with much calcareous cement, wholly calcareous; aperture a small depression formed by the junction of the last 3 chambers, with a valvular flap extending over it; color white.

Length of holotype, 1.63 mm.; breadth, 1.10 mm.

This species may be distinguished from the more common *V. oviedoiana* by the following criteria: its test is longer and more slender, it does not expand as markedly as does the short, stout *Valvulina oviedoiana*; its chambers are more numerous and less inflated in the adult; the sutures of *V. laevis* are straight, while those of *V. oviedoiana* are decidedly curving; its wall is smoother and finer-grained; its aperture is similar but smaller.

The above description applies to the microspheric form which is by far the commoner. There is one individual in the Bermuda collection which represents the megalospheric form of this species. It is smaller, and proportionately longer and narrower than the microspheric form. It is triserial only in the early portion of the test, and soon coils with
4 chambers to a whorl, the chambers placed directly upon the chambers of the preceding whorl, thus forming four columns of chambers.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1860

TROCHAMMINA INFLATA (Montagu)

Pl. 2, figs. 4 a-c.

Nautilus inflatus Montagu, Test. Brit. Suppl., 1808, p.81, pl.18, fig.5.


Description: Test small, trochoid, very low-spired, almost equally biconvex, periphery broadly rounded, all chambers visible from the dorsal side, only those of last whorl visible from ventral side, umbilicate; chambers inflated, high, subglobose, rapidly increasing in size as added, 5 chambers to a whorl, early chambers characteristically broken on the dorsal wall; sutures slightly depressed, straight, radial; wall smooth, shiny, truly siliceous, rarely with a few minute calcareous
grains smoothly attached by a thin coating of calcareous cement; color
dark brown to honey yellow.

Diameter, 0.84 mm.; height, 0.40 mm.

The nomenclature given above for Trochammina inflata cites only
these references in which good figures are given and in which the
figure corresponds to material in the Cushman Laboratory collection.
These records show that T. inflata has a wide distribution. It occurs
in Recent material from such scattered places as off the British Isles,
the Shetland Islands, Australia, off the Scandinavian Peninsula, the
Baltic region, off Iceland, the Island of Delos, the Bay of Palermo,
off Buenos Aires, Long Island Sound, the Harlem River, the Gulf of
Mexico, Gaspé Bay, and the coast of New England. This species apparent-
ly has a great depth range as well as a wide geographic range, for it
is found at 1½ fathoms at Bermuda and at 1,900 fathoms off Buenos Aires.

From the discrepancy of the ecological conditions in which this
species is found it would be logical to conclude that there are two
species under consideration, one a cold-water or deep-water species,
and the other a sub-tropical or shallow-water species. However, this
does not seem to be the case. The writer has not examined specimens of
T. inflata from all the recorded localities, but the figures and des-
criptions in the literature agree very closely. Hence there is un-
doubtedly only one species. T. inflata may be a very adaptable species
not controlled by depth or temperature, or it may be highly specialized
with respect to some other limiting factor.

The writer here suggests that this species may be controlled by
the acidity of the water. This suggestion is upheld by the occurrence
of _T. inflata_ in Bermuda in very acid waters, by its occurrence outside of Bermuda in waters which may possibly be high in acid, and by the chemical composition of the test itself.

In Bermuda this species is found only in one very restricted locality, in the acid, mud-bottomed, swampy waters of Crow Lane. Crow Lane is a long, narrow arm of Hamilton Harbor. It is so shallow that mangrove bushes and other vegetation grow almost to the center of the lane. At low tide it is a typical swamp. The writer collected from the two stations at the head of Crow Lane at high tide when a rowboat could barely be rowed over the black muddy bottom and between the reeds and bushes. The sample taken at the extreme head of Crow Lane was mud and vegetable matter from the muck between the bushes. The sample taken in the middle of Crow Lane was also black mud and vegetable debris from a small clearing in the mangroves where the water was about 1½ fathoms deep. Exact chemical data for the water of Crow Lane is not available, but when so many plants are growing and decaying in the lane the water must be high in carbonic acid. This arm of the ocean cannot be called brackish or estuarine in the strict sense because there are no rivers emptying into it. The salinity of the water here is lowered only by the drainage of rain water into the basin. Thus the water of Crow Lane must be dominantly acid instead of "brackish" in the sense of very low salinity.

The majority of records of _T. inflata_, cited in the above nomenclature, give "brackish water" and "estuarine conditions" for the localities where the species is found, especially those off the British Isles and the Scandinavian peninsula. Whether these places correspond to Crow Lane or are near the mouths of rivers is not
certain. In any case, the acids contributed by rivers, in true brackish-water places, may possibly have as much bearing on the occurrence of T. inflata as does the low salinity. In The Data of Geochemistry, Clarke states¹ that there is more free carbonic acid in the ocean water in cold latitudes than in tropical latitudes, the acid being derived from carbon dioxide in the air. The free carbonic acid in cold shallow waters may account for the occurrence of T. inflata in such places as Gaspé Bay and off the coast of the Scandinavian Peninsula.

The chemical composition of the shell of Trochammina inflata is of interest in connection with its occurrence in waters high in acid. It is one of the few Bermuda species made entirely of silica and chitin. Several specimens of it were put in glacial acetic acid to test the wall material. No bubbling took place and the shell was unaffected. In fact, the specimens which had been in the acid were put back in the slide with the untested individuals and mixed up. They could not be distinguished from the others. Such a siliceous foraminifer could live in acid waters more easily than one secreting a shell of calcium carbonate. At the Crow Lane station are found several other siliceous and chitinous species not found in the other Bermuda stations, while the calcareous species are here dwarfed, poorly ornamented, and with thinner shells than elsewhere.

Family MILIOLIDAE

The Miliolidae family is noteworthy for the extreme variability of its included genera and species. Members of this family are doubtless the most variable of all the foraminifera. Not only do the species blend into one another, but genera recapitulate ancestral genera in their young stages. *Triloculina* goes through a quinqueloculine young stage; *Pyrgo* develops through quinqueloculine and triloculine stages; *Massilina* departs from quinqueloculine coiling only in its maturity. Other examples are too numerous for mention here. Because of this variability of the Miliolidae, many workers on the foraminifera have made erroneous specific and generic identifications, and our literature is confused thereby.

Unfortunately, many of the older specific identifications and descriptions were based on characteristics which are inconstant. Many of the generic identifications were based on young forms when adults were not found, due to lack of material or poor microscopes. Our present technique of washing, and of floating off foraminifera with heavy liquids enables us to gather plenty of material from which we may draw more accurate conclusions than the earlier workers. With large suites of specimens, segregated for one or two specific characters, and graduated in size, we may prove that certain of these specific distinctions are paramount to older generic classifications. For instance, a group of Miliolids with pebbly calcareous walls of a milky blue color and with an aperture covered by a broad flap-like tooth, may show quinqueloculine, triloculine, and planispiral coiling in various stages of their development. In such a case a new genus is
needed, based on characteristics which were hitherto considered of specific value only. In other cases, large suites of graduated specimens are needed in order to determine the genus of the typical adult of the species.

In order to determine which variations occur within a species, work must be done with the living animal. The author hopes that workers at the Marine Biological Station laboratory in Bermuda will carry on such investigations. The highly variable species are pointed out in this paper. If a few very typical living specimens of these species could be segregated in tanks and propagated, and the resultant variations noted, we would be able to fix the limits of the species.

The only other accurate means of delimiting a species is the collecting of large numbers of individuals, from many different dredging stations. From a careful study of the station-to-station mutation, and the individual variation at any given station, a fairly accurate knowledge of specific characters can be obtained. The writer has followed this method. The Bermuda fauna carries a large percentage of Miliolidae, both in species present and individuals. Numerically, about 80 per cent of the individuals at most stations are Miliolids. Hence the writer feels that the Bermuda fauna furnishes an adequate basis for generalities in regard to that family.

One of the purposes of this paper is to point out the characteristics of the Miliolidae which are constant and those which are not. Arranged in order, from the most constant to the most variable, these features are: 1. shape of the aperture; 2. type of wall; 3. shape and position of apertural end, and dependent upon it, the shape of the
basal end and position of the suture on it; 4. type of coiling; 5. tooth; 6. shape of the test; 7. shape of the chambers; 8. shape of the periphery; 9. carina; 10. costae. There are only two features which are truly constant, the shape of the aperture and the type of wall.

If an elongate narrow aperture is typical of a species, it will be possessed by young and adult forms, through quinqueloculine, triloculine, and planispiral coiling, by costate or smooth forms, by keeled or rounded forms. If a wide round aperture is typical, it will be constant in all stages regardless of other variations. The aperture varies only in abnormally compressed or inflated specimens. The same is true of the wall material, which is an inherent function of the protoplasm of the animal. A smoothly polished heavy wall, or a vitreous wall which is transparent, or a dull wall with gouged or etched lines in the surface, or a rough "pebbly" wall, will be constant for all members of a species. The wall becomes thicker with old age, but retains its diagnostic type.

The shape and position of the apertural end is almost as constant as the shape of the aperture. A truncated apertural end with the aperture at one side in the plane of the last chamber is constant. A truncated apertural end with the aperture in the median plane of the test is constant. However, an elongated apertural end is not so constant, as the elongation is seldom pronounced in the young, only the adults showing a strongly drawn out neck. The everted lip and constriction below the apertural orifice are characters best shown by the adults, though at times well developed in the young. The shape of the basal end of the test is as diagnostic as the shape of the
apertural end, since it covers the foregoing aperture. An elongate apertural end or a projecting tooth will produce an inflated apertural end, or one with a backward projection. The position of the suture at the base of the test is, in some species, one of the most diagnostic characters. It is, of course, wholly dependent upon the shape of the preceding lip and aperture.

The type of coiling, whether quinqueloculine, triloculine, or planispiral, is a character which can be applied to mean adults only. Very old or accelerated adults deviate from it, as do the young. However, since all of our generic distinctions are based on it, the type of coiling is the most important characteristic of the adults.

The tooth is a characteristic part of the test which has received undue consideration in the past. It is frequently broken in Recent material, and typically broken in fossil material. The Bermuda material has been collected and washed with such care that the author feels better qualified to discuss the subject of teeth than many of the previous writers, who have made erroneous descriptions of them. The tooth varies from individual to individual, and from young stages to adult stages. Young and average adult forms possessing an elongate simple tooth will be found, in well-developed adults or very old specimens, to have a tooth which is slightly bifid at the tip. Accelerated individuals show the bifid character sooner than do their associates. The simple elongate tooth is evidently a primitive character retained by some species, but not by all members of that species alike. The young of most species show a simple tooth, whereas the adults show a bifid one. Very inflated individuals have a tooth which is broadened
at the tip, frequently becoming truly bifid. The tendency of a tooth
to project out of the orifice is a character which is constant for young
and old alike, and is not an old-age character, but one which is sub-
ject to wide individual variation. If a projecting tooth is typical
of a species, about half the individuals both young and old will show
it. It is a highly diagnostic character when present, as most species
show no tendency to project the tooth.

The shape of the test is highly variable. It may vary from as
long as it is wide to three times as long as it is wide. Only in
pronounced spherical species or pronounced elongate species, is this
criterion of value. The shape of the chambers is also highly variable.
Only in the case of chambers which are bulbous at the base and taper-
ing toward the apertural end is the shape diagnostic. Triangular
shaped chambers may become rounded or truncated and square.

The shape of the periphery is a decidedly variable criterion.
An angled periphery generally becomes rounded in old age. Some species
with rounded peripheries develop strongly angled peripheries in old
age. A truncated periphery is generally an old-age character of a
species with rounded young. The truncated periphery is generally
acquired gradually; the first chamber to show truncation being slightly
flattened at the base, the succeeding chamber being flattened for half
the length of the chamber, and the next chamber truncated along the
entire periphery. As a general rule a species varies between two
types of periphery, but there are cases where all three types are
shown by one species.
Costae, wrinkles and surface ornamentation are the most variable characteristics of the Miliolidae. Most costate species tend to lose the striations in old age, although there is also a wide individual variation in this respect. The tendency of costae to bend inward toward the center of the test is fairly constant. The tendency of costae to break up into two or three more costae before the length of the chamber is run is a diagnostic feature. Smooth shiny costae as compared with rough uneven costae are important in that they reflect the nature of the wall. Low, broad, indefinite-appearing costae as compared with narrow, high, sharp costae are also diagnostic, as one species does not produce both types. Wrinkles and bosses on the surface are generally an old-age character, or at best, of varietal importance only. They are not to be confused, however, with true corrugations or regular transversal undulations which are evenly spaced and run the entire length of the chamber.

The specific and varietal distinctions made in this paper are based upon the foregoing evaluation of characteristics. Any mutation along the lines of one or two of the highly variable characteristics is worthy only of varietal distinction. Mutation in the more constant characters requires generic and specific recognition.
Genus QUINQUELOCULINA d'Orbigny, 1826

SPECIES WITH AN AGGLOMINATED OR GRANULAR EXTERIOR

QUINQUELOCULINA AGGLUTINANS d'Orbigny

Pl. 3, figs. la-c.


Description: Test nearly as broad as long, apertural end not produced, periphery rounded to slightly angled; chambers indistinct, circular in transverse-section; sutures indistinct, not depressed; wall rough, composed of coarse calcareous material cemented on the outside of a calcareous wall; position of the aperture typically in the median plane; aperture loop-shaped, narrower at the base than at the top; lip thickened, not encircling the whole aperture but fusing with the chamber wall at the base of the aperture, lip typically raised at the top of the aperture, depressed at the base; tooth large, bifid, with a short stem and widely spreading long prongs, stem attached at base of aperture where lip is absent.

Length, 1.17 mm.; breadth, 1.04 mm.; thickness, 0.67 mm.

This is one of the commonest Quinqueloculinas at Bermuda, as large suites of the species have been collected from nearly every station. The Bermuda species agrees very closely with d'Orbigny's
original figures from Cuba. It agrees also with Cushman's collection from Tortugas, although none of the Bermuda specimens show two teeth such as Cushman describes.¹

The aperture illustrated in figure 1c, plate 3, is not typical, but that of the variety bidentata in figure 2a, is very typical for the species.

QUINQUELOCULINA AGGLUTINANS d'Orbigny, var. BIDENTATA d'Orbigny

Pl. 3, figs. 2a-c.


Test similar to Q. agglutinans except that the periphery is truncated. The distinction based on the tooth, as d'Orbigny mentions, does not hold true for large suites of specimens, as the tooth is precisely similar to that of Q. agglutinans. However, d'Orbigny's specific name, bidentata, has been retained for the variety because it is so well established in the literature. This variety is not as common at Bermuda as the species.

Length, 0.73 mm.; breadth, 0.58 mm.; thickness 0.30 mm.

QUINQUELOCULINA TROPICALIS Cushman, var. BERMUDIENSIS Carman, n.var.

Pl. 3, figs. 3-6; Pl. 11, fig. 10.

Description: Test elongate, three times as long as broad; apertural end much produced typically at one side in the plane of the last chamber; basal end projecting backward and inflated; chambers enlarged in the basal half, tapering toward the apertural end; sutures indistinct, suture areas depressed and distinct; wall dual in character, an inner clear or transparent wall with etched or incised irregular lines, this inner wall visible only in the young or in the intermediate stages near the sutures and at the neck, and an outer covering of rough, dull, granular material which covers the periphery of each chamber in the young, and covers the whole chamber in well-developed adults, always absent at the neck, very thick in old specimens; aperture circular, with an elongate constricted neck and thin everted lip; tooth small, simple, but with a thickening at the tip.

Length of holotype, 0.81 mm.; breadth, 0.30 mm.; thickness, 0.24 mm.

The Bermuda variety is very similar to Q. tropicalis described by Cushman from Samoa. The Bermuda specimens are much more granular and somewhat more inflated than the Pacific species, and have a tendency to become flattened at the base of the last chamber. However, since Q. tropicalis is not abundant at Samoa, a study of more Pacific material might prove the species and its variety to be identical.

Brady1 described and figured Miliolina gracilis which is probably this species and variety. But Brady’s name for this species cannot be corrected to Quinquelooulina gracilis because Q. gracilis has been

used by d'Orbigny for a species from Cuba which appears to be quite different. Woodward\(^1\) mentioned Brady's species in his list of the foraminifera from Bermuda, and was doubtless referring to \textit{Q. tropicalis} var. bermudensis.

This variety is very common at Bermuda, as it is abundant at nearly every station. On account of its abundant occurrence at Bermuda it is surprising that it has not been recorded from the West Indies, but so far there have been no references to it from that region.

Figure \textit{10}, plate \textit{II}, is a conventionalized camera-lucida drawing to show the dual nature of the wall, which is so characteristic of this variety. The same specimen is illustrated in plate 3, figure 6. Figure 5, plate 3, shows an average specimen with depressed suture areas which are not entirely covered by the granular coating, while figure 4, shows an old-age specimen thickly coated over the entire surface. Aside from this variation in the extent of the coating, and slight variations in width of the test, this variety is remarkably constant.

SPECIES WITH THE SURFACE ORNAMENTED BY COSTAE OR STRIAE

QUINQUELOCULINA POEYANA d'Orbigny

Pl. 3, figs. 7a-c.


Quinqueloculina laevigata d'Orbigny, of authors, and in part.

Description: Test two or three times as long as broad, nearly elliptical in end view; chambers slightly appressed; periphery rounded; apertural end very slightly produced, position of aperture in the median plane of the test; basal end rounded, not inflated; chambers distinct, very slightly inflated in basal half; sutures depressed, distinct; wall clear, thin, ornamented with closely spaced rounded costae which extend very evenly for the entire length of the chamber, in rare cases becoming plain in old age; aperture circular, without constriction, but with a slightly thickened ring around it; plane of the aperture typically sloping downward toward the center of the test; tooth very small, short, bifid.

Length, 0.61 mm.; breadth, 0.28 mm.; thickness, 0.11 mm.

This species is very common at Bermuda, and shows almost no variation.

Many of the specimens referred by Cushman and other authors to Q. laevigata are smooth forms of this species, which show the striated character in the early chambers.
QUINQUELOCULINA SUBPOEYANA Cushman

Pl. 3, figs. 8a-c, 9a-c.

Quinqueloculina subpoeeyana Cushman, Carnegie Inst. Washington, Publ.311, 1922, p.56; U. S. Nat. Mus., Bull.104, pt.5, 1929, p.31, pl.8, figs.3a-e; Fla. Geol. Surv., Bull.4, 1930, p.21, pl.2, figs.7a,b; Bull.9, 1932, p.44, pl.2, figs.4a-c.

Description: Test small, three or four times as long as broad, chambers not compressed together, loosely coiled; periphery rounded; apertural end much elongated, and produced beyond the outline of the test, typically at one side and not in the median plane of the test; basal end slightly inflated, rounded, basal suture line not in median plane but placed well over on the preceding chamber; wall rough, dull, ornamented by numerous high, rough costae discontinuous and becoming bifurcated, thus giving the test a ragged appearance, costae continuing to the aperture; aperture circular, without lip or constriction; tooth not observed.

Length, 0.45 mm.; breadth, 0.18 mm.; thickness, 0.12 mm.

This species is commoner at most Bermuda stations than Q. poeyana, from which Q. subpoeeyana may be distinguished by its dull rough surface, its loose coiling, its rough irregular costae, and its prolonged apertural end. There is considerable variation to this species although the costae are a constant characteristic in their appearance and development. The test is tending to become massiline in its coiling, some individuals are extended in width, and there are many individuals which grade into the shorter stouter form figured on plate 3, figures 9a-c.

The occurrence in Bermuda of this species provides another extension of the West Indian fauna along the Gulf Stream to Bermuda, as this is one of the species most typical of the West Indies and Florida. It is present in the Miocene of Florida also.
Description: Test somewhat longer than broad, triangular from end view, apertural end very slightly prolonged, basal end inflated, rounded; periphery sharply angled, typically carinate, varying to non-carinate and rounded angled; chambers compressed together, with greatest width in the central portion, triangular in transverse-section; wall very heavy, polished, ornamented with heavy rounded costae which bend obliquely inward and do not run the full length of the chamber; aperture circular, with a lip which is very slightly everted, with a short bifid tooth.

Length, 0.74 mm.; breadth, 0.52 mm.; thickness 0.34 mm.

This very common species is one of the most variable at Bermuda. There are possibly more than one species included in the limits of this description, and work must be done breeding the living animal before the limits can be fixed. Transverse sections are necessary for the accurate identification of this species. The typical form has a very heavy wall and chambers which are triangular in transverse-section even in the very young stages, as shown in the section figured on plate 3, figure 13. The author has encountered a very thin-walled form in which the chambers are triangular but not as closely
compressed as in the typical form. This form is included with *Q. funafutiensis* in the Bermuda collection because there is no means of separating the two forms without sectioning each individual, and because there is no certainty that such a variation does not take place in the microspheric form. There are also in the collection, thick-walled specimens in which the last few chambers are very rounded at the periphery, but which show the angled chambers in the younger stages. The tendency to lose costae and become smooth is most marked in old specimens, but is exhibited by some young ones as well, and is shown by both rounded and highly angled forms. Thus this species will be seen to vary from sharply-angled and carinate and costate, to rounded and smooth. I have arranged specimens in graduated suites, and examined several hundred individuals without being able to draw any line of separation for varieties of the species.

**QUINQUELOCULINA VERSATILIS** Carman, n.sp.

Pl. 4, figs. 1-6, 2, 3, 4.

**Description:** Test somewhat longer than broad, rounded triangular in end view, periphery rounded, apertural end very slightly prolonged, basal end inflated, rounded, projecting backward slightly; chambers nearly circular in transverse-section in both the young and adult stages; wall thin, porcellanous, polished, typically costate, but frequently smooth; costae typically added in adult stages following smooth young stages, costae most numerous at the periphery, bending inward obliquely, moderately sharp; aperture circular with a slightly everted lip and short bifid tooth.

Length of holotype, 1.00 mm.; breadth, 0.66 mm.; thickness, 0.48 mm.
This species does not seem close to any of the costate species recorded and figured from the Atlantic and hence is here recorded as a new species. The costae are extremely variable. The species is typically more heavily costate in old age and adult specimens than in young specimens. This is the reverse of the usual development, as loss of costae is a well-known old-age characteristic. Many of the less accelerated forms are smooth in all stages, some others are smooth in the young and costate in the adults, and still others are costate throughout. The intermediate stage wherein the young are smooth and the adults heavily costate seems to be the most abundant. The entirely costate forms are next in abundance, and the entirely smooth forms are the most scarce. The specimen figured on plate 4, figures 1a,b, shows very clearly the younger chambers which are smooth and last few chambers which are heavily costate at the periphery. A smooth adult is shown in figure 3, plate 4.

The inward bending costae resemble the costae of Q. funafutiensis and the outward appearance of the test suggests that species in many ways. The transverse section shown on plate 4, figure 4, demonstrates that the two species are not related closely, as the wall of Q. versatilis is very thin for a porcellaneous form, and the chambers are rounded in section. Transverse sections are necessary for the accurate identification of this species, to distinguish it from the rounded forms of Q. funafutiensis, but in general the rounded forms of the latter show their younger chambers on the four-chambered side, and these are generally angled. Q. versatilis is rounded throughout.

This species is very common at Bermuda. It occurs with Q. funafutiensis, but the abundance of the two species at the same station is generally variable, one or the other being dominant.
SPECIES WITH SURFACE ORNAMENTED BY TRANSVERSE WRINKLES AND UNDULATIONS

QUINQUELOCULINA LAMARCKIANA d'Orbigny, var. AUBERIANA d'Orbigny

Pl. 4, figs. 6a,b, 7.


Description: Test moderately large, elliptical in shape from side view, nearly triangular from end view; apertural end typically somewhat produced, position of the aperture in the median plane of the test; basal end typically slightly produced backward; periphery angled to rounded; chambers of nearly uniform width throughout their length, roughly triangular in transverse-section, not inflated, sides of the chamber noticeably complanate; sutures depressed; wall polished, heavy, porcellaneous, ornamented by irregular transverse ridges and bosses on the surface, and very irregular deep transverse wrinkles which affect the periphery as well as the sides of the chamber, not regular undulations nor evenly spaced indentations; aperture small, typically circular, sometimes oval, plane of the orifice at right angles to the long axis of the test, typically without constriction but with a slightly thickened ring about it; tooth small, bifid.

Length, 1.00 mm.; breadth 0.82 mm.; thickness, 0.46 mm.

As far as can be ascertained from the figures and descriptions in the literature, the species auberiana has not been correctly cited since d'Orbigny originally described it. All of the specimens and descriptions I have been able to refer to are unornamented forms without wrinkles or undulations. These errors are due to a discrepancy between d'Orbigny's figures and his description, later authors following the figures solely.
D'Orbigny's original figures show a plain specimen with no ridges or undulations on the chamber walls; but since the figures are the work of his artist, and the description is d'Orbigny's own, we must place more confidence in the description. My literal translation of the French version is as follows.

"*Quinqueloculina auberiana.* Test suborbicular, a little oval, very convex, brilliant, polished, gentle transverse undulations, obtuse at its extremities, a little carinated at the periphery. Chambers triangular, inflated at the sides, truncated in front, slightly sharpened in back, slightly carinated at the back, suture slightly depressed. Aperture oval, without peristome, elongate simple tooth. ***** It differs from its neighbors *Q. lamarckiana* and *Q. cuvieriana* by the transversal undulations with which it is ornamented. Not rare at Cuba."

The description of the Bermuda material and d'Orbigny's description do not agree in all details, but agree in the more constant characters. The Bermuda specimens vary in shape of the test, especially in length, and angulate periphery, and development of ornamentation. Many individuals, especially young ones, do not have a prolonged apertural end. Plate 4, figures 6a,b, show a specimen which is similar in shape to the one figured by d'Orbigny. The species *auberiana* is here given only varietal distinction because it digresses from *lamarckiana* in minor characters which are seldom constant in the Miliolidae; but the shape and position of the aperture and apertural end, and the wall material and general appearance are the same.

This variety is not as common at Bermuda as *Q. lamarckiana*, and has an erratic occurrence. It is fairly abundant at a few stations, but was not found at most stations.

It may be distinguished from *Q. parkeri* which has an elongate, narrow aperture with flaring lip, and has regular ridges between regularly spaced wide indentations.
QUINQUELOCULINA PULCHRA Carman, n.sp.
Pl. 4, figs. 5a-c.

Description: Test somewhat longer than wide, rather small, apertural end very slightly prolonged, basal end rounded; chambers not inflated, not compressed together, chamber walls corrugated into regular, evenly spaced undulations, periphery rounded to somewhat angled, crenated; wall dull, comparatively heavy for so small a form, ornamented with fine longitudinal striations which appear discontinuous due to the depressions between the ridges; aperture circular, with a slightly thickened lip which is not everted, with a short bifid tooth, with a very slight neck.

Length of holotype, 0.35 mm.; breadth, 0.27 mm.; thickness, 0.17 mm.

This species is rare at Bermuda. It has been found at Tortugas but is not recorded by Cushman. Its small size, and crenulations combined with striations, will serve to distinguish it from other similar species.

QUINQUELOCULINA PARKERI (H.B.Brady), var. OCCIDENTALIS Cushman
Pl. 4, figs. 8, 9a-d.


Description: Test short, stout, nearly as wide as long, apertural end not prolonged, basal end very bluntly pointed; chambers quadrangular,
truncated, ornamented on the peripheral face with opaque somewhat granular carinae, which become reticulate and irregular, frequently enclosing pit-like depressions between their curves, frequently becoming tricarinate, chambers not as highly ornamented on the sides as on the peripheral face; wall clear, translucent between the carinae, etched with fine incised lines; aperture elongate, typically compressed, without a neck or thickened lip, with a long bifid tooth.

Length, 0.52 mm.; breadth, 0.37 mm.; thickness, 0.33 mm.

This species is similar in many ways to Q. berthelotiana. It is shorter and stouter and without a neck, but a few sparsely ornamented specimens appear so similar that it is probable that the ancestry of the two forms was the same. Q. parkeri var. occidentalis is to be distinguished from Q. tricarinata by the fact that the latter is not translucent and has a long slender neck. It is to be distinguished from Q. kerimbatica var. philippinensis of the Pacific by the fact that the latter has a very long, slender, cylindrical neck, has a very heavy, granular wall which is very regularly ornamented with deep depressions in the form of pits. It is also distinguished from Q. parkeri in that the latter has very heavy granular walls and a sharply angled periphery which is not affected by the ornamentation. This variety, occidentalis, may be an altogether different species, but larger suites of material, or investigations of the living animal are necessary before it can be proven. As stated above, the Bermuda specimens seem nearer Q. berthelotiana than to Q. parkeri of the Pacific. It is not common at Bermuda.
SPECIES WITH ANGLED, CARINATE PERIPHERY

QUINQUELOCULINA BERTHELOTIANA d'Orbigny

Pl. 5, figs. 1a-d, 2.


Description: Test somewhat longer than broad, tapering rapidly toward both ends, with a stellate appearance in end view; apertural end produced beyond the rest of the test in the median plane of the test; basal end a bluntly rounded protuberance projecting backward in the median plane of the test; chambers with major portion much compressed in the plane of the coiling and triangular in transverse-section, but with the basal portion of each compressed at right angles to the coiling, and thus flattened, truncated, quadrangular in transverse-section; periphery sharply angled and with a single, blunt carina in the central and forward portion of each chamber, but with double carina in the basal truncated portion of the chamber; wall of the major portion of the test clear, translucent, thin, becoming opaque and thicker at the carinae, wall ornamented with minute longitudinal etchings, straight but discontinuous; aperture oval, elongate, with a rectangular-shaped neck which appears very narrow from edge view and very broad from side view, due to the compression of the chambers; tooth simple, projecting slightly above the aperture.

Length, 0.62 mm.; breadth, 0.34 mm.; thickness, 0.26 mm.

In d'Orbigny's description of this species from the Canary Islands he states that it has "chambers straight, triangular and prolonged in
front, spreading and quadrangular in the rear; back carinated forward, bicarinated rearward, with a large flat part on this rear portion; aperture oval." He also states that "this species is distinguished from all others by this singular character in which all the chambers have a single carina in front, and have two in the rear."

The Bermuda specimens agree very closely with this description. The figures given on plate 5, figures la, b, d, show the flattening at the base of the last chamber. Figure ld, gives the edge view of the last chamber showing the flattened area and two carinae at the base, with the single carina on the major portion of the chamber, which is typical of the species. Figure 2, shows the last chamber of an unusual individual in which the periphery is truncate with two keels for the whole length of the chamber. This seems to be an old-age character, as the preceding chambers on the same specimen have the normal keel development. The figure is included here for the sake of showing the relation of this species to other similar species, such as Q. sulcata var. atlantica, and Q. parkeri var. occidentalis.

Quinqueloculina berthelotiana may be distinguished from Q. polygona by its clear wall material, whereas the latter has an opaque wall, and by its blunt, opaque keels whereas the latter has sharp clear keels.

This species shows a few variable characters at Bermuda, but evidently does not vary as widely as the Pacific species recorded by Cushman. The keels may become sharper and appear clear; the keels and the chambers may become sinuous. But the shape of the test seems constant and the flattened area at the base of the chamber is constant.
QUINQUELOCULINA POLYGONA d'Orbigny, var. UNICARINA Carman, n.var.

Pl. 5, figs. 3a-c.

Description: Test elongate, gradually tapering from the widest portion in the central area, nearly triangular in end view; chambers triangular to rounded in transverse-section, of uniform diameter throughout their length; periphery in adults ornamented with one carina of clear material, in the very young stages with two carinae; wall dull, ornamented with irregularly spaced, elongate pits, which give the surface a rough appearance; aperture circular, with a somewhat prolonged neck, varying from a position in the median plane of the test to the plane of the last chamber; tooth with a flattened plate at its extremity, becoming bifid.

Length of holotype, 0.64 mm.; breadth, 0.28 mm.; thickness, 0.14 mm.

This variety is not as common at Bermuda as Q. polygona with which it generally occurs. Its young stages show that it was probably derived from that species, and it may be distinguished from it by the single keel and more pitted surface.

QUINQUELOCULINA ALIFERA Carman, n.sp.

Pl. 5, figs. 4a-c.

Description: Test small, subcircular in side view, highly angled and stellate from end view; apertural end not prolonged, basal end projecting very sharply, extending beyond the outline of the test for a distance equal to the breadth of the newly-formed chamber; chambers very sharply angled, much compressed near the periphery, with the
greatest width in the central portion, periphery of each chamber keeled with a very sharp carina; wall translucent, not especially thin but of very clear material, smooth; aperture circular with no lip and no neck, with a short bifid tooth.

Length of holotype, 0.55 mm.; breadth, 0.43 mm.; thickness, 0.26 mm.

This species is very rare at Bermuda. On account of its rarity, and the fact that no such form has been recorded from the West Indies, it is possible that it may be a sport from *Q. lamarckiana*. However, the illustrated holotype is a very perfect specimen and seems worthy of recording here as a species.

**SPECIES WITH TRUNCATE, CARINATE PERIPHERY**

**QUINQUELOCULINA POLYGONA d'Orbigny**

Pl. 5, figs. 5a-c, 6.


Description: Test two to three times as long as broad, not strongly tapering toward either end; apertural end extending beyond the outline of the test and forming a short cylindrical neck, position of the neck in the plane of the last chamber; basal end produced backward and varying in shape from rounded to bluntly pointed, extending somewhat beyond the preceding chamber; periphery truncate to concave between the angles, with sharp-edged carinae of clear material at the angles; chambers quadrangular in transverse-section, long, of nearly
uniform diameter throughout their length, somewhat inflated at the basal end; wall opaque, dull to shiny, of porcellanous material etched with fine lines and minute pits which give a dull appearance to the surface; aperture typically elongate, with a small bifid tooth, without thickening of the lip which is very slightly everted.

Length, 0.67 mm.; breadth, 0.29 mm.; thickness, 0.19 mm.

Quinqueloculina polygona may be distinguished from the other species of double-keeled Quinqueloculinas by its elongate shape, its opaque porcellanous wall with minute etchings, by its keels of clear material, and by its rounded, somewhat inflated basal end which is only rarely produced into a blunt point. It is the commonest of the double-keeled Quinqueloculinas at Bermuda, but is not found in great numbers at any of the stations. It is very constant in its characters and shows little variation.

The double keel and truncate periphery are present in all the very young specimens found at Bermuda, hence they do not seem to be characteristic of old age. This is unusual because most of the bicastrate species of the Miliolidae pass first through a stage with rounded periphery and single keel, becoming truncated and double-keeled only in the adult chambers. That this species reverses the usual keel development is indicated by the presence of Q. polygona var. unicarina in which the young have two keels, and the adults have only one keel and a somewhat rounded periphery.

In a few adults the coiling seems to approach the massilina type, giving the test a flattened appearance. One of these specimens is figured on plate 5, figure 50. It is possible that the species is evolving toward Massilina.
QUINQUELOCULINA SULCATA d'Orbigny, var. ATLANTICA Carman, n.var.

Pl. 6, figs. 1a-d.


Description: Test elongate, two to three times as long as broad, tapering gradually from its widest portion in the center of the test; apertural and basal ends much prolonged in the median plane of the test; basal end sharply pointed; chambers quadrangular throughout, truncated, concave between the peripheral angles, with blunt carinae at the angles; wall thin, very delicate, translucent, becoming opaque near the carinae, delicately etched with longitudinal incised lines; aperture circular, with a long cylindrical neck, and short bifid tooth.

Length of holotype, 0.67 mm.; breadth, 0.24 mm.; thickness, 0.17 mm.

This variety is very close to Q. berthelotiana, but has a more delicate wall, a cylindrical neck and circular aperture, and sharply-pointed, prolonged basal end, and is bicarinate throughout. Figure 1b, plate 6, shows a specimen in which the early chambers have a forked carina, indicating that this species was probably derived from the same ancestry as Q. berthelotiana. However, the above mentioned differences between the species seem to be quite constant.

Cushman describes1 and figures Q. sulcata from the tropical Pacific. His material is very similar to the Bermuda variety except that the specimens are much larger and wider, and with much heavier wall. The young specimens in the Pacific collection are very close to the Bermuda variety.

QUINQUELOCULINA GRANULOSA Carman, n.sp.

Pl. 6, figs. 2a-c.

Description: Test somewhat longer than broad, with truncated periphery, typically concave at the periphery between the angles of the chamber, with projecting carinae at the angles; chambers of nearly uniform diameter throughout, the last chamber projecting and overlapping the preceding chamber for a considerable distance, last chamber very much flattened at the base; wall very rough and granulose, but not of agglutinated material, carinae also granular and rough with a crenulated appearance at their edges; aperture at the end of a prolonged neck, typically projecting in the plane of the last chamber and at one side, shape of aperture circular, with a thickened everted lip and very short-stemmed bifid tooth.

Length of holotype, 0.55 mm.; breadth, 0.32 mm.; thickness, 0.19 mm.

This species has been found in the Pacific and at Tortugas and has been included in the collections under Q. polygona. It is abundant enough at Bermuda to permit the conclusion that it is a different species. The extended, flattened basal end, and the very granular carinae will serve to distinguish it from Q. polygona, while these characters combined with its very granular wall will distinguish it from other truncated Quinqueloculinas. It is fairly abundant at Bermuda, where it is present at about one-third of the stations and abundant at several of those.
SPÉCIES WITH SMOOTH SURFACE AND ROUNDED OR ANGLED PERIPHERY

QUINQUELOCULINA BOSCIANA d'Orbigny

Pl. 6, figs. 3a, b, 4.


Quinqueloculina laevigata d'Orbigny, Cushman (in part), and of authors.

Description: Test small, elongate, two and one-half to three times as long as broad, oblong from side view, elliptical from end view, chambers typically closely compressed together; periphery rounded; apertural end very slightly if at all produced; position of aperture typically at one side in the plane of the last chamber; basal end smoothly rounded; base of the last-formed chamber overlapping the preceding chambers in an involute manner so that it covers the whole basal end of the test; chambers inflated in the basal half and thus having an elongate bulbous appearance at the base, forward half of each chamber strongly tapering toward the aperture with a constricted appearance about two-thirds of the distance up the chamber; suture lines very oblique smooth curves typically without angular change of direction at the basal end of the test, very slightly depressed; wall thin, translucent to opaque, of a bluish-white color, highly polished, smooth, without costae or signs of costae; aperture small, circular, with a slight constriction and slightly thickened ring about it; tooth very small, short, bifid.

Length, 0.53 mm.; breadth, 0.21 mm.; thickness, 0.11 mm.
My literal translation of d'Orbigny's original description is as follows.

"Test elongate, oblong, compressed, polished, brilliant, truncated in front, rounded obtuse in the rear, convex at the periphery. Chambers convex, very elongate, a little arched, very straight in front, strongly enlarged crosswise (en crosse) in the rear, at the back rounded; separated by slightly deep sutures. Aperture very small, circular, without exterior peristome; provided with a little tooth, short and simple.

"More elongated than Q. laevigata, it differs from it also, as well as all the others of the same shape, by its large disproportion of width of its chambers, all of them being very straight in front and very widened in back.

"From Cuba, St. Thomas and Jamaica."

D'Orbigny's original figures are identical with the ones given here from Bermuda, plate 6, figures 3a,b. The illustrated specimen is typical of the Bermuda material in every respect.

I have seen the specimens in the Cushman Collection, labelled Q. laevigata, which come from Tortugas and Porto Rico, and which are cited, respectively, in Carnegie Inst. Washington, Publ.311, 1922, p. 65, pl.13, fig.2; and Carnegie Inst. Washington, Publ.344, 1926, p.81. Most of them are Q. bosciana and a few of them are old-age specimens of Q. poeyana which show the costae only in the early chambers. I have found, after a careful study of the literature, that most of the figures referred by authors other than Cushman to Q. laevigata should be placed under bosciana.
Furthermore, the name Quinqueloculina laevigata d’Orbigny should be allowed to lapse, as d’Orbigny listed it without description or figures in 1826, not publishing it until 1839. In the interim, Deshayes, in 1831, applied the name to a totally different species, and published it. D’Orbigny’s Q. laevigata applied to a fossil Eocene species found in the Paris Basin, while Q. bosciana was applied to the Recent West Indian species, a further reason for dropping the former name.

From the dependable references cited above, it will be seen that Q. bosciana d’Orbigny has a wide distribution in Recent seas, as it is reported from Cuba, St. Thomas, Jamaica, Tortugas, Porto Rico, Bermuda, the Malay Archipelago, and Funafuti.

Cushman has recorded\(^1\) Massilina bosciana (d’Orbigny) from the Miocene of Florida, but this is a true Massilina and does not belong in the synonymy of Quinqueloculina bosciana d’Orbigny.

**Quinqueloculina Lamarkiana** d’Orbigny

Pl. 6, figs. 5a-c.


**Description:** Test typically nearly as long as broad, varying to somewhat longer than broad, periphery bluntly angled, not carinate, triangular in end view, compressed; chambers triangular in transverse-section, with greatest width near the median portion of the chamber; sutures depressed; wall porcellaneous, highly polished; apertural end

\(^1\) Cushman and Ponton, Fla. Geol. Surv., Bull.9, 1932, p.46, pl.3, figs.5a-c.
with a slightly produced neck in the median plane of the test; aperture circular, without a thickened lip, with a small bifid tooth.

Length, 0.64 mm.; breadth, 0.50 mm.; thickness, 0.33 mm.

Typical specimens of this species are not abundant at Bermuda, but there are many which are assigned to this species. The synonymy is here omitted because there are so many dubious references to smooth Quinqueloculinas.

Genus DENTOSTOMINA Carman, n. gen.

Test coiled in quinqueloculine manner, with five chambers visible from the exterior; wall pseudo-arenaceous, composed of a calcareous, imperforate, inner layer, with an external layer of agglutinated material cemented together with calcareous cement; aperture loop-shaped to circular, with a long bifid tooth, the inner surface of the aperture encircled with small regularly-spaced projections separated from each other by uniform depressions, thus giving the appearance of a cogwheel, the projections frequently prolonged forward and visible from the side-view.

This genus is very similar to the pseudo-arenaceous Quinqueloculinas, but differs from them in the ornamentation of the aperture. D'Orbigny figured and described specimens belonging to this genus in 1839. He referred to it as Quinqueloculina enoplostoma, which he described as not over one millimeter long, covered with sand grains, with chambers truncate to concave between the angles, and with an aperture surrounded by a row of small teeth. From his description and figures, his species undoubtedly belongs in this genus. He recorded it as rare at Cuba but
common at Guadalup and St. Thomas. There may be other species referred to *Quinqueloculina* which belong in this genus.

One very large representative, *Dentostomina bermudiana*, described below, is very common in the Bermuda waters, hence adequate material has been available for the study of this new genus.

**DENTOSTOMINA BERMUDIANA** Carman, n.sp.

*Pl. 6, figs. 6a-c.*

**Description:** Test very large, coiled in quinqueloculine manner with five chambers visible in the adult, periphery rounded, basal and rounded, position of the aperture typically in the plane of the last chamber, but varying to a position nearly in the median plane; chambers nearly circular in transverse-section, of nearly uniform diameter throughout their length; sutures very slightly, if at all depressed, each chamber-wall overlapping very slightly upon its predecessor; wall calcareous, imperforate, with an outer layer of calcareous grains smoothly cemented together with calcareous cement; aperture loop-shaped in the young and becoming circular in adult specimens, with a long bifid tooth, with the inner surface of the aperture ornamented with a ring of tooth-like projections which are directed toward the center of the aperture and which frequently project forward beyond the plane of the orifice.

Length of holotype, 1.85 mm.; breadth, 1.01 mm.; thickness, 0.55 mm.

Maximum length, 3.07 mm.; maximum breadth, 1.75 mm.

This species is very striking at Bermuda on account of its size, as it is the largest foraminifer present there. It is abundant at many stations. It is most abundant on coarse, sandy bottoms away from
shore, and is also found in large numbers at stations where there is considerable tide-current, where it and Archaias angulatus are the chief components of the fauna. It is scarce at acid-water and mud-bottomed stations where eel grass grows.

Genus SCHLUMBERGERINA Munier-Chalmas, 1882

SCHLUMBERGERINA ALVEOLINIFORMIS (H.B.Brady), var. OCCIDENTALIS Cushman

Pl. 6, figs. 7a,b.

Quinqueloculina alveoliniformis Cushman (not H.B.Brady), Carnegie Inst. Washington, Publ.311, 1922, p.64.

Schlumbergerina alveoliniformis (H.B.Brady), var. occidentalis Cushman, U. S. Nat. Mus., Bull.104, pt.6, 1929, p.36, pl.7, figs.2a,b.

Description: Test elongate with greatest width in the median portion and tapering toward both ends, chambers coiled in quinqueloculine fashion about an elongate axis, six to eight chambers visible; aper
tural end not produced, basal end rounded; chambers tubular in appearance; wall with the exterior covered with sand grains; aperture central, composed of a number of pores in a plate-like covering which closes the aperture.

Length, 0.73 mm.; thickness, 0.38 mm.

This species is not common at Bermuda. It is the same as that recorded by Cushman from Tortugas and Porto Rico.
Genus MASSILINA Schlumberger, 1893

MASSILINA ARENATA (Cushman)

Pl. 7, figs. 2a,b.


Description: Test flattened in the plane of the coiling, very loosely coiled, early portion quinqueloculine, only the adult portion planispirally coiled; apertural end typically much produced beyond the rest of the test, and typically at one side; basal portion protruding over the preceding chamber; periphery rounded; chambers inflated in the basal half; sutures depressed; wall rough, with coarse agglutinated material roughly adhering; aperture formed by the open end of the last chamber, without constriction or lip; no tooth observed.

Length, 0.71 mm.; breadth, 0.41 mm.; thickness, 0.11 mm.

This species is present at most stations in Bermuda, and is abundant at the more acid-water stations, or on muddy bottoms away from the coral reefs. It varies in shape from long and narrow to almost as wide as it is long. The color of the wall is generally white, but sometimes a yellowish brown. The apertural end is more produced in the elongate individuals than in the wider ones. The inflation of the basal half of each chamber is very constant.

A study of the material in the Cushman Collection shows that this is the same species which Cushman recorded from Tortugas and Porto Rico. Both Dr. Cushman and the author are of the opinion that the genus is Massilina and not Spiroloculina.
MASSILINA CUSHMANI Carman, n.sp.

Pl. 7, figs. 1a-c.

Massilina bosciana Cushman and Ponton, Fla. Geol. Surv., Bull.9, 1932, p.46, pl.3, figs.5a-c.

Description: Test much elongated, narrow, with the last chambers coiling in the same plane; apertural end slightly prolonged, basal end sharply curved over the preceding chambers; chambers with their greatest diameter at the base; sutures distinct, somewhat depressed; wall moderately thick, varying from rough and somewhat granular to faintly costate with granular low costae; aperture circular, with a thickened everted lip and short bifid tooth.

Length of holotype, 0.85 mm.; breadth, 0.32 mm.; thickness, 0.15 mm.

I have seen the Florida specimens which were identified as Massilina bosciana (d'Orbigny) and believe them to be the same as this Bermuda species. Both the Bermuda species and the Florida species are a Massilina which has not developed far from the quinqueloculine stage of coiling. The species is not common at Bermuda.
Genus SPIROLOCULINA d'Orbigny, 1826

SPIROLOCULINA ANTILLARUM d'Orbigny

Pl. 7, figs. 3a,b.


Description: Test complanate, elongate, with apertural and basal ends projecting, test thinnest at the center growing thicker toward the periphery; chambers tubular, circular in transverse-section, base of chamber projecting over preceding chamber; sutures distinct, depressed; wall vitreous, of bluish-white color, ornamented with large, rounded, longitudinal costae, typically somewhat oblique; aperture circular with a slightly thickened lip and short bifid tooth.

Length, 1.00 mm.; breadth, 0.50 mm.; thickness, 0.17 mm.

This species is widely distributed but not common at Bermuda.

SPIROLOCULINA ANTILLARUM d'Orbigny, var. ANGULATA Cushman


Spiroloculina grata Terquem, var. angulata Cushman, U. S. Nat. Mus., Bull.71, pt.6, 1917, p.36, pl.7, fig.5.

Spiroloculina antillarum d'Orbigny, var. angulata Cushman, U. S. Nat. Mus., Bull.100, vol.4, 1921, p.406, pl.81, figs.5a,b; Carnegie Inst. Washington, Publ.311, 1922, p.62; Publ.342, 1924, p.55, pl.20, fig.2; Publ.344, 1926, p.80; U. S. Nat. Mus., Bull.104, pt.6, 1929, p.43, pl.9, figs.4a,b.

This variety differs from the species in that its chambers are quadrangular in transverse-section and its periphery is flattened to concave. It occurs with the species and is slightly more abundant.
Genus HAUERINA d'Orbigny, 1839

HAUERINA BRADYI Cushman

Pl. 7, figs. 4a,b.


**Description:** Test complanate, early chambers coiled in quinqueloculine manner, later coiling in one plane with 3 to 4 chambers to a coil; periphery roundly angled; chambers elongate, arcuate, triangular in transverse-section; wall thin, dull; aperture arched, triangular, typically covered with a sieve-plate.

Diameter 0.47 mm.; thickness, 0.17 mm.

This species is more common at Bermuda than is _H. ornatissima_, but it is rare in comparison with other species of the Miliolidae. Very few of the Bermuda specimens show a development of the sieve-plate, but enough of them have it to identify the genus as _Hauerina_.

HAUERINA ORNATISSIMA (Karrer)

Pl. 7, fig. 5.


Description: Test complanate, early chambers coiled so as to form a sphaeroidal initial portion, later chambers coiling about the initial portion in roughly planispiral manner, each chamber varying somewhat from the plane of the preceding one; chambers compressed in the plane of coiling; chamber walls corrugated with regular, even, transverse undulations which spread radially; sutures indistinct; wall very thin, clear, transparent to opaque, ornamented with fine longitudinal striations which cross the undulations; aperture composed of a number of pores in the apertural face of the last chamber.

Diameter, 0.33 mm.; thickness, 0.08 mm.

Hauerina ornatissima is very rare at Bermuda. This is the second recording of this species in the Atlantic, as it is typical of the Indo-Pacific. Thus it forms another interesting link of relationship between the West Indian and Pacific faunas.
Genus SIGMOILINA Schlumberger, 1887

SIGMOILINA sp?

Pl. 7, figs. 6a, b.

One specimen of a smooth-walled Sigmoilina was found at Bermuda. As the one specimen should be preserved without sectioning it, and since there is no more material at hand, it seems wise not to attempt an identification.

Genus ARTICULINA d'Orbigny, 1826

ARTICULINA CASSIS (d'Orbigny), var. MUCRONATA (d'Orbigny)

Pl. 7, figs. 7a, b, 8, 9, 10, 11, 12.

Vertebralina mucronata d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.72, pl.7, figs.16-19; Foram. Foss. Vième, 1846, p.120, pl.21, figs.18,19.----Cushman, Proc. U. S. Nat. Mus., vol.59, 1921, p.64, pl.15, figs.2,3,5-8 (not 1,4).


Description: Test with the early portion close-coiled in milioline fashion, later portion with the chambers in a rectilinear series, much compressed; chambers complanate, inflated somewhat at the base, increasing in breadth as added; wall heavy, porcellaneous, polished, ornamented with numerous heavy longitudinal costae; aperture elongate, compressed, with a heavy thickened everted lip which extends backward at the sides of the test producing pointed projections.

Length, 1.10 mm.; breadth, 0.62 mm.; thickness, 0.20 mm.

As shown in the transverse section illustrated on plate 7, figure 12, the early stages of this species are not planispirally coiled,
hence the generic identification as *Vertebralina* can no longer be used, and *Articulina* must be substituted. The coiling, while not typically triloculine, seems more nearly triloculine than quinqueloculine. A series of young individuals are illustrated on plate 7, figures 8 to 11, because they show the developmental stages of this species, and because they are very common at most of the Bermuda stations.

This is one of the commonest of the foraminifera at Bermuda. It seems to be intermediate between the two forms found at Tortugas and the West Indies, where a rounded form and a definitely keeled form exist. Some of the Bermuda specimens have a slight keel throughout, many of them have traces of a keel on one or two chambers, but none of them show a well-developed keel. The majority of the Bermuda specimens are rounded and wholly without a keel, hence the Bermuda species is referred to *A. cassis* var. *macronata*, which is the rounded form.

A few of the Bermuda specimens show a stronger resemblance to Pliocene\(^1\) and Miocene\(^2\) material from Florida than they do to the Recent West Indian material. The Florida species were identified as *Vertebralina cassis*. This fact is of interest in that it may indicate that the Bermuda fauna is more primitive than the West Indian fauna, or that its development has been retarded.

2. Cushman and Ponton, Fla. Geol. Surv., Bull. 9, 1932, p. 57, pl. 8, figs. 1a, b.
ARTICULINA sp?

Pl. 7, fig. 12.

There is figured on plate 7, figure 12, an Articulina which seems to be intermediate between A. cassis var. mucronata and A. sagra. It has the initial end of A. sagra, and the broad chambers and heavy wall of A. cassis var. mucronata. It is the only complete specimen of its kind found at Bermuda, but many broken tops of such a form were found. It serves as a further proof that specimens hitherto classified as Vertebralina cassis belong in the genus Articulina.

ARTICULINA SAGRA d’Orbigny

Pl. 8, figs. 3, 4a,b.

Articulina sagra d’Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.160, pl.9, figs.23-26.-----
Cushman, Proc. U. S. Nat. Mus., vol.59, 1921, p.73, pl.18, figs.2-5; Carnegie Inst. Washington, Publ.311, 1922, p.70;
Publ.344, 1926, p.82.

Description: Test elongate, compressed, earlier portion with chambers coiled in milioline fashion, later portion with chambers in a rectilinear series; chambers complanate, increasing in breadth as added; wall thin in early stages, becoming heavier in the adult chambers, ornamented by high, sharp costae; aperture typically compressed, elongate, with a thickened everted lip with flares backward at the sides of the test.

Length, 0.74 mm.; breadth of last chamber, 0.20 mm.; thickness of last chamber, 0.10 mm.

Articulina sagra has wide variations toward a heavier-walled, wider-chambered form which is very close to A. cassis var. mucronata,
and it is possible that the two species merge into one species with
A. sagra a small variety. In Bermuda there were not enough unbroken
intermediate specimens to determine this relation. Until this species
has received further study, it may be distinguished from A. cassis and
A. cassis var. mucronata by its more slender form, and thinner wall,
and less everted lip, and smaller, more delicate initial end. It may
be distinguished from A. mayori by its thicker wall and complanate
test, and from A. lineata by its everted lip.

ARTICULINA LINEATA H.B.Brady

vol.9, 1884, p.183, pl.12, fig.19,----Cushman, U. S. Nat.
Mus., Bull.104, pt.6, 1929, p.52, pl.11, fig.10; U. S. Nat.
Mus., Bull.161, pt.1, 1932, p.47, pl.11, figs.1,2.

Description: Test much compressed throughout, initial portion
with broad chambers coiled in milioline fashion, later portion com-
posed of one or two chambers in a rectilinear series; periphery
carinate with a broad flat keel; chambers complanate, broad; sutures
convex forward; wall dull, mat-surfaced, thin, with sharp costae
irregularly branching and discontinuous; aperture elongate, compressed,
with a thickened, slightly everted lip.

Brady's first records of this species were of three stations in
the Pacific and one off Bermuda. His figures were of specimens from
Bermuda, and as they have been copied in so many other publications
they are not given here. His figures and descriptions include a
keeled form and a non-keeled form. Since the two are quite distinct
at Bermuda, and since the collections at the Cushman Laboratory show
the keeled form to be most typical of the Pacific and the non-keeled
form to be most typical of the West Indies, it seems wise to separate
the two forms into the species (with keel) and its non-keeled variety.
The keeled form is herewith designated as typical of the species merely
by the Rule of Priority.

Articulina lineata is less common at Bermuda than is A. lineata
var. sinocarinata. Both may be distinguished from A. cassis var. mucronata
by the fact that the lip does not flare backward; and from A. sagra by
its heavier wall and more flattened test.

ARTICULINA LINEATA H.B. Brady, var. SINECARINA Carman, n. var.

Pl. 8, figs. 1a,b, 2a,b.

9, 1884, p.183, pl.12, figs.20,21----Cushman, Carnegie Inst.
Washington, Publ.311, 1922, p.70, pl.12, fig.4; U. S. Nat. Mus.,
Bull.104, pt.6, 1929, p.52, pl.11, figs.8,9; pl.12, fig.1.

Description: Test differing from A. lineata in that it has a much
heavier wall which is typically polished, and rounded costae which vary
from straight and regular to discontinuous and inward-bending, and a
rounded periphery without a keel.

Length of holotype, 0.83 mm.; breadth, 0.24 mm.; thickness, 0.13 mm.

This variety seems to be far more common in the West Indian region
than the keeled form. Two of Brady's figures are of a non-keeled form,
Cushman's figures from Tortugas show a rounded periphery, and at
Bermuda the rounded form is much more common.

The young of this variety is here figured, plate 8, figures 1a,b,
as it is more common than the well-developed adult. This young speci-
men shows the extreme variation of the costae which bend inward and do
not run the full length of the chamber. The adult figured on plate 8,
figures 2a, b, shows the other extreme of costae, with a smooth initial end and straight, even costae in the adult chambers. There are gradations between these two extremes. The young specimen shows the extreme involute character exhibited by a few of the specimens; while the adult shows, in its early coils, the more typical evolute coiling.

ARTICULINA MAYORI Cushman

Pl. 8, figs. 6, 7, 8.

Articulina mayri Cushman, Carnegie Inst. Washington, Publ. 311, 1922, p. 71, pl. 13, fig. 5; U. S. Nat. Mus., Bull. 104, pt. 6, 1929, p. 52, pl. 12, fig. 5.

Description: Test elongate, very slender, slightly arcuate, early portion with chambers coiled in quinqueloculine manner, later portion with chambers in a rectilinear series; chambers elongate, cylindrical in transverse-section, enlarged at the base and tapering toward the apertural end; wall thin, translucent, ornamented by faint costae; aperture circular with a thickened everted lip.

Length, 0.80 mm.; thickness, 0.10 mm.

This species is more abundant at Bermuda than would be expected for so delicate a form. It is easily distinguished from the other Articulinas in the region, by its long, slender, cylindrical test, as it is never compressed, and by its delicate translucent wall, and chambers which taper toward the apertural end.
Genus TUBINELLA Rhumbler, 1906

TUBINELLA FUNALIS (H.B.Brady)

Pl. 8, fig. 5.


Description: Test elongate, cylindrical, typically arcuate, composed of a small bulbous initial chamber, followed by a long, narrow, tubular portion which comprises most of the test, the tubular portion showing no signs of division or constrictions; wall very thin, hyaline, transparent, ornamented with faint regular longitudinal costae or striations; aperture formed by the open end of the tubular portion.

Length, 2.20 mm.; diameter of tubular portion, 0.07 mm.; diameter of initial end, 0.10 mm.

This is the second record of this species in the Atlantic. Although it has not been recorded from any of the other West Indian collections, it is such a small fragile species that it may easily have been overlooked or lost in washing by other workers in the West Indian region. At Bermuda it is abundant and well preserved at only a very few stations, but fragments of it are present at most stations.
Genus TRILOCULINA d'Orbigny, 1826

SPECIES WITH UNORNAMENTED SURFACE

TRILOCULINA ROTUNDA d'Orbigny

Pl. 8, figs. 9a-c.


Description: Test large, inflated, the last chamber frequently shortened and not extending the full length of the test thus giving the test a ventricose appearance; apertural end not produced; position of the aperture at one side in the plane of the last chamber; basal end of each chamber inflated and covering the entire basal end of the test; sutures depressed; wall heavy, porcellaneous, smooth, polished, occasionally with very gentle undulations due to thickening of the shell at the base of the chamber; aperture circular, large, as large as the end of the chamber, with a thickened lip not everted; tooth projecting, with stem arching upward at the base, sometimes with a broad thickened triangular plate at the tip, sometimes with two widely spread prongs.

Length, 0.63 mm.; breadth, 0.54 mm.; thickness, 0.40 mm.

This is a very common species at Bermuda. It varies in shape from oblong to very wide and ventricose. Many of the Bermuda specimens are more inflated and thus thicker than the one illustrated in plate 8, figures 9a-c. The tooth always has a very slender stem, hence it is
generally missing. This stem always arches upward. But the variations of the tip of the tooth are interesting because about one-half of the individuals show a thickened plate, and the other half the bifid spreading prongs, regardless of their state of inflation, and regardless of whether they are young or old. Probably the more primitive plate is retained by the microspheric form, and the U-shaped prongs are developed by the more rapidly evolving megalospheric form.

TRILOCULINA CUvieriana (d'Orbigny), var. NUDA Carman, n.var.

Pl. 8, figs. 10a-c, 1la-c.


Description: Test circular from side view, nearly triangular from end view; apertural end truncated, not prolonged; basal end with a protuberance projecting backward, not at the suture line, sharper in the young, more inflated in adults; periphery typically roundly angled; chambers nearly triangular in transverse-section; sutures very slightly depressed; wall smooth, polished, porcellanous, heavy in adults; aperture narrow, elongate, without lip or constriction; tooth narrow, elongate and simple.

Length of holotype, (well-developed adult), 0.54 mm.; breadth, 0.48 mm.; thickness, 0.33 mm.

Length of young specimens, 0.35 mm.; breadth, 0.29 mm.; thickness, 0.14 mm.
The general appearance of the test is similar to *T. cuvieriana*, except that it is without costae, and true carina, and has a more pronounced basal protuberance. This variety is far more common at Bermuda than the species, as it is found abundant at nearly every station.

The illustrated specimens are very typical of the Bermuda material. Figure 10a-c, plate 8, is a young specimen, illustrated because there are so many young at every station. Figure 11a-c, plate 8, is an adult showing the more inflated character of the adult test. The quinqueloculine young grade into the triloculine adults with no break in the series, when arranged in graduated suites, as I have done with material from many stations.

I have compared this variety from Bermuda with the type specimens of Cushman and Valentine, (*Quinqueloculina sp.?*), and find that they are identical. These authors state that there are a few individuals in their collection of Recent California material which seem to be in an intermediate stage between *Quinqueloculina* and *Triloculina*, and which they refer to *Quinqueloculina*. This intermediate stage is characteristic of the variety in Bermuda also, as most of the individuals are intermediate. Brady's figures are much closer to this variety than to *T. cuvieriana* as they show no costae, hence Brady's reference is included here. His stations are from the Indo-Pacific.

The geologic and geographic distribution of this variety is probably as wide as its associate, *T. cuvieriana*, but it has doubtless been confused in the literature or overlooked because it is a smooth form without diagnostic ornamentation.
TRILOCULINA OBLONGA (Montagu)

Pl. 8, figs. 12a-c, 13.


Triloculina oblonga d'Orbigny, Ann. Sci. Nat., vol.7, 1826, p.300, No.16; Modèles, No.95; in De la Sagra, Hist. Phys. Pol. Nat. de Cuba, 1839, "Foraminifères", p.175, pl.10, figs.3-5.----


Description: Test oblong, elongate, chambers slightly compressed together; apertural end very slightly, if at all produced; position of the aperture typically at one side, in the plane of the last chamber; basal end rounded becoming almost square; chambers cylindrical, uniformly inflated, abruptly tapering very near the aperture; sutures deep, the suture line on the 2-chambered side nearly straight and with a pronounced angular change of direction at the basal end, not oblique; wall smooth, polished, heavy and porcellanous; aperture circular with a slightly thickened ring around it, without constriction, tooth short, small, bifid, slightly projecting.

Length, 0.67 mm.; breadth, 0.32 mm.; thickness, 0.22 mm.

The specimen illustrated in plate 8, figures 12a-c, shows the typical development. Figure 13, shows a very square individual with the aperture at the extreme side; this is a very ideal specimen, while figures 12a-c, show an average adult.
This species is not very common at Bermuda. It may be distinguished from *T. planciana* by its round aperture and smooth polished surface without incised lines. It may be distinguished from *Q. bosciana*, which it resembles in the young stages, by its larger size and greater width, by its heavier wall, by its uniformly inflated chambers, and especially by its suture lines. The suture lines of *T. oblonga* are nearly straight and parallel to the sides of the test, those of *Q. bosciana* are very oblique. In *T. oblonga* the suture line makes an angular change of direction at the base of the test, while in *Q. bosciana* it is a smooth curve.

**TRILOCULINA PLANCIANA d'Orbigny**

Pl. 9, figs. 5, 6a,b.


**Description:** Test varying in shape from elongate and oblong to oval and somewhat inflated; periphery typically rounded, varying to slightly truncated; apertural end typically not produced, but the raised flaring collar about the aperture frequently giving the appearance of a prolonged apertural end; basal end rounded; chambers somewhat inflated; sutures deep, suture line on the 2-chambered side typically straight except at the base of the test; wall polished.
thin, porcellanous, marked with fine, short, incised lines, not easily seen and extending longitudinally; aperture elongate, extending across the full width of the chamber, loop-shaped, narrower at the base than at the top, typically with a thin translucent flaring collar which does not completely encircle the aperture but which blends into the chamber walls at the base of the aperture; tooth typically projecting, very long, nearly as long as the aperture, very slender at the base and bifid at the tip, attached not to the collar but to the inferior wall of the chamber; both the tooth and the flaring collar subject to variation.

Length, 0.50 mm.; breadth, 0.36 mm.; thickness, 0.24 mm.

While this species seems to vary considerably at Bermuda, the shape of the aperture, attachment of the tooth, and polished wall with short incised lines are very constant and serve to distinguish it from all other Triloculinas.

A tendency to become inflated causes variation in the shape of the test. Some specimens are short and rather stout with an oval shape and more or less curving sutures. Others are elongate and oblong and only slightly inflated. The size is also variable, in that some specimens appearing to be adults are much smaller than others with no other basis of differentiation than that of size. The periphery shows variations from rounded to slightly flattened at the base of the last chamber. The truncated, to truncated and carinated specimens are referred to *T. quadrilatera*. These are individual variations which are observed at nearly every station.
The variations of the apertural collar and tooth are of interest because they provide part of the basis for combining *T. planciana* and *T. gualteriana* in the synonymy. About 50 per cent of the specimens have a collar which projects forward, which is somewhat everted at the periphery of the test, and which slopes inward from the periphery to the base of the aperture. Some specimens show this to a lesser degree, and many show no collar at all, or show merely an incipient slightly raised ridge at the periphery of the test. In such cases this incipient collar shows the same translucent character of the wall as is exhibited by the well-developed collar. This seems to be a case of individual variation rather than the development of an old-age characteristic. Since this difference is not constant, and no other basis of distinction is obvious, it seems advisable not to separate them by varietal distinction. The specimen illustrated in plate 9, figures 6a,b, is average in shape, size, sutures, and development of the collar, and does not represent one extreme or the other. Its tooth is missing.

The length of the tooth and its attachment are constant. The tooth is so long that in many specimens it appears to abutt against the wall of the aperture. It is very slender at its base and very delicately attached to the floor of the chamber. For this reason it is easily broken out, and many specimens are without it entirely. The tooth typically projects above the aperture. However, in specimens which appear to have a rapid development of the collar, the tooth, in side view, is hidden by the forward prolongation of the collar, and this is to be expected when the tooth is not attached to the collar.
and the two develop independently of each other. It seems probable that the position of the tooth, and the amount of its upward bending are constant, while the prolongation of the collar is variable. In his original figures, d'Orbigny shows a specimen with a flaring collar and no projecting tooth which he calls T. gualteriana; and another specimen without much of a collar and a tooth which projects prominently, this he calls T. planciana. In my opinion, they represent the same species. The specimen here figured in plate 9, figure 5, shows the attachment of the tooth and its typical length.

Furthermore, it seems advisable to combine d'Orbigny's two species for the following reasons. His description of T. planciana and his figures of T. gualteriana fit typical material from Tortugas, Porto Rico and Bermuda. The sutures, and shape of the chambers, and flaring collar in his figures of gualteriana correspond with the non-inflated, oblong, and collared specimens in the collections at the Cushman Laboratory, and these specimens seem most typical of the species from the West Indies. D'Orbigny's description of planciana with a polished wall and incised lines, and an elongate aperture, and projecting tooth also fits the material in the collection. The inflated chambers and curving sutures which he ascribes to planciana fit the more inflated specimens from the West Indies. D'Orbigny's end views of the two species showing the apertures, seem almost identical. They are poor reproductions in the original plates. Also, d'Orbigny's descriptions of the two species are so very close that the above-mentioned variations of the species can account for the discrepancies.

I believe that the name planciana should take precedence over gualteriana because it is more thoroughly established in the literature.
There have been several references to *planciana* since d'Orbigny described it, all of which have come from near the type locality in the West Indies, and all based on d'Orbigny's own description of *planciana*. There has been only one record of *gualteriana* since 1839, and that is of a fossil from the Mediterranean region.

The species is fairly common at most Bermuda stations hence the above discussion is based on adequate material.

**SPECIES WITH COSTATE OR STRIATA SURFACE**

**TRILOCULINA LINNEIANA** d'Orbigny

Pl. 9, figs. 1-4.

*Triloculina linneiana* d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.172, pl.9, figs.11,13.

--- Cushman, U. S. Nat. Mus., Bull.71, pt.6, 1917, p.72, pl. 27, fig.4; Proc. U. S. Nat. Mus., vol.59, 1921, p.70, pl.17, figs.3,4; U. S. Nat. Mus., Bull.104, pt.6, 1929, p.61, pl.16, figs.1,2.

**Description:** Test large, apertural end very slightly prolonged, basal end inflated; chambers large, with greatest diameter in the central portion and tapering slightly toward either end; sutures not depressed, indistinct; wall heavy, dull, typically ornamented with large, sharp, raised costae, frequently with many minute costae and a few large heavy ones which are sharp; aperture circular with a thickened lip which is slightly everted, and a large bifid tooth, tooth projecting beyond the orifice.

Length, 1.55 mm.; breadth, 0.87 mm.; thickness, 0.50 mm.

This common species in the West Indian region is very well developed at Bermuda and abundant there. The young appear to have the minute costae covering their surfaces with one or two large
keel-like costae at the periphery. The typical form illustrated on plate 9, figures 1 and 2, possesses the minute costae between the heavier ones, but these do not appear in the drawing. The specimens figured on the same plate, figures 3 and 4, show the minute costae and the larger ones. There are variations of the costae, all grading into one another, as the larger costae seem to develop and grow more numerous as the smaller ones diminish.

TRILOCULINA CUVIERIANA d'Orbigny

Pl. 9, figs. 7, 8, 9, 10a-c.


Description: Test circular in outline from side view, triangular to oval from end view; apertural end truncated, not projecting; basal end variable, typically rounded and slightly inflated, sometimes with an inflated protuberance projecting backward, giving the appearance of a blunt spine, this protuberance is on the wall of the chamber, not at the suture line; periphery typically carinate, becoming rounded in very old specimens; chambers slightly inflated, roundly triangular in transverse-section, carinate, the broad keel terminating in the protuberance at the base of the chamber; sutures very slightly depressed; wall porcellaneous, polished, heavy in adult specimens, decorated with low broad costae which are often indistinct, costae best developed in the young stages, and in adults at the peripheral angle and at the base of the chamber; aperture in the median plane, typically elongate and narrow, plane of the orifice sloping downward and inward toward the
median line; without an everted lip or constriction thus giving a truncated appearance to the apertural end, occasional inflated specimens showing a thickened ring about a nearly circular aperture; tooth projecting, long slender, typically simple, becoming bifid at the extreme tip in a few specimens.

Length, 0.58 mm.; breadth, 0.54 mm.; thickness, 0.38 mm.

Since d'Orbigny's original descriptions and figures are available to very few workers in America, a translation and discussion of his figures is given herewith. Dr. Cushman has courteously extended to me the use of his very rare original volume in French, by d'Orbigny, cited above, which is in the Cushman Laboratory and of which there are very few copies in the United States. My literal translation is as follows:

"Test suborbicular, bowed out, convex, smooth and polished, strongly truncated in front, rounded in the back, very carinate at the periphery. Two or three longitudinal costae accompanying the carina on each side. Chambers triangular, very large," (broad ?) "arched, narrowed in back, truncated in front, carinated in back, keeled. Sutures slightly marked. Aperture very elongate, compressed, oblong, without peristome turned back (réfléchi), with a long projecting tooth, straight and simple. A few very old individuals have shown their surfaces as scratched, marked with interrupted striae, hardly visible. This species differs from Q. lamarckiana by its truncated chambers not prolonged in front, by its carina more keeled, and accompanied by longitudinal striae, whereas it is smooth in the other, and by its elongate aperture. Common at Cuba."

D'Orbigny here states that loss of costae is an old-age characteristic. As I have stated in general before, loss of costae and rounding of the periphery are both old-age characters, as proven by many graduated suites of both Quinqueloculinas and Triloculinas from Bermuda. Hence, the costae and "carina", or angled periphery, mentioned by d'Orbigny cannot always be considered wholly diagnostic. The shape of the apertural end, and of the aperture are constant and specific
characters of the Miliolidae. D'Orbigny has cited the three most diagnostic characters of this species in his reference to the truncated apertural end with no neck and lip, the elongate aperture, and the long, simple tooth which projects above the orifice. The tooth is, in general, typical of a species, although not wholly constant. In very inflated specimens the tooth may swell at the tip and become so broad as to be truly bifid. In very old individuals, a very elongate simple tooth may show a narrowly bifurcated tip developing, with the prongs bending inward. The polished surface which d'Orbigny describes is another characteristic which is constant for the Miliolidae, and for this species, as the wall composition is a function of the protoplasm of the animal itself.

D'Orbigny's figures show a Quinqueloculina which appears about to lose the extra chambers and become a true Triloculina. The chambers are broad with angled and keeled periphery. A few costae are shown at the peripheral angles of the three largest chambers. The end view shows chambers which are roundly triangular in cross-section, and an elongate narrow aperture with a long simple tooth.

The Bermuda material has many specimens in the quinqueloculine stage such as d'Orbigny figured. This is a very puzzling species until large suites are collected and graduated in size from young specimens to adults. I have done so with this species, and more successfully with its variety nuda, which is much more abundant in Bermuda. With material arranged in such a series, it is obvious that the adult form in Triloculina. Only the very young show truly quinqueloculine coiling. Intermediate forms are generally typically
triloculine with only a small patch of the keel and periphery of the fourth and fifth chambers visible. Such a showing of the extra chambers is typical of highly angled Triloculinas. In many ways the variety *muda* is more typical of d'Orbigny's description. It is the commoner form at Bermuda, and it is to be suspected that d'Orbigny based parts of his description and his opinion of the frequent occurrence, on a combination of the two which doubtless occur together in Cuba. D'Orbigny's mature specimens, with costae nearly invisible may have been variety *muda*, large individuals.

The specimen figured in plate 9, figures 10a-c, is not ideal. It shows typical carinae and the striations at either side. Its end view, figure 10c, illustrates the typical triloculine character, although the side views of the same individual show patches of the extra chambers. The aperture and tooth are not typical.

Figure 9, plate 9, is included because it shows the 2-chambered side of a true *Triloculina*. It also shows how heavily costate some extreme specimens may become, as in contrast to figures 7 and 8, plate 9.

Figures 7 and 8, plate 9, are included in order to show the typical narrow aperture and triloculine coiling. Figure 8, shows a typical, elongate, simple tooth. Figure 7, illustrates the tooth of a very old specimen in which the bifurcated tip is just developing. Both specimens have lost most of their striations, having a few costae poorly developed only at the base of the last chamber.

I have discussed and illustrated this species in detail because there is so much confusion in regard to it. Brady applied the name to a species which was *Q. lamarckiana*. Most of the descriptions and
figures in the literature cite unstriated species with round apertures and prolonged apertural ends. Cushman did not record it from Tortugas, and in U. S. Nat. Mus., Bull.104, Part 6, he mentions it only as a dubious synonym of Q. lamarckiana.

There is no need for this confusion, as both T. cuvieriana and T. cuvieriana var. nuda, in their quinqueloculine stages, may be distinguished from Q. lamarckiana by their truncated apertural end, and narrow elongate aperture, and sharp protuberance at the base of the chamber, this protuberance separated from the suture area by a depression. Q. lamarckiana typically has a neck and prolonged apertural end with a constriction below the aperture, has a circular to oval aperture, and has only a slight basal swelling which inflates the whole base of the chamber beginning at the suture line. The costae of T. cuvieriana are an additional but not constant means of distinguishing it from Q. lamarckiana, which is always smooth. T. cuvieriana and its variety may be distinguished from Q. auberiana, with which it has been confused in the literature, by the fact that T. cuvieriana does not have transverse wrinkles or undulations, whereas Q. auberiana possesses them to a marked degree.

TRILOCULINA GRANDIS Carman, n.sp.

Pl. 9, figs. 11a-c.

Description: Test compressed, triangular in end view, periphery typically sharply angled, varying from almost carinate to very broadly angled; apertural end not prolonged, basal end slightly inflated; chambers compressed together, triangular in transverse-section; sutures
depressed, distinct; wall heavy, polished and typically ornamented
with faint striations; aperture elongate, large, with a somewhat
thickened lip which is not everted, with a long-stemmed bifid tooth.

Length of holotype, 1.24 mm.; breadth, 0.82 mm.; thickness, 0.50 mm.

This species is common at Bermuda at only a few stations where it
is abundant and is not found outside of these stations. It appears
to have developed from a form very similar to *T. rotunda* as the aperture,
basal end, and thickness of the wall suggest such a relation.

**SPECIES WITH RETICULATE SURFACE**

**TRILOCULINA RETICULATA d'Orbigny**

Pl. 9, figs. 12, 13, 14a,b; pl.11, figs.1-9.

*Triloculina reticulata* d'Orbigny, Ann. Sci. Nat., vol.7, 1826,
Bologna, ser.6, vol.2, 1905, p.60, pl.1, fig.4.

vol.9, 1884, p.177, pl.9, figs.2-4.------Sidebottom, Mem. Proc.
Manchester Lit. Philos. Soc., vol.48, No.5, 1904, p.10, pl.3,
figs.8-10.

*Triloculina carinata* d'Orbigny, in De la Sagra, Hist. Fis. Pol.
Nat. de Cuba, 1839, "Foraminifères", p.179, pl.10, figs.
15-17.------Cushman, Proc. U. S. Nat. Mus., vol.59, 1921, p.71,
pl.17, figs.9,10; Carnegie Inst. Washington, Publ.311, 1922,
p.75, pl.12, fig.6; U. S. Nat. Mus., Bull.104, pt.6, 1929,
p.55, pl.17, fig.4.

*Triloculina bicarinata* d'Orbigny, in De la Sagra, Hist. Fis. Pol.
Nat. de Cuba, 1839, "Foraminifères", p.158, pl.10, figs.18-20.
76, pl.12, fig.7; U. S. Nat. Mus., Bull.104, pt.6, 1929, p.66,
pl.17, fig.5.

**Description:** Test large nearly twice as long as broad, apertural
end not prolonged, basal end rounded and somewhat projecting; shape
and ornamentation of the periphery variable; shape of the periphery
varying from rounded to flattened only at the base of the last chamber, to wholly truncated, to undulating and corrugated; carina on the periphery varying from totally absent, to a single keel, to a single keel which is split into two keels on the basal half of the last chamber, to wholly bicarinata, to keels which are discontinuous and crenulated and showing a tendency to become tricarinata; wall heavy, porcellaneous, polished, ornamented with numerous deep pits which tend to merge and form an irregular reticulate pattern; aperture elongate, loop-shaped, with an everted lip which does not wholly encircle the aperture, with a long bifid tooth.

Length, 1.16 mm.; breadth, 0.74 mm.; thickness, 0.42 mm.

When d'Orbigny originally described T. carinata and T. bicarinata from the West Indies in 1839, he stated that they could be distinguished from T. reticulata of the Mediterranean by the fact that the two former species possessed carinae, whereas the latter was rounded and without a keel. His own distinction does not seem valid, because in his 1826 listing of T. reticulata he gives as a synonym, Frumentaria reticulata Soldani, for which Soldani had figured a keeled specimen. Soldani's material was from the Mediterranean. In more recent years, Sidebottom has published figures and descriptions of T. reticulata from off the Island of Delos. He states that three forms exist, a rounded form, a single-keeled form, and a double-keeled form with an intermediate form in which the keel is split halfway down the chamber into two keels. I have examined material from Delos and find that the three forms are present as recorded by Sidebottom. It is the same species as that found in Bermuda and the West Indies. Hence the specific name reticulata takes precedence over carinata and bicarinata for the Bermuda species.
Figures 14a,b, on plate 9, show a rounded specimen without a keel. Figure 13, is of a specimen which is corrugated but without carinae, although some of the wrinkled forms have an irregular keel development. Figure 12, is of a specimen which is tending toward a tricarinate form, and in which the keels are very irregular and discontinuous. The outline drawings on plate 11, are made from camera lucida sketches and are included here to show the progressive development of the keel and truncated periphery. The wrinkled specimens with irregular carinae cannot be said to represent the old age of the species, as they are not found at many of the stations where the other forms are abundant. They probably represent an accelerated development of the species at stations especially favorable to its growth. Nor can the rounded specimens be considered the young of the carinated forms, as very large apparently very old round plain specimens are found at Bermuda. The same can be said of the specimens with a single keel. However, no double-keeled specimens were found which did not show a single-keeled stage in the young chambers, and broken specimens show that this form develops from a rounded form through a single-keeled form to an adult bicarinate form. In other words, the state of the keel seems to be a matter of individual development in all the forms except the bicarinate one, and in this form the double keel can truly be considered an old-age characteristic. The wrinkled specimens do not occur in the Mediterranean material which I have seen.

If we are to recognize d'Orbigny's species, carinata and bicarinata, as varieties of T. reticulata we should also recognize a variety for the wrinkled forms which have no carina, and a variety for the wrinkled
forms which possess crenulated carinae, and a variety for the rounded plain form. So many varieties for a species seems inadvisable, especially when those varieties are based on such variable characteristics as the carina and wrinkles on accelerated forms which occur with their more typical affinities.

The species is very abundant at Bermuda. It does not occur in great numbers at the mud-bottomed stations, but seems to thrive in clearer water between the reefs and coral formations.

**SPECIES WITH TRUNCATE AND CARINATA PERIPHERY**

**TRILOCULINA QUADRILATERA d'Orbigny**

Pl. 10, figs. 1a-c.


Description: Test somewhat longer than broad; periphery truncated, with sharp projecting angles becoming truly carinate, convex between the angles; chambers quadrangular in transverse-section; sutures not much depressed; wall with many fine short incised lines which are curving and irregular and which make the surface appear dull; aperture very compressed in the plane of the coiling, elongate, oblong, with a prolonged translucent collar which does not completely enclose the aperture, typically everted at the periphery of the test; tooth very long and very slender, simple, not bifid, nor projecting.
Length, 0.69 mm.; breadth, 0.49 mm.; thickness, 0.28 mm.

This species is abundant at Bermuda. It is very close to *T. planciana*, but *T. quadrilatera* shows minor differences from *T. planciana* in those characters which are constant for the Miliolidae. The shape of the aperture is different. In *T. quadrilatera* it is very much compressed with sides nearly parallel, while in *T. planciana* it is loop-shaped and broader at the top. The tooth of the former is constant in shape, being long and very slender, and slender at the tip with no indication of a bifid tendency. The tooth of the latter is swollen and bifid at the tip. In the Bermuda material, the tooth of *T. quadrilatera* is depressed below the orifice, while in *T. planciana* it is typically projecting. The wall of the former has incised lines but they are much finer, more closely spaced, and irregularly curving, hence they give the surface a different appearance from the polished surface of *T. planciana*. These differences in the constant characters, combined with the fact that *T. quadrilatera* is not only truncated but also truly carinate, elevate the distinction from varietal to specific.

Forms from the Pacific referred to *Massilina annectens* are truly *Triloculina quadrilatera*, as a study of the material in the Cushman Collection has shown. The specimens appear to be approaching *Massilina*, but the median plane of each chamber is 120 degrees removed from the median planes of the other two chambers, thus indicating triloculine coiling. The Pacific species and the Bermuda species appear to be identical. In old age they have a tendency to become very highly carinate.
SPECIES WHICH ARE TRIANGULAR FROM END VIEW

TRILOCULINA TRICARINATA d'Orbigny

Pl. 10, figs. 3a,b.


Description: Test triangular from end view, inflated, nearly as broad as high; chambers inflated, convex between the angles, angles with broadly rounded carinae; chambers added in such a manner as to conceal all but one of the carinae of the preceding chambers; sutures depressed; wall heavy, dull; aperture nearly circular, with a thickened lip which does not enclose the aperture at the base; tooth bifid.

Length, 0.43 mm.; breadth, 0.36 mm.

This is not a common species at Bermuda. It may be distinguished from T. trigonula at Bermuda by the following criteria: its wall is dull, whereas T. trigonula has a highly polished wall; it has rounded carinae at the angles, whereas T. trigonula is very smoothly rounded at the angles; and it is convex between the angles, while the other is complanate between the angles.
TRILOCULINA TRIGONULA (Lamarck)

Pl. 10, figs. 4a, b.

Miliola trigonula Lamarck, Ann. Mus., vol. 5, 1804, p. 351, No. 3; vol. 9, 1807, pl. 17, fig. 4.


Description: Test triangular in end view; angles broadly rounded; sutures near the angles and deeply depressed, sinuous; walls complanate, not convex between the angles; chambers tapering toward the apertural end; wall procellaneous, smooth, highly polished; aperture circular, with a thickened ring which does not entirely enclose the aperture; tooth short, bifid.

Length, 0.48 mm.; thickness, 0.32 mm.

This species, while comparatively rare at Bermuda, is commoner than the other triangular-shaped Triloculinas. It may be distinguished from T. tricarinata by its shiny, highly polished surface, and its broadly rounded corners without ridges or carinae.
TRILOCULINA BERTHELINIANA (H.B.Brady)

Pl. 10, figs. 2a,b.


**Description:** Test triangular from end view; periphery with rounded ridges projecting beyond the remainder of the test; walls complanate between the ridges; chambers compressed; sutures distinct; surface pitted with numerous small round indentations; aperture circular, with a slightly thickened lip; no tooth observed.

Length, 0.67 mm.; thickness, 0.44 mm.

This is the first record of this species from the Atlantic, as it has hitherto been confined to the tropical and Indo-Pacific. It is very rare at Bermuda.
Genus MILIOLINELLA Wiesner, 1931

This genus has been little used in the very recent literature, but is deserving of full recognition in our classification of the Miliolidae. Wiesner has emphasized the importance of the aperture as a basis for classifying the Miliolidae. The genus Miliolinella includes those species in which a small flap-like plate stands in front of the aperture, and in which the aperture is elongated at right angles to the plane of coiling. The coiling may be quinqueloculine, triloculine, or massiline. Many species hitherto referred to Triloculina are now placed in this genus.

MILIOLINELLA CIRCULARIS (Bornemann)

Pl. 10, figs. 9a-c.

Triloculina circularis Bornemann, Zeitschr. deutsch. geol. Ges., vol. 7, 1885, p. 349.-----Cushman, Bull. 71, U. S. Nat. Mus., pt. 6, 1917, p. 67, pl. 25, fig. 4; pl. 26, fig. 1; Bull. 100, vol. 4, 1921, p. 462, pl. 32, figs. 1, 2; Carnegie Inst. Washington, Publ. 342, 1924, p. 69, pl. 25, figs. 5, 6; U. S. Nat. Mus., Bull. 104, pt. 5, 1929, p. 58, pl. 13, figs. 6, 7; pl. 14, figs. 1, 2.


Description: Test subspherical, inflated, coiled in triloculine manner in adult stages, the last chambers strongly embracing; wall highly polished, thin; aperture hooded, elongated at right angles to the plane of coiling, extending the entire width of the last chamber, somewhat arched, with a flap-like plate projecting in front of the aperture and nearly closing it in very old specimens, both plate and hood with a thin everted lip.

Length, 0.45 mm.; breadth, 0.40 mm.; thickness, 0.31 mm.
This is a small species and easily overlooked. It is fairly abundant at some stations but does not seem to be present at many of them. It is, next to M. labiosa, the most abundant species of this genus at Bermuda. It may be distinguished from M. labiosa by its highly polished wall and subspherical shape. Frequently the last chamber is flattened at the periphery which serves as another distinguishing factor, but this is not constant enough to be included in a description of the species. It may be distinguished from M. suborbicularis by its lack of costae.

MILIOLINELLA LABIOSA (d'Orbigny)

Pl. 10, figs. 5a-c, 6a,b, 7.

-----Cushman, U. S. Nat. Mus., Bull.71, pt.6, 1917, p.70;
Proc. U. S. Nat. Mus., vol.59, 1921, p.70, pl.16, figs.13,14;
Carnegie Inst. Washington, Publ.511, 1922, p.77, pl.12, fig.1;
U. S. Nat. Mus., Bull.104, pt.6, 1929, p.60, pl.15, figs.2,3.


Description: Test circular to ventricose, somewhat complanate, coiling in triloculine fashion in the young and intermediate stages, coiling in various planes in the older stages, coiling approaching the massiline type but not wholly in one plane; ventricose appearance due to the shortening of the last chamber in the adult stages; apertural end not produced, basal end inflated and frequently protruding backward in a large bulge; periphery broadly rounded; sutures very slightly depressed; wall thin, slightly translucent, giving the test a milky blue color, wall surface apparently smooth but rendered dull by minute
pebbly protuberances and short incised lines; aperture an arched slit, hooded on the peripheral side, and nearly closed on the opposite side by a flap-like plate, with a thin everted lip, very old specimens with the aperture slit in three directions with three flat plates enclosing it.

Length, 0.50 mm.; breadth, 0.57 mm.; thickness, 0.28 mm.

This species is common at Bermuda and the West Indian region. It is the commonest representative of the genus *Miliolinella* and probably the best known. Large suites of it have been collected at Bermuda to determine whether the flattened, highly ventricose forms were the same species or a variety, and they were determined to be old-age individuals. The illustrations on plate 10, figures 5a-c, show typical adults, and in figures 6a,b, and 7, two very old individuals, which have the somewhat complanate test and ventricose arrangement of the chambers. The figured apertures are of interest in that they show, in the older specimens, the flap-like plate growing higher and closer to the hood than in the younger specimens.
MILIOLINELLA SUBORBICULARIS (d'Orbigny)

Pl. 10, figs. 8a-c, 10.

Triloculina suborbicularis d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 300, No. 12; in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p. 177, pl. 10, figs. 9-11.----Gashman, U. S. Nat. Mus., Bull. 71, pt. 6, 1917, p. 70, pl. 21, fig. 3; Bull. 104, pt. 6, 1929, p. 65, pl. 16, fig. 5; pl. 17, fig. 3.


Description: Test subcircular, much compressed in the plane of the coiling, coiling in the early stages quinqueloculine, later triloculine or nearly so, and finally in one plane with more than two chambers to a coil; chambers only slightly embracing, slightly inflated at the base, with the periphery of the last few chambers broadly angled; wall very thin, translucent, ornamented with faint to prominent low costae; aperture nearly circular, only slightly hooded, with a small plate which stands in front of the aperture and which does not close the aperture but is strongly everted, hood with a much everted, somewhat thickened lip.

Length of average specimen, 0.38 mm.; breadth, 0.32 mm.; thickness, 0.21 mm.

In this species the flap-like plate is frequently broken off due to its position away from the apertural orifice. This species is rare at Bermuda. It may be distinguished from the other species of Miliolinella by its low, rounded costae.
Genus PYRGO Defrance, 1826

PYRGO DENTICULATA (H.B. Brady)

Pl. 10, figs. 11a-c.


Biloculina denticulata Cushman, U. S. Nat. Mus., Bull. 71, pt. 6, 1917, p. 80, pl. 33, fig. 1; Bull. 100, vol. 4, 1921, p. 476, pl. 98, figs. 3a, b.

Pyrgo denticulata Cushman, U. S. Nat. Mus., Bull. 104, pt. 6, 1929, p. 69, pl. 18, figs. 3, 4.

Description: Test large, somewhat elongate, nearly quadrangular from side view, elliptical from end view, periphery sharply keeled or angled, apertural end produced beyond the outline of the rest of the test, basal end ornamented with a row of spiny projections; sutures slightly depressed, not sinuous from edge view; chambers somewhat embracing, each chamber enclosing the peripheral keel of the preceding one, with greatest diameter in central portion, very much compressed at each end; wall heavy, porcellaneous, typically polished; aperture very elongate and low, with a long large tooth which nearly obstructs the orifice, and with a thin lip which is prolonged forward beyond the rest of the test.

Length, 0.84 mm.; breadth, 0.73 mm.; thickness, 0.40 mm.

The sharp keel and spines on the basal end will serve to distinguish this species from all others of this genus at Bermuda. It is fairly common.
PYRGO STRIOLATA (H.B. Brady)

Pl. 10, figs. 13a, b.


Biloculina denticulata (H.B. Brady), var. striolata (H.B. Brady), Cushman, U. S. Nat. Mus., Bull. 71, pt. 6, 1917, p. 80, pl. 33, figs. 2, 3; Bull. 104, pt. 6, 1929, p. 69, pl. 16, figs. 5a-c.

Description: Test elongate, greatest width in central portion, gradually tapering toward each end, oval from side view, periphery broadly rounded, apertural and basal ends rounded, test from edge view very thick at each end; chambers not strongly embracing, inflated at the basal end and not strongly compressed at the apertural end; sutures deep, sinuous from edge view; wall heavy, porcellaneous, typically somewhat dull, ornamented with deep striations or furrows which are so closely spaced as to give the wall a costate appearance, the basal ends of these furrows giving the base of the chamber a denticulate appearance; aperture small, not much elongated, without projecting lip, with a comparatively large tooth which obstructs the aperture.

Length, 0.60 mm.; breadth, 0.36 mm.; thickness, 0.40 mm.

This species which has hitherto been recorded as a variety of P. denticulata appears to the author to be distinct in the constant characters and has therefore been elevated to a separate species. The aperture is not at all similar to that of P. denticulata as it is much higher and much shorter. The periphery is broadly rounded in contrast to the sharp periphery of P. denticulata, and the chambers are not compressed at each end. This species is not very common at Bermuda.
**PYRGO SUBSphaerica (d'Orbigny)**

Pl. 10, figs. 12a,b.


*Pyrgo subsphaerica* Cushman, *U. S. Nat. Mus.*, Bull.104, pt.6, 1929, p.68, pl.18, figs.1,2.

**Description:** Test nearly spherical, circular from side view, nearly circular from end view; chambers inflated, somewhat embracing; periphery rounded; sutures much depressed, sinuous from edge view; wall porcellanous, highly polished; aperture large oval, nearly twice as broad as high, with a much thickened and very slightly everted lip, with a comparatively slender tooth which is elongated parallel to the long axis of the aperture, tooth very slightly projecting above the plane of the orifice.

Length, 0.58 mm.; breadth, 0.52 mm.; thickness, 0.48 mm.

The very rotund spherical shape of this *Pyrgo* will distinguish it from all others at Bermuda, where it is the most common representative of its genus.

**PYRGO SUBSphaerica (d'Orbigny), var. COSTATA Carman, n.var.**

Pl. 10, figs. 14a,b.

This variety differs from the species only in the faint costae which ornament the wall. It was found at several stations in Bermuda.
Family OPHTHALMIDIDAE

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA INVOLVENS (Reuss)

Pl. 12, figs. 1a,b.


Description: Test small, planispirally coiled, circular from side view, periphery rounded, large proloculum typically obvious; coiled part typically involute to the extent of partially covering the preceding coil; wall smooth, highly polished, thin, imperforate, translucent in early coils; aperture formed by the open end of the tubular chamber.

Diameter, 0.33 mm.; thickness, 0.11 mm.

This species is small and fragile and may have been lost or broken at many stations, as it is not a common one from my records at Bermuda.
Genus **NODOBACULARIA** Rhumbler, 1895

**NODOBACULARIA ANTILLARUM** (Cushman)

Pl. 12, figs. 3a, b, 4.

*Articulina antillarum* Cushman, Carnegie Inst. Washington, Publ. 311, 1922, p. 71, pl. 12, fig. 5; Publ. 342, 1924, p. 66, pl. 25, fig. 1; U. S. Nat. Mus., Bull. 104, pt. 5, 1929, p. 52, pl. 12, fig. 4.


**Description:** Test with the early stages planispirally coiled about an enlarged proloculum with transparent hyaline wall, resembling *Cornuspira*, later stages with chambers in a rectilinear series; chambers very much longer than broad, circular in transverse-section, with walls nearly parallel, not inflated; each chamber of greater diameter than the preceding one; sutures typically straight, not convex; wall in early stages clear and frequently smooth, in later stages very heavy, porcellanous and ornamented with very coarse, high costae widely spaced; aperture circular, formed by the open end of the last chamber, with a thickened everted lip.

Length, 1.15 mm.; diameter 0.15 mm.

This species is moderately well represented at Bermuda, where broken pieces of it are common, and perfect specimens abundant at a few stations. It was thought to be the megalospheric form of an *Articulina* in which the microspheric form showed milioline coiling in the early stages, but a later study of more material has led to the conclusion that no satisfactory microspheric form exists, hence the genus is *Nodobacularia*. This species appears to be restricted to the West Indies and Bermuda. Cushman has recorded *N. antillarum* var. *pacifico* from the Fiji and Tonga Islands, and it is very close to the West Indian species but distinct from it.
Genus CORNUSPIRAMIA Cushman, 1928

**CORNUSPIRAMIA ANTILLARUM (Cushman)**

*Nubecularia antillarum* Cushman, Publ. 311, Carnegie Inst. Washington, 1922, p. 58, text figs. 7 and 8.


**Description:** Test attached, early stages consisting of a proloculum and undivided second chamber coiling loosely about it; later stages consisting of tubular portions somewhat flattened and branching at an angle of nearly 90 degrees; wall calcareous, imperforate; apertures formed by the open ends of the tubes.

This species is to be distinguished from algae, worm tubes, and other incrusting forms which are very common at Bermuda, by the presence of the coiled early stages and the characteristic manner of branching. Well preserved specimens are generally found attached to the inside of pelecypod shells.

Genus PLANISPIRINA Seguenza, 1880

**PLANISPIRINA AURICULATA** Egger

Pl. 12, figs. 2a, b.


**Description:** Test minute, thin, oval from side view, biconvex, two chambers to a coil, planispirally coiled, periphery acute to keeled;
chambers of uniform width; sutures typically with one or more shelly processes extending across the suture uniting the last two chambers; wall translucent to opaque, porcellaneous, highly polished; aperture very large, circular to elliptical, in the median plane of the test, turned so that the orifice opens entirely on one side of the test, with a large, flaring, everted lip, without a tooth.

Length, 0.28 mm.; breadth, 0.17 mm.

This small species is found only at a few stations. Woodward mentions three species of this genus which he found at Bermuda, but which are not found by the writer. The Planispirina celata Costa which he lists is probably Sigmoidina, the P. exigua (H.B.Brady) resembles Cornuspira, and nothing similar to the figure of P. communis Seguenza was found.

GENUS ? SPECIES ?

Pl. 12, figs. 5a-c.

Two specimens were found at Bermuda of a genus which has hitherto been recorded from the Pacific as Quinqueloculina cultrata H.B.Brady, Miliolina durandii Millett, Pyrgo milletti Cushman. The Pacific species are very thin-walled and appear to be wholly planispiral and thus belonging to the genus Spiropthalmidium or close to it. The Bermuda specimens are very thick-walled, complanate, and with a keel, with three chambers visible from the exterior, and coiling in one plane in the adult stage, with the chambers somewhat embracing and involute. This species must be sectioned before it can be generically identified, and as only two specimens were found in the entire Bermuda collection, it was thought wise to figure the specimen, but to withhold identification until more material is available for sectioning.
Family LAGENIDAE

Genus LAGENA Walker and Jacob, 1798

LAGENA cf. SULCATA (Walker and Jacob), var. APICULATA Cushman


Description: Test globular, somewhat elongated; apertural end with a long narrow neck and everted lip, basal end tapering to a long projecting spine, circular in transverse-section; wall vitreous, very finely perforate, with prominent sharp costae which extend from the base of the neck to the projecting basal spine.

Only one specimen of this species was found at Bermuda.

LAGENA cf. SQUAMOSA (Montagu)


Description: Test sub-globular, rounded at the base, slightly truncated at the apertural end, without a neck; wall surface reticulate, areoles slightly arched toward the apertural end.
Only one specimen was found at Bermuda. Cushman states\(^1\) that this species has not been recorded from the Western Atlantic, and with only one from Bermuda it seems wiser not to attempt a definite identification. However, the specimen seems very close to toptype material from off the coast of Ireland.

**Family NONIONIDAE**

**Genus NONION Montfort, 1808**

**NONION GRATELOUPI (d'Orbigny)**


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**Nonion grateloupi** Cushman, Bull.104, U. S. Nat. Mus., pt.7, 1930, p.10, pl.3, figs.9-11; pl.4, figs.1-4.

**Description:** Test planispiral, bilaterally symmetrical, almost wholly involute, periphery slightly lobate, rounded, test with sides nearly parallel from apertural view, not inflated and biconvex; chambers numerous, 10 or more in the last-formed coil, slightly inflated; sutures depressed; wall smooth, very finely perforate; aperture a narrow slit at the base of the terminal face of the last-formed chamber.

Diameter, 0.42 mm.; thickness, 0.16 mm.
This species is not as abundant at Bermuda as it is in the West Indies, in fact, the whole genus is so sparingly represented that specimens which probably belong to other species of this genus cannot be identified with accuracy.

Genus *ELPHIDIUM* Montfort, 1808

*ELPHIDIUM DISCOIDEUM* (d'Orbigny)

Pl. 15', figs. 3a, b.


Description: Test planispirally coiled, involute; periphery subacute, somewhat spinose in the early stages, becoming slightly lobate in adults; 9 to 10 chambers to a coil; umbilical area filled with a large boss of clear material which is typically ornamented with perforations which are the terminations of the interseptal canals; sutures slightly depressed, with very small delicate reticulations with rounded depressions between the retral processes in the young and with elongate depressions in the adults; wall clear, finely perforated; aperture formed by a row of large pores at the base of the terminal face of the last chamber.

Diameter, 0.37 mm.; thickness, 0.19 mm.
This is the most abundant species of this genus at Bermuda. The boss of clear material in the umbilical area serves to distinguish it from *E. poeyana*. The apertures of almost all the specimens of this species and other species of the same genus at Bermuda are typically filled with a calcareous deposit, so that only in very young specimens can the apertural pores be seen in their best development.

**ELPHIDIIUM SAGRUM** (d'Orbigny)

*Pl. 15*, figs. 2 a, b.

*Polystomella sagra* d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères", p.55, pl.6, figs.19,20.-----


**Description:** Test thick, not compressed, each coil thicker than preceding coil; slightly depressed at the umbilical area, without a boss of shelly material at the umbilicus; periphery rounded to slightly angled, not lobate; chambers fairly distinct, apertural face of last chamber inflated; sutures raised and limbate with strong, prominent retral processes which merge into the limbate suture and retral processes of the preceding chamber thus giving the appearance of continuous ridges, depressions between the retral processes, not deep, oblong, elongate; aperture formed by a group of pores at the base of the terminal face of the last chamber.

Diameter, 0.60 mm.; thickness, 0.43 mm.
This species seems to be more abundant at Bermuda than in the West Indies, as it can hardly be considered rare in Bermuda. It is somewhat intermediate between *E. chipolensis* of the Miocene of Florida and *E. sagra* of Recent deposits of the West Indies, but is nearer to the latter. In most of the Bermuda specimens the apertural pores are filled with a limy deposit which renders them difficult to see.

**ELPHIDIIUM POEYANUM (d'Orbigny)**

Pl. 18, figs. 4 a, b.

*Polystomella poeyana* d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères", p. 55, pl. 6, figs. 25, 26.----

Cushman, Publ. 311, Carnegie Inst. Washington, 1922, p. 55, pl. 9, figs. 9, 10; Publ. 344, 1926, p. 79.


**Description:** Test of small size for the genus, compressed; periphery rounded, prominently lobate; umbilical area depressed, without a boss of shelly material; chambers somewhat inflated, 8 to 12 in the last coil; sutures depressed, marked by a few short, broad and tapering retral processes which do not overlap far on the preceding chamber; wall very thin, smooth, very finely perforate, translucent; aperture a series of pores at the base of the terminal face of the last chamber.

Diameter, 0.40 mm.; thickness, 0.16 mm.

This species, while not as abundant as *E. discoidale*, is fairly common at Bermuda. The larger specimens are so thin-walled that they are generally broken.
Family CAMERINIDAE

Genus HETEROSTEGINA d'Orbigny, 1826

HETEROSTEGINA ANTILLARUM d'Orbigny

Pl. 17, fig. 5.


Description: Test much compressed, subcircular in outline, flattened, greatest thickness in the central area, tapering toward the periphery, periphery subacute; chambers curved, flaring backward, the peripheral portion of each chamber subdivided into chamberlets; sutures distinct, limbate, not depressed; wall opaque, smooth; aperture composed of small pores on the terminal face of the last chamber.

Diameter, 1.90 mm.

This species is very rare at Bermuda and no ecological data is available for the stations at which it was found.
Family PENEROPLIDAE

Genus PENEROPLIS Montfort, 1808

PENEROPLIS PROTEUS d'Orbigny

Pl. 12, fig. 7.


Peneroplis dubius d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.62, pl.6, figs.21,22.


Description: Test complanate, nearly discoidal, with the early portion close coiled and involute, later portion becoming somewhat evolute and spreading in flaring manner; chambers elongate, narrow, not divided into chamberlets; sutures distinct, regular; wall heavy, porcellaneous, smooth and typically polished, not pitted; aperture formed by a row of pores on the apertural face.

Diameter up to 1.50 mm.

This is a very common species at Bermuda and in the West Indies. It is not as abundant as Archaias angulatus from which it may be distinguished by its lack of chamberlets within the chambers.
Peneroplis bradyi Cushman

Pl. 12, figs. 6a,b.


Description: Test complanate, very thin, with the early portion planispirally coiled and evolute, later portion flaring with very long chambers; sutures frequently irregular, slightly depressed; wall very thin, translucent, with minute pits on the surface; aperture formed by a row of pores on the apertural face.

Diameter up to 0.75 mm.; thickness, 0.11 mm.

This species is not as abundant at Bermuda as P. proteus, from which it may be distinguished by the fact that P. bradyi is evolute in its coiling whereas P. proteus is involute. The very thin test and delicate wall will also distinguish P. bradyi from other species of the genus. It is of interest to note that Brady's original specimens were from Bermuda.
Genus SPIROLINA Lamarck, 1804

SPIROLINA sp?

Pl. 12, figs. 8a,b.

The species of this genus vary tremendously at Bermuda, as they do at every other locality where the genus is found. The Bermuda material may represent one species which is capable of wide variations, or it may represent two species. When all the Bermuda specimens belonging to the genus Spirolina are arranged in graduated suites the two end forms seem distinct. They are described below merely as end forms which are very close to the species cited. However, the intermediate specimens merge so delicately that no line of separation can be drawn, and biological research with the living animals is necessary to prove whether both end forms could be derived from the intermediate forms, or whether they are two separate species. The specimen illustrated on plate 12, figures 8a,b, is intermediate, possibly a little nearer to "End form of S. arietinus" than to the other end form.

End form of S. arietinus

Description: Test complanate, considerably flattened in all stages, with the early portion planispirally coiled and evolute, not wholly evolute but strongly so, later portion uncoiled with chambers arranged in a rectilinear series; periphery of both the coiled and the uncoiled portions typically angled and narrowed; chambers in the rectilinear portion compressed in the plane of the coiling, oval in transverse-section, five or six times as broad as high; wall very thin, clear, translucent, of a milky bluish color which is very characteristic, ornamented with very numerous regular rounded costae
which grow more numerous in the adult stages; aperture a large, elongate, depressed area in the terminal face of the last chamber and occupying the entire face, filled with shell material which is punctured by regular round pores in the adults and by irregular dendritic small openings in the younger stages.

End form of *S. cylindracea*

**Description:** Test not compressed, not flattened, with the early portion planispirally coiled and wholly involute, later portion uncoiled and with the chambers arranged in rectilinear fashion; periphery of both the uncoiled and the coiled stages broadly rounded, not angled; chambers in the rectilinear portion not compressed, typically increasing somewhat in height as added, roughly circular in transverse-section, becoming nearly as high as broad; wall heavy, opaque, porcellanous, ornamented with a few sharp, irregular costae which become more irregular and sharper in the adult chambers; aperture an oval depression on the terminal face of the last chamber, with dendritic pores in the young stages and with rounded pores in the adult stages.

Both end forms have raised limbate sutures in the younger coiled portions, and depressed non-limbate sutures in the adult portions.

All the older literature, as well as most of the more recent literature, shows that previous workers have found this genus a very confusing one to subdivide into species. Dreyer¹, in a paper in which he endeavored to work out the morphology of this genus, (*Peneroplis* of Dreyer), gave 254 illustrations of the mutations which may occur, and reached no satisfactory conclusions. Many of the forms referred to as *Peneroplis*

partusus, *P. arietinus*, *P. malchallus*, *Dendritina antillarum*, *Nautilus arietinus*, *Spirolina arietinus* and *S. cylindracea* are represented by the Bermuda material which I have classified as *Spirolina sp.?*. To add to the confusion of the literature, the original specific descriptions of the earlier authors are inadequate and do not mention the variations or limitations of the species in question.

Genus *MONALYSIDIUM* Chapman, 1900

*MONALYSIDIUM POLITUM* Chapman(?)

Pl.12, fig. 10.


*Peneroplis (Monalysidium) polita* Chapman, Journ. Linn. Soc. London, Zool., vol.28, 1902, p.4, pl.1, fig.5(?)


Description: Test consisting of a series of delicate globular chambers in a rectilinear series, joined together by a stolon-like neck, almost invariably broken at the basal end; wall hyaline, transparent to translucent, surface ornamented by rows of minute, projecting bosses; aperture circular, terminal with a slightly everted lip.

Diameter, 0.10 mm.

The specimens from Bermuda referred to this species are identical with figures in the recent literature and with material in the Cushman Collection from Tortugas.
MONALYSIDUM LITUUS (Gmelin)

Pl. 12, figs. 9a,b.


_Nautilus acicularis_ Batsch, Conch. Seesandes, 1791, p.4, pl.6, figs.16a,b.


Description: Test close coiled and involute in the early stages, later uncoiled in a rectilinear series; chambers enlarging very slightly as added, wider than high; sutures limbate in the early portions of the test, becoming depressed and not limbate in the adult portions; wall clear, transparent, thin, ornamented with longitudinal rows of minute bosses of shell material and minute tubercles which give the appearance of costae; aperture circular to oval, terminal, with a thickened, raised lip.

Length, 0.51 mm.; breadth of last chamber, 0.12 mm.; thickness, 0.09 mm.

The rows of minute bosses of shell material, which resemble rows of tiny beads, and the small tubercles arranged in rows, and the circular or oval aperture place this species in the genus _Monalysidium_. All the material examined from Bermuda appeared to be very close to _M. politum_. This species is fairly abundant at Bermuda for such a delicate species. It seems to thrive away from shore, on fine sandy bottoms in protected places.
Genus ARCHAIAS Montfort, 1808

ARCHAIAS ANGULATUS (Fichtel and Moll)

Pl. 13, fig. 1.


Description: Test compressed, the early portion coiled involutely and comprising the thickest portion of the test, the later portion composed of more than one layer of chambers, much compressed and flaring; chambers divided into chamberlets; wall heavy, ornamented with minute pits which give the surface a granular appearance; aperture composed of a band of pores on the apertural face or peripheral edge of the test.

Diameter up to 3.50 mm.

This species is so abundant at some stations at Bermuda as to be the dominant species. It is most noticeable at current stations or rough-water stations where other species cannot exist, but it is present at every station examined.
ARCHAIAS COMPRESSUS (d'Orbigny)

Pl. 13, fig. 2.

*Orbiculina compressa* d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.73, pl.8, figs.4-7.


**Description:** Test discoidal, very much compressed, early portion planispirally coiled, involute; later portion uncoiled with the chambers flaring at the edges of the test until they meet and become annular, producing a large very flat disc in the adult stages; chambers divided into small chamberlets; sutures very slightly depressed; wall porcellaneous and very minutely pitted, rather thin; aperture formed by a double row of pores or band of pores at the peripheral edge of the test.

Diameter up to 1.50 mm.

This species is not at all common at Bermuda. It is very close to *Archaias angulatus* from which it may be distinguished because it has a much thinner wall, more minute chamberlets, a much reduced early thick portion, and a very large compressed portion. The compressed portion is much thinner than in *A. angulatus*. None of the specimens of *A. angulatus* observed at Bermuda became truly discoidal, whereas *A. compressus* assumes the discoidal shape very early in its development.
Genus SORITES Ehrenberg, 1838

SORITES MARGINALIS (Lamarck)

Pl. 14, fig. 3.


Description: Test thin, discoidal, composed of a single layer of chambers throughout, each chamber subdivided into numerous small chamberlets; early portion of the test planispirally coiled and involute, frequently with very thick chambers in this portion; later followed by an intermediate stage in which the coiling is evolute; finally uncoiled and with the chambers flaring backward at either side of the test until they meet and become annular, encircling the whole test; sutures typically limbate in the early portion of the test, in the later portion not limbate but depressed; wall varying from thin and clear in the early portions of the test to thick and opaque in the adult portions and near the periphery; aperture composed of a single row of very fine pores on the peripheral edge of the test.

Diameter up to 3.25 mm.

This is a very common species at Bermuda, where it is heavier and with a thicker wall than in the West Indies and the Pacific.
It resembles both Peneroplis and Archaias compressus. Peneroplis has chambers which are not divided into chamberlets, while Sorites has numerous fine chamberlets. Archaias compressus also has chamberlets, but is composed of a double layer of chambers, in the young at least, and has a double row of pores on the peripheral edge.

Genus AMPHISORUS Ehrenberg, 1838

AMPHISORUS HEMPRICHII Ehrenberg

Pl. 14, figs. 1,2.


Description: Test much compressed, discoidal; in the megalospheric form with a large translucent proloculum, followed by several more large chambers which are translucent and coiled about the proloculum in planispiral fashion, later followed by annular chambers which wholly encircle the test, and which are subdivided into small chamberlets; with a single layer of chambers in the young and intermediate stages, and with a double layer of chambers in the adult stages; wall very thin and translucent; aperture formed by a double row of pores along the peripheral edge of the test.

Diameter up to 2.50 mm.

The chamberlets of Amphisorus hemprichii are very round and globular in appearance, thus giving the false impression of growing
independently of the larger annular chamber. The whole test is very translucent, except at the periphery where there are two layers of chambers. There do not seem to be any microspheric forms in the Bermuda collection, as all the specimens examined have a large initial chamber, which is surrounded with more large but elongated chambers which precede the annular chambers.

Family **ALVEOLINELLIDAE**

Genus **BORELIS** Montfort, 1808

**BORELIS PULCHRA** (d'Orbigny)

Pl. 12, figs. 11a,b.


**Description:** Test globular to fusiform, small, wholly involute, coiling planispirally about a short axis; chambers distinct, typically five to a coil, low, divided into chamberlets; sutures depressed somewhat; wall heavy, bluish white to yellowish, polished; aperture a single row of pores at the base of the apertural face, one pore to each chamberlet.

**Diameter 0.29 mm.**
This species is identical with material from the West Indies. It has an erratic occurrence at Bermuda, as it is abundant at some stations and totally lacking at others. It seems to be commonest at rough-water or current stations.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

BULIMINELLA MILLETTI Cushman, MS.

Pl. 15, figs. 7 a, b.


*Description:* Test small, short and stout, initial end blunt, diameter of test rapidly increasing to a rounded apertural end, 3 or more whorls making up the test, 4 or 5 chambers to a whorl in the adult portion; chambers distinct, somewhat inflated in adult stages; sutures distinct, slightly depressed, the spiral suture more depressed than the others; wall smooth, opaque, heavy for so small a species, very finely perforate; aperture a small crescentic opening at the bottom of an elongate depression in the inflated terminal face of the chamber, this pronounced depression elongated at right angles to the long axis of the test.

Length, 0.25 mm.; thickness, 0.13 mm.

Cushman is about to publish a description of this new species which he has found in shallow water in the tropical Pacific. I have compared his specimens with mine from Bermuda and they are very
The Bermuda material is heavier-walled, but the shape and size of the test and peculiar aperture are identical. This is the first Atlantic record of this species.

**Genus BOLIVINA d'Orbigny, 1839**

**BOLIVINA PULCHELLA (d'Orbigny)**

Pl. 17, figs. 4a, 5b.


**Description:** Test typically biserial throughout, rapidly tapering from a somewhat inflated apertural end to a roundly pointed initial end; sutures nearly at right angles to the long axis of the test, nearly straight; chambers inflated, rounded, numerous; wall thin, very finely perforate, ornamented with sharp, high ridges or costae on each chamber, but not crossing the suture lines; aperture very large, nearly rectangular in shape, extending from the base of the inner margin of the last chamber almost to the periphery, with a thickened lip.

Length, 0.33 mm.; breadth, 0.23 mm.; thickness, 0.13 mm.
This is one of the commonest of the Bolivinas at Bermuda. Its ornamentation which is confined to each chamber and does not extend continuously for the whole length of the test will distinguish this species from other costate Bolivinas. It is common at both the mud-bottomed stations and among the reefs in clearer water.

BOLIVINA cf. BEYRIGHI Reuss

Pl. 15, figs. 5a, lv.

Description: Test typically biserial throughout, small, narrow, elongate, gradually tapering, much compressed, sharply angled at the periphery becoming almost carinate; chambers elongate, very slightly inflated near the median part of the test, tapering and compressed near the periphery, curving backward over the preceding chambers, terminating in a spinose projection; sutures somewhat depressed; wall thin, finely perforate; aperture elongate, at the inner margin of the last chamber, aperture comparatively large for so small a species.

Length, 0.48 mm.; breadth, 0.15 mm.; thickness, 0.06 mm.

The Cushman Collection has topotype material from the Middle Eocene of Germany from which Reuss first described this species.\(^1\) The specimens are better-developed, larger, and less compressed than the Bermuda ones, and for that reason a definite identification is not made here, although the relation seems very close. Possibly the Bermuda specimens represent a species living in an environment to which it is not suited, as the individuals appear emaciated and

\(^1\) Reuss, Zeitscher. Deutsch. geol. Gesellsch., vol. 3, 1851, p. 83, pl. 6, fig. 51.
dwarfed. No attempt has been made to furnish a synonymy for this species, as so many spinose Bolivinas have been referred to it. This is either a widely distributed species or else more than one species is under consideration. It is not common at Bermuda.

BOLIVINA RHOMBODALIS (Millett)

Pl. 15, figs. 7a, 8.


Description: Test small, rapidly tapering from a bluntly-pointed initial end to a rounded apertural end, test wedge-shaped from edge view, rhomboidal from end view; periphery concave with projecting angles which are rounded but not carinate; sutures very slightly depressed, almost straight; wall coarsely perforate for so small a species; aperture at the inner margin of the last chamber, elongated in the plane of the greatest compression of the test.

Length, 0.30 mm.; breadth, 0.20 mm.; thickness, 0.12 mm.

This species is fairly common at Bermuda. It seems to be an intermediate species between the genera *Bolivina* and *Bolivinita*. Its distribution seems to be fairly wide, as it is recorded from the tropical Pacific, the Malay Peninsula, off the Falkland Islands, off the Island of Delos, and rare in the Caribbean region. It is more common at the muddy stations in Bermuda than among the reefs in clear water.
Genus LOXOSTOMUM Ehrenberg, 1854

LOXOSTOMUM MAYORI (Cushman)

Pl. 15, figs. 6a,b; pl. 17, fig. 4.


Description: Test elongate, compressed, sides nearly parallel, not much tapering, early portion frequently twisted; periphery angled to rounded; chambers numerous, very slightly inflated near the median portion of the test, the last chambers in the adult becoming uniserial or very much widened; sutures depressed, strongly convex forward, not straight; wall clear, transparent, perforate, ornamentation varying from heavily costate throughout, to costate only in the young stages, to non-costate; aperture semi-elliptical, elongated parallel to the plane of compression of the test.

Length, 1.00 mm.; breadth, 0.20 mm.; thickness, 0.10 mm.

The variation of this species is very marked from a costate form to a smooth form such as that figured on plate 17, figure 4. The perforations in the wall and the forward curving sutures and the tendency for the chambers to become wide and assume the uniserial arrangement are the only diagnostic features, hence young plain forms, such as the one figured on plate 15, figures 6a,b, can be identified only by their resemblance to other specimens. Loxostomum mayori is the most abundant of all the Buliminidae at Bermuda. It is commonest at the mud-bottomed stations in very shallow water.
Genus REUSSELLA Galloway, 1933

REUSSELLA SPINULOSA (Reuss)

Pl. 17, figs. 2 a, b.


Description: Test typically triserial throughout, triangular in transverse-section, sharply angled to carinate at the peripheral angles, strongly tapering from the pointed initial end to a broad apertural end; chambers compressed, typically somewhat spinose at the periphery; sutures limbate, straight to slightly convex forward; wall clear, coarsely perforate, the perforations most numerous near the sutures and periphery; aperture in the center of the apertural end of the test, a rounded arch at the inner margin of the last chamber.

Length, 0.50 mm.; thickness, 0.36 mm.
Reussella spinulosa is very common at Bermuda. It seems to be widely distributed in the ocean today, and has been recorded from the Miocene of Europe and America, with a few rather dubious records from the Eocene of Europe and the Oligocene of the Coastal Plain of the United States.

Genus Siphogenerina Schlumberger, 1883

Siphogenerina raphanus (Parker and Jones)

Pl. 15, figs. 4, 6.

Uvigerina (Sagrina) raphanus Parker and Jones, Philos. Trans. vol. 155, 1865, p. 364, pl. 18, figs. 16, 17.


Siphogenerina costata Schlumberger, Feuille des Jeunes Naturalistes, ann. 15, 1883, p. 118, fig. 13.

Description: Test elongate, very slightly tapering, cylindrical, not compressed, early portion triserial, later biserial, adult portion uniserial; chambers numerous, wider than high; sutures not at right angles to the long axis of the test until adult stage is reached; wall thin, translucent, perforate, ornamented with prominent high costae which are frequently lacking on the early chambers and the final chambers, costae irregular, not wholly straight; aperture terminal, nearly circular, with a thickened raised lip.
Length, 1.00 mm.; diameter, 0.23 mm.

This is the only species of the genus Siphogenerina found at Bermuda. It is not abundant. It occurs most frequently at mud-bottomed stations.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA OCCIDENTALIS (Cushman)

Pl. 17, figs. 3a, b.

Uvigerina angulosa Cushman (not Williamson), Carnegie Inst. Washington, Publ. 311, 1922, p. 34, pl. 5, figs. 3, 4.


Description: Test minute, triserial, triangular in transverse-section, periphery irregular and angled; chambers of the early portion more rounded and appressed, later chambers spreading out and separated from each other and becoming more angular; sutures depressed; wall costate in early stages, perforate; aperture at the end of a long narrow neck, with an everted lip.

Length, 0.30 mm.; thickness, 0.17 mm.

This species occurs at many of the Bermuda stations, but not in great numbers. It is most abundant at the mud-bottomed stations. The angles on some of the adult chambers become so pronounced as to be true carinae.
Family ROTALIIDAE

Genus SPIRILLINA Ehrenberg, 1841

SPIRILLINA VIVIPARA Ehrenberg

Pl. 15, figs. 1a, b.


Description: Test planispiral throughout, much compressed, consisting of a proloculum and long tubular second chamber; the tubular second chamber coiled in slightly involute manner on one side of the test; suture distinct; wall thin, clear, finely perforate; aperture formed by the open end of the tubular chamber.

Diameter, 0.30 mm.; thickness, 0.04 mm.

This species, which has a wide distribution in the ocean today, occurs sparingly at Bermuda, but is present at nearly every station. It is very small.
Genus DISCORBIS Lamarck, 1804

DISCORBIS MIRI Cushman

Pl. 15, figs. 9 a - c.


Discorbis mira Cushman, Carnegie Inst. Washington, Publ. 311, 1922, p. 39, pl. 6, figs. 10, 11; Publ. 344, 1926, p. 77; U. S. Nat. Mus., Bull. 104, pt. 8, 1931, p. 25, pl. 5, figs. 5, 6a-c.

Description: Test typically plano-convex, occasionally biconvex, the dorsal side with three whorls in a low spire, with five to six chambers to a whorl; ventral side with four to six chambers of the last-formed whorl visible; sutures on the dorsal side limbate and very slightly, if at all, depressed, spiral suture not lobate, sutures on the ventral side not limbate, depressed; periphery slightly angled, becoming lobate in adult stages; wall heavy, clear, coarsely punctate with punctations widely spaced; aperture an elongate slit on the inferior margin of the last chamber.

Diameter, 0.59 mm.; height, 0.30 mm.

This is the most abundant species of Discorbis found at Bermuda. It is to be distinguished by its coarse punctations, and reddish brown color which, while typical of the young for most species of this genus, is retained by this species through the young and intermediate stages, being lost only in the adult chambers.
DISCORBIS ORBICULARIS (Terquem)

Pl. 15, figs. 10 a-c.

Rosalina orbicularis Terquem, Anim. sur la Plage de Dunkerque, 1876, p.75, pl.9, figs.4a,b.


Description: Test plano-convex, the dorsal side convex with several whorls and moderately high-spired, the ventral side flattened to concave showing two to three chambers of the last whorl; periphery smooth, circular in outline, angled; chambers increasing rapidly in length as added, the adult chambers typically half a coil or more in length, crescentic; sutures distinct, not depressed; wall varying from clear and translucent to opaque and white, color of the early whorls light brown, finely perforate; aperture an elongate slit on the concave side of the test, beneath a flap-like projection of the last chamber.

Diameter, 0.37 mm.; height, 0.20 mm.

Discorbis orbicularis is not as abundant at Bermuda as Discorbis mira but is generally to be found at most of the stations. Its circular outline and crescentic-shaped chambers distinguish it from other species of this genus.
DISCORBS AUBERII (d'Orbigny)

Pl. 15, figs. 1-3.

Rosaliza auberii d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères", p.94, pl.4, figs.5 to 8.


Description: Test plano-convex to biconvex, the dorsal side definitely convex, and the ventral side flattened with a tendency to become convex in the adult chambers; test slightly inflated; periphery roundly angled, not acutely so, lobate in adults; chambers somewhat inflated in the central portion, rapidly increasing in size, especially in width, as added, five chambers to a coil in the young stages, four to a coil in adults; sutures on the ventral side depressed, nearly straight, radial, on the dorsal side limbate, somewhat curving and oblique, not depressed, spiral suture distinct, not lobate; wall thin, translucent, finely perforate, with a clear unperforated border on each chamber, perforations sparse near the umbilical area on the ventral side; aperture a narrow slit extending from the periphery almost to the umbilicus.

Diameter, 0.50 mm.; height, 0.23 mm.

This species is fairly common at Bermuda. As developed at Bermuda it seems to be intermediate between several species, as it has characteristics which would identify it with Discorbis auberii, D. bertheloti, and D. nitida, but does not conform wholly to any of these. It seems nearest to Discorbis auberii (d'Orbigny). The radial sutures on the ventral side and the fine perforations distinguish it from other species of Discorbis at Bermuda.
Genus Siphonina Reuss, 1850

Siphonina Pulchra Cushman

Pl. 16, figs. 40, 8.


Description: Test nearly circular from side view, equally biconvex from edge view; periphery acute; chambers distinct, five in the last whorl, not inflated; sutures slightly depressed on the ventral side, somewhat limbate on the dorsal side; wall translucent, ornamented with transverse undulations and crenulations at the periphery, and with papillae and coarse perforations away from the periphery; aperture elliptical, at the end of a short, raised neck, with a slightly everted lip.

Diameter, 0.50 mm.

This species is rare at Bermuda, but is sufficiently well-developed to make identification with the West Indian species certain. It is found at the mud-bottomed stations and at the stations among the reefs.
Family AMPHISTEGINIDAE

Genus AMPHISTEGINA d'Orbigny, 1826

AMPHISTEGINA LESSONII d'Orbigny

Pl. 17, figs. 6a-c.


Amphistegina gibbosa d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. de Cuba, 1839, "Foraminifères", p.120, pl.8, figs.1-3.

Description: Test biconvex, compressed, the periphery acute; chambers numerous, simple, bending back upon the preceding chambers near the periphery, supplementary chambers bending backward at the periphery also; sutures limbate and angled; aperture a small slit on the ventral side at the base of the terminal face of the last supplementary chamber.

Diameter, 0.75 mm.; thickness, 0.28 mm.

This species is rare at Bermuda, but its handsome suture pattern renders it very noticeable wherever it occurs.
Family CYMBALOPORETTIDAE

Genus CYMBALOPORA Hagenow, 1850

CYMBALOPORA BRADYI Cushman

Pl. 13, figs. 1a-c.

Cymbalopora bradyi Cushman, Carnegie Inst. Washington, Publ. 342, 1924, p. 34, pl. 10, figs. 2-4; Bernice P. Bishop Museum Bull. No. 27, 1925, p. 131.----Macfadyen, Geol. Surv. Egypt, 1930 (1931), p. 97, pl. 4, figs. 7a-c.

Description: Test convex on the dorsal side, concave on the ventral side as in Discorbis; periphery rounded to slightly angled; dorsal side showing early chambers coiled in a low spire and later chambers spreading out flatly in more or less annular series which are irregularly added and which produce a flattened test; ventral side with a simple small depression in the umbilical region not filled with shell material, showing only the chambers of the last coil which have shelly processes which project inward toward the umbilicus but do not become confluent; chambers separated from one another by deep radial depressions which are not true sutures but are produced by the alternating arrangement of the chambers along the periphery; wall translucent, coarsely perforate with perforations widely spaced, early chambers a reddish brown color, later ones colorless; apertures slits underneath the shelly processes of the ventral side.

Diameter, 0.64 mm.; height, 0.25 mm.

This is the first record of this species from the Atlantic as it has hitherto been recorded only from the Pacific. It is not common at Bermuda. Well-developed specimens show that it is a true Cymbalopora, as the above description and accompanying illustrations
show. It may be distinguished from *Tretomphalus* by its more flattened spreading aspect, and may be distinguished from *Planorbulina* and *Acervulina* by its concave hollow umbilical area.

**Genus *TRETOAPHALUS* Moebius, 1880**

*TRETOAPHALUS BULLOIDES* (d'Orbigny)

Pl. 16, figs. 1a-c.


*Cymbalopora bulloides* of authors.


**Description:** Test with the dorsal side convex and the ventral side concave, circular in outline, with the early chambers coiled in a spire as in *Discorbis*, the later chambers spreading out in a more flattened manner; chambers becoming slightly larger and more inflated as added; sutures depressed on both sides of the test, simple, without processes of shelly material on the ventral side; wall coarsely perforate throughout; color, in the early chambers of some specimens, a reddish brown; aperture a narrow slit near the periphery on the inner margin of the last chamber.

Diameter, 0.44 mm.; height, 0.24 mm.

The Bermuda specimens do not show the "float chamber" which is
characteristic of the genus, but this is probably developed only at certain seasons of the year. This genus and related genera are, at the time of this writing, receiving careful study from Dr. Cushman, and it is possible that the Atlantic species will be referred to another genus. The Bermuda material seems to on the border between Discorbis and Tretomphalus.

Family GLOBIGERINIDAE

Genus GLOBIGERINELLA Cushman, 1927

GLOBIGERINELLA AEQUALATERALIS (H.B.Brady), var. INVOLUTA (Cushman)

Pl. 16, figs. 5a,b.


Description: Test small, planispirally coiled, involute, each coil nearly covering the preceding coil; chambers inflated, globular, rapidly increasing in size as added; wall rough with very short spines; aperture an arched slit at the base of the last chamber and superposed upon the periphery of the preceding coil.

Diameter, 0.35 mm.; thickness, 0.22 mm.

This species is more closely coiled and involute than the specimens figured by Brady, but agrees with Cushman’s figures for the variety. It is not common in the shallow water at Bermuda but is probably more abundant in deeper water. It is very close to specimens from the Gatun Formation Miocene.
Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA TRUNCATULINOIDES (d'Orbigny)

Pl. 16, figs. 6a-c.


Pulvinulina truncatulinoides Parker and Jones, Philos. Trans., vol. 155, 1865, p.396, pl.16, figs.41-43.----Rhumblar, in Brandt, Nordische Plankton, Heft.14, 1900, p.17, fig.16.----Cushman, U. S. Nat. Mus., Bull.71, pt.5, 1915, p.59, pl.23, fig.4; Bull.100, vol.4, 1921, p.339, pl.67, figs.2a-c.


Pulvinulina repanda, var. menardii, subvar. micheliniana Parker and Jones, Philos. Trans., vol.155, 1865, p.396, pl.14, fig.16; pl.16, figs.41-43 (not Rotalina micheliniana d'Orbigny).


Description: Test plano-convex, flattened on the dorsal side, convex to conical on the ventral side with an open umbilical area; periphery angled to carinate, with a band of clear, unperforated shell material which gives the impression of a carina; chambers increasing rapidly in thickness as added, five to six in a whorl; sutures limbate on the dorsal side, depressed on the ventral side; wall thin, transparent, finely punctate, smooth except for coarse papillae near the umbilical region in the young; aperture a long narrow slit at the basal margin of the terminal face of the last chamber, extending from the umbilicus nearly to the periphery.
Diameter, 0.52 mm.; height, 0.34 mm.

This species is common at Bermuda, and seems to be common in all parts of the world. It is not as spinose in its external appearance as are other species of the genus.

Family ANOMALINIDAE

Genus PLANULINA d'Orbigny, 1826

PLANULINA DEPRESSA (d'Orbigny)

Pl. 16, figs. 2a,b; 3a,b.


Planulina depressa Cushman, Fla. Geol. Surv., Bull.4, 1930, p.60, pl.12, figs.2a-c.----Cushman and Ponton, Fla. Geol. Surv., Bull.9, 1932, p.100.

Cibicides lobatulus (Walker and Jacob), var. ornatus Cushman, Fla. Geol. Surv., Bull.4, 1930, p.52.

Description: Test nearly planispiral, somewhat involute, typically less involute on the dorsal side than on the ventral side; test somewhat plano-convex, with the dorsal side flattened and the ventral side convex, typically compressed, the last few chambers of accelerated adults showing inflated chambers; periphery subacute with a carina of clear imperforate material in the young, lobate in adults; sutures curving, limbate on the dorsal side, much less limbate and depressed on the ventral side; wall heavy, clear, ornamented with coarse papillae in the young and intermediate stages, coarsely punctate;
aperture an arched slit at the peripheral angle, extending further into the ventral side than into the dorsal side.

Diameter, 0.63 mm.; thickness, 0.21 mm.

This species is fairly common at Bermuda. It is common also in the Miocene of Florida, but has not been recorded from the West Indies since d'Orbigny's 1839 paper, and he recorded it as rare at Cuba and Jamaica. The Bermuda specimens seem to be growing more inflated on the ventral side, and slightly more involute on the ventral side, and resemble Cibicides, as the Miocene specimens do. The Bermuda material seems to be closer to the Miocene, in this case, than to the Recent specimens classified under this specific name. There seems to be a rather wide range of variations for all the material assigned to this species.

Family PLANORBULINIDAE

This family presents a puzzling problem. The forms included in the genera classified here are rather characterless masses of encrusting chambers. They are attached by the dorsal side, spread laterally by growing in irregular annular fashion and conform in shape to the object of attachment, or if the object is small, grow irregularly about it sometimes curling under at the periphery or curling completely about the object. The generic limitations and specific identifications within this family seem to be a moot question. The literature is very confused on this subject, and the type specimens are not available.
The family is represented at Bermuda by two genera, *Planorbulina* d'Orbigny, 1826, and *Acervulina* Schultze, 1854. The genera may be distinguished by the fact that *Planorbulina* has a single layer of chambers and *Acervulina* has more than one layer with the chambers overlapping in scale-like fashion or piled one upon the other.

Genus *PLANORBULINA* d'Orbigny, 1826

**PLANORBULINA MEDITERRANEENSIS** d'Orbigny

Pl. 18, figs. 2a-c.


**Description**: Test attached, flattened, spreading out, the early chambers coiled in an indistinct spiral, later spreading out laterally thus producing a flat test; chambers in a single layer, inflated and globular in appearance on the ventral unattached surface, flattened on the dorsal attached surface, chambers added in an irregular annular fashion; periphery rounded to sharply angled, typically lobate; sutures much depressed on the ventral side, not depressed, limbate, on the dorsal side; wall typically thin and translucent, varying to thick and opaque, the more inflated older specimens being more typically opaque, ornamented with coarse perforations widely spaced; apertures small openings at either side of the chamber with a slightly raised lip.
Diameter, 0.76 mm.; thickness, 0.20 mm.

This species is the only one of the genus to be found at Bermuda where it is more abundant than records would indicate in the West Indies.

**Genus ACERVULINA Schultze, 1854**

**ACERVULINA INHAERENS Schultze**

Pl. 18, figs. 3a-c.


**Gypsina inhaerens** Brady and authors.

**Description:** Test attached, very flattened, spreading laterally, the early chambers coiled, but typically hidden by the following chambers which pile one upon the other in several layers; periphery typically lobate, sharply angled; chambers very much compressed in the plane of the test, thin, frequently overlapping upon one another in scale-like fashion; sutures limbate on the dorsal attached side, slightly depressed on the ventral unattached side; wall thick, opaque, rather finely perforated with closely spaced perforations which form the apertures.

Diameter, 0.80 mm.; thickness, 0.10 mm.

This species is more abundant at Bermuda than *Planorbulina mediterranensis* with which it may be confused. *Acervulina inhaerens* may generally be distinguished by its opaque wall, finer perforations, thin non-inflated chambers, and double or treble layers of chambers.
Family HOMOTREMIDAE
Genus HOMOTREMA Hickson, 1911

HOMOTREMA RUBRUM (Lamarck)


Carpenter, Parker, and Jones, Introd. Foram., 1862, p.235, pl. 13, figs.18-20.


Description: Test attached to the under side of dead corals or pelecypod shells, the early stages coiled, later spreading laterally with stout projecting portions; test honeycombed, reticulate, the walls between the openings solid, the upper surface of each opening typically covered with a very thin, finely perforated plate; long spines and spicules attached to the upper surface of the solid walls, frequently papillate; color light pink to deep red.

The specimens I have found at Bermuda are all broken and eroded and do not show very well the characteristics described above. Good specimens with the sieve plates intact can probably be found there however. The material brought up in dredgings has doubtless been beaten off the reefs by the waves. For purposes of identification, the bright, rosey, pink color and honeycombed test are diagnostic in most cases. The Bermuda specimens, although very abundant, do not warrant illustrating. The pink sand of Pink Beach and many other places owes its color largely to this foraminifer.
V. DATA DERIVED FROM WELL SAMPLES FROM BERMUDA

Samples have been available from a deep well drilled in Bermuda in 1912. The well penetrated nearly 1400 feet, the upper 700 feet of which were in sedimentary rocks, and the lower 700 feet in uneroded igneous rock. Pirsson\(^1\) states that the igneous basement is dominantly a melilite basalt, and finds several flows, each marked at the top by vesicular structures. He found also a second group of lavas of lamprophyric type. I have examined only the sedimentary samples.

These samples of sedimentary rock have been taken in erratic manner from the sand brought up by cable tools used in the drilling and hence the data derived from them cannot be interpreted with the strict accuracy which might be feasible with core samples. All the samples are small, uniform quantities of sand, soil, partially consolidated material, and gravel. One sample may represent 5 feet of sediments drilled through, and the next sample may represent 100 feet of sediments. The procedure followed was to wash and screen one-half of each sample and make paleontological and sedimentary notes on the residue. Thus it will be seen that no correlation can be made with the detailed stratigraphy of "fossil soils" of Bermuda as published by Sayles and other workers in this field, especially as they give no thicknesses for the soils which they discuss.

The sedimentary formations at Bermuda can be divided into three large groups. The upper 383 feet is white partially consolidated "lime sand" of very much broken shells and particles of calcareous

material which vary from coarse to fine-grained. It is evidently a
dune wand slightly consolidated, as it contains worn foraminifera and
land snails with some evidence of cementing of the larger pellets of
calcareous material. Below this there is a thin transition zone, 10
feet thick, of very fine-grained, buff-colored calcareous sand. Below
this, from 393-583 feet, there is a red oxidized formation with coarse
pebbles of gray igneous rock, and much red stain on the cementing
material. From 583 feet to the base of the sedimentary series, at
695 feet, there is a gray unoxidized formation composed of the same
coarse gray pebbles of igneous rock and calcareous cementing material
which were found in the higher bed.

Pirsson\(^1\) was of the opinion that the gray unoxidized bed and the
red oxidized bed represent one formation, the basal portion of which
has been protected from oxidation by its permanent position below
sea-level, and the upper portion of which has been exposed to oxidation
by oscillations of the Bermuda platform or by removal of water from the
ocean by the Pleistocene ice caps. His conclusion was probably
supported by the evidence of the same gray pebbles of igneous material
in both formations. These pebbles are rather scarce in the uppermost
part of the red formation, become very numerous toward its base, and
comprise the major part of the gravel of the lower gray formation.
He assumes that they are the eroded material of the igneous platform.
However, the case seems to be somewhat more complicated than the mere
eroding and oxidation of the original platform.

1. Ibid.
Pirsson finds seven lava flows in the record of the well samples between 695 and 1400 feet. They are marked by vesicular structures at their tops. Most of them he describes as very dense and black at their tops and grading into gray below, and the highest of the flows he describes as basaltic, very dense, and amygdaloidal at the top. These flows vary in thickness from 55 feet to 120 feet. My observations have shown that nearly all the gray pebbles are composed of a light gray ground-mass with comparatively large angular phenocrysts of a black mineral, and occasional pink or white veinlets, which can be seen with ease with a magnification of from 20-30 diameters.

In the red beds there are minerals whose presence Larsen\(^1\) cannot explain. He gives a chemical analysis of the red soils of Bermuda in which \(\text{SiO}_2, 29\%\); \(\text{Al}_2\text{O}_3, 26\%\); \(\text{Fe}_2\text{O}_3, 12\%\); and water, 22\% make up the chief constituents, with \(\text{CaCO}_3, 5\%; \text{MgO, 1.72\%; and } \text{TiO}_2, 1.56\%\) as minor constituents. He also gives data for the mineral residue of these red soils which he treated with dilute hydrochloric acid to remove the calcite and iron oxides before making immersion studies of the residue. Larsen gives the minerals as: quartz, 32\%; pyroxene, 27\%; perovskite, 21\%; magnetite, 7\%; orthoclase, 4\%; glass, 3.5\%; titanite, 2\%; brown garnet, 1\%; plagioclase, 1\%; pink garnet, 0.5\%; and a miscellaneous 1\% of epidote, zircon, tourmaline, rutile, leucoxene, corundum, muscovite, cyanite, staurolite, biotite, spinel, chlorite, and hornblende. Larsen states, "the presence of such typically continental minerals as quartz, orthoclase, pink garnet, zircon, 1. Larsen, E.S., in Sayles, "Bermuda During the Ice Age", Proc. Amer. Acad. Arts and Sci., vol.66, 1931, No.11, pp.439-444.
tourmaline, rutile, muscovite, hornblende, staurolite, and cyanite is quite unexpected in Bermuda. Clearly these minerals are not native to Bermuda and must have been introduced from elsewhere. I have no satisfactory solution of the source of these exotic minerals. The discussion of the foreign minerals in these red beds is included here because it affords a parallel to the problem of the fauna of the red beds, and also affirms the complex aspect of the Bermuda geology.

The foraminifera found in the well samples are all poor specimens, much eroded and broken. The fauna of the upper, white "lime sand" is wholly Recent, and while some of the species which have a long geologic range and which are found in both fossil and recent deposits are not marked in the table as being diagnostic they may be considered as conclusive evidence of a Recent fauna when associated with restricted Recent species. All of the species found in the first 8 samples, or down to a depth of 363 feet, are identical with those found living today in Bermuda or the West Indies.

Below this level, the fauna of the red formation presents an interesting problem. Most of the diagnostic species are referable to the Miocene, Chipola of Florida. In the next to the last sample containing foraminifera there was found *Rotalia armata*, a species known in America only from the Upper Eocene of Florida. It is badly eroded. In the last sample to contain any foraminifera there were found several much worn pieces of what appears to be a foraminifera near the Eocene material identified as *Gypsina globularis*. All foraminifera in the red bed are worn.

1. Ibid. p.443.
From this evidence it is impossible to state the age of the Bermuda sediments with any degree of scientific accuracy. One of three cases may be the actual fact. There may be an Eocene bed at the base followed by a Miocene bed, with the Recent white "lime sand" on top of that with a break representing Pliocene and Pleistocene time. Or there may be a true Miocene bed with a few reworked remnants of an older Eocene bed contained in it. Or the whole of the red bed may be of Pleistocene age but containing reworked Miocene and Eocene foraminifera, which came from older beds somewhere in the vicinity of Bermuda. The extent of the oxidized zone, 200 feet, is in accordance with Daly's calculations of the amount of water removed from the ocean by the Continental Ice Sheets of Pleistocene age, and the oxidized zone on top of an unoxidized zone at least gives evidence of emergence and atmospheric weathering. In any of these cases it is necessary to postulate a Miocene fauna living somewhere in the neighborhood of Bermuda, whether in situ in the red bed or in sediments which were reworked into the red bed. The reworked theory is upheld by the fact that the only common species of foraminifer is a heavy-walled resistant Amphistegina which may have been the only species to withstand the eroding.

A log of the well, giving sample numbers with depths, paleontological notes, and remarks as to the character of the sediments is offered herewith.
## VI. LOG OF SAMPLES FROM DEEP WELL

**AT BERMUDA**

<table>
<thead>
<tr>
<th>Sample No. and Depth</th>
<th>Fauna Contained</th>
<th>Character of Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td>#2 61-110</td>
<td>Quinqueloculina lamarckiana, Archaia angulatus, Triloculina reticulata (Recent), Elphidium sagrum, Eponides sp., Asterigerina carinata (Recent), Land gastropods</td>
<td>Coarse, rounded, calcareous pebbles and organic fragments. A few signs of consolidation of material. White.</td>
</tr>
<tr>
<td>#3 110-216</td>
<td>Eponides cf. umbonata (Recent), Land gastropods</td>
<td>Same.</td>
</tr>
<tr>
<td>#4 216-241</td>
<td>Amphistegina lessonii, Homotrema rubrum (Recent), Asterigerina carinata (Recent), Quinqueloculina ? agglutinans ? Land gastropods</td>
<td>Very well rounded calcareous and organic fragments. Not cemented together. White.</td>
</tr>
<tr>
<td>#5 241-286</td>
<td>Barren</td>
<td>Very fine &quot;lime sand&quot;, angular fragments. White.</td>
</tr>
<tr>
<td>#</td>
<td>286-331</td>
<td>Barren</td>
</tr>
<tr>
<td>-----</td>
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<td>--------------------------------------------</td>
</tr>
<tr>
<td>#7</td>
<td>331-341</td>
<td>Asterigerina ? carinata ? (Recent)</td>
</tr>
<tr>
<td>#8</td>
<td>341-383</td>
<td>Amphistegina cf. lessonii (becoming much stouter than typical Recent specimens) (abundant)</td>
</tr>
<tr>
<td>#9</td>
<td>383-393</td>
<td>Amphistegina chipolensis (Miocene) (abundant) Hanerina bradyi var. (specimens typical of Florida Miocene, not typical of Recent Bermuda)</td>
</tr>
<tr>
<td>#13</td>
<td>505-518</td>
<td>Barren</td>
</tr>
<tr>
<td>Sample No. and Depth</td>
<td>Fauna Contained</td>
<td>Character of Sediment</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
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</tr>
<tr>
<td>#14 518-544 ft.</td>
<td>Barren</td>
<td>Very fine, well rounded, thoroughly oxidized red grains.</td>
</tr>
<tr>
<td>#15 544-550</td>
<td>Barren</td>
<td>Mostly very fine material, light brown mud removed in washing. Residue: black grains of igneous rock, a few stained quartz and calcite grains, also larger pebbles of gray igneous rock with pink veinlets.</td>
</tr>
<tr>
<td>#18 573-574</td>
<td>Barren</td>
<td>Unoxidized. Very fine black mud when wet. Fine black dust when dry. A few white rough pellets, possibly amygdaloids.</td>
</tr>
<tr>
<td>#19 574-578</td>
<td>Barren</td>
<td>Partially oxidized. Large rounded igneous pebbles.</td>
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</tr>
<tr>
<td>#21</td>
<td>583-645</td>
<td>Unoxidized. Very coarse, large pebbles of dark gray igneous rock.</td>
</tr>
<tr>
<td></td>
<td>Barren</td>
<td></td>
</tr>
<tr>
<td>#22</td>
<td>645-665</td>
<td>Unoxidized. Same as #21</td>
</tr>
<tr>
<td></td>
<td>Barren</td>
<td></td>
</tr>
<tr>
<td>#23</td>
<td>665-695</td>
<td>Unoxidized. A few coarse pebbles of dark gray igneous rock. Large lumps of white or grayish brown kaolin with small crystals of black mineral intact and imbedded in the kaolin.</td>
</tr>
<tr>
<td></td>
<td>Barren</td>
<td></td>
</tr>
</tbody>
</table>
VII. SOURCES OF THE BERMUDA FAUNA

The accompanying table gives a list of the species and varieties of foraminifera found at Bermuda. The table shows also which species are living today in the West Indian region, which are of widespread distribution in all recent oceans, which are characteristic of the Indo-Pacific, and which are found fossil in the surrounding Caribbean basin. Out of the 112 species and varieties found at Bermuda, 86 of these are found today in the West Indian region. Hence the fauna is very similar to that of Tortugas, Cuba, Porto Rico, and the coast of Florida.

The Bermuda fauna as presented in this paper is smaller in number of species than the West Indian fauna, but that may be accounted for by the fact that no stations over ten fathoms in depth were available from Bermuda, while many deeper-water stations are represented in the collections from the West Indies. The Bermuda material which I have observed lacks such genera as Robulus, Dentalina, Marginulina, Nodosaria, Vaginulina, Polymorphina, Guttulina, and shows a very poor assemblage of species of Lagena and Globigerina. All of these genera are practically confined to below the ten fathom line. Hence it is to be expected that the Bermuda fauna from shallow-water and deeper-water stations combined would very nearly parallel that of the West Indies.

The Bermuda fauna is what is termed a "diluted fauna". Such a fauna is closely related to another richer fauna from a nearby region whence it migrated, but lacks some of the genera and species which
were unable to make the migration. A few genera and species characteristic of shallow water in the West Indies were not found at Bermuda, such as Bigenerina, Spiroloculina grateloupii, S. ornata and S. eximia, Textularia mayori, and T. rugosa. However, the Bermuda fauna is not considered an excellent example of a "diluted fauna" because there are not many outstanding examples of absent shallow-water foraminifera. The species of Clavulina, Quinqueloculina, Triloculina, Massilina, Articulina, Pyrgo and Elphidium equal in number the species found at Tortugas, generally the identical species. The drift of the Gulf Stream past Bermuda probably accounts for the unusually large number of West Indian foraminifera present in Bermuda. Other isolated islands such as Hawaii which have a "diluted fauna" do not have such excellent transportation from the mainland for their fauna and hence shows fewer species. Probably the young of the West Indian species float along in the Gulf Stream, or attach themselves to floating masses of sargasso. When the young floating stage of a benthonic species is very short, its representatives sink out of the Gulf Stream into the deeper water before Bermuda is reached at the normal rate of the Gulf Stream. Thus the life-cycle of the species missing at Bermuda doubtless explains their absence.

The Bermuda fauna may have been derived, in part, from the Miocene of Florida and the Caribbean basin. Of the 112 species from Bermuda 35 of these can be traced to the Miocene of Florida and Santo Domingo. This fact is not of great note because all of the West Indian fauna bears the same relation to the Miocene, tracing its ancestry in 30 to 50 per cent of the species directly to the Miocene. However, in Chipola time, Lower Miocene, a shallow-water fauna was living in
Florida. Well samples from Bermuda show that Chipola species are present there also. Hence it is logical to assume that part of the Bermuda fauna migrated thither in Lower Miocene time and has been evolving there since then.

There are certain species rare at Bermuda which are at present characteristic of and most abundant in the Indo-Pacific. These rare species are also found in the West Indies. Their fossil derivation is often a moot question, but Cushman believes that the West Indian specimens are persistent remnants of species which were previously more abundant in the Atlantic and are now well-developed only in the Pacific. Some of these species are: Cymbalopora bradyi, Triloculina bertheliniana, Hauerina ornatissima and Buliminella milletti. They have no especial bearing on the sources of the Bermuda fauna but are of biological interest. They are to be contrasted with such forms as Archaeas angulatus and Olevulina nodosaria and Articulina cassia which are characteristic solely of the West Indian region and have been so since far back in Tertiary time. The Tertiary migrations between the Atlantic and Pacific cannot be correlated satisfactorily across the Isthmus of Panama because the Gatun Miocene carries a fauna characteristic of very deep water, and the Emperador and Culebra Oligocene formations are heavy limestones with only Orbitoid fauna.
VIII. TABULAR ARRANGEMENT OF

FOSSIL AND RECENT DERIVATIONS OF THE BERMUDA FAUNA

SPECIES OCCURRING AT:

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<th>Species</th>
<th>Recent</th>
<th>Recent Elsewhere</th>
<th>Pliocene</th>
<th>Miocene</th>
<th>Oligocene</th>
<th>Eocene</th>
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REOPHACIDAE

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<tr>
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</tr>
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MILIOLIDAE

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<td>Species</td>
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**SPECIES OCCURRING AT:**

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IX. CONCLUSIONS

A detailed study of the Recent fauna of Bermuda from many dredging stations about the islands has established the fact that the fauna is more restricted than that of the West Indian region, although it is similar in many ways. It may be termed a "diluted" fauna. Foraminifera contained in well samples from a deep boring at Bermuda show conclusively that there is a fauna older than the Recent one. Whether this can be dated as Miocene or Eocene cannot be definitely stated on the basis of the available broken specimens. The eroded and broken condition of these specimens may indicate that they are from a reworked bed, and the date of the reworking is suggested as possibly Pleistocene. It seems reasonable to assume, however, that the original Miocene or Eocene beds were in the near vicinity of Bermuda.

A comparison of the three faunas, from Bermuda, from the West Indies, and from the Miocene of Florida leads to the conclusion that the Bermuda fauna was derived in part from the Miocene of Florida, and in part from the West Indian Recent fauna. The presence of Lower Miocene foraminifera in the well samples indicate that part of the Bermuda fauna had migrated there by early Miocene time.
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EXPLANATION OF PLATES

PLATE 1.

Figures  1a,b. *Ammobaculites reophaciformis* Cushman. X 27. From off Ely's Harbor. a, side view; b, apertural view.

2a-c. *Ammobaculites reophaciformis* Cushman, var. *parvum* Carman, n.var. X 33. Holotype. From middle of Crow Lane. a, side view; b, edge view; c, apertural view.


5, 6. *Reophax communis* Lacroix. X 60. From middle of Crow Lane. Figure 5, side view; figure 6, apertural view.

7a,b. *Spiroplectammina delicatula* (Cushman and Kellett). X 60. From middle of Crow Lane. a, side view; b, edge view.


9a,b. *Textularia candiana* d'Orbigny. X 20. From Bermuda. a, side view; b, edge view.

10a,b. *Textularia agglutinans* d'Orbigny. X 22. From Bermuda. a, side view; b, edge view.

Figures 1a-c. **Textularia conica** d'Orbigny. X 40. From Bermuda. a, side view; b, edge view; c, apertural view.

2a,b. **Textularia conica** d'Orbigny. After d'Orbigny.

3a,b. **Textularia floridana** Cushman. X 20. From Hogfish Cut. a, side view; b, edge view.

4a-c. **Trochammina inflata** (Montagu). X 33. From middle of Crow Lane. a, dorsal side; b, ventral side; c, edge view.

5a,b. **Clavulina tricarinata** d'Orbigny. X 20. Both specimens from Hogfish Cut. Figure 5, microspheric form; a, side view; b, apertural view; figure 6, megalospheric form.

7, 8. **Clavulina nodosaria** d'Orbigny. X 22. From Mangrove Bay off King's Point. Figure 7, side view; figure 8, apertural view.

9, 10. **Valvulina oviedoiana** d'Orbigny. X 20. Figure 9 from Castle Roads. Figure 10 from Nonsuch Scaur. Figure 9, side view; figure 10, apertural view.

11, 12. **Valvulina laevis** Carman, n.sp. X 20. From near Pigeon Rocks. Figure 11, side view; figure 12, apertural view.
Figures 1a-c. *Quinqueloculina agglutinans* d'Orbigny. X 27. From north side of Castle Harbor. a, b, opposite sides; c, apertural view.

2a-c. *Quinqueloculina agglutinans* d'Orbigny, var. *bidentata* d'Orbigny. X 40. From north side of Castle Harbor. a, b, opposite sides; c, apertural view.

3-6. *Quinqueloculina tropicalis* Cushman, var. *bermudiensis* Carman, n.var. X 47. From Long Bay. Figure 4, Holotype. Figures 3, 5, 6, Paratypes showing variations. Figure 3, apertural view.

7a-c. *Quinqueloculina poeyana* d'Orbigny. X 47. From Long Bay. a, b, opposite sides; c, apertural view.

8a-c. *Quinqueloculina subpoeyana* Cushman. X 56. From middle of Dolly's Bay. a, b, opposite sides; c, apertural view.

9a-c. *Quinqueloculina subpoeyana* Cushman. X 56. From middle of Crow Lane. Specimen showing variation of the species.

10a-c. *Quinqueloculina funafutiensis* (Chapman). X 47. From north side of Castle Harbor. a, b, opposite sides; c, apertural view.


Figures 1a-c. Quinqueloculina versatilis Carman, n.sp. X 33. From entrance to Mangrove Bay. Holotype. a, b, side views; c, edge view.

2, 3. Quinqueloculina versatilis Carman, n.sp. X 33. From Mangrove Bay. Figure 2, apertural view; figure 3, side view of a smooth individual.

4. Quinqueloculina versatilis Carman, n.sp. X 60. From Mangrove Bay. Transverse section.

5a-c. Quinqueloculina pulchra Carman, n.sp. X 80. From Nonsuch Scaur. a, b, opposite sides; c, apertural view.

6a-c. Quinqueloculina lamarckiana d'Orbigny, var. suberiana d'Orbigny. X 33. From near Pigeon Rocks. a, b, opposite sides; c, apertural view.

7, 8a-d. Quinqueloculina parkeri (H.B.Brady), var. occidentalis Cushman. X 60. Figures 8a-d, from Hogfish Cut. a, b, opposite sides; c, apertural view; d, edge view. Figure 7, from Nonsuch Scaur.
Figures 1a-d. Quinqueloculina berthelotiana d'Orbigny. X 60. From Nonsuch Sound. a, b, opposite sides; c, apertural view; d, edge view.

2. Quinqueloculina berthelotiana d'Orbigny. X 60. From Castle Roads. Edge view of bicarinate specimen.

3a-c. Quinqueloculina polygona d'Orbigny, var. unicarina Carman, n.var. X 60. From head of Mangrove Bay. a, b, opposite sides; c, apertural view.

4a-c. Quinqueloculina alifera Carman, n.sp. X 47. From Hogfish Cut. a, b, opposite sides; c, apertural view.

5a-c, 6. Quinqueloculina polygona d'Orbigny. X 60. Figures 5a-c, from Long Bay; figure 6, from east of Monkey Hole. Figures 5a, b, opposite sides; figures 5c and 6, apertural views.
PLATE 6.

Figures 1a-d. *Quinqueloculina sulcata* d'Orbigny, var. *atlantica* Carman, n.var. X 60. From north side of Castle Harbor. a,b, opposite sides; c, apertural view; d, edge view.

2a,b, 3. *Quinqueloculina bosciana* d'Orbigny. X 47. From off St. Catherine's Point and Long Bay. Figures 2a,b, opposite sides; figure 3, apertural view.

4a-c. *Quinqueloculina granulosa* Carman, n.sp. X 60. From Nonsuch Sound. a,b, opposite sides; c, apertural view.

5a-c. *Quinqueloculina lamarckiana* d'Orbigny. X 47. From Castle Roads. a,b, opposite sides; c, apertural view.

6a-c. *Dentostomina bermudiana* Carman, n.sp. X 27. From north side of Castle Harbor. a,b, opposite sides; c, apertural view.

7a,b. *Schlumbergerina alveoliniformis* (H.B. Brady), var. *occidentalis* Cushman. X 47. From Castle Roads. a, side view; b, apertural view.
Figures 1a-c. Massilina oushmani Carman, n. sp. X 47. From Hogfish Cut. a, b, opposite sides; c, apertural view.

2a,b. Massilina arenata (Cushman). X 47. From middle of Crow Lane. a, side view; b, apertural view.

3a,b. Spiroloculina antillarum d'Orbigny. X 47. From near Pigeon Rocks. a, side view; b, apertural view.

4a,b. Hauerina bradyi Cushman. X 60. From Bermuda. a, side view; b, apertural view.


6a,b. Sigmoilina sp? X 47. From outside northeast entrance to Ely's Harbor.

7a,b. 8-10. Articulina cassia (d'Orbigny), var. macronata (d'Orbigny). X 33. From Long Bay. Figure 7a, side view; 7b, apertural view; figures 8, 9, 10, younger specimens.

11. Articulina cassia (d'Orbigny), var. macronata (d'Orbigny). X 60. From Bermuda. Camera lucida outline drawing of transverse section.

Figures 1a,b. Articulina lineata H.B. Brady, var. sinecarina Carman, n.var. X 47. From Long Bay. a, side view; b, aperture view. Young specimen, heavily costate.

2a,b. Articulina lineata H.B. Brady, var. sinecarina Carman, n.var. X 47. From Harrington Sound, Trunk Island Bay. Holotype. a, side view; b, aperture view.

3, 4a,b. Articulina sagra d'Orbigny. X 47. Figure 3, from north side of Castle Harbor; figures 4a,b, from entrance to Mangrove Bay. Figure 4a, side view; b, aperture view. Figure 3, young specimen.


6-8. Articulina mayor Cushman. X 47. Figures 6 and 8 from head of Mullet Bay; figure 7 from west entrance to Ferry Reach. Figures 6 and 8, side views; figure 7, aperture view.

9a-c. Triloculina rotunda d'Orbigny. X 47. From north side of Castle Harbor. a,b, opposite sides; c, aperture view.

10a-c. Triloculina cuvieriana (d'Orbigny), var. nuda Carman, n.var. X 60. Young specimen showing quinqueloculine stage. From north side of Castle Harbor. a,b, opposite sides; c, aperture view.

11a-c. Triloculina cuvieriana (d'Orbigny), var. nuda Carman, n.var. X 60. From outside Ely's Harbor. Typical adult specimen. a,b, opposite sides; c, aperture view.

12a-c. Triloculina oblonga (Montagu). X 47. From Nonsuch Sound. a,b, opposite sides; c, aperture view.

Figures 1-4. Triloculina linneiana d'Orbigny. X 27. Figures 1,2 from Long Bay; figures 3,4 from entrance to Mangrove Bay. Figure 2, typical adult; figure 1, apertural view; figures 3,4, adults with finer costae showing variation of the species.

5,6a,b. Triloculina planociana d'Orbigny. Figure 5, X 37; very large adult; from Harrington Sound, Trunk Island Bay; apertural view. Figures 6a,b, X 47; typical adult; from north side of Castle Harbor; a,b, opposite sides.

7-10a,b. Triloculina cuvieriana (d'Orbigny). X 33. Figure 7, from outside northeast entrance to Ely's Harbor; figure 8, from Long Bay; figure 9, from head of Mullet Bay; figures 10a-c, from inside southeast entrance to Ely's Harbor.

11a-c. Triloculina grandis Carman, n.sp. X 33. From Hogfish Cut. a,b, opposite sides; c, apertural view.

12-14a,b. Triloculina reticulata d'Orbigny. X 47. Figure 12, from Nonsuch Sound; specimen irregularly bicarinate becoming tricarinat; figure 13, from Nonsuch Sound, specimen with wrinkled surface; figures 14a,b, from off Ely's Harbor, typical non-carinate specimen.
PLATE 10.

Figures 1-5. *Triloculina reticulata* d'Orbigny. X 35. From Bermuda. Camera lucida outline drawings of five different specimens showing variation of keel development, from apertural view.

6-9. *Triloculina reticulata* d'Orbigny. X 35. From Bermuda. Camera lucida outline drawings of four different specimens showing the keel development on the periphery of the last-formed chamber.

10. *Quinqueloculina tropicalis* Cushman, var. *bermudensis* Carman, n.var. X 47. Camera lucida outline drawing, conventionalized to show dual character of the wall.
Figures 1a-c. *Triloculina quadrilatera* d'Orbigny. X 47. From north side of Castle Harbor. a, b, opposite sides; c, apertural view.

2a, b. *Triloculina bertheliniens* (H.B. Brady). X 47. From Hogfish Cut. a, side view; b, apertural view.

3a, b. *Triloculina tricarinata* d'Orbigny. X 47. From north side of Castle Harbor. a, side view; b, apertural view.

4a, b. *Triloculina trigonula* (Lamarck). X 47. From north side of Castle Harbor. a, side view; b, apertural view.

5-7. *Miliolinella labiosa* (d'Orbigny). X 47. Figures 5a-c, from north side of Castle Harbor, typical adult specimen; figures 6a, b, 7, from Harrington Sound, Trunk Island Bay, very large, ventricose adults.

8a-c, 10. *Miliolinella suborbicularis* (d'Orbigny). X 47. From north side of Castle Harbor. a, b, opposite sides; c, apertural view. Figure 10, large adult showing massiline coiling.

9a-c. *Miliolinella circularis* (Bornemann). X 40. From Long Bay. a, b, opposite sides; c, apertural view.

11a-c. *Pyrgo denticulata* (H.B. Brady). X 33. From middle of Dolly's Bay. a, side view; b, edge view; c, apertural view.

12a, b. *Pyrgo subsphaerica* (d'Orbigny). X 33. From Nonsuch Scaur. a, side view; b, apertural view.

13a, b. *Pyrgo striolata* (H.B. Brady). X 33. From Hogfish Cut. a, side view; b, edge view.

14a, b. *Pyrgo subsphaerica* (d'Orbigny), var. *costata* Carman, n.var. X 33. From Harrington Sound, Green Bay. a, side view; b, edge view.
Figures 1a,b. *Coronaspina involvens* (Reuss). X 60. From Bermuda. a, side view; b, edge view.

2a,b. *Planispirina auriculata* Egger. X 60. From off St. Catherine's Point. a,b, opposite sides.

3a,b. *Nodobaculina antillarum* (Cushman). X 47. From head of Mullet Bay. Figure 3a, side view of large broken specimen; 3b, apertural view; figure 4, side view showing early coiled portion.


6a,b. *Peneroplis bradyi* Cushman. X 47. From Bermuda. a, side view; b, apertural view.


8a,b. *Spirolina* sp? X 33. From entrance to Mangrove Bay. a, side view; b, apertural view.

9a,b. *Monalsidium lituus* (Gmelin). X 60. From west entrance to Ferry Reach. a, side view; b, apertural view.


11a,b. *Borelis pulchra* (d'Orbigny). X 60. From off St. Catherine's Point. a, apertural view; b, end view.
Figures


Figures 1, 2. *Amphisorus hemprichii* Ehrenberg. X 30. From Bermuda.  
Figure 1, large adult; figure 2, young specimen showing large initial chamber.

Figures 1a,b. *Spirillina vivipara* Ehrenberg. X 95. From west entrance to Ferry Reach. a, side view; b, edge view.

2a,b. *Elphidium sagrum* (d'Orbigny). X 40. From Nonsuch Scaur. a, side view; b, apertural view.

3a,b. *Elphidium discoidale* (d'Orbigny). X 60. From Mangrove Bay, off King's Point House. a, side view; b, apertural view.

4a,b. *Siphogenerina raphana* (Parker and Jones). X 47. From middle of Crow Lane. a, side view; b, apertural view.

5a,b. *Bolivina cf. beyrichi* Reuss. X 90. From Mangrove Bay, off King's Point House. a, side view; b, apertural view.

6a,b. *Loxostomum mayori* Cushman. X 60. From St. George's Channel. a, side view; b, apertural view.

7a,b. *Bolivina rhomboidea* (Millett). X 90. From Nonsuch Scaur. a, side view; b, apertural view.

8a,b. *Buliminella milletti* Cushman, MS. X 100. From Hogfish Cut. a, side view; b, apertural view.

9a-c. *Discorbis mira* Cushman. X 47. From middle of Crow Lane. a, dorsal view; b, ventral view; c, peripheral view.

10a-c. *Discorbis orbicularis* (Terquem). X 60. From Nonsuch Scaur. a, dorsal view; b, ventral view; c, peripheral view.

11a-c. *Discorbis auberi* (d'Orbigny). X 47. From Nonsuch Scaur. a, dorsal view; b, ventral view; c, peripheral view.
Figures 1a-c. Tretomphalus bulloides (d'Orbigny). X 60. From Nonsuch Scoir. a, dorsal view; b, ventral view; c, peripheral view.

2a,b, 3a,b. Planulina depressa (d'Orbigny). X 47. From Nonsuch Scoir. Figure 2, a large inflated adult; a, ventral view; b, peripheral view. Figure 3, a normal adult; a, dorsal view; b, peripheral view.

4a,b. Siphonina pulchra Cushman. X 47. From Long Bay. a, dorsal side; b, ventral side.

5a,b. Globigerinella aequilateralis (H.B.Brady), var. involuta (Cushman). X 60. From Nonsuch Scoir. a, side view; b, peripheral view.

6a-c. Globorotalia truncatulinoides (d'Orbigny). X 47. From Castle Roads. a, ventral view; b, dorsal view; c, peripheral view.
PLATE 17.

Figures 1a, b. Bolivina pulchella (d'Orbigny). X 80. From Hogfish Cut.  
a, side view; b, apertural view.

2a, b. Reussella spinulosa (Reuss). X 47. From Hogfish Cut.  
a, side view; b, apertural view.

3a, b. Angulogerina occidentalis (Gushman). X 80. From Nonsuch  
Scaur. a, side view; b, apertural view.

4. Loxostomum mayor (Gushman). X 40. From middle of Crow  
Lane. Side view.

Side view.

6a-c. Amphistegina lessonii d'Orbigny. X 40. From Bermuda.  
a, dorsal side; b, ventral side; c, apertural view.
Figures 1a-c. Cymbalopora bradyi Cushman. X 47. From Mangrove Bay off King's Point House. a, dorsal side; b, ventral side; c, peripheral view.

2a-c. Planorbulina mediterranensis d'Orbigny. X 40. From Nonsuch Scour. a, dorsal side; b, ventral side; c, peripheral view.

3a-c. Acervulina inhaerens Schultze. X 40. From Mangrove Bay off King's Point House. a, dorsal side; b, ventral side; c, peripheral view.

4a,b. Elphidium poeyanum (d'Orbigny). X 60. From Mangrove Bay off King's Point House. a, side view; b, peripheral view.

5a,b. Nonion grateloupi (d'Orbigny). X 60. From Nonsuch Scour. a, side view; b, peripheral view.