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CONTENTS OF VOLUME 76

INDEX

No separate index is included in the volume. Each number is indexed separately. Contents of the volume are listed in the begining of the volume.

BULLETINS OF AMERICAN PALEONTOLOGY

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No. 306

LEPADOMORPH AND VERRUCOMORPH BARNACLES (CIRRIPEDIA) OF FLORIDA AND ADJACENT WATERS, WITH AN ADDENDUM ON THE RHIZOCEPHALA

By

Norman E. Weisbord

1979

Paleontological Research Institution
Ithaca, New York 14850, U.S.A.

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By

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CONTENTS

TABLES

LEPADOMORPH AND VERRUCOMORPH BARNACLES (CIRRIPEDIA) OF FLORIDA AND ADJACENT WATERS WITH AN ADDENDUM ON THE RHIZOCEPHALA

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ABSTRACT

Fifty-eight species of barnacles belonging to the families Heteralepadidae through Verrucidae are described, compared, and illustrated, and their ranges and geographic distribution recorded. This report covers the same region as two previous ones (Weisbord, 1975, 1977), and all three constitute a catalogue of most of known non-balanomorph species of Cirripedia except those of the order Ascothoracica. Because of the location and unique configuration of Florida, the area of these reports includes not only that state, but also the surrounding waters of the Gulf of Mexico, the Western Atlantic Ocean, and the Caribbean Sea. Illustrations of all available type species are reproduced herein to facilitate comparison with synonymous species, some of which may prove to be distinct. Three of the species discussed have been reported as fossils, but only one has been confirmed as such. This is *Verruca stroemia* (O. F. Müller) which, in addition to its wide distribution in present seas, is recorded from middle Miocene to Pleistocene age strata in Europe.

Five of the six species discussed in the Addendum should be added to the inventory of Rhizocephala listed in Weisbord (1975).

INTRODUCTION

This, my third report dealing with the non-balanomorph barnacles of the Florida region, is concerned with the individual species within the families Heteralepadidae, Lepadidae, Oxynaspididae, and Poecilasmatidae, in the suborder Lepadomorpha, and within the family Verrucidae in the suborder Verrucomorpha.

The two previous papers (Weisbord, 1975, 1977) dealt with the barnacles of the orders Acrothoracica and Rhizocephala and with the Scalpellidae of the suborder Lepadomorpha. Thus, with the completion of the present paper, most of the living species of non-balanomorph cirripeds in the greater Florida region, with the exception of the order Ascothoracica, have now been annotated, described, and illustrated. In substance the work constitutes a catalogue of the known species within the area and purview of the investigation.

The region encompassed is large, including Florida proper, the Gulf of Mexico, the Western Atlantic Ocean, and the Caribbean Sea. Like many other cirripeds, the lepadomorphs and verrucomorphs may be widely dispersed, and this geographical range, coupled with their relatively short geologic life-span, make barnacles excellent stratigraphic markers where they are preserved as fossils. However, of the 58 species discussed in this work, only three have been recorded as fossils. *Verruca stroemia* (O. F. Müller) has not been documented as living or fossil within the subject area but its eventual discovery therein is remotely possible. The fossil occurrences of *V. stroemia* are in Europe: in the middle to upper Miocene of Italy; the lower to middle Pliocene of Italy and Sicily; the middle to upper Pliocene of England and Italy; the upper Pliocene of Italy; and the Pleistocene of Scotland, England, Norway, and Italy. *Lepas hillii* (Leach) was reported as a fossil from Pliocene deposits near Messina, Sicily. The type of this taxon, a single tergum, was destroyed in the Messina earthquake of 1908, but Withers (1953), noting, on an illustration of the type, a difference in the orientation of the growth lines, doubted that the destroyed tergum belonged to *L. hillii*. *Lepas anatifera* Linnaeus was reported as a fossil from the lower Miocene of New Zealand, but Withers (1953) suggested that this might well be the endemic *L. harringtoni* Laws.

The present work is based nearly entirely on published material, the sources of which are given under References Cited. Most of the holotypes as specified by the original authors are reproduced herein, as are those of species judged synonymous by later taxonomists. My own views concerning the validity of the synonyms are expressed in the body of the work.

I wish to acknowledge with thanks the help given me by Henry R. Spivey of the Florida State University Department of Biological Science, for his garnering of important items of literature, and by Peter R. Hoover of the Paleontological Research Institution for his painstaking editorial supervision.

ABBREVIATIONS OF TYPE REPOSITORIES

ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania.
USNM	National Museum of Natural History, Washington, D.C.

BATHYMETRIC, GEOGRAPHIC AND STRATIGRAPHIC RANGES OF SPECIES

Species	Depth range (meters)	Distribution
Family HETERALEPADIDAE		
Heteralepas belli (Gruvel)	Coastal waters	Cuba
Heteralepas cornuta (Darwin)	90 - 4315	Caribbean, W. Atl., E. Atl., Indian O., E. Pacific
Heteralepas cygnus Pilsbry	?	Monterey, Calif.; West Indies?

Heteralepas lankesteri (Gruvel)	92 - 1497	Caribbean; W. Atl., on cable
Paralepas americana Pilsbry	74 - 147	Florida waters
Family LEPADIDAE		
Lepas anatifera Linnaeus	Pelagic	All seas, 80°N to 57°S Lower Miocene in New Zealand?
Lepas anserifera Linnaeus	Pelagic	Cosmopolitan, 60°N to 35°S
Lepas hillii (Leach)	Pelagic	Cosmopolitan, 60°N to 55°S Pliocene in Sicily?
Lepas pectinata Spengler	Pelagic, but found on sponge in Adriatic	Cosmopolitan, 61°N to 57°S Depth of Adriatic sponge, 422 m
Lepas (Dosima) fascicularis Ellis and Solander	Pelagic	Cosmopolitan, 71°N to 57°S, Siberia to Cape Horn
Conchoderma auritum (Linnaeus)	Pelagic	Cosmopolitan, 71°N to 69°S, Norway to Deception Island
Conchoderma virgatum (Spengler)	Pelagic	Most seas, 66°N to 57°S, Iceland to Cape Horn
Family OXYNASPIDIDAE		
Oxynaspis celata hirtae Totton	?	West Indies
Oxynaspis floridana Pilsbry	92 - 110	Off Palm Beach, Florida
Oxynaspis gracilis Totton	?	West Indies
Oxynaspis patens Aurivillius	125 - 135	Near Anguilla Island
Family POECILASMATIDAE		
Poecilasma inaequilaterale Pilsbry	22 - 2012	W. Atl., Gulf Mex., E. Atl?, Indian O.
Poecilasma inaequilaterale breve Pilsbry	852	Gulf of Mexico
Poecilasma kaempferi litum Pilsbry	313	Straits of Florida, Gulf of Mex.
Poecilasma kaempferi novangliae Pilsbry	357 - 1596	Western Atlantic
Megalasma (Glyptelasma) annandalei Pilsbry	1436	W. Atl., off South Africa
Megalasma (Glyptelasma) gracilius Pilsbry	454 - 945	W. Atl., Caribbean
Megalasma (Glyptelasma) hamatum Calman	368 - 3778	W. Atl., Caribbean, Pacific O., Indian O., Australia, Cuba?
Megalasma (Glyptelasma) subcarinatum Pilsbry	2860 - 2957	Western Atlantic
Megalasma (Glyptelasma) rectum Pilsbry	2860 - 2957	Western Atlantic
Octolasmis americanum Pilsbry	1593 - 2957	Western Atlantic
Octolasmis antiguae (Stebbing)	Shallow water	Caribbean, on palinurids
Octolasmis brevis Pearse	Shallow water	Bahamas, on mud crabs
Octolasmis dawsoni Causey	441 - 736	Florida waters, on crabs
Octolasmis forresti (Stebbing)	Shallow water	Caribbean, Gulf of Mexico

Octolasmis geryonophila Pilsbry	412 - 1861	W. Atl., Gulf of Mexico, Carib., off India, off Japan
Octolasmis hoeki (Stebbing)	±10 - ±30	Caribbean, Gulf of Mex., Cape Verde Islands, E. Atl.
Octolasmis lowei (Darwin)	Near shore to 457	In seas from 41°N to 43°S, and 48°W to 155°E
Octolasmis mülleri (Coker)	Near shore to 30	W. Atl., Gulf of Mexico
Octolasmis prototypus Pilsbry	Shallow water	Montego Bay (Jamaica) on spider crab
Octolasmis sinuata (Pearse) *non* Aurivillius	?	Florida, Australia, SW Pacific, S. Africa, Egypt, off S. Korea, off Japan
Octolasmis uncus Pearse	Shallow water	Bahama Islands
Pagurolepas conchicola atlantica Keeley and Newman	201 - 256	Florida waters
Family VERRUCIDAE		
Verruca alba Pilsbry	83 - 386	Western Atlantic 24° - 35° N and 75° - 80°W
Verruca alba barbadensis Pilsbry	195	Barbados
Verruca alba caribbea Pilsbry	276	Guadeloupe
Verruca calotheca Pilsbry	315 - 832	Western Atlantic; Indomalaysia
Verruca calotheca flavidula Pilsbry	92 - 961	W. Atl., Caribbean Sea
Verruca calotheca heteropoma Pilsbry	517	Caribbean Sea
Verruca entobapta Pilsbry	508 - 808	Western Atlantic
Verruca floridana Pilsbry	74 - 276	Off Palm Beach and Key West, Fla.
Verruca nexa Darwin	61	Cuba; West Indies
Verruca stroemia (O. F. Müller)	Shore to 2439	N. European waters, Medit. Sea, Red Sea, S. Atlantic. Middle Miocene to Pleistocene of Europe
Verruca tarasovi Zevina	1230 - 1700	E. Pacific off Chile
Verruca xanthia Pilsbry	519 - 798	Western Atlantic
Verruca xanthia insculpta Pilsbry	508 - 809	Western Atlantic
Verruca (Altiverruca) bicornuta Pilsbry	3145	W. Atlantic 355 mi. E. of N.Y.
Verruca (Altiverruca) darwini Pilsbry	2844 - 3182	W. Atlantic 39°-41°N and 66°-69°W
Verruca (Altiverruca) gibbosa Hoek	38 - 1895	S. Atl., E. Pacific, Indian O.
Verruca (Altiverruca) hoeki Pilsbry	496	Caribbean Sea
Verruca (Altiverruca) rathbuniana Pilsbry	3253 - 3494	W. Atlantic; Cape Verde Islands
Verruca (Cameraverruca) euglypta Pilsbry	809	W. Atl., off Fernandina, Florida
Verruca (Metaverruca) coraliophila Pilsbry	366 - 798 (?)	W. Atlantic; Gulf of Darien

DESCRIPTION OF SPECIES

Suborder LEPADOMORPHA Pilsbry, 1916

Family **HETERALEPADIDAE** Nilsson-Cantell, 1921

Heteralepas belli (Gruvel) Pl. 1, figs. 1-3

Alepas belli Gruvel, 1901, pp. 258-259; 1902b, p. 44; 1902c, pp. 278-282, pl. 24, figs. 1A, 2, 3, 17-19, 28, 29; 1905, p. 161, fig. 177.

Heteralepas belli (Gruvel), Pilsbry, 1907, p. 101; Annandale, 1909, p. 130; Nilsson-Cantell, 1927, p. 760; Newman, 1960c, p. 109.

Gruvel's original description (1901) is translated as follows:

Diagnosis. — Capitulum nearly triangular, with the anterior border almost straight. No true dorsal crest, but slightly projecting over the entire length. External orifice elongated, narrowed in the upper part but rounded in its lower part.

No scuta.

Cuticle nearly smooth, with only some irregular wrinkles. Dorsal surface absolutely smooth, delimited by a groove.

Peduncle cylindrical in form, separated from the capitulum by a slight contraction of the capitulum.

Caudal appendages with fifteen articles.

Internal rami of the fifth and sixth pairs of cirri atrophied, each bearing twenty-seven articles.

Habitat. — Coasts of Cuba.

This species, dedicated to Professor J. Bell of the British Museum, is close to *A. Lankesteri,* A. Gruvel.

Further descriptive details and excellent illustrations were provided by Gruvel (1902c) in which he stated that the capitulum of the type was 25 mm long and 16 mm wide and the peduncle 32 mm long and 9.5 mm wide.

Type locality. — Coast of Cuba.

Although the coast of Cuba is the only locality thus far recorded, it is anticipated that *Heteralepas belli* will be found eventually in the waters off Florida proper.

Heteralepas cornuta (Darwin) Pl. 1, fig. 6

Alepas cornuta Darwin, 1851, pp. 165-169, pl. 3, fig. 6; Hoek, 1883, pp. 29, 56-59; Weltner, 1897, p. 239, Gruvel, 1902b, p. 44; 1905, pp. 161-162, fig. 178.

Heteralepas cornuta (Darwin), Pilsbry, 1907, p. 101; Broch, 1927, pp. 16-18, 33, 37, pl. 4, figs. 26-29, text-figs. 3a-c; Nilsson-Cantell, 1938, pp. 2, 18, 27-28, as *Heteralepas (Heteralepas)*; Krüger, 1940, p. 2; Newman, 1960c, p. 109; Ross, Cerame-Vivas, and McCloskey, 1964, p. 312; Stubbings, 1964a, pp. 103, 107; 1965, pp. 876, 880; 1967, pp. 231, 239, 307, 312; U.S. Naval Inst., 1967, p. 194; Ross, 1975, pp. 17-20, figs. 1a-i.

The type illustrated by Darwin is about 6 mm long (including the prominence atop the aperture) and 2.6 mm wide (including the carinal prominence). However, the largest specimen examined by Darwin was half an inch long (12.5 mm) and 0.3 inches (4.5 mm) across the capitulum.

The capitulum is globular, slightly flattened, smooth, translucent, and destitute of valves. The orifice is small, slightly protuberant, parallel with the longitudinal axis of the peduncle, with the edges sinuous. Three small flexible, horny, irregular prominences project from the carinal margin — one at the bottom of the capitulum, a second about halfway up it, and a third commonly close to the orifice. The prominences are imperforate, and vary a little in position and character, being either rounded and very small, or flattened and prominent; in the membrane under them there are a few tubuli with summits roughened by minute points and beads of chitin; others, still smaller, are scattered over the whole capitulum.

The peduncle is short, narrower than the capitulum into which it blends insensibly. The peduncle is strongly wrinkled, with a wide attachment surface.

Outer maxillae with the inner bristles divided into two groups; segments of the posterior cirri extremely numerous, each with one pair of main spines; inner rami of the first and sixth cirri rudimentary.

Type locality. — Off St. Vincent Island (13°15′N, 61°12′W), Windward Islands.

Florida locality. — Off Fort Lauderdale (26°08′N, 80°08′W), water depth 90 meters.

Other localities. — North Carolina, off Cape Lookout (34°11′N, 76°08′W), 50 fathoms (91 meters); Eastern Pacific, off Chile (28°18′S, 80°02′W), west of Carrizal Bajo and due south of Islas de Los Desventurados, 4235-4315 meters (Ross, 1975); Eastern Atlantic — Morocco, "Vanneau" sta. 83 (30°27′N, 9°56′10″W), depth of water 125 meters, about 18 statute miles west of Agadir (30°30′N, 9°30′W); Cape Verde Islands — "Calypso" sta. 91 (15°34.5′N, 23°11.5′W), 185 meters; Western Africa — Senegal; Gorée, attached to the crustacean *Paromola cuvieri* together with the barnacles *Trilasmis kaempferi* (Darwin, 1851) and *Scalpellum scalpellum* (Linnaeus); between Kayar (14°53′N, 17°09′W) and 15°30′N, 750 meters, attached to hydroid stem and the bivalve *Pteria atlantica* Lamarck; north of Almadi Point, Cap Vert

(14°43′N, 17°33′W), 160-700 meters, attached to hydroid stem; Indian Ocean (Nilsson-Cantell, 1938).

Heteralepas cygnus Pilsbry Pl. 1, fig. 4

Heteralepas cygnus Pilsbry, 1907, pp. 101-103, text-fig. 35, pl. 5, figs. 7, 8, 12, 13; Annandale, 1909, p. 130; Zullo, 1968a, p. 212.

Although this species is known only from California, it is included here because of Annandale's statement concerning a specimen in the Royal Scottish Museum identified as *Heteralepas cygnus* and labeled "Locality unknown, probably West Indies."

Pilsbry's description of the exterior of *Heteralepas cygnus* was the following:

> The capitulum is oval, its width about three-fourths of the length, not much compressed, the diameter being about half the length; distinctly differentiated from the peduncle, strongly keeled dorsally, integument transversely wrinkled, without hairs or bristles. The orifice is ovate, somewhat exceeding one-third the length of the capitulum. The occludent margin below the orifice is convex.
>
> The peduncle is very long, about three times the length of the capitulum, cylindric, conspicuously wrinkled transversely, widest near the base, tapering slowly to about two-thirds the greatest width at the neck where it joins the capitulum. Along its dorsal side a low ridge continues the keel of the capitulum.
>
> The color is light yellow, sometimes a shade darker, slightly brownish, on the peduncle.
>
> Length of capitulum 23, breadth 18, diameter 12.5 mm. Length of peduncle 70 mm, breadth near the base 12.5, near the capitulum 8 mm . . . .

Type locality. — Monterey, California (36°35′N, 121°55′W).

Other localities. — West Indies?

Heteralepas lankesteri (Gruvel) Pl. 1, fig. 5

Alepas lankesteri Gruvel, 1900a, pp. 195-199, pl. 8, figs. 1-11; 1905, p. 163, fig. 181.

Heteralepas lankesteri (Gruvel), Pilsbry, 1907, p. 101; Annandale, 1909, p. 130; Nilsson-Cantell, 1927, pp. 759-761, pl. 1, fig. 5, text-fig. 7; Newman, 1960c, p. 109.

Gruvel's original description is summarized, in part, as follows:

> The capitulum is entirely devoid of plates, swollen laterally, and covered with a thick, extremely transparent, chitinous envelope ornamented with transverse folds which are especially numerous near the orifice. There are no dorsal crests, but simply a slight continuous ridge extending from the orifice to the base of the peduncle. The orifice forms a short tubular duct in which the cirri are set. In profile the capitulum is semicircular, the anterior part at the base straight and the posterior part regularly curved. The largest capitulum is 20 mm in height, 18.5 mm in breadth, and 8.5 mm in thickness.
>
> The peduncle continues from the capitulum without a break. Broad above, it contracts and is almost cylindrical toward the middle, then enlarges greatly to the base to form its surface of attachment.

The cuticle of the capitulum and peduncle is composed of chitinous processes separated somewhat irregularly. Some of the processes are wide at their base, the summits terminating in three or four pointed branches which are recurved and divergent, forming hooks; others are shorter and simply conical. These processes have nearly the same height in the same zone, the height varying from 4.8 microns to 24 microns. Near the middle of each of these zones is a sensory bristle receiving at its base a distinct nerve filament which is long and slender and terminates in a fine point. The average length of the filaments is 95 to 100 microns. In general the zone of the many-pointed hooks is surrounded by a zone of conical spines, and it is usually also in the zone of hooks that the sensory bristle is placed.

The opening of the capitulum is heart-shaped, and on the median dorsal line there is a circular protuberance delimiting a depression and not a true canal.

The mandibles have four strong teeth on their free margin. The inner branch of the fifth and sixth pairs of cirri are atrophied and unequal.

Type locality. — Mona Channel, between the Dominican Republic and Puerto Rico, 814 fathoms (1497 meters).

Other localities. — Nilsson-Cantell (1927) reported this species from 7°37′S, 34°26′5″W, 50-150 fathoms (92-276 meters), on the St. Vincent-Pernambuco cable, near Goiana, Brazil.

Heteralepas lankesteri is found at a considerable distance from Florida but judging from the northward range of other Cirripedia known in Brazilian-Caribbean waters, its eventual discovery in the Floridan province would not be unexpected.

Paralepas americana Pilsbry Pl. 1, fig. 7, a-e

Paralepas minuta americana Pilsbry, 1953, pp. 16-18, figs. 3a-e; Newman, 1960c, p. 109; Zullo, 1968, p. 211.

Pilsbry's description is summarized as follows:

The capitulum is plump and oval, the carinal region rounded. The surface is smooth, without hairs, marked with irregular stripes of red on a pale gray or gray-buff ground. The vestiges of minute, uncalcified scuta are visible as very short creases below the orifice, which is about a fourth the length of the capitulum, its edges not produced but finely puckered.

The capitulum is 4.5 to 5 mm in length, 5 mm in width, and 4 mm in diameter. The peduncle is 1 to 1.5 mm in length.

The mandible has three teeth at the acute lower point. The maxilla has a deep notch below the upper great spine. The first cirrus has somewhat unequal rami, cirrus II to VI equal rami of about the same length. None of the spines is feathered. The penis is long, measuring 2.3 mm coiled; it is indistinctly annulate, without hairs except for a group at the end.

Type locality. — "Triton" sta. off Palm Beach (26°41′N, 80°02′W), Florida, 60 to 80 fathoms (110-147 meters), on the sea urchin *Cidaris affinis* Philippi.

Other localities. — "Triton" sta. southeast and southwest of

Sombrero Key, Florida (24°38′N, 81°07′W), in 70 and 40 fathoms (129 and 74 meters), respectively.

Because *Paralepas minuta* (Philippi) has "beautifully and conspicuously feathered spines" and *P. minuta americana* has no feathers at all; because the type of *P. minuta* was found in Sicily and the type of *P. m. americana* in Florida; and because the generic name has been changed from *Alepas* to *Paralepas,* I propose that the subspecific rank of *P. m. americana* Pilsbry be raised to the specific rank of *Paralepas americana* Pilsbry.

Family **LEPADIDAE** Darwin, 1851

Lepas anatifera Linnaeus Pl. 2, figs. 1, 2

Lepas anatifera Linnaeus, 1758, pp. 668-669 (with numerous pre-Linnean references); 1761, p. 514; 1764, p. 468; 1767, p. 1109; Mohr, 1786, p. 126, No. 309; Spengler, 1790, pp. 196-197; Bruguière, 1791, p. 144, pl. 166, fig. 1; Gray, 1825, p. 100; Darwin, 1851, pp. 73-77, pl. 1, figs. 1, 1a-c; Chenu, 1858, p. 76; Dyce, 1864. p. 316; Heller, 1865, pp. 253, 267; Verrill *in* Baird, 1873, pp. 382, 392; Verrill, Smith, and Harger *in* Baird, 1873, p. 580, Seguenza, 1876, p. 473; Hoek, 1876, pp. 20, 49, 51, 57; 1883, pp. 4-8, 21, 36-38, 40-42, pl. 1, figs. 1-2; 1907a, pp. 1, 2; 1913, p. xiii; 1914, p. 3; Leidy, 1888b, p. 432; Pilsbry, 1890, p. 443; 1906, p. 193; 1907, pp. 79-80, pl. 9, figs. 3-5; 1927, p. 305; 1927a, p. 37; Aurivillius, 1894, pp. 8, 10, 105, 107; Alessandri, 1894, pp. 256-257, pl. 1, figs. 2a, b; 1906, pp. 229, 269, pl. 14, fig. 9; Weltner, 1895, pp. 288-289; 1897, p. 244; 1897a, pp. 437-438; 1898, pp. 4, 10, 13, 15; 1900, pp. 290-291, 300, 304, 305, 308, 309; 1922, pp. 103, 107; Gruvel, 1902d, p. 524; 1905, pp. 108-109, fig. 120; 1907a, p. 161; 1909, pp. 208, 224; 1912, p. 348; 1920, pp. 35, 36, 67, 69, 71, 73, 75, 81, 83; Nordgaard, 1905, pp. 40, 182; Rathbun, 1905, p. 84; Annandale, 1906a, p. 138; 1909, pp. 73, 74, 128; Stebbing, 1910, p. 563; Fowler, 1912, pp. 41, 42, 44, 148-150, 501, 636, pls. 41, 42, 44, figs. 7, 9, 10; Stephensen, 1915, pp. 56, 71; 1938, pp. 2, 9; Jennings, 1915, pp. 285-290, text-figs. 1a-o, 2; 1918, p. 57; Nilsson-Cantell, 1921, pp. 236-237; 1926, p. 1; 1927, pp. 752-754; 1929a, p. 484, text-figs. 1a-i; 1930, p. 247; 1931b, pp. 105-106; 1938, pp. 2, 20, 27; 1939a, p. 3; 1957, pp. 4, 5, 9, 15, 23, 24; Broch, 1922, p. 266; 1924a, p. 204; 1924b, pp. 7, 8, 11, 12, 45-49, 103, 117, figs. 15a-g; 1927, pp. 15, 33, 37; 1931, p. 128; 1933, p. 5; 1953b, p. 10; Barnard, 1924, p. 50; Krüger, 1927, pp. 2, 7, 15, 16, 30, figs. 2A-B, 25B, 30A; 1940, pp. 2, 17, 21, 22, 34, 63, 67, 68, 69, 112, 125, 129, 135, 225, 229, 328, 342, figs. 20, 23, 66, 67, 122, 125, 126, 229, 238; Vatova, 1928, p. 185; Visscher, 1928, p. 199; Stubbings, 1936, pp. 1, 3, 67; 1961a, pp. 7, 13, 14; 1967, pp. 231, 237; Hiro, 1937, pp. 386, 396-399, figs. 2, 3A; 1939b, p. 204; Oliveira, 1940, pp. 152, 159; 1947, pp. 3, 14, 40; Utinomi, 1949, p. 20; 1958, pp. 267, 306; 1968, pp. 165, 166, 183; 1970, p. 341; Smith, Williams, and Davis, 1950, pp. 134, 137; Behre, 1950, p. 17; Hedgpeth, 1950, p. 76; Cornwall, 1951, pp. 342-343, pl. 6, fig. E; pl. 7, fig. D; 1955, pp. 8-9, figs. 2-3; Graaf, 1952, pp. 1-5; Bouxin and Legendre, 1952, pp. 121, 122; Withers, 1928, pp. xi, 13, fig. 14; 1953, pp. 318, 322, 325, 332, 335; Voss and Voss, 1955, p. 226; Hulings, 1961, p. 216; Patel and Crisp, 1961, pp. 103, 104, fig. 4; Zullo, 1963a, pp. 3, 4, 21, 27, 29, fig. 62; Bassindale, 1964, pp. 28, 33; Moyse and Knight-Jones, 1966, pp. 605, 607, fig. 9; Wells, 1966, p. 88; Utinomi and Kikuchi, 1966, p. 4; MacIntyre, 1966, pp. 637, 638; Newman, 1967b, p. 1053, fig. 8A; 1972a, p. 36; U.S. Naval Inst., 1967, p. 194; Lacombe and Liguori, 1969, pp. 170-180, figs.

1-18; Newman, Zullo, and Withers, 1969, p. R223, fig. 93(12); p. R279, fig. 114, 7; Petriconi, 1970, pp. 541, 545; Gordon, 1970, pp. 8, 28-31, fig. 9; Newman and Ross, 1971, p. 31, pl. VC, text-fig. 7; Kozloff, 1973, pp. 209-210, fig. 163; Arnaud, 1973, pp. 157, 159, 161; Kajihara, Ura, and Tachibana, 1975, pp. 131, 132, 133, 134; Southward, 1975, p. 3.

Lepas anatifa Linnaeus, Chemnitz, 1785, pp. 340-344, pl. 100, figs. 853-855.

Anatifa laevis Bruguière, 1789, pp. 62-63; 1791, p. 144, pl. 166, fig. 1; Gould, 1841, pp. 19, 20, woodcut p. 11; DeKay, 1843, pp. 285, 286; Chenu, 1847, p. 350, fig. 1216; Leidy, 1855, p. 151.

Pentalepas laevis (Bruguière), Blainville, 1825, p. 594, pl. 84, fig. 3.

Anatifa engonata Conrad, 1837, p. 262, pl. 20, fig. 15.

Anatifa dentata Gould, 1841, p. 21, fig. 11.

Lepas anatifera is a variable species with smooth or delicately striated valves that are white, translucent, and thick, with tinges of bluish-gray, brownish-cream, or purple. The terga are relatively narrow, longer than high, subrounded to subangular in front, attenuated behind, and marked by a ridgelet or angulation across the anterior running from the basal angle to the umbo. This angulation is continued on the scutum from its upper angle downward to the umbo. The scuta are large, the basal margin straight to a little concave. The right-hand scutum is fitted with an umbonal tooth that is not present in the left-hand scutum. The interspace between the carina and tergal and scutal valves is not wide. The carina exteriorly is convex, and either relatively smooth or furnished with knobs or long sharp barbs; at the base of the carina there are two prongs diverging from each other at less than a right angle. The peduncle is smooth or wrinkled, its length from barely one, to six or seven times at long as the capitulum. There are never more than two filamentary appendages of variable length on each side of the body.

According to Darwin, the capitulum may attain a length of 5.1 cm, and the longest specimen examined by him was 40 cm, including the peduncle.

This pelagic barnacle is found on the surface of all seas, the depths of which range from shore to 9,200 meters in the Philippine Trench. Latitudinally, *L. anatifera* ranges from the Spitzbergen (Svalbard) Islands, 76° to 81° North, to southeast off Cape Horn, about 57° South.

The species of *Lepas* found in Floridan or nearby waters are *L. anatifera* Linnaeus, *L. anserifera* Linnaeus, *L. fascicularis* Ellis and Solander, *L. hillii* (Leach), and *L. pectinata* Spengler. Of these, according to Pilsbry (1907, p. 79), *L. anatifera* most closely resembles *L. hillii* but is distinguished by the finely, faintly striated valves, the presence of an umbonal tooth in the right scutum, none in the left, and the proximity of the base of the carina to the scutum.

Arnaud (1973, p. 161) suggested, on the basis of the few geographic and morphologic differences between them, that *L. australis* Darwin might be a poorly calcified subspecies of *L. anatifera,* and proposed renaming it *Lepas anatifera australis.*

Florida localities. — Biscayne Bay; Soldier Key, on driftwood; Triumph Reef; East Elliot Key; Boca Chica (24°34′N, 81°40′W); Key West (24°34′N, 81°48′W); Gulf of Mexico — at Panama City (30°10′N, 85°41′W), on driftwood; at St. Andrews State Park, on *Janthina;* at "Albatross" sta. 2379 (28°00′15″N, 87°42′W), about 287 miles west of Dunedin.

Other localities. —

Western Atlantic, Gulf of Mexico, and Caribbean Sea. — Massachusetts: Vineyard Sound; Woods Hole (41°32′N, 70°39′W); Boston (42°20′N, 71°05′W). Rhode Island: off Newport (41°30′N, 71°19′W). New Jersey: Atlantic City (39°23′N, 74°27′W); Beasley's Point. Maryland: "Albatross" sta. 2039, about 360 statute miles east off Berlin. Gulf Stream: "Challenger" sta. 30 (29°5′N, 65°1′W), about 160 statute miles south of Bermuda. Gulf of Mexico, off Mississippi coast. Louisiana: Cameron (29°47′N, 93°19′W); Grand Isle, very common on beach and baydrift. Texas: along coast on driftwood and *Sargassum.* Mexico: Vera Cruz (19°11′N, 96° 10′W). Virgin Islands: St. Thomas (78°22′N, 64°57′W). Windward Islands: Martinique (about 14.5°N, 61°W). Venezuela. Swan Islands. Netherland Antilles: St. Eustatius (Schilpaddenbaai), Curaçao (Caracasbaai). Barbados (Conset Bay). Tobago. Brazil: Rio de Janeiro (22°53′S, 43°17′W); Baia de Guanabara; Bahia coast; Rio Grande do Sul coast. Argentina (Tierra del Fuego). Chile (Cape Horn, 56°S, 67°15′W); "Eltanin" sta. 122 (57°01′S, 63°16′W), southeast off Cape Horn in Scotia Sea.

North Atlantic, Eastern Atlantic, Europe. — Spitzbergen (Svalbard) (81° to 76°N, 11° to 30°E). Greenland (Strömfjord and Giesecke Lake, 65°20′-66°20′N, 49°25′-54°25′W). Between Greenland and Iceland (63°08′N, 31°1′W). Iceland: Kollafjaroarnes (65°38′N, 21°22′W); Vestmannaeyjar (63°25′N, 20°15′W); Grindavík (63°50′N, 22°27′W). Norway: Oslofjord; Kleven; Hå; Stavanger; Kvitengsoy; Haugesund (59°25′N, 5°16′E); Bergen (60° 23′N, 5°20′E); Bergensfjord; Skjaergård; Herdla (60°34′N, 4°56′E); Trondhjemsfjordes, northeast of Trondheim (63°36′N, 10°23′E); Rödöy (66°42′N, 13°05′E); Saltenfjord, Moskenes (67°55′N, 13°E); Svolvar (68°15′N, 14°40′E); Bø (68°38′N, 14°35′E); Tromsø (69°42′N, 19°E); Tørsnes (60°14′N, 6°13′E); Moursund; Ost-Finmarken; Trollfjordsund (68°22′N, 15′E); Porsangerfjord; Vardø (70°22′N, 31°06′E); Rotjes; Obwohl. Shetland Islands (off northernmost point at about 61°N). North Sea (58° 36′N, 1°53′E). Skagerrak Channel. Denmark (Faroe Islands, 54°58′N, 12°E). Helgoland Island (54°09′N, 7°52′E). Belgium, along coast. English Channel. England (Plymouth, 50°23′N, 4° 10′W). France: Le Pouliguen (47°17′N, 2°26′W; Brest (48°23′N, 4°30′W); Le Havre (49°30′N, 0°06′E); La Rochelle (46°10′N, 1°10′W). Adriatic Sea: Rovinj, Jugoslavia (45°05′N, 13°40′E). Italy: Trieste (45°39′N, 13°47′E, Adriatic Sea); Lago di Ganzirri; Messina, Sicily (38°13′N, 15°33′E); Gulf of Naples. Bay of Biscay and vicinity: 46°52′N, 5°30′45″W; 44°11′N, 5°42′W. Spain, Santander (43°28′N, 3°48′W); 43°04′N, 19°43′30″W, between Bay of Biscay and Azores; 42°31′21″N, 17°17′53″W, west of Cabo Finisterre; Isla Alborán (35°57′N, 3°05′W); along coast of Galicia. Portugal (São Vicente, 38°57′N, 7°13′W). Azores Islands and neighboring waters: 41°48′22″N, 22°28′45″W; 39°26′N, 31°21′3″W; 39°38′N, 26°40′W; 39°29′N, 29°01′45″W; 39°22′N, 31°07′45″W; 39°27′05″N, 30°05′W; 38°06′N, 26°57′45″W; 37°16′N, 24°44′ 45″W; 37°16′15″N, 24°45′45″W; Faial (38°35′N, 28°35′W); São Miguel (Ponta Delgada, 37°29′N, 25°40′W); Ilha Madeira (Funchal, 32°40′N, 16°55′E).

Mediterranean-Africa. — Monaco (43°44′N, 17°25′E). Algeria (Cap Ferrat, 35°54′N, 0°25′W). Red Sea. Morocco: Mazagan (33°19′N, 8°35′W); Casablanca (33°39′N, 7°35′W); Fédala (33°43′N, 7°20′W), on cinders, with *Balanus perforatus,* and on cork with *Lepas pectinata.* West Africa: Senegal, off west coast; Liberia (Port Marshall, 6°10′N, 10°23′W); Ghana (Takoradi, 4°55′N, 1°45′W); Nigeria (Lagos, 6°27′N, 3°28′E); Cameroons (along coast). Atlantic Ocean, west of Ascension Island (7°57′S, 14°22′W). Between Cape of Good Hope and Tristan da Cunha (35°59′S, 1°26′E). Between St. Helena (15°58′S, 5°43′W) and

Ilha Trindade (Brazil) [20°30′S, 29°20′W]. South Africa: Cape of Good Hope; Cape Town (33°56′S, 18°28′E). East Africa: Mombasa (4°04′S, 39°40′E), Kenya.

Indian Ocean. — Malagasy Republic (Madagascar). Mauritius (20.5°S, 57.5°E). India: Gulf of Manaar (Cheval Paar); Bay of Bengal (Katchall Island (about 8°S, 43.3°E) in the Nicobar Islands, on floating bamboo. Ceylon (Galle, 6°01′N, 80°13′E). Seychelles Islands (about 55.5°E, 4°S).

Western Pacific. — Chatham Island (44°S, 176°30′W), east of New Zealand. Australia: on buoy recovered at 31°14′S, 153°12′E, about 35 statute miles east off Camden Haven, NSW. Kermadec Islands, north of New Zealand; at Sunday Island (29°15′S, 173° 52′W), mouth of Waitakerei River, washed up on beach. Indonesia: Java Sea (5°32′S, 112°41′E); Sunda Strait, between Java and southern tip of Sumatra, at about 6°S, 106°E; Strait of Malacca (4°20′N, 98°54′E), between northern end of Sumatra and Singapore (1°20′N, 103°50′E). Philippine Islands: Mindanao Sea (8°48′N, 124°09′E), Iligan Bay; Philippine Trench (11°13′N, 126°21′E), about 115 statute miles east off Tugnug Point, Samar. Japan: Kagoshima (31°37′N, 130°32′E) Bay, south Kyushu; Amakusa Island (Tomioka, 33°54′N, 134°40′E), south of Sasebo; Miyakejima Island (about 34°1′N, 139°32′E); Seto Marine Biological Laboratory; Okinoshima Island (34°14′N, 130°05′E); Turuga, Hukui-ken; Misaki (35°10′N, 139°37′E), south of Yokohama; Sasebo (35°10′N, 129°42′E), on ships bottoms; Toyama (36°42′N, 137°14′E) Bay, southwest of Niigata; off Kinkasan (38°16′N, 141°34′E), Miyagi-ken; Niigata (37°58′N, 139°02′E), west coast of Honshu Island; Sado Island (about 38°N, 138.3°E; off Onawaga Bay at 38°27′N, 141°28′E; Syôbutahama, near Matsushima (38°22′N, 140°02′E), Miyagi-ken, on floating timber; Sagami Bay, Hayama (35°16′N, 139°39′E), off Akitani, Issiki, Samezima, on floating bamboo, timber, and buoy; Hukaura, Aomori-ken (40°50′N, 140°43′E), north Honshu; Ryuku Islands, on tar globules.

Central Pacific. — Hawaiian Islands: Molokai Island (Kupehu); Oahu Island (Malaekahama, about 21°34′N, 157°52′W); Johnston Island (16°45′N, 169°32′W).

Eastern Pacific. — Chile: Isla Juan Chiloé (about 43°S, 69°W); Juan Fernández Islands (Cumberland Bay, 33°38′S, 78°20′W);

Amsterdam Island (37°50′S, 77°36′W); Golfo Corcovado (42°50′S, 73°27′W), on light buoy. Panama. California: Santa Catalina Island (33°25′N, 118°25′W), on floating wood; La Jolla. Oregon. Washington. British Columbia coast. Straits of Fuca. Alaska: Unalaska (53°51′N, 166°35′W), Aleutian Islands; Sitka (57°05′N, 132° 20′W); Bering Island.

Fossil occurrence. — *Lepas anatifera* Linnaeus has been reported from the lower Miocene Southland Series of New Zealand by Newman, Zullo, and Withers (1969, p. R279). In an earlier account, Withers (1953, p. 332, fig. 100) suggested that the species in question was *Lepas harringtoni* Laws which resembles *L. anatifera* but lacks the low ridge extending from the umbo to the scutal angle of *L. anatifera.*

Lepas anserifera Linnaeus Pl. 2, figs. 3, 4

Lepas anserifera Linnaeus, 1767, p. 1109; Chemnitz, 1785, pp. 344-345, pl. 100, fig. 856; Darwin, 1851, pp. 81-85, pl. 1, fig. 4; Verrill *in* Baird, 1873, pp. 382, 392; Verrill, Smith, and Harger *in* Baird, 1873, p. 580; Seguenza, 1876, p. 473; Hoek, 1876, p. 57; 1883, pp. 4, 6, 7, 21, 37, 39, 40, pl. 1, fig. 4; 1907a, pp. 1, 2; 1913, pp. vi, xiii, xxii-xxiv; 1914, p. 3; Fischer, 1884, p. 356; Whitelegge, 1889, p. 215; Weltner, 1897, p. 244; 1897a, pp. 438-439; 1898, pp. 10, 13; 1900, p. 308; 1922, pp. 75, 88, 90, 93, 95, 106; Lanchester, 1902, p. 372; Gruvel, 1902d, p. 524; 1905, p. 106, fig. 117; 1907b, p. 163; 1912, pp. 344-345; 1920, pp. 35, 67, 81, 85; Rathbun, 1905, p. 84; Annandale, 1906a, pp. 138, 139; 1909, pp. 73-76; Pilsbry, 1907, pp. 79, 80-81, pl. 8, figs. 1, 3; 1927, p. 306; Fowler, 1912, pp. 150-152, 501, 635, 636, pls. 39, 44, figs. 1-3; Nilsson-Cantell, 1921, pp. 234-235; 1927, p. 752; 1928, pp. 12-15; 1931b, p. 105; 1933, p. 504; 1934, pp. 43, 54-55; 1934b, pp. 32, 38; 1938, pp. 2, 20, 26, 27; 1939a, p. 3; Schaper, 1922, p. 243; Broch, 1924a, pp. 202-204; 1931, p. 128; Barnard, 1924, p. 50; Krüger, 1927, pp. 2, 7, 36; 1940, pp. 78, 256, fig. 82e; Sundara Raj, 1927, p. 111, pl. 14, figs. B1-2; Visscher, 1928, p. 199; Withers, 1928, pp. xii, 48, 49, figs. 77-81; 1953, pp. 318, 325, 327, 386; Stubbings, 1936, pp. 1, 3, 67; 1961a, pp. 7, 14; 1963, pp. 3, 4-5; 1964a, p. 104; 1964b, pp. 328, 330; 1965, pp. 876, 878; 1967, pp. 231, 237, 238; Hiro, 1937, pp. 386, 399-400; 1939a, pp. 246, 248; 1939b, p. 204; Oliveira, 1940, p. 138; Henry, 1940, p. 11; 1954, p. 444; 1960, p. 145; Kolosváry, 1943, p. 70; 1944, p 160; Edmondson, 1946, p. 226, fig. 132b; Utinomi, 1949, p. 20; 1958, pp. 287, 306; 1968, p. 166; 1970, p. 341; Hedgpeth, 1950, p. 76; Graaf, 1952, pp. 1-5; Bouxin and Legendre, 1952, pp. 121, 122; Daniel, 1955, pp. 2, 7, pl. 2, fig. 16; Longhurst, 1958, p. 85; Ross, 1962, p. 6; Zullo, 1963a, pp. 3, 4, 20, 27, 29, fig. 60; 1973, pp. 1, 6; Zevina and Tarasov, 1963, p. 77; Bassindale, 1964, pp. 28, 33; Utinomi and Kikuchi, 1966, p. 4; U.S. Naval Inst., 1967, p. 194; Jones, 1968, pp. 312-313, pl. 1, figs. 1-2; Roskell, 1969, pp. 103-104; Gordon, 1970, pp. 8, 32-35, fig. 10; Bayer, Voss, and Robins, 1970, p. A43; Newman, 1972a, pp. 31-34, figs. 1A-L; Southward, 1975, pp. 3-4.

Anatifa striata Bruguière, 1789, p 64; 1791, pl. 165, fig. 3; Spengler, 1790, pp. 195, 196; Gould, 1841, pp. 20, 21.

Pentalasmis dilatata Leach, 1818, p. 413.

Pentalasmis anseriferus (Linnaeus), Brown, 1844, pl. 51, fig. 1.

Anatifa sessilis (?) Quoy and Gaimard *in* Dumont d'Urville, 1832, pl. 93, fig. 11.

Anatifa anserifera (Linnaeus), DeKay, 1843, p. 254, pl. 34, fig. 315.
Lepas nauta MacGillavray, 1845, p. 300.
Lepas striata Gmelin, Chenu, 1858, p. 76.

Lepas anserifera Linnaeus is a pelagic barnacle, its capitulum composed of five completely calcified plates. The valves are white, thick, and approximate, the terga sometimes equally, sometimes only two-thirds the length of the scuta. The scuta are large, the right-hand scutum with a strong internal umbonal tooth, the left-hand scutum with a small tooth or ridge. There is a marked angulation or ridge running from the apex of the scutum to the occludent angle of the tergum. Both the terga and scuta are sculptured by concentric growth lines and by radial striae and furrows, generally stronger on the terga. The carina is strongly arched and pronged at the base, deeply concave within, and often strongly barbed along the margin. There are generally five, sometimes six filaments on each side of the body. The peduncle is about as long as the capitulum but in young specimens is short. The largest specimen of *L. anserifera* observed by Darwin was 3.8 cm in length.

Although *L. anserifera* resembles *L. pectinata* Spengler, they differ chiefly in the scutum and carina.

> The occludent border of the scutum is strongly arched forming a comparatively wide area between the border and the ridge running from the umbo to the apex of the plate, and the carina is not contracted just above the fork. In *L. pectinata* the ridge on the scutum runs very close to the less arcuate occludent border, leaving but a very narrow area, and the carina viewed dorsally is conspicuously contracted just above the basal fork. (Pilsbry, 1907, p. 80).

Lepas anserifera is a cosmopolitan floating species found on sargassum, driftwood, branches, ships' bottoms, cuttlefish bones, pumice, scoria, logs, and bamboo. It thrives in cold and warm seas but is absent in polar waters. It ranges latitudinally from the Shetland Islands (60°N) to the Cape of Good Hope (35°S). Curiously enough for an otherwise widespread floater, I have seen no definitive record of the presence of *L. anserifera* in the entire length of the Eastern Pacific Ocean off the Americas. Gruvel (1902d, p. 524) reported it from Panama but I do not know whether this refers to the Atlantic or Pacific coast of that country.

Florida localities. — In Florida, *L. anserifera* has been reported from "Albatross" sta. 2674, about 4 kilometers east of Delray Beach; Florida Keys; and in the Gulf of Mexico at "Albatross" sta. 2379, about 287 statute miles west off Dunedin.

Other localities. —

Western Atlantic-Caribbean. — Newfoundland, George's Bank. Massachusetts: Martha's Vineyard; Vineyard Sound; Boston (42°20′N, 71°05′W), on vessels; Nobska Point (41°31′N, 70° 39′W); Cape Cod (40°N, 70°01′W), on whales. New York harbor on ships. New Jersey: Asbury Park (40°14′N, 74°W); "Albatross" sta. 2221 (39°05′N, 70°44′30″W), about 292 statute miles east of Wildwood; "Albatross" sta. 2711 (38°59′N, 70°07′W), about 252 statute miles east off Wildwood; "Albatross" sta. 2584 (39°05′30″N, 73°23′20″W), about 54 statute miles east off Wildwood. Delaware: "Albatross" sta. 2104 (38°48′N, 72°40′30″W), about 133 statute miles east of Cape Henlopen; "Albatross" sta. 2715 (38°29′30″N, 70°54′30″W), about 225 statute miles east off Bethany Beach. Maryland: "Albatross" sta. 214 (38°22′N, 70°17′30″W), about 256 statute miles east off Ocean City; "Albatross" sta. 212 (38°20′N, 70°05′30″W), about 254 statute miles east off Ocean City; "Albatross" sta. 2713 (38°20′N, 70°08′30″W), about 251 statute miles east off Ocean City. Virginia: Smiths Island; Cherrystone; "Albatross" sta. 2097 (37°56′20″N, 70°57′30″W), about 238 statute miles east off Chincoteague. North Carolina: off Cape Hatteras (35°14′N, 75°31′W). Bermuda (off to southeast at 28°46′N, 55° 10′W). Louisiana (Gulf of Mexico at Cameron, 29°47′N, 93°19′W). Texas (along coast in Gulf of Mexico, on driftwood and sargassum); Jamaica. Barbuda. West Indies: Virgin Islands. Netherlands Antilles: Aruba (12°30′N, 70°W) at Boca Oraus; Curaçao (Boca Grande, Caracasbaai, Boca Tabla, and Playa Canoa); Bonaire (12° 15′N, 68°27′W), at Zuidpunt, Cay, and Lagoen. Colombia: "Pillsbury" sta. P382 (10°16′N, 76°W to 10°20′N, 75°54.9′W), on surface, about 60 kilometers southwest of Cartagena in Caribbean Sea; Puerto Rico, off Guayama (18°N, 66°07′W), on buoy. Brazil.

Eastern Atlantic-Europe. — North Sea: Scotland: Shetland Islands; Oban (56°25′N, 5°29′W). Denmark: Copenhagen (55° 54′N, 12°34′E), on ships' bottoms: Helgoland Island (54°09′N, 7°52′E). Ireland: Cork (51°54′N, 8°26′W). France: LeHavre (49°30′N, 0°06′E). Azores Islands and vicinity between 41° and 36°N and 37° and 29°W, on surface; Atlantic Ocean between Azores and Bermuda at 32°N, 43°W; 32°46′N, 58°52′W; 32°30′N, 43° 10′W; between French Guiana and Liberia at 6°15′N, 25°W. Aegean Sea: Greece, off Xanthus (41°07′N, 24°56′E). Between coast of

Sierra Leone and Venezuela. "Calypso" sta. 62, Cape Verde Islands (16°N, 24°W) at São Tiago, between Punta Achada da Baleia and Praia Baixa.

Western Africa. — Between Cap Blanc (20°44′N, 17°05′W), Spanish Sahara and Dakar (14°38′N, 17°27′W). Senegal, at Gorée and Yoff Beach, on cuttlefish bone; elsewhere attached to floating fishing nets. Off coast of Guinea, on fragments of floating bamboo. Off Sierra Leone at 7°30′N, 24°10′W. Liberia: Port Marshall (6°10′N, 10°23′W). Ivory Coast at Port Bouet and Gonzagueville, on driftwood. Ghana: Accra (5°33′N, 0°15′W); Tokoradi; Pramproin. Dahomey (Lagoon Kotonou). Nigeria: Lagos (6°27′N, 3° 28′E); Bibundi (4°16′N, 8°56′E); Debunsha Beach (4°08′N, 8°56′E); Fernando Poo Island. Off Cameroons coast. Equatorial Guinea (Bata). Gabon: off Pointe Matouti at 3°33′S, 10°35′E, small specimens attached to cuttlefish bone; Off Pointe Noire at 4°48′S, 11°30′E, small specimens attached to twigs, woody seeds, and cuttlefish bones. Congo: off Congo River, 6°11′05″S, 10°39′E, with *Lepas fascicularis*. Angola: off Moita Seca at 6°15′S, 11°37′E, with *Lepas fascicularis;* off Pointa do Dandé at 8°29′S, 13°11′E, small and recently metamorphosed species attached to twigs, woody seeds and cuttlefish bones; off Cuanza at 9°22′S, 13°01′E, on floating wood and cuttlefish bone; off Cap Morro at 10°45′5″S, 13°31′E. South Africa: Table Bay; Algoa Bay.

East Africa. — Kenya, Mombasa (4°04′S, 39°40′E). Zanzibar (6°10′S, 39°12′E); Mozambique Channel — 14°20′S, 45°09′E; 13°41′S, 46°40′E, on eel grass near surface, depth of water 3,450 meters. Malagasy Republic, on east coast at Tamatave (18°10′S, 49°23′E).

Red Sea. — Farasan Islands (approximately 17°N, 42°E); Babel Mandeb; Gulf of Aden.

Indian Ocean. — Mauritius (20° to 20°30′S, 57° to 57°45′E); East of Chagos Archipelago at 8°44′S, 83°13′E; Chagos Archipelago at Diego Garcia (6°34′S, 72°24′E); Between Seychelles and Sumatra at 4°20′S, 85°34′E; On equator at longitude 90°E. Ceylon (Colombo, 6°55′N, 79°52′E). Maldives Islands (0° to 8°N, 73°E), north side of Fuladu Island. Nicobar Islands (6° to 9°N, 93° to 94°E). Bay of Bengal, at Octavia Bay and Mancouri Harbor. Andaman Islands (10° to 14°N, 92° to 93°E) at Aberdeen and Port Blair (11°40′N, 92°44′E). India: Gulf of Manaar (7° to 9°N, 75°E), on driftwood; along Madras coast (8° to 12°N), at San Thomé Beach; Triplicane District Beach; Porto Novo (11°30′N, 79°45′E); Chidambarum; Krusadi Island; Godavari Delta (about 17°N, 82°E), Bay of Bengal; along Orisa coast at Puri (19°49′N, 85°54′E).

Andaman Sea. — Butang Islands, west off Satun, Thailand (6°38′N, 100°02′E).

Southwestern Pacific-Australasia. — Australia: Sydney (33° 55′S, 151°10′E); Port Jackson; Low Island (16°18′S, 145°35′E). New Guinea (Raine Island and on north coast). New Caledonia (20° to 22°S, 164° to 167°E). Gilbert Islands (Ocean Island, 0°52′S, 169°35′E). Indonesia: Lombok Island (about 8°30′S, 116°30′E), along west coast and in Bay of Labuan Tring; Java Sea; Java (Djakarta, 6°08′S, 106°45′E); Banda Sea (Kai Islands, 5°42′S, 132°25′E, on branch); 5°26′S, 130°58′E, on plants and pumice; off Ceram Island at 4°32′S, 128°30.5′E; Ambon Island (Ambon, 3°41′S, 128°10′E); Daram Island, off east coast of Misool (about 2°S, 130°E), with *Lepas fascicularis*; Buton Strait; Banka (about 0°30′S, 118°30′E); Ternate (0°48′N, 127°23′E); Celebes (Kema, 1°23′N, 125°05′E); Patani (0°20′N, 128°46′E), Halmaheira, Strait of Malacca at 2°54′N, 120°04′E), on floating algae; Amboina (3°41′S, 128°10′E); off north end of Celebes at 6°30′N, 121°55′E; off west coast of Celebes, on driftwood; Makasar (5°09′S, 119°28′E); between Celebes and Flores; Sumatra (Sabang, 5°53′N, 95°17′E); Singapore (1°20′N, 103°50′E); Thailand. Philippine Islands: Mindoro Strait at 13°N, 121°E; Manila (14°36′N, 120° 59′E); off Laysan Island.

Northwestern Pacific. — Taiwan (about 22° to 25°30′N, 120° to 121°E),) at Kiirun and Taihanratu; Daitô-zuma (about 26°N, 131°E); East of Okinawa Island, on buoys. Bonin Islands (about 27°N, 142°E). Japan: Tomioka (33°54′N, 134°40′E), Amakusa Island, on pumice-stone; Sigasima, mouth of Hakata Bay (about 34.2°N, 133°E); Sagami Bay, Hayama (35°16′N, 139°31′E), off Akitani, on floating bamboo and pumice; Kazusa (35°18′N, 145° 05′E), Nagasaki-ken, on cuttlefish bones; Husiki, Toyama-ken (36°42′N, 137°14′E); Niigata (37°58′N, 139°02′E); Nezugaseki, Toyama-ken (38°16′N, 140°19′E); Sado Island (about 38°N, 138.3°E); Hukaura, Aomori-ken (40°50′N, 140°43′E). North China waters.

Central Pacific. — Caroline Islands (Truk, 7°25′N, 151°45′E), on beach-washed pumice and segments of *Pandanus* fruit; on glass fishing float, with *Conchoderma virgatum* and *Lepas hillii;* Ponape (6°55′N, 158°15′E), on segments of *Pandanus* fruit; Kapingamarangi Atoll (1°05′N, 154°50′E), juveniles on *Turbinaria.* Hawaiian Islands: Oahu, Honolulu (21°19′N, 157°W); off Mokapu Lighthouse, on beached log; Kailua Bay; In Pacific Ocean between Hawaiian Islands and California.

Lepas hillii (Leach) Pl. 2, figs. 5, 6

Pentalasmis hillii Leach, 1818, p. 413; Tuckey, 1818, p. 413.

Lepas hillii (Leach), Darwin, 1851*, pp. 77-81, pl. 1, fig. 2; Hoek, 1876, p. 57; 1883, pp. 4, 21, 37, 38-39, pl. 1, fig. 3; 1907a, pp. 1, 2; 1913, p. xiii; 1914, p. 3; Seguenza, 1876, pp. 371-372, 415-416, 422, 425, 432, 462, 473, pl. VI, fig. 2; Fischer, 1884, pp. 355-356; Whitelegge, 1889, p. 215; Aurivillius, 1894, p. 8; Alessandri, 1894, pp. 234, 255-256, pl. 1, fig. 1; 1897, pp. 47-48; 1906, pp. 229, 268; Weltner, 1897, p. 245; 1897a, pp. 438-440; 1898, pp. 4, 10, 13, 15; 1900, pp. 305, 306, 308, 309; Gruvel, 1902b, pp. 5, 25; 1905, pp. 110-111, fig. 124; 1907a, p. 161; 1909, pp. 209, 224; 1912, p. 348; 1920, pp. 36, 37, 71, 73, 85; Rathbun, 1905, p. 84; Pilsbry, 1907, pp. 79, 80, pl. 8, figs. 2, 7; Annandale, 1909, p. 128; Stebbing, 1910, pp. 563-564; Jennings, 1915, pp. 287, 290; 1918, p. 57; Nilsson-Cantell, 1921, pp. 237-238; 1927, p. 752; 1928, pp. 15-16, fig. 6; 1931b, p. 106; 1938, pp. 9, 20; Schaper, 1922, pp. 214-217, 243, 245, 246, text-fig. 1; Broch, 1924a, p. 204; 1924b, pp. 45, 46, 49, 50, 117, fig. 16; 1931, p. 128; Barnard, 1924, p. 50; Krüger, 1927, pp. 2, 7, 15, 36, fig. 2c; 1940, pp. 121, 131, 492, fig. 129a; Visscher, 1928, pp. 199, 211, 215; Withers, 1928, pp. x, 7, fig. 1; 1953, pp. 318, 353-354, pl. 59, figs. 8a-b; MacDonald, 1929, p. 528; Stubbings, 1936, pp. 1, 3, 4; 1967, pp. 231, 238; Stephensen, 1938, p. 10; Bage, 1938, p. 7; Henry, 1940, p. 11; Kolosváry, 1943, pp. 69, 70; 1944, p. 159; 1947, p. 3; Graaf, 1952, pp. 1-5, figs. 1-2; Bouxin and Legendre, 1952, pp. 120, 121; Cornwall, 1955, pp. 11-13, figs. 1B, 6-7; Utinomi, 1958, pp. 287, 306; Zullo, 1963a, pp. 3, 5, 21, 29, figs. 63-64; Southward and Crisp, *in* Ray, 1963, p. 45, fig. 25a; Bassindale, 1964, pp. 28, 33; U.S. Naval Inst., 1967, p. 194; Utinomi, 1968, p. 166; Ross and Newman, 1969, pl. 17, Map 3; Newman, 1972a, pp. 36-37, figs. 2H-I.

Lepas hillii is a cosmopolitan pelagic barnacle that attaches itself to such floating objects as ships, turtles, wood, cork, and flotsam in general. Its latitudinal range is from about 60° North to 55° South. The taxon has not been found in Florida waters but has been reported both to the north and south on ships.

This barnacle resembles *Lepas anatifera* Linnaeus from which it can be distinguished, according to Pilsbry (1907, p. 80), by the

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*Darwin (1851) placed the following in synonymy with *Lepas hillii* (Leach): *Pentalasmis tricolor* Quoy and Gaimard, 1827, pp. 224, 235, pl. 7, fig. 7; Quoy and Gaimard, *in* Dumont d'Urville, 1830-34, pl. 93, fig. 4; *Anatifa substriata* Conrad, 1837, p. 262, pl. 20, fig. 14.

smoother valves, the absence of umbonal teeth within the scuta, and by the presence of three filaments on each side of the body (*L. anatifera* has only one or two).

Fossil localities. — *Lepas hillii* is recorded as ranging from Pliocene to Recent, the Pliocene form occurring in Italy and Sicily. In Italy it has been reported from the port of Rosignano (43°24′N, 10°28′E); in Sicily from the Astian Stage near Messina, and in the upper Zanclean (Plaisancian) Stage at Scoppo. According to Withers (1953), a single tergum in the Seguenza collection identified as *Lepas hillii* from the Plaisancian Pliocene at Scoppo, near Messina, Sicily, was destroyed in the Messina earthquake of 1908. However, comparing the drawings of the destroyed specimen with the typical *L. hillii,* Withers noted a difference in the disposition of the growth lines and was extremely doubtful that the tergum in question belonged to *L. hillii.*

Recent localities. —

Western Atlantic-Caribbean. — New Brunswick (Grand Manaan Island). Le Have Bank. Massachusetts: Woods Hole (41°32′N, 70°37′W); Gloucester (42°37′N, 70°41′W); Menimsha; Martha's Vineyard. West Indies. Brazil. Falkland Islands. South Georgia Island.

Eastern Atlantic-Europe. — Norway: Bergen (60°23′N, 5° 20′E); Drøbak (59°40′N, 10°40′E). Skagerrak Channel. Denmark (Copenhagen, 55°43′N, 12°41′E), on ships from the West Indies. West Germany (Helgoland Island, 54°09′N, 7°52′E). Scotland (St. Andrews, 56°20′N, 2°48′W). Wales (Swansea, 51°38′N, 3°57′W), on bottom of barque "Antarctic", 8 Sept. 1898. Italy (Bay of Naples). Adriatic Sea (Rijeka [Fiume], 45°20′N, 14°27′E). Spain (Cadiz, 36°32′N, 6°18′W). Azores Islands and adjacent waters between 38° and 36°N, and 27° to 23°W, floating on flotsam at surface, and in the metanauplius stage to depths of 30 meters below the surface. Strait of Gibraltar. Atlantic Ocean between St. Helena (15°58′S, 5°34′W) and Ilha da Trinidade (20°30′S, 29°20′W).

Africa. — Tangier, on floating wood and cork. off Morocco. off Spanish Sahara. Cape Verde Islands (16°N, 24°W), São Vicente Island. Ghana (off Tenbopo). Cape Town (33°56′S, 18°28′E), South Africa. Kenya: Mombassa (4°04′S, 39°40′E).

Indian Ocean. — South of Malagasy Republic [Madagascar.]

Greater Pacific. — Australia: Port Stephen; Port Jackson;

Sydney (33°55′S, 151°10′E). New Zealand: Dunedin (45°52′S, 170°30′E), South Island; Lyttelton Harbour (43°36′S, 172°42′E), South Island, on "Terra Nova" hull; Wellington (41°17′S, 174° 47′E), North Island. Macquarie Island (54°29′S, 158°58′E), in Southern Ocean between Tasmania and Antarctica. Caroline Islands (Truk, 7°25′N, 151°45′E). Japan: on beach of Zyôgasima, south of Misaki (35°10′N, 139°37′E).

Eastern Pacific. — Ecuador: off Esmeraldas which is 0°56′N, 79°40′W. California: off San Francisco which is 37°45′N, 122°27′W. British Columbia coast. Alaska: Aleutian Islands, Unalaska (53° 51′N, 166°35′W). Shumagin Islands; Bering Island.

Lepas pectinata Spengler Pl. 2, figs. 7-9

Lepas pectinata Spengler, 1792, pp. 106-108, pl. X, figs. B, 2a-c; Darwin, 1851, pp. 85-89, pl. 1, figs. 3, 3a; Verrill *in* Baird, 1873, p. 579; Seguenza, 1876, p. 474; Hoek, 1876, pp. 52, 57; 1883, pp. 5, 6, 21, 37, 40, 41; 1907a, p. 1; 1914, p. 3; Fischer, 1884, p. 356; Whitelegge, 1889, p. 216; Weltner, 1897, p. 246; 1898, pp. 7, 10, 13; 1899, p. 442; 1900, pp. 306, 308, 309; Gruvel, 1902d, p. 524; 1905, p. 107, fig. 119; 1907a, p. 161; 1909, pp. 208, 244; 1912, p. 348; 1920, pp. 35, 67, 69, 71, 73, 77, 81, 83, 85; Rathbun, 1905, pp. 5-6; Pilsbry, 1907c, p. 193; 1907, pp. 79, 81, pl. 8, figs. 4-6, 8; Fowler, 1912, pp. 152, 153, 501, 636, pls. 43-44, figs. 4-6, 8; Jennings, 1915, pp. 286-287; 1918, pp. 57-58; Borradaile, 1916, p. 131; Nilsson-Cantell, 1921, pp. 235-236, text-fig. 35d; 1938, pp. 2, 20, 27; 1957, pp. 4, 6, 9; Broch, 1922, pp. 266-270, figs. 26-28; 1924a, p. 204; 1924b, pp. 45, 46, 50, 51, 117, fig. 17; 1927, pp. 15, 33; 1953a, pp. 3, 5, 6, Map I; Barnard, 1924, p. 50; Krüger, 1927, pp. 2, 7, 36, fig. 2D; 1940, pp. 225, 248, 256, 259; Withers, 1928, pp. xii, 48, 49, figs. 82-85; 1953, pp. 318, 332, 386; Stubbings, 1936, p. 3; 1967, pp. 231, 239; Hiro, 1937, p. 400, fig. 3C; 1939b, p. 204; Stephensen, 1938, p. 10; Kolosváry, 1943, pp. 70-71; 1944, p. 160; Utinomi, 1949, p. 20; 1968, p. 166; 1970, p. 341; Hedgpeth, 1950, p. 76; Graaf, 1952, pp. 1, 5; Bouxin and Legendre, 1952, p. 120; Henry, 1954, p. 444; Daniel, 1955, pp. 2, 7, pl. 2, figs. 17-20; Cornwall, 1955, fig. 8; Zullo, 1963a, pp. 3, 5, 21, 27, 29, fig. 61; 1973, p. 1; Bassindale, 1964, pp. 28, 33; Moyse and Knight-Jones, 1966, pp. 605, 607, fig. 9; Wells, 1966, pp. 88, 89, 93; Utinomi and Kikuchi, 1966, p. 4; Rosell, 1967, pp. 279, 284-286, pl. 1, figs. 1-8; U.S. Naval Inst., 1967, p. 194; Kajihara, Ura, and Tachibana, 1975, pp. 13, 133, 134, 135.

Lepas muricata var. Poli, 1795, pl. 6, figs. 23, 29.

Lepas anserifera Poli, 1795, pl. 6, figs. 25-27.

Lepas sulcata Montagu, 1803, pl. 1, fig. 6.

Pentalasmis spirulae var. Leach, 1818.

Pentalasmis sulcata Leach, 1824, pl. 57.

Anatifa sulcata Quoy and Gaimard *in* Dumont d'Urville, 1830-34, p. 93, figs. 18-20.

Pentalasmis inversus Chenu, 1843, pl. 1, fig. 14.

Anatifa dentata DeKay, 1843, p. 255, pl. 34, fig. 317; Leidy, 1855, p. 151.

Pentalasmis radula var. Brown, 1844, p. 51.

Pentalasmis sulcatus Montagu, Brown, 1844, p. 51, figs. 3-6.

Lepas (Anatifa) pectinata Spengler, Annandale, 1909, pp. 73, 74, 128.

Following is a free English version of Spengler's original Danish description of *Lepas pectinata.* This was provided by Henry R.

Spivey of Florida State University, who recorded it on tape from an oral translation by a colleague.

> 2 *Lepas pectinata.* Tab X, fig. 2. [page 106]
>
> The small *Lepas* is assigned to the class Conchiformes, and to the division Quinquevalves. We have known previously only 4 types of five-shelled clams belonging to the Lepades; the new type, the fifth, has the combined beauty of all the other four. The second figured shell, in addition to the difference in size, appears as if [it] were blown up. Found on the bottom edge where the animal is connected, is a large opening covered by a membrane, and also on the back, as the second figure shows, is a protruding edge cut with teeth throughout its length, which is an unusual condition and [end of page 106] does not occur on other types of *Lepas.* The rounded top surface of the second head shell, fig. 2a, is covered with very fine running stripes, originating from the bottom edge of the back, which radiate out evenly toward the top edge.
>
> On the front side where the third and fourth fine shells are, are also found stripes that come together into teeth at the carved edge, as the teeth on the comb clam (*Pectines*).
>
> The stripes on the large shells are very smooth, and the small ones on the back have scales with small hooks. These erupt at the middle, along the front and near the point, fig. b.
>
> The fifth and last shell is the smallest, and is used to connect the other four. It is just as *Lepas anatifera,* only with a peculiar difference at the thin edge along both sides, that turn against the fourth shell and hold them together, into which are cut teeth. The animal's catch-net lies unnoticed inside of the small shell, beautifully arranged against the outside edge of the front part, as seen in the back part of the figure of the shell. The color of this clam is violet, and it was taken, strewn together with several others of the same type [end of page 107] attached to *Fucus,* from the Mediterranean near Cadiz.

Lepas pectinata Spengler is a pelagic barnacle attached to floating substrates such as seaweeds, feathers, pumice stone, ships bottoms, tar globules, and the shells of *Janthina,* a pelagic gastropod. It has also been observed living in the sponge *Cystosira* in the Adriatic Sea at a depth of 422 meters.

The species is characterized by its radially striate or grooved valves which are often profusely spinose. The tergum is notched to receive the apex of the scutum. And, according to Pilsbry (1907, p. 81), smoother forms of the species often have the capitulum conspicuously inflated. It can be distinguished from *Lepas anserifera* by the very narrow area between the occludent border and the ridge from umbo to apex of the scutum.

Lepas pectinata is occasionally associated with two other species of *Lepas, L. anatifera* Linnaeus and *L. fascicularis* Ellis and Solander. It differs from *L. anatifera* in its coarser radial markings, and from *L. fascicularis* in lacking the buoyancy sac at the base of the stalk.

Lepas pectinata is common in warm seas but does occur in colder and subpolar waters, having a latitudinal range from about

61°N at Bergen, Norway to about 57°S off Cape Horn in the Southern Ocean.

Type locality. — Mediterranean Sea, near Cadiz (36°32′N, 6°18′W), Spain.

Florida localities. — Florida Keys; St. Andrews State Park, Bay County, washed ashore on floating seaweed and shells of *Janthina*; Gulf of Mexico, about 287 statute miles west off Dunedin at "Albatross" sta. 2379 (28°00′15″N, 87°42′W).

Other localities. —

Western Atlantic, Gulf of Mexico and Caribbean Sea. — Newfoundland. Bay of Fundy. Maine (Casco Bay); Georges Bank. Massachusetts: Vineyard Sound; Provincetown (42°04′N, 70° 11′W). New York Harbor, on ships. New Jersey: Beasley's Point; Atlantic City (39°23′N, 74°27′W). Virginia: "Albatross" sta. 2097 (37°56′20″N, 70°57′30″W), about 235 statute miles east off Chincoteague. North Carolina: "Albatross" sta. 2109 (35°14′20″N, 74°59′10″W), about 56 statute miles east off Ocracoke. South Carolina: "Albatross" sta. 2314 (32°43′N, 77°51′W), about 200 statute miles east of Beaufort. Texas: along coast on driftwood and sargassum. West Indies. Brazil: east of St. Paul's rocks (1°40′N, 23° 15′W). Argentina: off mouth of Rio de La Plata at latitude of 36°47′S. Chile (Cape Horn, 56°S, 67°15′W).

Eastern Atlantic, Europe. — Norway (Bergen, 60°33′N, 5° 20′E). Denmark: Jutland Peninsula; Copenhagen (55°43′N, 12°34′E). North Sea: Scotland (Oban, 56°25′N, 5°29′W). Ireland (Belfast, 54°35′N, 5°55′W). France: Nice (43°42′N, 7°16′E); Cannes (43°33′N, 7°E); Toulon (43°07′N, 5°55′E); Villefranche-sur-Mer (43°33′N, 17°18′E). Spain: west off Cabo Finisterre at 42°52′N, 9°16′W; Valencia at 40°33′N, 3°55′W; Mediterranean. Portugal (off Coimbra at 41°22′N, 10°22′W). Bay of Biscay at 47°33′N, 8°31′45″W; 46°52′N, 5°30′45″W; 44°43′N, 6°24′W. Northwest of Azores Islands at 43°29′30″N, 19°13′25″W; 43°24′ 50″N, 19°20′30″W; 43°04′30″N, 19°43′30″W; 43°04′N, 19°42′W; 41°48′22″N, 22°28′45″W. Azores Islands at 39°25′N, 29°55′W; 37°52′N, 24°42′45″W; 37°18′N, 20°15′45″W; 36°41′N, 25°29′W; 35°18′N, 37°W. 38°59′N, 28°20′57″W; Adriatic Sea, northwest off Drac, Albania at 41°29′N, 18°49′E, embedded in large sponge (*Cystosira*), trawled at 422 meters. Italy: Gulf of Naples. Sicily: Messina (38°13′N, 15°33′E).

Africa, Mediterranean. — Algeria (Mostaganem, 35°54′N, 0° 05′E). Morocco (Fédala, 33°30′N, 7°20′W), with *Lepas anatifera* and *Balanus perforatus* on cinders, and with *Lepas fascicularis.* Madeira Island (32°45′N, 17°W). Canary Islands: Las Palmas (28°08′N, 15°27′W); San Sebastian de la Gomera. Gulf of Aden (Djibouti, 11°35′N, 43°11′E). Cape Verde Islands (16°N, 24°W) at São Vicente. Guinea (off west coast on sargasso and floating pumice). Estuary of Rio Congo (about 6° south latitude). South Africa (west off Cape of Good Hope, which is 34°20′S, 18°25′E).

Indian Ocean. — Between Malagasy Republic and Australia at 28°21′S, 86°10′E. West of Cocos Island (13°34′S, 79°51′E). Southeast of Chagos Archipelago (8°44′S, 83°13′E). Between Chagos Archipelago and Sumatra, Indonesia (4°20′S, 85°34′E). India: Andaman Islands; Bay of Bengal; Fort Blair, Madras coast; Kilakarai (9°14′N, 78°47′E), on floating feather.

Greater Pacific. — Australia: Port Jackson-Sydney (33°55′S, 151°10′E), on east coast; Brighton? (35°03′S, 138°32′E), on south coast; southeast of Norfolk Island (29°50′S, 172°E); Tasman Sea at 36°S, 150°21′E; 37°S, 150° 05′E, and at 42°10′S, 170°10′E. New Zealand: Auckland (36°55′S, 174°45′E), North Island; Three Kings Islands; Chatham Islands (33°S, 176°30′W). Kermadec Islands (Sunday Island, 29°15′S, 173°52′W), washed up on beach at Waitakerei River. New Guinea. Banda Sea at 5°29′S, 130°59′E, on floating algae, depth of water 7,270 meters. Sulu Sea. Philippine Islands at 7°54′N, 121°30′E. Baluarte. Molo. Iloilo (10°41′N, 122° 33′E), Lusaran. Lapaz, Nueva Vaiencia. China (Hong Kong). Japan: Sado Island; Tomiaka (33°54′N, 134°40′E), on shells of *Janthina,* pumice stone, and floating wood; Seto; Ryuku Islands, on tar globules.

Eastern Pacific. — Chile: San Fernandez Islands (approximately 33.5°S, 81°W) and in the waters between them and Valparaiso (33°05′S, 71°40′W). Peru, west coast. Panama (Taboga, 8°47′N, 79°33′W). California: off Point Loma Light, San Diego (32°45′N, 117°10′W), on surface; Catalina Island (33°25′N, 118° 25′W). ?Oregon to British Columbia. Bering Island. Bering Sea.

Lepas (Dosima) fascicularis Ellis and Solander **Pl. 2, figs. 10, 11**

Lepas fascicularis Ellis and Solander, 1786, pl. 15, fig. 6, [no text]; Montagu, 1808, pp. 5, 164; Gray, 1825, p. 100; Darwin, 1851, pp. 92-99, pl. 1, figs. 6, a-c-; Verrill, Smith, and Harger, *in* Baird, 1873, pp. 382, 579, pl. 7, fig. 34; Willemoes-Suhm, 1876, pp. 131-154; pls. 10-15; Hoek, 1876, p. 57; 1883, pp. 4, 6, 7, 37, 41-43, pl. 1, figs. 5-7; 1907a, pp. 1-3; 1913, pp. vi, xiii; 1914, pp. 3-4; Leidy, 1888a, pp. 80-81; 1888b, pp. 431-432; Aurivillius, 1893, p. 672; 1894, p. 8; Weltner, 1897, p. 245; 1897a, pp. 438-439; 1898, pp. 10, 13; 1899, p. 442; 1900, pp. 300, 304, 306, 309; Gruvel, 1902d, p. 524; 1905, pp. 105-106, fig. 116; 1907a, p. 161; 1909, pp. 208, 224; 1920, pp. 34, 35, 67, 69, 71, 77, 79, 83, 85; Rathbun, 1905, p. 85; Pilsbry, 1907, pp. 79, 81-82, pl. 9, fig. 6; 1907b, p. 193; Annandale, 1909, pp. 77, 128; Stebbing, 1910, p. 564; Fowler, 1912, pp. 146-148, 501, 636, 650, pls. 40, 44, fig. 2; pl. 150, fig. 10; Jennings, 1915, pp. 286-287; 1918, p. 58; Nilsson-Cantell, 1921, p. 238, text-fig. 40a; 1931a, p. 106; 1934b, pp. 32, 39; Schaper, 1922, pp. 214, 217-220, 243, 245-247, text-figs. 2-8; Barnard, 1924, p. 50; Broch, 1924a, p. 204; 1924b, pp. 7, 8, 11, 12, 45, 51-54, 103, 104, 105, 117, figs. 18, a-g, 35; 1927, pp. 15, 33; 1933, p. 5; Visscher, 1928, p. 201, fig. 6d; Hiro, 1937, pp. 386, 400, fig. 3D; 1939b, p. 204; Stephensen, 1938, pp. 2, 9, 10; Krüger, 1940, pp. 17, 19, 22, 129, 225, 244, 248, 249, 260, 317, 318, 327, 493, figs. 21, 22, 256, 258; Henry, 1940; pp. 10, 11, 37, figs. 6, 7; Edmondson, 1946, p. 226, fig. 133a; Kolosváry, 1947, p. 3; Graaf, 1952, p. 5; Withers, 1953, pp. 318, 319, 322, 330, 386; Cornwall, 1955, pp. 9-11, figs. 4-5; Utinomi, 1958, pp. 288, 306; 1968, p. 167; 1970, p. 341; Zullo, 1963a, pp. 3, 5, 20, 29, fig. 59; 1973, pp. 1, 5, 6, figs. 7, 12; Southward and Crisp, *in* Ray, 1963, p. 19; Stubbings, 1963, pp. 5-6, fig. 1; 1965, pp. 876, 878-879; 1967, pp. 231, 239; Bassindale, 1964, pp. 28, 33; U.S. Naval Inst., 1967, p. 194; Newman, Zullo, and Withers, 1969, p. R279, fig. 114,3; Gordon, 1970, pp. 8, 39-41, fig. 12; Petriconi, 1970, pp. 541, 544, 545, fig. 3; Newman and Ross, 1971, pp. 33-34; pls. 5, D, text-figs. 10A-H; Kozloff, 1973, p. 209, pl. 23, bottom; Ross and Emerson, 1974, pp. 25, 43, illustr.

Lepas cygnea Spengler, 1790, pp. 198-201, pl. 6, fig. 8.
Lepas dilata Donovan, 1804.
Pentalasmis spirulicola Leach, 1818, p. 413.
Pentalasmis donovani Leach, 1818, p. 413.
Anatifera vitrea Lamarck, Coates, 1829b, pp. 138-140; Darwin, 1851, p. 92.
Lepas fasciculata Montagu, Coates, 1829b, p. 135.
Pentalepas vitrea Lesson, 1830, pl. 16, fig. 7.
Anatifa oceanica Quoy and Gaimard *in* Dumont d'Urville, 1832-1835, pl. 93.

The adult *Lepas fascicularis* is the only pelagic barnacle to produce its own gas-filled float thus enabling it to sustain itself on the sea surface. The cyprid larvae, however, become attached to small objects in the usual manner, and these metamorphosed forms have been found on such diverse materials as seaweed, feathers, cranberries, sargassum, cuttlefish bone, and even apples. The adult species has a relatively short stalk with a large sac at the base, and the shell plates are almost transparent.

Lepas fascicularis has been reported as far north as northern Siberia (about 71°N) and as far south as off Cape Horn to about 57°S. Depths of the sea below its surface range from shore to 7,290 meters (in the Banda Sea). In the Pacific Ocean, *L. fascicularis* has been observed floating along the 35th parallel from Japan to the vicinity of the Hawaiian Islands.

Florida localities. — I have seen no notice of this species occurring in Florida waters, but it has been observed off the coast of North Carolina, some three degrees of latitude to the north.

Other localities. —

Western Atlantic. — New Brunswick: Grand Manaan Island; Bay of Fundy. Nova Scotia. Maine: Casco Bay, on floating seaweed and other small objects. Massachusetts: Martha's Vineyard; Vineyard Sound; Provincetown (42°04′N, 70°11′W); Long Point; Nantucket Island, attached to apples, cranberries, and flotsam. New Jersey: Beach Haven (39°34′N, 74°14′W); Atlantic City (39°23′N, 74°27′W); Cape May (38°56′N, 74°54′W). North Carolina, at "Albatross" sta. 2425 (36°20′24″N, 74°46′30″W), about 58 statute miles northeast off Kitty Hawk. Venezuela. Brazil (Rio de Janeiro, 22°53′S, 43°17′W). Chile (Cape Horn, 56°S, 67°15′W).

Eastern Atlantic. — Iceland: North Iceland; Skagaströnd (65° 50′N, 20°19′W), Mýraburger (64°40′N, 15°48′W), on feathers; 62°10.5′N, 19°36′W, on feathers; Vestmannaeyjar Island (63°25′N, 20°15′W). North Sea (56°2′ to 56°36′N, 1°53′ to 3°35′E). Norway: Flekefjord (58°17′N, 6°40′E); Torunga; Langesund; Frederiksvern; Moss (59°36′N, 10°41′E); Espevaer (59°36′N, 5°09′E); Bergen (60°23′N, 5°20′E); Turøyknappen; Kristiansund (63°06′N, 7°58′E). Skagerrak Channel. West Germany, Helgoland Island (54°09′N, 7°52′E). France (La Rochelle, 46°10′N, 1°10′W). Bay of Biscay to Azores Islands at 47°33′N, 8°31′45″W; 46°48′N, 5°39′45″W; 46°07′N, 5°20′W; 46°45′45″N, 5°50′W; 45°38′44″N, 21°06′W; 45°27′N, 6°05′W; 44°44′N, 21°36′W; 44°11′N, 5°42′W; 43°29′30″N, 19°13′25″W; 43°24′50″N, 19°20′30″W; 43°04′N, 19° 43′30″W; 43°04′N, 19°42′W; 42°31′21″N, 17°17′53″W; 41°48′ 22″N, 22°28′45″W; 37°58′N, 25°56′45″W; 37°52′N, 24°42′45″W; 37°18′N, 20°15′45″W; 36°32′30″N, 11°42′05″W; 34°32′N, 8°44′ 45″W; 34°09′N, 9°01′45″W; 28°38′N, 17°59′40″W. Spain: Santander (43°28′N, 3°48′W); off Cabo Finisterre (43°04′N, 19°42′ 30″W). Adriatic Sea.

Africa. — Morocco: Fédala (33°43′N, 7°20′W), with *Lepas pectinata;* off northwest coast at 39°09′N, 9°01′45″W; 35°44′N, 12°44′W (half grown and smaller forms on fragments of wood and with some epizoic cypris larvae and newly developed metamorphosed forms). Canary Islands (28°38′N, 17°59′40″W). Senegal, at Gorée

Beach, Yoff Beach, Cambèrene, and off coast. Guinea, off coast. Sierra Leone, rare, off coast. Ghana, rare, off coast. Congo River Estuary (6°11′05″S, 10°E), with *Lepas anserifera.* Angola: off Ambrizette at 7°16′S, 12°47′E and 17°16′S, 12°08′E; off Moita Seca, 6°15′S, 11°37′E, with *Lepas anserifera*; 6°56′05″S, 11°54′E, (on cuttlefish bone, numerous juveniles, some cypris and newly metamorphosed specimens). Malagasy Republic. South Africa: off Port Alfred, 35°13′S, 27°45′E, water depth 4380 meters.

Indian Ocean. — South off Malagasy Republic (Madagascar).

Greater Pacific. — Indonesia: off east end of Misoöl Island, attached to floating debris, with *Lepas anserifera;* Celebes Island; Borneo; Amboina (3°41′S, 128°10′E); Banda Sea at 5°36′S, 131° 01′E, 7280 meters, juveniles on floating sargassum; 5°26′S, 130° 58′E, floating, on eel grass, 7290 to 7250 meters; off Sumatra. Japan: Misaki (35°10′N, 139°37′E), encrusted with hydroids; Sado Island; along 35th parallel (to Hawaiian Islands); vicinity of Seto Marine Biological Laboratory. Tasman Sea at 42°10′S, 170°10′E, 610 meters. Sunday Island (29°15′S, 177°52′W), in the Kermadec Islands, washed up on beach at Waitakerei River. New Zealand: North Cape (34°23′S, 173°04′E), North Island; Christchurch (43° 33′S, 170°40′E), South Island; Dunedin (45°52′S, 170°30′E) and Otago Harbour, South Island. Chatham Island (33°S, 176°30′W).

Eastern Pacific. — Mexico: off west coast of Baja California at 29°51′N, 116°15′W; south point of South Los Coronados Islands at about 32°25′N, 117°15′W. Between San Francisco, California (37° 45′N, 122°27′W) and Unalaska (53°40′N, 166°40′W), in the Aleutian Islands. British Columia coast. North coast of Siberia.

Conchoderma auritum (Linnaeus) Pl. 3, fig. 1

Lepas aurita (Linnaeus), 1767, p. 1110; Seba, 1758, vol. 3, pl. 16, fig. 5; Ellis, 1758, pp. 848-849, fig. 1a-g, 7 (as *Lepas nuda carnosa aurita*); Chemnitz, 1785, pp. 345-346, pl. 100, figs. 857-858; Spengler, 1790, pp. 205-206; Gray, 1825, p. 100; Leach, 1826, pp. 208-215.

Lepas leporina Poli, 1795, pl. VI, fig. 21.

Conchoderma auritum (Linnaeus), Olfers, 1814, p. 177; Darwin, 1851, pp. 141-145, pl. 3, figs. 4, 4a-c; Verrill, *in* Baird, 1873, pp. 382, 392; Verrill, Smith, and Harger, *in* Baird, 1873, p. 580; Hoek, 1876, p. 56; 1883, pp. 5, 6, 7, 53-55; Seguenza, 1876, p. 474; Weltner, 1895, pp. 288-290; 1897, p. 240; 1898, pp. 6, 10, 13; 1900, pp. 300, 304, 308; 1922, pp. 82, 87, 107; Gruvel, 1902d, p. 525; 1905, p. 144, fig. 167; 1907a, p. 161; 1909, pp. 211, 224, 225; 1911, p. 292; Rathbun, 1905, p. 85; Nordgaard, 1905, p. 182; Pilsbry, 1907, pp. 99, 119, pl. 9, fig. 2; Annandale, 1909, p. 79; Stebbing, 1910, pp. 565-566; Fowler, 1912, p. 498; Borradaile, 1916, p. 132; Jennings, 1915, p. 287; 1918, pp. 58-59; Nilsson-

Cantell, 1921, pp. 10, 240-241, text-fig. 41a-f; 1930, pp. 249-251, pl. 1, figs. 1-3; 1931b, p. 106; 1939b, pp. 226, 235; 1957, pp. 4, 6, 9; Schaper, 1922, p. 243; Barnard, 1924, p. 61; 1925, p. 1; Broch, 1924a, p. 204; 1924b, pp. 8, 11, 12, 54-58, 106, 107, 117, figs. 19a-e; Visscher, 1928, pp. 199, 201, 212; Vatova, 1928, p. 185; Stephensen, 1938, pp. 3, 9, 10; Hiro, 1937, pp. 401-402, fig. 4; 1939a, pp. 246, 248; 1939b, p. 205; Krüger, 1940, pp. 22-24, 44, 80, 82-84, 91, 92, 113, 114, 248, 249, 251, 326, 338, figs. 30b, 84a3, 84b3, 84c3, 84d3, 97a, 98e; Kolosváry, 1943, p. 71; 1947, p. 3; 1966, p. 393; Bouxin and Legendre, 1952, p. 121; Cornwall, 1955, pp. 14-16, figs. 9-10; Tarasov and Zevina, 1957, pp. 115-118, figs. 30-31; Stubbings, 1961a, pp. 7, 15; 1967, pp. 231, 240; Zullo, 1963a, pp. 3, 6, 21, 28, 29, fig. 66; Bassindale, 1964, p. 27, fig. 53; Clarke, 1966, pp. 153, 155-167, tables 2-7, figs. 4-7; Quezada, 1966, pp. 51-61, figs. 1-8; U.S. Naval Inst., 1967, pp. 129, 194, fig. 13D; Ross and Newman, 1969, pl. 17, maps 1, 3, fig.; Newman, Zullo, and Withers, 1969, p. R279, fig. 114,4a; Petriconi, 1970, pp. 544-545; Newman and Ross, 1971, pp. 36-37, 187-188, pl. 3; Best, 1971, p. 185, fig. 1; Seidler, 1973, pp. 44, 45, figs. 1, 2; Zevina, 1974, p. 209; Ross and Emerson, 1974, p. 50, fig.

Conchoderma leporium Olfers, 1814, p. 177.
Branta aurita (Linnaeus), Oken, 1815, p. 362.
Lepas cornuta Montagu, 1815, p. 579.
Malacotta bivalvis Schumacher, 1817; Gray, 1825, p. 100.
Gymnolepas cuvierii Blainville, 1825-27, pl., fig. 1.
Otion cuvierianus Leach, 1826, p. 211.
Otion blainvillianus Leach, 1826, p. 211.
Otion bellianus Leach, 1826, p. 210.
Otion dumerillianus Leach, 1826, p. 211.
Otion rissoanus Leach, 1826, p. 212.
Otion depressa Coates, 1829a, pp. 132-133.
Otion saccutifera Coates, 1829a, pp. 134-135.
Otion cuvieri Gould, 1841, p. 23.
Otion auritus (Linnaeus) Macgillavray, 1845.

Conchoderma auritum is a nude pelagic species found in all seas but more commonly in cold or temperate waters. Its latitudinal range is from 71° North to 63° South. It is often adherent on the whale barnacles *Coronula diadema* (Linnaeus) and *Coronula reginae* Darwin which themselves are attached to the skin of the humpback or blue whale. *C. auritum* also occurs on the teeth of the sperm whale and on baleen plates of the fin whale.

Conchoderma auritum is characterized by the two long "ears" rising behind the positions of the terga, and by the very small or absent terga and carina. In places *C. auritum* may be attached to and intermingle or otherwise be associated with *C. virgatum* (Spengler), the latter being distinguished by its well-developed though small plates and by the handsome stripes on the capitulum.

Type locality. — Probably Stavanger (approx. 59°N, 5°30′E), Norway. Seven specimens on the whale louse *Coronula* cut off the lip of a whale thrown upon the coast in 1757.

Florida localities. — I have seen no record of *C. auritum* having been found off Florida proper but as it occurs both to the north and south its eventual discovery in Florida waters is anticipated.

Other localities. —

Western Atlantic and Caribbean. — West Greenland. New England, on whales. Massachusetts: Vineyard Sound; Provincetown (42°04′N, 70°11′W), on whales; Woods Hole, on ships from Caribbean; Gloucester (42°37′N, 70°41′W), on barque from Cadiz, Spain. North Carolina: Cape Hatteras (35°14′N, 75°31′W), on iron buoy; this is the nearest locality to Florida. Bermuda Island. Swan Island (approx. 17°35′N, 83°45′W). South Georgia Island (approx. 55°S, 37°W), on *Coronula diadema* and *Coronula reginae,* and *Coronula reginae* attached to whales, and Husvik (54°11′S, 36°52′W) on teeth of sperm whale. "Sourabaya" sta. (57°20′S, 32°W) from humpwhale and on *Coronula diadema.* South Shetland Islands (approx. 62°S, 58°W), on *Coronula diadema* attached to whales. Deception Island (approx. 63°S, 59°W), on fin whale. Antarctic waters between 60°S and 64°S.

Eastern Atlantic. — Norway: Mehavn (71°N, 27°50′E) on *Megaptera boops;* Tanafjord; Vadsö (70°05′N, 29°47′W); Jan Mayen Island (70°10′N, 9°W); Stavanger (approx. 59°N, 5°30′E); Lofoten Islands (approx. 67°N, 14°E). Iceland: Bakkafjörour, Seyorisfjörour, and Vestmannaeyjar, on *Coronula diadema* attached to the whale *Megaptera boops.* Ireland. Wales (Swansea, 51°38′N, 3°57′W). France: LeHavre Basin and Languedoc coast. Italy: Trieste (45°39′N, 13°47′E), Adriatic Sea; Gulf of Naples. Jugoslavia: Rovinj, 45°05′N, 13°40′E, Adriatic Sea. Azores Islands: Ponta Delgada, 37°29′N, 25°40′W.

Africa and Southern Atlantic. — Mediterranean Sea. Mauritania (off west coast). Guinea: Gulf of Guinea (0°20.2′N, 6°45′W), on ships, water temperature 23.1°C, and on flotsam. Between St. Helena (15°58′S, 5°43′W) and Ilha Trindade (20°30′S, 29°20′W). North of Tristan da Cunha which is 37°15′S, 12°30′W. South Africa: Saldanha Bay, on *Coronula reginae,* attached to blue whale; Walvis Bay, on *Coronula diadema;* Table Bay, on *Coronula* attached to humpback whale; Simonstown (34°12′S, 18°26′E), on ship; Sandbaai near Hermanus (34°25′S, 19°14′E), attached to the elephant seal *Mirounga leonina.* African shelf, on lower jaw of dolphin.

Indian Ocean. — South Africa: (Durban, 29°53′S, 31°E). India: (Bombay, 18°56′N, 72°51′E).

Western, Northern, and Southern Pacific. — Indonesia. Japan: Akhesi Gulf; vicinity of Seto Marine Biological Laboratory; Ayukawa (38°18′N, 141°30′E) and Aomori (40°50′N, 140°43′E) on whale *Megaptera nodosa.* Bonin Islands, on whales. Taiwan: Taihanratu, on *Coronula diadema.* New Zealand: Bay of Islands; Three Kings Islands; Cape Brett (35°12′S, 174°22′E), North Island; Auckland (36°55′S, 174°45′E), North Island; Lyttleton Harbour (43° 36′S, 172°42′E), on hull of "Terra Nova", North Island. Kermadec Island (30°S, 178°30′W), washed on beach at Waitakerei River. Chatham Island (44°S, 176°30′W). Kerguelen Islands.

Eastern Pacific. — Chile: Talcahuano (36°40′S, 73°10′W), on *Coronula diadema*; Valparaiso (33°05′S, 71°40′W); north of Gulf of Arauco (36°10′S to 36°S and 73°36′W to 73°47′W) on teeth of the sperm whale *Physeter catodon* (Linnaeus). Peru: Callao (12° 05′S, 77°08′W) and Tumbes (3°37′S, 80°27′W). California. British Columbia. Bering Sea. Alaska (Plover Island and Aleutian Islands). USSR, off Murmansk coast.

Conchoderma virgatum (Spengler) Pl. 3, fig. 2

Lepas virgata Spengler, 1790, pp. 207-208, pl. 6, fig. 9; 1792, pp. 103, 108-110.

Lepas coriacea Poli, 1795, pl. 6, fig. 20.

Lepas membranacea Montagu, 1808, pl. 12, fig. 2.

Conchoderma virgatum (Spengler), Olfers, 1814, p. 177; Darwin, 1851, pp. 146-151, pl. 3, figs. 2, 2a-b; pl. 9, fig. 4; Verrill, *in* Baird, 1873, pp. 382, 392; Verrill, Smith, and Harger, *in* Baird, 1873, p. 580; Seguenza, 1876, p. 474; Hoek, 1876, p. 56; 1883, pp. 4-7, 21, 53, 55, pl. II, figs. 13-15; Aurivillius, 1893, p. 657; Weltner, 1895, p. 288; 1897, p. 240; 1898, pp. 4, 10, 13, 15; 1900, pp. 305, 308, 309; Gruvel, 1902d, p. 525; 1905, pp. 144-145, fig. 168; 1907a, p. 161; 1909, pp. 211, 225; 1920, pp. 38, 67, 69, 71, 73; Rathbun, 1905, p. 85; Pilsbry, 1907, p. 99, pl. 9, fig. 1; Annandale, 1909, pp. 79-81; Stebbing 1910, p. 466; Fowler, 1912, pp. 143-145, 498, 635, pl. 39; Jennings, 1915, p. 287; 1918, p. 59; Crozier, 1916, pp. 636-640; Nilsson-Cantell, 1921, p. 242; 1928, pp. 16-17, figs. 7a-d; 1930, pp. 251-252; 1931b, p. 106; 1939b, p. 236; 1957, pp. 4, 6, 9; Schaper, 1922, p. 243; Barnard, 1924, p. 61; Broch, 1924b, pp. 10, 11, 58-61, 106-107, 117, figs. 20a-e; 1931, p. 128; Stubbings, 1936, pp. 1-4; 1961a, pp. 7, 15, 16; 1965, pp. 876, 878, 879; 1967, pp. 231, 240; Hiro, 1937, pp. 386, 400, fig. 5; 1939a, pp. 246, 248; 1939b, p. 205; Stephensen, 1938, pp. 3, 9, 10; Krüger, 1940, pp. 22-24, 44, 92, 112, 113, 225, figs. 25, 30a, 98b; Kolosváry, 1943, p. 71; 1947, p. 3; Bouxin and Legendre, 1952, pp. 120-123; Cornwall, 1955, pp. 16-18, figs. 11-12; Daniel, 1955, pp. 1, 2, 8, pl. 1, fig. 4; pl. 2, figs. 21-24; Newman, 1960a, p. 90; 1972a, pp. 31, 36; Zullo, 1963a, pp. 2, 3, 6, 21, 29; Southward and Crisp, *in* Ray, 1963, p. 45, fig. 25b; Bassindale, 1964, p. 27, fig. p. 53; Clarke, 1966, pp. 153-157, 164, table 1, figs. 2-3; Wells, 1966, pp. 89, 91, 93; MacIntyre, 1966, pp. 637-638; U.S. Naval Inst., 1967, pp. 129, 130; Daniel and Prem-Kumar, 1967, pp. 132-133, photos; Beckett, 1968, pp. 2707-2710, table 1; Jones, Rothschild, and Shomura, 1968, pp. 194-196, figs. 1-2; Balakrishnan, 1969, pp. 101-103; Dawson, 1969, pp. 58-62, fig. 1, table 1; Roskell, 1969, pp. 103-104; Utinomi, 1970, p. 341; Newman and Ross, 1971, pp. 35-36, 196, pl. 5E, text-fig. 11.

Branta virgata (Spengler), Oken, 1815, p. 362.
Senoclita fasciata Schumacher, 1817.
Cineras cranchii Leach, 1818, p. 412.
Cineras chelonophilus Leach, 1818, p. 412.
Cineras olfersii Leach, 1818, p. 412.
Cineras vittata Leach, 1824, p. 170, pl. 57, fig. 1; Brown, 1844, pl. 51, figs. 16-18; Gould, 1841, p. 22.
Gymnolepas cranchii Blainville, 1824.
Pamina trilineata Gray, 1825, p. 100.
Cineras megalepis Leach, 1826, p. 208.
Cineras montagui Leach, 1826, p. 208.
Cineras rissoanus Leach, 1826, p. 208.
Cineras bicolor Risso, 1826, p. 383.
Cineras membranacea (Montagu), MacGillivray, 1845, p. 171.

Conchoderma virgatum is a pelagic species which attaches itself to a wide variety of floating objects and to nekton such as turtles, fishes, and whales as well as to certain sessile barnacles (*Coronula*), themselves adherent to the skin of whales. The floating objects may be seaweed, flotsam in general, and commonly the bottom of ships. The species shows a preference for settling below the surface of the sea rather than on it.

Geographically, *C. virgatum* has been found in most seas and has a latitudinal range from about 66° North off Iceland to about 56° South off Cape Horn. Not infrequently *C. virgatum* occurs together with *Conchoderma auritum* (Linnaeus), but is distinguished from it by its lack of "ears" and by having wavy longitudinal stripes on the sides of the capitulum and peduncle.

Type locality. — Near St. Barthélemy (17°55′N, 62°50′W), Lesser Antilles.

Florida locality. — Gulf of Mexico at entrance to St. Andrews Bay (about 30°6′N, 85°16′W), Bay County, on dorsal fin of an orange filefish (*Alutera schoepfi*) and from the head of a cowfish (*Lactophrys tricornis*).

Other localities. —

Western Atlantic, Gulf of Mexico, and Caribbean. — From Flemish Cap (46°42′N, 45°W) southward to Tierra del Fuego, Argentina. Grand Banks, Canada. Massachusetts: Woods Hole (on ship from Caribbean Sea); Gay Head; Martha's Vineyard on *Mola rotunda;* Vineyard Sound; Gloucester (42°37′N, 70°41′W). Rhode Island (12 miles southeast of Block Island). New Jersey: off Beach Haven on *Mola rotunda,* a sunfish. Off Maryland, at "Albatross" sta. 2713 (38°20′N, 70°08′30″W), about 265 miles east of Ocean City on the crab *Neptunus sayi*; Mississippi: near Round Island attached to the fish *Hyporhampus unifasciatus*; off the western end of Horn Island (30°13′N, 88°40′W) attached to the fish *Rachycentron canadum* and the copepod *Lernaeolophus sultanus*. Off North Carolina. Puerto Rico. Venezuela, off La Guaira (10°38′N, 66°55′W). Falkland Islands. "Eltanin" sta. 117 about 55° south latitude, off Tierra del Fuego.

Eastern Atlantic and Africa. — Iceland. Norway: along the coast on whales: at Bergen (60°23′N, 5°20′W); Bergensfjord; Glesvaer. Sweden: Skagerrak Channel. Denmark, on whales. Ireland, on whales. Wales: Swansea (51°38′N, 3°57′W). France: Le Havre (49°30′N, 0°06′E). Italy: Bay of Naples on *Pennella* sp. and *Pennella balaeonopterae*; Trieste (45°39′N, 13°39′E), Golfo di Venezia; Adriatic Sea; off Palermo (38°08′N, 13°23′E), Sicily. Azores Islands at 39°56′10″N, 34°W; 39°04′35″N, 31°04′07″W to 37°43′W; and Faial (38°35′N, 28°42′W), on whales. Madeira: Funchal (32°40′N, 16°55′W). Cape Verde Islands (Ilha São Vicente). Gulf of Aden. Spanish Sahara at 23°22′N, 23°29′W, about 540 miles west of Villa Cisneros. Senegal, at Gorée, on the fishes *Caranx hippos, Echeneis naucrates,* and *Isurus oxyrhynchus* Rafinesque which were attached to the barnacle *Platylepas hexastylos* (Fabricius) on the skin of the turtle *Chelone mydas*. Liberia: Port Marshall. Guinea: west off coast, on flotsam with *Conchoderma auritum* (Linnaeus). Ghana: Takoradi (4°55′N, 1°45′W). Ascension Island (7°57′S, 14°22′W). St. Helena (15°58′S, 5°43′W). Between St. Helena and Trindade (20°30′S, 29°20′W). South Africa at Cape of Good Hope and Saldanha (33°S, 17°56′E), on the crustacean *Pennella* attached to a blue whale.

Indian Ocean. — India: Cochin, from bar mouth at 9°58′N, 76°15′E, on *Diodon hystrix*; along Malabar coast and off Krusadi Island, on turtle; "Vityaz" sta. at 13°32′04″S, 105°04′03″E, on a parasitic copepod attached to the abdominal region of the flyingfish *Cypsilurus speculigar*.

Western Pacific. — Japan: Siriyazaki, Aomori-ken (40°50′N, 140°43′E); Tasaya on Sado Island; vicinity of Seto Marine Biological Laboratory; Sagami and Tosa Bay. Taiwan: Suô, on ? *Pennella*. New Zealand: Auckland (36°55′S, 174°45′E); Lyttelton Harbour (43°36′S, 172°42′E), on hull of the "Terra Nova"; Dunedin

(45°52′S, 170°30′E), on ship's hull. Australia: on buoy recovered at 31°14′S, 153°12′E, about 35 statute miles east off Camden Haven, New South Wales.

Central Pacific. — West side of Moen Island, Truk (7°25′N, 151°45′E), Caroline Islands, with *Lepas hillii* (Leach). According to Newman (1972a, p. 36), the *C. virgatum* found here on a large glass fishing float may be the varietal form *C. v. intermedium* Annandale.

Eastern Pacific. — Chile: Iquique (20°15′S, 70°08′W). Peru: Off Paita (5°09′S, 81°08′W), on whales. Galapagos Islands (vicinity of the equator and 90°W). California: San Francisco (37°45′N, 122° 27′W). British Columbia, on ? *Pennella* attached to the fin whale *Balaenoptera physalus*.

For additional species of host fishes or intermediate copepods not mentioned in the foregoing text but recorded in association with *Conchoderma virgatum* elsewhere in the seas, see Dawson (1969, p. 60).

Family **OXYNASPIDIDAE** Pilsbry, 1907

Oxynaspis celata hirtae Totton Pl. 3, fig. 3

Oxynaspis celata Darwin var. *hirtae* Totton, 1940, p. 474, figs. 10-11; Newman, 1972b, p. 206.

Following is Totton's original description:

> On some specimens of *Parantipathes hirta* from the West Indies there are Oxynaspids which differ from typical *O. celata* in having a proportionately longer occludent margin to the tergum (one that is less curved and more nearly in line with that of scutum) and a tergum the distal end of which is more acute. In the carina of this variety the distal limb may exceed twice the length of the basal limb. In a lateral view of the capitulum the basal margins of the carina and scutum are more nearly in alignment than in the typical *celata*.
>
> There is one pair of filamentary appendages at the bases of the first cirri, but no boss between them.

Of the four specimens illustrated by Totton, none was designated as type, nor were any direct measurements given. However, judging from the scale markers indicated on Totton's figures 10 and 11, the capitulum of his figure 10A is about 1.9 mm in length and 1 mm in width; 10B, 4.2 mm × 2.6 mm; and 10C, 7.4 mm × 4.6 mm. Totton's figure 11 of the carina is about 7.2 mm in length and 3.5 mm in width across the elbow. All of Totton's illustrations are reproduced on Plate 3, figure 3 with 3B being chosen as the lectotype.

The type locality of *Oxynaspis celata hirtae* is given as the "West Indies" by Totton, and inasmuch as many barnacles from the West Indies occur also in Floridan waters, the taxon is included here.

Oxynaspis floridana Pilsbry Pl. 3, fig. 4

Oxynaspis floridana Pilsbry, 1953, p. 15, text-fig. 1; Zullo, 1968, p. 212; Newman, 1972b, p. 206.

The capitulum is lanceolate, 8 mm in length, and 4 mm in breadth. The body is brown with a dark purplish-brown streak down the middle. The plates are white and calcareous. The parts of the capitulum adjacent to the peduncle and the peduncle itself are sparsely set with chitinous spinules, but the layer of the antipatharian over these parts of the barnacle is extremely thin.

The tergum is long and very narrow, widest above the middle; the scutal margin is convex, the carinal margin straight, becoming concave near the apical end which is thickened and somewhat enlarged.

The scutum has the form of an inverted "Y". The umbo is submedian, the prolongation above it band-like and blunt at the tergal end which abuts the carinal margin of the tergum; below the umbo, the scutum divides into two branches, one shorter band tapering along the occludent margin, the other longer and extending toward the base of the carina.

The carina is strongly arched, bluntly angular at the umbo which is near the lower third of its length. The sides of the carina are narrow.

The peduncle is about 2 mm in length.

Type locality. — "Triton" sta. 656, off Palm Beach (26°41′N, 80°02′W), Florida, broken shell bottom, on a slender antipatharian axis, depth 50-60 fathoms (92-110 meters).

Oxynaspis gracilis Totton Pl. 3, fig. 5

Oxynaspis gracilis Totton, 1940, pp. 472-473, fig. 8; Withers, 1953, p. 20, fig. 33; Newman, 1972b, pp. 205, 206.

Totton's original description was as follows:

> *Description.* — Valves covering capitulum except for a small interspace between angle of carina and scutum. Tergum: length of occludent margin is five-sevenths that of scutal margin; distal angle moderately rounded, only very

slightly reflexed; occludent margin in line with the corresponding margin of scutum. Scutum unlobed, rostral angle well marked, carinal margin broadly rounded, occludent margin straight. Carina: umbo about the middle, with two limbs of about equal length, rostral angle of basal expansion not produced round peduncle.

The type-locality is the 'West Indies.' The types were found on *Antipathella gracilis,* British Museum Register no. 1843.2.8.25.

Remarks. — This species is remarkable for its slenderness, the length of the capitulum being two or more times its width. The occludent margins of scutum and tergum are in alignment and the scutal umbo central.

This is a small species, the syntypes averaging a total length of 5 mm, a capitular width of about 2 mm across the carinal elbow, and a peduncular length and width of about 1 mm. The illustrations also indicate that the occludent margins of the tergum and the upper half of the scutum are minutely serrate.

The "West Indies" is the only locality mentioned, but that being so there is always the possibility that *Oxynaspis gracilis* will be found in Florida waters.

Oxynaspis patens Aurivillius Pl. 3, figs. 6-9

Oxynaspis patens Aurivillius, 1892, pp. 123, 124; 1894, pp. 38-41, pl. 3, figs. 1-2; pl. 6, figs. 13-15; pl. 8, fig. 9; Gruvel, 1905, pp. 103-104, fig. 115; Pilsbry, 1907, p. 79; 1953, p. 15; Stubbings, 1936, pp. 9, 10, 11; Totton, 1940, pp. 466, 476-477, fig. 16; Withers, 1953, p. 22, fig. 41; Newman, 1972b, p. 206.

The diagnosis of this species by Aurivillius is translated as follows:

Capitulum almost trapezoidal, the post-umbonal carinal border the longest; with 5 plates. Carina bent into an obtuse angle from the medial-lying umbo. The scuta occupy only the ventral half of the capitulum.

Peduncle cylindrical, not calcified, hardly half as long as the capitulum.

The whole body, including the plates, bears spines noticeably resembling those from the horny skeleton of *Antipathes* to which the animal is attached.

Color not known.

Dimensions — length of animal 14 mm, length of capitulum 8 mm; width of capitulum across carinal umbo 4 mm.

Locality and occurrence — Antilles Sea, near the Island of Anguilla, depth 125-1235 meters.

Synonymy, 1892, *Oxynaspis patens* C. W. Aurivillius.

In his more detailed description of *O. patens,* Aurivillius elaborated on the structure of the chitinous spines occurring on both the plates and peduncle which he believed originated in the epithelium of the barnacle mantle. In continuing his description Aurivillius stated that the primordial plates of the terga are oval and lie in close proximity to the apex which is above, whereas the primordial plates of the scuta are keel-shaped or triangular, with the apex down. Lines of growth are concentric. The upper lip of the mouth is tongue-shaped, bent back from and not arched over the mouth parts. The palpi are short conical, with numerous setae. The mandibles bear four or five teeth. The first pair of cirri is not far from the second. The second to sixth cirri carry 4 to 5 pairs of bristles, these smaller proximally, larger distally. There are 16 and 17 segments in the fifth pair of cirri and 18 and 19 segments in the sixth pair. Terminal appendages are absent. The penis is as long as the fifth or sixth cirri, the distal half cylindrical, with some hairs.

Type locality.—Near the Island of Anguilla (18°14′N, 63° 05′W), Leeward Islands, 125-135 meters (68.4-73.7 fathoms).

Other localities. — "Albatross" sta. 2651 (24°02′N, 77°12′ 45″W), 97 fathoms, white ooze; off Green Cay, Bahama Islands, close to the eastern border of the Tongue of the Ocean, about 320 statute miles east-southeast of Key West, Florida.

Concerning the problem of whether the spines on the capitulum and peduncle of *Oxynaspis* were produced by the barnacle or by the coral (Antipatharian) it is now generally believed that "for those species epizoic on Antipatharians, the spines have a dual origin from the cuticle of the cirripede and from the overlying skeleton of the Antipatharian." (Stubbings, 1936).

Family **POECILASMATIDAE,** Nilsson-Cantell, 1921

Poecilasma inaequilaterale Pilsbry Pl. 4, figs. 1-3

Poecilasma inaequilaterale Pilsbry, 1907, pp. 83, 85-87, pl. 6, figs. 6-8, 11-12; Fowler, 1912, p. 501; Nilsson-Cantell, 1921, pp. 254, 255 *pars*; Boone, 1930, p. 16; Henry, 1954, p. 444; Zullo, 1968, p. 214.

Poecilasma kaempferi inaequilaterale Pilsbry, Barnard, 1924, pp. 51-52.

Trilasmis (Poecilasma) kaempferi inaequilaterale (Pilsbry), Pilsbry, 1953, pp. 13-14, pl. 1, fig. 1.

The following remarks are taken from Pilsbry's original description:

> The capitulum is 11.5 mm in length, 7 mm in width, and 3.2 mm in thickness. It is inequilateral and oblong, the occludent border much less convex than the carinal. The valves are glossy, white or faintly pink, and are sculptured by fine radial striae and coarse concentric wrinkles; in the narrow area between the occludent margin and the apico-umbonal keel there are fine oblique striae.
>
> The tergum is small and wedge-shaped, the carinal end truncate or rounded, the valve marked with radiating and growth striae.
>
> The scutum is somewhat arcuate along the occludent margin, the greatest curvature near the apex and base; the basal margin is short and oblique, and the umbo is a little produced and incurved. There is only a semblance of a

curved ridge from the umbo to the junction of the tergum and carina, and no distinct angle is present in the outline of the valve at the tergocarinal suture. There is, however, a distinct ridge or angle from the umbo to the apex, this nearly straight in the upper half where it defines a narrow occludent area. Within the scutum there is a strong but narrow rounded basal rib and a stout but low umbonal tooth. The two scuta are more or less unequal in convexity.

The carina is regularly arcuate, very narrow and slender; the roof is narrow and rounded, slightly wider above than near the umbo, but the sides somewhat wider below. Internally, the surface of the carina is concave near the umbonal end, elsewhere convex. There are no distinct teeth, and no postumbonal expansion or disk.

The peduncle is one-half to one-fourth the length of the capitulum, with prominent annuli.

The mouth parts and cirri closely resemble those of *P. kaempferi,* but the edges of the teeth of the mandible are slightly serrate.

This species is very variable in the degree of symmetry, some specimens being nearly symmetrical others decidedly asymmetrical with either the right or left scutum being the more convex.

Type locality. — "Albatross" sta. 2744 (38°35′N, 73°05′ 15″W), 554 fathoms (1019 meters), 30°F bottom temperature, blue mud, Western Atlantic, about 105 statute miles east off Ocean View, Delaware.

Florida localities. — Off Key West in the Gulf of Mexico (24° 34′N, 81°48′W), 70-80 fathoms (129-147 meters), on the crab *Scyramathia crassa*; off Palm Beach (26°41′N, 80°02′W) in the Western Atlantic, usually on the carapace and limbs of the crab *Cancer borealis* Stimpson; off Miami, 1100 fathoms (2012 meters) on *Cancer borealis.*

Other localities. — Off the east coast of the United States from Martha's Vineyard, Massachusetts at about 41 degrees of latitude to Key West in the Gulf of Mexico at about 24 degrees of latitude, occurring frequently on the crab *Geryon quinquedens* A. Milne Edwards between the latitudes of 39 degrees to 37 degrees. Depths range from 12 fathoms (22 meters) at Hampton Roads, Virginia to 963 fathoms (1771 meters) at "Albatross" sta. 2216 (39°47′N, 70°30′30″W), bottom of green mud, bottom temperature 39.5°F, about 200 statute miles east off Barnegat Light, New Jersey.

When Pilsbry described *Poecilasma inaequilaterale* in 1907 he recognized certain similarities with *P. kaempferi* Darwin, distinguishing it from that form by its "decidedly smaller tergum, less arcuate occludent border and frequently more asymmetrical valves, though some individuals are nearly equivalve." In 1924 Barnard stated he considered *P. inaequilaterale* a variety or subspecies of *P. kaempferi,* a union Pilsbry acknowledged in 1953 by naming specimens collected off Palm Beach, Florida *Trilasmis (Poecilasma) kaempferi inaequilaterale.* However, Pilsbry did not mention the occurrence of *P. inaequilaterale* off South Africa, an occurrence which Barnard implied by stating that "a few of a large number of specimens . . . all taken from a single specimen of *Geryon quinquedens* . . . are indistinguishable from Pilsbry's figures of *inaequilaterale*." If the taxa are indeed the same, then the range of *P. inaequilaterale* should be extended to include, in the Eastern Atlantic, the station 29 miles southwest of Cape Point (34°21′S, 18°29′E) off South Africa in 250-300 fathoms (460-552 meters) and in the Western Indian Ocean, the station 15 miles off Buffalo River, N., in 310 fathoms (570 meters) on the crustacean *Jasus parkeri* Stebbing, also off South Africa.

Poecilasma inaequilaterale breve Pilsbry Pl. 4, figs. 4, 5

Poecilasma inaequilaterale breve Pilsbry, 1907, p. 87, pl. 6, figs. 9, 10; Nilsson-Cantell, 1921, p. 254 *pars*; Barnard, 1924, p. 53 *pars* [= *Poecilasma crassum* (Gray)]; Henry, 1954, p. 444; Zullo, 1968, p. 211.

Pilsbry's original comments were as follows:

> Similar to *P. inaequilaterale,* but the capitulum is very short and broad, and the tergum is much reduced. It differs from *P. crassum* by the straight occludent border of the scutum.
>
> Length of capitulum 7.5, breadth 5.3, diameter 3 mm.
>
> Only two specimens were taken.

Type locality. — "Albatross" sta. 2352 (22°35′N, 84°23′W), 463 fathoms (852 meters), bottom of white coral, bottom temperature 45°F, on *Bathyplax typhla* A. Milne Edwards, about 15 statute miles due west of Rio de Medio, Cuba and 168 statute miles southwest of the Dry Tortugas, Florida.

Barnard (1924) proposed uniting this subspecies with *Anatifa crassa* Gray (1848), a species later described and illustrated by Darwin (1851) as *Poecilasma crassa* from specimens attached to the crustacean *Homola cuvierii* collected off the Island of Madeira. Barnard's reasons for synonymizing *P. i. breve* with *P. crassum* are most persuasive, although it must be pointed out he did not examine *P. i. breve* from the type locality off Cuba and could not compare it with his many specimens of *P. crassum* from off South Africa;

also, and apart from the great distance between them and certain morphologic differences between the two, the host of the type of *P. i. breve* is the crustacean *Bathyplax typhla* whereas the host of the type *P. crassum* is *Homola cuvierii.*

References to *Poecilasma crassum* that I have noted are the following:

Anatifa crassa Gray, 1848, p. 44, Annulosa, pl. III, fig. 6, as *Anatifa ovalis* (Pl. 14, fig. 2).

Poecilasma crassa (Gray), Darwin, 1851, pp. 107-109, pl. II, figs. 3, 3a (Pl. 14, fig. 1); Barnard, 1924, pp. 52-54; Stubbings, 1936, p. 6.

Poecilasma crassum (Gray), Hoek, 1883, pp. 28, 44; Gruvel, 1902d, p. 525; 1905, p. 116, fig. 132; 1920, pp. 38, 69, 73, 75, 77; Pilsbry, 1907, p. 87; Weltner, 1922, p. 78, pl. IV, figs. 17, 17a.

Trilasmis crassa (Darwin), Nilsson-Cantell, 1938, p. 9.

Trilasmis (Poecilasma) crassum (Gray), Withers, 1953, p. 29; Stubbings, 1967, pp. 231, 241.

The type locality of *Poecilasma crassum* (Gray) is given by Darwin as Madeira [Island] (32°45′N, 17°W) in the Eastern Atlantic, collected on *Homola cuvierii.*

Other localities reported are:

Eastern Atlantic adjacent to the Azores at the following co-ordinates (Gruvel, 1920):

"Prince de Monaco" sta. 219 (39°39′37″N, 31°03′W), 1,386 meters, black sand.

"Prince de Monaco" sta. 235 (38°59′35″N, 27°55′35″W), 195 meters, gray sand, on *Geryon affinis.*

"Prince de Monaco" sta. 563 (37°53′N, 25°40′15″W), 578 meters, hard sand rock.

"Prince de Monaco" sta. 701 (39°21′20″N, 31°05′53″W), 1,360 meters, on *Geryon affinis.*

"Prince de Monaco" sta. 884 (38°29′10″N, 28°36′45″W), 512 meters.

Cape Verde Islands, "Prince de Monaco" sta. 1189 (15°14′N, 23°03′45″W), 628 meters, muddy sand.

Off Angola, "Valdivia" sta. 76 (16°33′S, 11°46′E), about 18 statute miles southwest of Porto Alexandre; Tiger Bay, *fide* Stubbings (1967).

Off South Africa, Eastern Atlantic, "Pieter Faure" sta. 29 miles southwest of Cape Town (33°56′S, 18°28′E), on *Geryon quinquedens.*

Indian Ocean, off South Africa, Great Fish Point (33°31′S, 27°07′E), 12 fathoms (22 meters); off Zanzibar Island (Zanzibar, 6°10′S, 39°12′E).

Philippine Islands (Bohol), approximately 9°48′N, 124°11′E.

There is some doubt of the validity of *Anatifa crassa* Gray (1848), described succinctly (p. 44) but illustrated under the name of *Anatifa ovalis* on Gray's plate Annulosa III, fig. 6. The drawing of *A. ovalis* Gray fits the description of *A. crassa* Gray very well but poses the question of why, if they were considered the same by Gray, they were not so indicated. Was it a *lapsus* or oversight of some kind? Darwin's figure of what he regarded as *Poecilasma* *crassa* (Gray) has a somewhat more ovate capitulum and a longer peduncle than Gray's figure of *Anatifa ovalis* but Darwin may have been constrained to consider it specifically the same as Gray's taxon because it came from the same locality (Madeira), and because the differences in appearance were individual rather than specific. Gruvel's illustration (1905, fig. 132) of *Poecilasma crassa* was taken from Darwin. Weltner's identification of *Poecilasma crassum* (1922, pl. IV, figs. 17, 17a) was based on the carina only, and although this feature is similar to that of *Anatifa ovalis* Gray and *Poecilasma crassa* Darwin, the match is not definitive. Since I have not seen additional literature on *Anatifa ovalis* Gray, the references to *Poecilasma crassa* listed above are believed to be based on Darwin's illustration and description of the taxon which was first reported from Madeira.

Poecilasma kaempferi litum Pilsbry Pl. 4, figs. 6, 7

Poecilasma kaempferi litum Pilsbry, 1907, p. 85, pl. 6, figs. 1-2; Annandale, 1909, p. 91; Krüger, 1911, p. 36, pl. 3, figs. 24-25, text-figs. 68-71; Nilsson-Cantell, 1921, p. 255 *pars*; Barnard, 1924, pp. 51, 52 *pars*; Henry, 1954, p. 444; Zullo, 1968, p. 214.

Pilsbry's original description was the following:

> The capitulum is equilateral, somewhat less swollen than the Japanese *P. kaempferi* examined. Scutum and tergum have distinct radial striae and very fine, close growth-lines. The ridge from umbo to apex of the scutum is well-defined, but that to the tergo-carinal angle is barely indicated. The base of the scutum is about three-fifths the length of the tergum. The occludent margin is very convex in its upper half, the area in front of the ridge running to the apex being wider than in *P. kaempferi*. Internally each scutum has an umbonal tooth and a narrow but rather high and sharp straight basal ridge. The tergum is shorter than in *P. kaempferi*, barely half as long as the scutum.
>
> Length of capitulum 12, width 6.8, diameter 3.3 mm. Length of carina 7.8, of peduncle 5 mm.
>
> The mouth parts and cirri closely resemble those of Japanese *P. kaempferi*.

Type locality. — "Fish Hawk" sta. 7512, off Fowey Rocks Light (25°35′N, 80°05′W), 170 fathoms (313 meters), about 15 statute miles southeast of Miami, Florida, Straits of Florida.

Other localities. — Gulf of Mexico (Henry, 1954).

Nilsson-Cantell (1921) and Barnard (1924) placed both *Poecilasma kaempferi litum* Pilsbry and *P. k. novaeangliae* Pilsbry in synonymy with *Poecilasma kaempferi kaempferi* Darwin. According to Barnard, *P. k. kaempferi* Darwin occurs in South African waters both off the west coast in the Eastern Atlantic and off the east coast in the Western Indian Ocean. The former locality is 29 miles southwest of Cape Town in 250-300 fathoms (460-552 meters) where *P. k. kaempferi* occurs with *Poecilasma crassa* (Gray) on the crab *Geryon quinquedens*, the latter 15 miles off Buffalo River, N., in 310 fathoms (570 meters) on the crustacean *Jasus parkeri* Stebbing.

Poecilasma kaempferi novaeangliae Pilsbry Pl. 4, figs. 8, 9

Poecilasma kaempferi novaeangliae Pilsbry, 1907, pp. 83, 85, pl. 6, figs. 13, 14; Annandale, 1909, p. 131; Nilsson-Cantell, 1921, p. 255 *pars;* Barnard, 1924, p. 51 *pars*; Zullo, 1968, p. 215.

Pilsbry's account of this species was as follows:

> Larger than *P. kaempferi*; the capitulum equilateral. The scutum has a strong ridge running from the umbo to the apex, and another to the tergo-carinal angle. The basal margin is very short, less than half the length of the tergum. It is sculptured with distinct radial striae and growth wrinkles.
>
> Length of capitulum 17, breadth 9.7, diameter 5.75 mm. Length of the carina 12, of the peduncle 9 mm.
>
> In *P. kaempferi* and *aurantia* there is no distinct ridge from the umbo to the tergo-carinal angle of the scutum, and the base is longer.
>
> A very small example, No. 9019, from *Albatross* Station 2115, is probably referable to the above subspecies. It occurred on *Lithodes agassizii.*

Type locality. — U.S. Fish Commission sta. 1120, off Martha's Vineyard, Massachusetts, 194 fathoms (357 meters), on the carapace of the crab *Eupagurus politus.*

Paratype locality. — "Albatross" sta. 2115 (32°49′30″N, 72° 34′45″W), 843 fathoms (1596 meters), bottom temperature 39°F, on *Lithodes agassizii*; about 163 statute miles east off Roanoke Island, North Carolina.

Other localities. — Martha's Vineyard, Massachusetts (not New Jersey), on *Geryon quinquedens, fide* Annandale (1909).

The report of this taxon some 2° north of Florida waters suggests it may eventually be found off Florida itself.

Barnard (1924) listed *P. k. novaeangliae* as synonymous with *P. kaempferi kaempferi.* If this is true, the taxon occurs in the Eastern Atlantic 29 miles southwest of Cape Point, South Africa, 250-300 fathoms, and in the Western Indian Ocean 15 miles off Buffalo River, N., 310 fathoms.

Megalasma (Glyptelasma) annandalei Pilsbry Pl. 4, figs. 10-15

Megalasma (Glyptelasma) annandalei Pilsbry, 1907, pp. 83, 87, 89-90, pl. 5, fig. 14, pl. 7, figs. 15-19; 1907a, p. 416; Calman, 1919, p. 363; Barnard, 1925, pp. 4-5; Zullo, 1968, p. 211.

The capitulum is 19 mm in length, 9 mm in width, and 5.5 mm in thickness. The lower half is very plump, the upper half compressed. The occludent and carinal margins are convex, the carinal margin more strongly so. The valves are strong, white, and sculptured with fine, faint radial striae and strong concentric grooves, with very fine intervening growth striae on the scuta, more crowded grooves on the terga. The peduncular orifice is nearly circular.

The tergum is rhombic, the occludent and carinal margins parallel, the carinal more than half the length of the occludent. The scutum has a convex occludent margin, a somewhat shorter tergal margin, a slightly convex carinal margin which is concave near the base, then strongly convex, and a very short basal margin. An angle runs from the umbo of the scutum to the apex, defining a very narrow lanceolate ventral area, and a curved ridge extends to the tergo-carinal angle; an oblique constriction or wide furrow defines an obliquely sulcate basal area. Internally, the scutum has a small umbonal tooth and a wide, low, and smooth basal callus.

The carina is 13 mm long. It is moderately curved, with a convex roof. The sides are narrow in the upper two-thirds, expanding markedly in the lower third, and sculptured with narrow oblique riblets. The umbo is incurved and projects below the base of the scutum. The basal margin is as long as that of the scutum and forms an obtuse angle with it. Internally, the scutum is concave throughout. The cavity of the base is enclosed by a concave plate with a notched upper margin, the sides produced in two short teeth.

The peduncle is cylindric, oblique to the capitulum, blackish, transversely wrinkled, and about one-fourth the length of the capitulum, or nearly 5 mm.

Type locality. — "Albatross" sta. 2731 (36°45′N, 74°28′W), 781 fathoms (1436 meters), gray ooze, on *Scalpellum velutinum* Hoek, in the Western Atlantic, about 100 statute miles east of Norfolk, Virginia.

Other localities. — Eastern Atlantic (34°32′S, 17°19′E), on *Scalpellum velutinum,* about 120 statute miles southwest of Cape Town, South Africa.

Megalasma (Glyptelasma) annandalei Pilsbry is expected to be found eventually off the east coast of Florida, because it occurs in the Western Atlantic some 7° North of Florida, and is associated with the barnacle *Scalpellum velutinum* Hoek, which occurs some 2° North of Florida off the coast of South Carolina.

Megalasma (Glyptelasma) gracilius Pilsbry Pl. 4, figs. 16-20

Megalasma gracile gracilius Pilsbry, 1907, pp. 83, 88-89, pl. 5, fig. 16, pl. 7, figs. 6-9; 1907a, pp. 414, 416; Annandale, 1909, p. 132; Zullo, 1968, p. 213.

The capitulum, measuring 11.8 mm in length, 5 mm in breadth, and 3 mm in thickness, is strongly inflated just below the middle, compressed above the inflation. The carinal border is much more convex than the occludent. The valves are sculptured with fine inconspicuous radial striae and with coarse wrinkles and occasional grooves along the lines of growth. The basal foramen is subcircular and small.

The tergum is rhombic, the short carinal margin about one-third the length of the occludent. The surface is divided into two unequal areas by a diagonal line from the apex to the baso-carinal angle, the larger area grooved lengthwise, the narrow upper area marked with lines at right angles to the others.

The scutum has a moderately curved occludent margin and a short straight basal margin; the tergal margin is slightly shorter than the carinal, which is convex, except near the base, where it is somewhat concave. A sharp keel extends from the umbo to the apical angle, and at a strong angulation to the tergo-carinal angle; the area in front of the keel is very narrow, forming a lanceolate figure in ventral view. Internally there is a very small umbonal tooth in each valve and a small polished area of attachment of the peduncle, but no basal callus.

The carina is 7.75 mm long, moderately and evenly curved, and has a flat roof. The umbo projects beak-like beyond the base of the scutum. The basal margin of the carina is as long as, and at right angles to the scutum. The sides of the carina are very wide in the basal third and are obliquely grooved. Inside, the carina is slightly concave throughout, and a narrow cavity penetrates downward behind a concave plate which extends over the basal region of the cavity; this plate, which becomes narrower above, is truncated, and its sides project to form two blunt teeth.

The peduncle is about one-tenth the length of the capitulum, or a little over 1 mm, and is transversely wrinkled and blackish.

Type locality. — "Albatross" sta. 2625 (32°35′N, 77°30′W), 247 fathoms (454 meters) on the echinoid *Cidaris papillata* Leske, bottom of gray sand with black specks, about 163 statute miles east off coast of Edisto Island, South Carolina.

Florida locality. — "Albatross" sta. 2658 (28°21′N, 78°33′W), 514 fathoms (945 meters), on *Scalpellum giganteum* Gruvel, bottom temperature 44.7°F, bottom of foraminifers and broken shells, about 120 statute miles east off Cape Canaveral.

Other localities. — Atlantic cable, West Indies on capitulum of *Scalpellum giganteum,* in Royal Scottish Museum; on capitulum and peduncle of *Heteralepas cygnus* Pilsbry, locality unknown, probably West Indies, in Royal Scottish Museum, *fide* Annandale. The identification of locality of *H. cygnus* Annandale (1909), given as Monterey, California in the Eastern Pacific, is suspect.

Megalasma (Glyptelasma) hamatum Calman Pl. 5, figs. 1, 2; Pl. 14, fig. 3

Megalasma (Glyptelasma) hamatum Calman, 1919, pp. 370-374, text-figs. 5-7; Nilsson-Cantell, 1927, pp. 770-772, text-fig. 11; 1928, pp. 23-25, fig. 11; 1931a, p. 10; 1934b, pp. 32, 49; U.S. Naval Inst., 1967, p. 194.

The capitulum is ovate, pointed at the apex, subtruncate at the base, convex in outline along the margins. The cuticle is thin, present only near the edges of the valves. The valves are thin, all of them in contact or nearly so, marked faintly with lines of growth and radial striations. The type capitulum is 24 mm long and 12.5 mm wide.

The tergum has straight margins except the occludent which may be gently curved, the carinal margin one-third to one-half as long as the occludent. The scutum has a convex occludent margin and a straight tergal margin; the carinal margin is convex above, more or less deeply concave or notched below; the basal margin is straight forming a right or obtuse angle with the chord of the occludent margin. There is a straight or gently curved submarginal ridge from the umbo to the apex and a very obscure ridge from the umbo to the carino-tergal angle. The basal margin of the scutum is more or less everted, and on the inner surface of each valve there is a small umbonal tooth. The area between the base and the peduncle is defined by a very narrow line of attachment.

The carina is narrow and evenly curved, the sides expanding in the lower part so that the margin is convex or even bluntly angled; the basal margin is more or less everted, straight or gently concave as seen from the side, in line or forming an even curve with the base of the scutum; the septum is notched in the middle, the lateral lobes more or less prominent in side view.

The peduncle is less than half as long as the capitulum, the carinal side obscurely keeled. The attachment is almost to the margins of the scuta and carina.

In place of filamentary appendages, the dorsal surface of the prosoma bears, close to the middle of its length, a pair of hook-like processes, turned forward and rather more firmly chitinized than the surrounding integument. The rami of the first cirrus bears 9 to 12 segments. The caudal appendages are very short, not more than one-fifth as long as the peduncle of the sixth cirri.

Type locality. — "Recorder" sta., north end of Victoria-Tasmanian cables, Australia.

Other localities. — Off the coast of Cuba, with specimen of *Megalasma carinatum* (Hoek), Caribbean Sea. Eastern Atlantic: "Britannia" sta. (14°54′N, 23°42′W), Cape Verde Islands, 990 fathoms (1821 meters), with *Megalasma carinatum* (Hoek); C/S "Lady Denison Pender" sta. (7°57.5′N, 21°49′W), roughly 800 kilometers west of Freetown, Sierra Leone, 2000 fathoms (3678 meters). Off East African coast: "Sherward Osborn" sta. (6°58′S, 39°16′E), near Dar-es-Salaam, Tanzania, 270 fathoms (497 meters); C/S "Lady Denison Pender" sta. (13°27′S, 40°47′E, 600 fathoms (1103 meters). Indonesia: North coast of Celebes (2°N, 120°-125°E), Menado-Kwandang telegraph cable, 750 meters; "Recorder" sta. (8°46′S, 114°44′E), about 30 statute miles west of Denpasar, Island of Bali, 400 fathoms (736 meters); "Patrol" sta. (11°S, 120°30′E and 11°S, 122°E), about 31 statute miles and 28 statute miles, respectively, southwest and south of the Island of Sawu, 500 to 600 fathoms (920 to 1103 meters). Australia-New Zealand: "Patrol" sta. (37°S, 165°E), Tasman Sea, 800 fathoms (1471 meters). Indian Ocean: Madras to Penang cable; C/S "Patrol" sta. (7°52′38″N, 92°59′13″E and 7°15′24″N, 92°59′E), southwest off Katchall Island, Nicobar; off south coast of Great Nicobar Island (6°10′N, 93°55′E); off west coast of Great Nicobar Island (6°39′N, 93°12′E), 800 fathoms (1471 meters); about 180 statute miles northwest of Penang (6°50′N, 97°25′E), 500 fathoms (920 meters).

Megalasma hamatum Calman occurs in the Atlantic, Pacific, and Indian Oceans at depths ranging from 270 fathoms to 2000 fathoms (457 to 3778 meters) as recorded above, and from 200 to 2000 fathoms (368 to 3778 meters) as stated by Nilsson-Cantell (1931a). Although the species is widespread, very few specimens have been recovered at the stations mentioned above, and at each locality the specimens exhibit minor differences from the type found on the Victoria-Tasmania cable off Australia. Nevertheless the species is included in this work because of its reported occurrence off the coast of Cuba which is close to Florida. The two specimens from Cuba are not quite identical with the Australia type but were nonetheless included with it by Calman, who wrote as follows:

> It is only after considerable hesitation that all the specimens recorded above have been included under one specific name. They all agree in the possession of the peculiar hook-like organs on the dorsal surface of the prosoma — a character which differentiates them from all the other species I have seen — but they differ greatly among themselves in the character of the capitular valves. As an example of the variations in these characters, I figure a specimen from off the coast of Cuba . . . It will be seen that it differs from the holotype . . . in the much narrower form of the capitulum, the relatively shorter carina, and the scutum with the basal margin at right angles to the chord of the occludent margin. Other specimens, however, both from the Atlantic and from the Indo-Pacific areas, are intermediate between the two forms, and I am unable to point out any characters by which they can be satisfactorily grouped.

Nilsson-Cantell (1927) agreed with Calman stating that the species "is easily recognizable internally by a pair of short, hook-like processes on the prosoma and by a narrow appendage at the base of the first cirrus."

Megalasma (Glyptelasma) subcarinatum Pilsbry Pl. 5, figs. 3-7

Megalasma (Glyptelasma) subcarinatum Pilsbry, 1907, pp. 83, 87, 91-93, pl. 7, figs. 1-5; 1907a, p. 416; Fowler, 1912, p. 501; Calman, 1919, p. 364; Zullo, 1968, p. 212; Newman, Zullo, and Withers, 1969, p. R280, fig. 116-11

The following remarks are re-arranged from Pilsbry's original description:

> The capitulum is pointed oblong, ventricose in the lower half, the occludent and carinal borders about equally convex, the total length about twice the greatest width. The plates are sculptured with fine, close, radiating impressions and distinct concentric wrinkles and spaced grooves. These are much closer on the terga and carina than on the scuta. The basal orifice is rounded-pentagonal, a little longer than wide.
>
> The tergum is trapezoidal, the carinal edge parallel with the occludent and nearly half as long.

The scutum is very large, the occludent border evenly arched; the tergal margin is straight, the carinal convex except near the base where it is concave to receive the enlarged side of the carina; the basal margin is short and straight. On the scutum there is an oblique depression from the umbo to the apical angle, defining a very narrow lanceolate area along the occludent margin; another less acute ridge runs to the tergo-carinal angle. In the interior there is a small but prominent umbonal tooth in each valve of the scuta, and a small basal area under which there are microscopic radial and growth striae. A small cavity extends from above under the umbonal tooth.

The carina is short and slightly arcuate. Its roof is rather wide and flattened above. The sides are narrow above, wider below the middle, and expand into a wide plate in the lower third. The basal margin is straight, and in basal view the sides are seen to form a right angle. The inner face of the carina is deeply concave throughout. A prominent septum or sheath, bilobed and projecting above, occupies slightly more than the lower fourth of the length; the cavity of the plate penetrates behind this septum to the apex.

The peduncle is so short that the capitulum appears to be sessile.

The type capitulum from "Albatross" sta. 2042 is 19 mm long, 10 mm wide, 5 mm in greatest thickness; the carina of the type is 12 mm long. A very large detached scutum from sta. 2042 is 23 mm long: this implies a length of about 28 mm for the capitulum.

Three other specimens, one from "Albatross" sta. 2041 and two from the type lot at "Albatross" sta. 2042 have the following measurements, in mm:

Length of capitulum	16.2	16.5	16.9
Width of capitulum	8.0	8.0	8.9
Thickness of capitulum	3.8	4.0	5.0
Length of carina	9.7	10.0	10.4

Type locality. — "Albatross" sta. 2042 (39°33′N, 68°26′45″W), on spines of a sea urchin, 1,555 fathoms (2860 meters), 38.5°F bottom temperature, *Globigerina* ooze, about 310 statute miles east of Atlantic City, New Jersey.

Paratype locality. — "Albatross" sta. 2041 (39°22′50″N, 68° 25′W), 1,608 fathoms (2957 meters), 38°F bottom temperature, *Globigerina* ooze; about 325 statute miles east of Ocean City, New Jersey.

This deep water species is known thus far only from the Western Atlantic some 310 to 325 miles east of the New Jersey coast. It is included in this work because of the possibility it may be discovered off the east coast of Florida.

Megalasma (Glyptelasma) rectum Pilsbry Pl. 5, figs. 8-12

Megalasma rectum Pilsbry, 1907, pp. 83, 90-91, pl. 7, figs. 10-14; 1907a, p. 416; Fowler, 1912, p. 501; Calman, 1919, p. 363; Zullo, 1968, p. 216.

The following description is adapted from Pilsbry's original:

> The capitulum of the type is 15.5 mm in length, 7.5 mm in breadth, and 2 mm in thickness. It is twice as long as wide, plump in the lower half, compressed above, the sides equally convex, the occludent margin nearly straight, the carinal strongly arched. The valves are minutely sculptured with fine, short, diverging impressions giving the effect of radial striae, and of coarse, widely-spaced concentric ridges. The peduncular foramen is large and cordate in shape.
>
> The tergum is trapezoidal, with parallel occludent and carinal borders, the former twice the length of the latter. A furrow runs from the umbo to the carino-scutal angle.
>
> The scutum has a nearly straight occludent margin, a well-arched carinal margin, and a straight basal margin forming an acute angle with the occludent. The basal edge flares broadly outward and there is a deep furrow or concavity above it. A distinct ridge runs almost straight from the umbo to the carino-tergal angle, dividing the scutum into two areas, the upper one slightly the greater. Internally the scutum has no basal rib and no umbonal tooth. There is a lusterless band of about equal width and no special sculpture along the internal basal margin where the peduncle is attached, contrasting with the glossy surface elsewhere.
>
> The carina is 10 mm in length and strongly arched. Its roof is flat, with a median depression; the sides are well developed toward the base, closely striated longitudinally. On each side of the apical umbo the sides are auriculate, being produced laterally and twisted. The carina does not project basally as far as the scutum, and its base forms only the dorsal border of the peduncular foramen, not clasping the peduncle. Internally the carina is concave; from its basal margin there arises a short, transverse bicuspid plate lying nearly parallel with the upper portion of the carina, but making a right angle with the umbonal portion.
>
> The peduncle is very short, about 2 mm.

Type locality. — "Albatross" sta. 2042 (39°33′N, 68°26′45″W), 1,555 fathoms (2860 meters), 38.5°F bottom temperature, bottom of *Globigerina* ooze; about 310 statute miles east of Atlantic City, New Jersey, in the Western Atlantic.

Paratype locality. — "Albatross" sta. 2041 (39°22′50″N, 68° 25′W), 1,608 fathoms (2957 meters), 38°F bottom temperature, bottom of *Globigerina* ooze; Western Atlantic, about 325 statute miles east of Ocean City, New Jersey.

This species occurs at the same localities as *M. subcarinatum* Pilsbry, but is quite distinct. So far as I know *M. rectum* has not been reported from Florida waters but its eventual discovery there would not be unexpected.

Octolasmis americanum Pilsbry Pl. 5, figs. 13-15

Octolasmis americanum Pilsbry, 1907, pp. 94, 96-97, fig. 33a-d; Fowler, 1912, p. 502; Zullo, 1968, p. 211.

The capitulum of the holotype is 8 mm long and 3.6 mm wide, semicordate in outline, and has a straight occludent margin and a convex carinal margin, especially near the base. The tergum is triangular, with the umbo on the carinal side, midway between the summit of the plate and the apex of the carina; a furrow runs from the umbo to the basioccludent angle, opposite the apex of the scutum, where there is a slight notch; the occludent margin is convex, the summit somewhat obtuse; the basal and carinal margins are nearly straight, the basal angle of the plate somewhat obtuse. The scutum consists of two straight branches, an occludent and a lateral portion. The lateral branch is about one-third the length of the occludent, and is somewhat narrower, tapering to a blunt end. The carina is strongly arched, more so at the base. The roof of the carina is flat, as broad as the plate at the upper end but tapering to a narrow keel at the base. The sides are broader than the roof but taper upward. The base forms a broadly crescentic cup, half embracing the top of the peduncle with very short horns. The peduncle is very short.

Type locality. — "Albatross" sta. 2041 (39°22′50″N, 68°25′W), 1608 fathoms (2957 meters), bottom of *Globigerina* ooze, about 325 statute miles east of Ocean City, New Jersey.

Other localities. — "Albatross" sta. 2709 (40°07′N, 67°54′W), 866 fathoms (1593 meters), bottom of brown mud, about 340 statute miles east of Belmar, New Jersey.

This species has not yet been recorded in Florida but is listed in this work because of the likelihood it will be found in the Gulf Stream off Florida as it is off the New Jersey coast some 8 degrees of latitude to the northeast.

Octolasmis antiguae (Stebbing) Pl. 5, figs. 16-18

Dichelaspis antiguae Stebbing, 1895, pp. 19-21, 25, pl. 2, figs. E-G; Weltner, 1897, p. 241; Gruvel, 1905, pp. 125-126, fig. 123; Annandale, 1909, p. 100, as *D. antiquae*.

Octolasmis antiguae (Stebbing), Pilsbry, 1911, p. 172; Nilsson-Cantell, 1927, *pars* pp. 763, 765; Causey, 1961, p. 52; Stubbings, 1967, pp. 247-250, figs. 5-7.

Stebbing described and illustrated two small, similar species from the Island of Antigua, one *Dichelaspis hoeki*, the other *Dichelaspis antiguae*. He noted that the valves of *D. antiguae* occupy a larger proportion of the capitulum and are much less opaque, thereby allowing the umbones of the terga and scuta to be seen much more clearly than in *D. hoeki.* The terga of *D. antiguae* are contracted below instead of widening downward, and the distal margin of the base of the carina is distinctly though not deeply emarginate. Moreover, the membrane of *D. antiguae* is devoid of the foramenate appearance which it has in *D. hoeki,* and the peduncle is relatively shorter.

Stebbing's illustrated examples of *Octolasmis antiguae* measure less than 0.15 inches (3.81 mm) and the capitulum not quite 0.1 inches (2.54 mm). They were collected from the maxillipeds of three different palinurids.

Type locality. — Antigua Island, 17°09′N, 61°49′W, in the Leeward Islands. Collector: W. R. Forrest.

Other localities. — Georgetown (6°46′N, 58°10′W), British Guiana.

Annandale (1909, p. 100) and Nilsson-Cantell (1927, pp. 763, 765) were of the opinion that *O. antiguae* should be synonymized with *O. hoeki,* which had page priority, because of overlapping characters. Stubbings (1967) examined numerous specimens of both taxa from the type locality and concluded that the two were indeed separate species. He found that the most reliable features for diagnosis were

> undoubtedly the proportions and setation of the cirral segments. In *O. hoeki* the length of the segments is less than twice the breadth and there are three or four pairs of setae. In *O. antiguae* the segments are more than twice, often three times, as long as broad, and there are six to eight pairs of setae.

Since these characters do not intergrade, Stubbings reinstated *Octolasmis antiguae* (Stebbing) as a distinct species.

I have seen no definitive record of this species in Florida waters, but inasmuch as other cirripeds occur both in Antigua and Florida, this one may also.

Octolasmis brevis Pearse Pl. 6, fig. 1

Octolasmis brevis Pearse, 1951, pp. 370-371, fig. 77, j.
Octolasmis brevis Pearse, *pars* Newman, 1960c, pp. 106, 108 [= *Octolasmis lowei* Darwin, *fide* Newman, 1960c, pp. 106-108, fig. 4].

Pearse's original description of *Octolasmis brevis* was the following:

> The capitulum is compressed, more than three-fourths as wide as long, and triangular. Occludent margin straighter than the carinal.

Scutum calcified in two segments; occludent segment thin, wider than the carinal, bent at an angle of less than 90°, carinal segment slender and gradually curved, flattened a little where it meets the occludent. Tergum large, slightly bifid at the proximal end, with a strong, recurved hook near its distal end; this hook is about one-fourth as long as the tergum. Carina tapered and curved distally; proximal edge rather straight. Peduncle less than half as long as capitulum, nodulose and spreading proximally.

Measurements: Length of 3.2-3.8 mm; width of capitulum 1.6-2.0 mm; length of capitulum 2.00-2.4 mm; length of stalk 1.2 mm.

Type. — U.S.N.M. No. 88580.

Host. — From the gill chambers of 186 mud crabs *Panopeus herbstii* H. Milne Edwards, 32 of these parasites were collected. Some of these bore ovate eggs.

Remarks. — This species resembles *O. geryonphila* Pilsbry (1907) and *O. mülleri* (Coker (1902)), but differs from them in having a shorter peduncle, a longer and stouter hook, and a bifid proximal end on the tergum. Also the actual segments come close together and even overlap, proximally, in the present species.

Type locality. — Bimini, Bahama Islands. The coordinates of Bimini North Island are 25°46′N, 79°14′W, and of Bimini South Island 25°43′N, 79°15′W. These islands lie on the western edge of the Great Bahama Bank, some 55 statute miles east of Miami, Florida.

As stated by Newman (1960c, p. 108), this species may require a fuller description; in the meanwhile Pearse's name of *Octolasmis brevis* is accepted.

Octolasmis dawsoni Causey Pl. 6, fig. 2

Octolasmis dawsoni Causey, 1960, pp. 95-98, figs. 2, 4, 6; 1961, pp. 50, 53, 54, 55, figs. 7-10, 14; Newman, 1961b, p. 328, as *Octolasmis aymonini dawsoni*; Monod, 1974, p. 220.

Dichelaspis (?) geryonphila Pilsbry, Pearse, 1932a, p. 110 [*Fide* Newman, 1961b, p. 328.]

Octolasmis aymonini geryonpila [*sic.*] Pilsbry, Newman, 1961b, addendum, p. 329.

Octolasmis aymonini Lessona and Canefri ssp. *geryonphila* Pilsbry, Monod, 1974, pp. 219-221, figs. 1-10.

O. dawsoni Causey is a small animal with an average capitulum length of 1.42 mm. It lives on the huge deep water isopod *Bathynomus giganteus* Milne-Edwards, attached to the ventral surface of the abdomen. The barnacle is light brown, almost salmon-colored, and is characterized by an apically notched tergum and an almost centrally placed umbo. The mandibles have three or four teeth, without ridges, and with hooks at the base of the teeth. The maxilla has a broad notch and more bristles or setae than does *O. lowei*, with which *O. dawsoni* was compared by Causey.

Type locality. — M/V "Oregon" sta. at 28°30′N, 86°11′W, 240 fathoms (441 meters), about 150 statute miles southeast of Pensacola, Florida, attached to *Bathynomus giganteus* Milne-Edwards.

Paratype locality. — M/V "Silver Bay" sta. at 24°11′N, 83° 21.5′W, 400 fathoms (736 meters), about 45 statute miles southwest of Fort Jefferson, Dry Tortugas, Florida, attached to *Bathynomus giganteus* Milne-Edwards.

After examining a number of *Octolasmis* specimens infecting the gills of *Geryon quinquedens* Smith near the localities in which the host isopods *Bathynomus giganteus* were recovered, Newman found "a complete series of forms intermediate between and including both *Octolasmis geryonphila* Pilsbry, 1907, and *O. a. dawsoni* Causey, 1960", and was persuaded that *O. dawsoni* should be united with the prior-named *O. geryonphila* Pilsbry. Here, however, *O. geryonphila,* first reported in the Western Atlantic from the host crab *Geryon quinquedens* 190 miles east off Barnegat, New Jersey, and *O. dawsoni,* first reported from the host *Bathynomus giganteus* in the Gulf of Mexico, about 150 miles southeast of Pensacola, Florida, are considered separate species. The rounded tergal apex of the type of *O. geryonphila* seems quite distinct from the notched tergal apex of *O. dawsoni,* and it was mainly on this latter character, together with other differences that Causey erected his *Octolasmis dawsoni.*

Octolasmis forresti (Stebbing) Pl. 6, figs. 3, 4

Trichelaspis forresti Stebbing, 1894, pp. 443-446, pl. 15; 1895, p. 20; Weltner, 1897, p. 242.

Dichelaspis forresti (Stebbing), Gruvel, 1905, pp. 132-133, figs. 154A-C; Annandale, 1969, pp. 99, 103.

Octolasmis forresti (Stebbing), Pilsbry, 1907, p. 96, fig. 32d; 1911, p. 171; Pearse, 1951, p. 369; Henry, 1954, p. 444; Causey, 1961, pp. 50, 53, 54, fig. 3.

The holotype of *Octolasmis forresti* shown on Stebbing's plate XV, measures approximately 5.5 mm in length, of which the peduncle occupies the larger half. The capitulum is triangular, compressed, the breadth about two-thirds the length, the occludent border microscopically crenate. The valves are translucent, and although they approach each other at certain points they are nowhere in contact.

The terga are deeply and widely bifid, the two segments or lappets equal in length and widest at the middle. The scuta have two segments, the occludent and the basal, forming an angle of about 70 degrees. The occludent segment is long and narrow, widening a little distally, the rounded apex near the tergum; the basal segment is very narrow and pointed, does not quite equal the length of the occludent segment, and its apex overlaps the fork of the carina. From the basal segment of the scutum there arises a median segment, also very narrow, a little crooked, and two-thirds the length of the occludent segment, from which it diverges much less than it does from the basal segment. All the segments are continuously calcified. The carina is arched, narrow, a little widened approaching the apex, which overlaps the terga without approaching them very closely; the fork at the base of the carina is variable, in some specimens much more pronounced than in others.

The peduncle is cylindrical, moderately stout, a little longer than the capitulum.

The crest of the labrum has a row of moderately acute teeth, the central ones more widely separated than those at the sides. In the mandibles there are six teeth, the largest at the extremity of the convex margin, remote from the rest; the convex border bears about six pairs of setules. The first maxilla have a group of three spines preceding the minute notch, and on the rest of the border there are five sets of smaller spines mixed with setae. The second maxilla are broadly lamellar.

The first pair of cirri are distant from the second and not more than half their length, and curl closely around the mouth organs; each ramus has seven segments, all with numerous stout spines except the terminal one. The remaining pairs have rami of twelve to fourteen segments, each with eight to thirteen pairs of smooth spines of which the distal are very long, the proximal very short. The caudal appendages are slender, shorter than the peduncles of the sixth pair of cirri, tipped with a group of spines two of which are considerably longer than the appendages themselves.

Type locality. — West Indies, on *Panulirus argus* (Latreille).

Florida localities. — Summerland Key (Atlantic side, about 30 miles northeast of Key West), in the gill cavities of *Panulirus argus* (Latreille), the host living in 2 to 3 feet of water. The crab *Panulirus argus* is reported from the Bermuda Islands, the Florida Keys and Bahama Islands to Brazil.

Other localities. — Texas: Gulf coast. Louisiana: Grand Isle (30°09′N, 89°21′W), from *Scyllarus arctus.* Bahama Islands: Bimini. (The coordinates of Bimini North Island are 25°46′N, 79° 14′W, and of Bimini South Island 25°43′N, 79°15′W).

Octolasmis geryonophila Pilsbry Pl. 6, figs. 5, 6

Octolasmis geryonophila Pilsbry, 1907, pp. 94-95, figs. 32a-b; Annandale, 1909, pp. 99, 101, 103, 106, 112-114, 134, pl. VI, figs. 11-15, as *Dichelaspis*; Fowler, 1912, p. 502; Pearse, 1932a, p. 110, as *Dichelaspis*; Hiro, 1937, p. 426; Henry, 1954, p. 444; Newman, 1961b, pp. 326-328, as *Octolasmis aymonini geryonophila;* 1967a, pp. 15, 19, 21, 27, 29, 30, figs. 1A-F, 2A-J; Causey, 1961, pp. 52, 53; Zullo, 1968, p. 212; Kujawa, 1971, pp. 285-286, fig. 2; Monod, 1974, pp. 220-222, figs. 1-10, as *Octolasmis aymonini geryonophila.*

The following synonyms of *Octolasmis geryonophila* have been recorded*. Demonstration of validity, especially for species not originally described from the type locality and neighboring waters, or those ascribed names other than that of the type, must await the results of further study.

Dichelaspis geryonophila Pilsbry var. *fissicarina* Annandale, 1909, p. 113 [*by Newman, 1967a, p. 15.]

Dichelaspis stella Annandale, 1909, pp. 106, 117, fig. 10 [*by Newman, 1967a, p. 15]; not *Octolasmis stella* (Annandale), Daniel, 1955, pp. 14-15, pl. 1, fig. 13, pl. 3, figs. 42, 43 [*by Newman, 1967a, p. 15] nor *Octolasmis stella* (Annandale) [*by Dinamini, 1964, pp. 357-362, figs. 1-2; 1965, pp. 92-96, figs. 1-2.]

Dichelaspis sinuata Aurivillius, Annandale *partim*, 1909, pp. 99, 100, 106, 121 [*by Newman, 1967a, p. 15.]

Octolasmis lowei (Darwin), *partim*, Nilsson-Cantell, 1927, p. 766; 1938, p. 11; Broch, 1931, p. 129; Henry, 1954, p. 445; Newman, 1960c, pp. 106-108, fig. 4 [*by Newman, 1961b, pp. 327-329.]

The capitulum of *O. geryonophila* is somewhat triangular, compressed, widest near the base, 2.5 mm wide, 3.2 mm long. The occludent margin is nearly straight, the carinal margin convex. The tergum is small, somewhat claw-shaped, the basal margin rounded, the upper portion tapering, hooked toward the occludent margin, the end acute. The scutum is calcified into two segments at right angles: the occludent segment is lanceolate; the basal segment is much broader, subtriangular, nearly two-thirds the length of the occludent segment, its upper margin straight. The carina is moderately arched above, strongly so near the base, and nearly three-fourths the length of the capitulum. The roof is rounded, and including the sides is rather wide throughout. The base of the carina is forked, the branches straight, extending about to the middle of the peduncle.

The peduncle is 2.5 mm to 3 mm long, cylindrical, and very finely, faintly wrinkled transversely.

Type localities. — "Albatross" sta. 2215 (39°48′N, 70°31′W), 578 fathoms (1120 meters), and "Albatross" sta. 2216 (39°47′N, 70°22′W), 963 fathoms (1861 meters), attached to the branchial cavity of the crab *Geryon quinquedens* Smith. These stations are about 190 statute miles east off Barnegat, New Jersey in the Western Atlantic.

Florida localities. — Dry Tortugas in the Gulf of Mexico, on the gills of the crab *Bathynectes superba* (Costa). It is probable that the species occurs elsewhere in the Gulf of Mexico off the west and south coast of Florida.

Other localities. — The taxon *Octolasmis geryonphila* s.s. was reported by Pilsbry beyond the 400-fathom line from south of Nantucket to off the Delaware capes, on *Geryon quinquedens,* in the Western Atlantic from 37°49′ to 39°51′ North and from 69°49′ to 73°22′ West, at depths varying from 435 meters to 1043 meters; by Monod in French Guiana, off the Guyana coast at "Thalassia" sta. 275 on the giant isopod *Bathynomus giganteus* Milne-Edwards at a depth of 604 meters (*Bathynomus giganteus* occurs abundantly in Guyana waters between 6°55′ and 7°50′ North and 52°28′ and 54°02′ West, at depths of 450 to 800 meters on a bottom consisting of soft gray mud with a little sand); by Annandale near the Laccadive Islands west of the mainland of India on *Geryon affinis,* 224 to 284 fathoms (412-522 meters), recovered at "Investigator" sta. 248; and by Hiro, in Japanese waters.

Octolasmis hoeki (Stebbing) Pl. 6, figs. 7, 8

Dichelaspis hoeki Stebbing, 1895, pp. 18-19, pl. 2, figs. A-D; Weltner, 1897, p. 241; Gruvel, 1905, p. 125, fig. 142.

Dichelaspis antiguae Nilsson-Cantell, 1927, pp. 763-765; *non* Stebbing, 1895.

Dichelaspis aurivilli Gruvel, 1900d, p. 111; 1902a, pp. 275, 292-296, 298, text-figs. 13-15, pl. 14, figs. 1-3, 33-34; 1905, p. 124, *fide* Nilsson-Cantell, 1927, pp. 763-765.

Octolasmis hoeki (Stebbing), Pilsbry, 1907, p. 94; Nilsson-Cantell, 1927, pp. 763-766, text-figs. 9a-j; Henry, 1954, p. 444; Hulings, 1961, pp. 216, 220; Causey, 1961, pp. 50, 53, 54, figs. 1-2; Wells, 1966, pp. 89, 93; Stubbings, 1964a, pp. 103, 106-107, fig. 2; 1967, pp. 242-247, 311, figs. 2-4.

The following description is mostly from Stebbing's original.

The capitulum, a little over 2.6 mm long, is compressed in breadth to nearly three-quarters the length. The valves are opaque, and although they are close to each other, they do not come in contact. The external membrane is translucent, closely speckled with little clear spots producing an appearance similar to that of an empty test of a *Globigerina*. The membrane is also traversed by strong growth markings, some smooth, others wrinkled and denticulate, but all following the contours of the valves. The peduncle is shorter than the capitulum, averaging about 1.4 mm long.

The terga are trapezoidal, the anterior end of the basal margin deeply excavated and lying above the apex of the occludent scutum; the apex of the terga is obtuse or acute. The scutal valves are unequal: the occludent segment is long, narrow, slightly curved, and acute at the base, the apex rounded and closely approximating the excavated margin of the tergum; the basal segment of the scutum is shorter than the occludent, but very much wider, and triangular, the longest margin gently convex and lying close to the inner margin of the occludent segment; the lower side of the scutum overlaps the basal part of the carina, and the inner side is slightly convex at the center. The junction of the two scutal segments is not solidly calcified.

The carina is strongly arched, overlapping the terga for more than half their length; the basal part of the carina is bent at right angles to the upper and is externally concave; the distal border of the base is not emarginate.

There are five teeth in the mandibles, the one at the extremity of the convex margin the largest and remote from the others, the remaining four comparatively broad and denticulate. The notch which follows the principal spines of the first maxillae is shallow. The first pair of cirri are the shortest and near the second; the rami have six or seven joints with numerous spines; the rami of the outer pairs have from eight to ten joints each, the sixth pair having the smaller number. The setose spines are not numerous. The caudal appendages are one-jointed, short, and narrow, and are tipped with a group of seta-like spines of various lengths.

Type locality. — Island of Antigua (17°09′N, 61°49′W), in the Leeward Islands group (Collector: W. R. Frost).

Florida localities. — Gulf of Mexico in the Dry Tortugas and Keys; off Panama City (30°10′N, 85°41′W), 30 to 100 feet, commensal in the branchial chamber of the oxystomatous crab, *Calappa flammea*.

Other localities. — Texas. Louisiana (Grand Isle). South Carolina (North Edisto River, on *Calappa flammea*). Cape Verde Islands (Ilha São Nicolao and "Calypso" sta. 85, Ile de Sal). Ghana (at Tema, 5°41′N, 0°00′W), on *Scyllarides*).

This species is now known from the Gulf of Mexico, Western Atlantic, Caribbean Sea, Cape Verde Islands, and the Eastern Atlantic off the African coast.

Octolasmis lowei (Darwin) Pl. 6, fig. 14

[It can be seen in the synonymy below that a number of species have been united with *Octolasmis lowei* (Darwin), and it is difficult to determine which one should be chosen for the Florida region. I have opted for *Octolasmis lowei* (even though the type locality is Madeira in the Eastern Atlantic) for the following reasons: Madeira is at about the same latitude as the southeastern coast of the United States and the Gulf of Mexico; *Octolasmis lowei* s. s. is the oldest of the names given to the taxa of the *O. lowei* complex; and numerous taxonomists have identified the species as *O. lowei* in Floridan and adjacent waters.]

Dichelaspis lowei Darwin, 1851, pp. 128-130, pl. 2, fig. 8; Hoek, 1883, pp. 28, 48, 50; Weltner, 1897, p. 242; Gruvel, 1905, pp. 131-132, fig. 153.

Dichelaspis darwinii Filippi, 1861a, pp. 71-73 (Pl. 14, fig. 4); 1861b, pp. 200-206, pl. 13, figs. 12-13, *fide* Nilsson-Cantell, 1927, p. 766; Weltner, 1897, p. 241.

Paradolepas neptuni J. D. MacDonald, 1869, pp. 440-444, pls. 23-24, *fide* Nilsson-Cantell, as *Dichelaspis (Octolasmis)*, 1927, p. 766; Gruvel, 1905, pp. 127-128, fig. 147, as *Dichelaspis;* Weltner, 1922, p. 241, as *Dichelaspis.*

Dichelapsis aymonini Lessona and Tapparone-Canefri, 1874, p. 191 (Pl. 14, figs. 5, 6), *fide* Nilsson-Cantell, 1927, p. 766.

Dichelaspis sinuata Aurivillius, 1894, pp. 17-19, pl. 2, figs. 3-5, *fide* Nilsson-Cantell, 1927, p. 766, as *Dichelaspis (Octolasmis)*; Gruvel, 1905, p. 129, fig. 149; Annandale, 1909, pp. 99, 100, 101, 102, 103, 121-122.

Dichelaspis trigona Aurivillius, 1894, pp. 19-20, pl. 2, fig. 8, *fide* Nilsson-Cantell, 1927, p. 766, as *Dichelaspis (Octolasmis)*; Gruvel, 1905, pp. 129-130, fig. 148; Annandale, 1909, p. 106; Krüger, 1911, p. 40, *fide* Newman, 1960c, p. 106; Hiro, 1937, p. 424.

Dichelaspis mülleri Coker, 1902, pp. 401-412, figs. 1-14, *fide* Nilsson-Cantell, 1927, p. 766.

Dichelaspis vaillanti Gruvel, 1900d, pp. 109-110; 1902a, p. 279, pl. 14, figs. 5, 13; 1905, pp. 128-129, fig. 148, *fide* Nilsson-Cantell, 1927, p. 766; Annandale, 1909, pp. 106, 121; Daniel, 1955, p. 13.

? Octolasmis geryonphila Pilsbry, 1907, pp. 94-95, figs. 32a, b, *fide* Nilsson-Cantell, 1927, p. 766; Annandale, 1909 *pars*, pp. 101, 102, 103, 106, 112-114, as *Dichelaspis.*

Octolasmis lowei (Darwin), Broch, 1924a, p. 204; Nilsson-Cantell, 1927, pp. 766-769, text-figs. 10a-g; 1934b, pp. 32, 46; 1938, pp. 11, 18; Hiro, 1937, p. 424; 1939b, p. 206; Krüger, 1940, pp. 221, 225, 333, fig. 297; Henry, 1954, pp. 444-445; Daniel, 1955, pp. 12, 13, 14, pl. 1, fig. 12, pl. 3, figs. 40-41; Menzel, 1956, p. 40; Causey, 1960, pp. 95, 98, figs. 1, 3, 5; 1961, pp. 50, 51, 53, 54, fig. 1; Newman, 1960c, pp. 106-108, fig. 4, A-D; 1961a, pp. 99, 100, 104, figs. 1-2; 1967a, pp. 14, 15, figs. 3A-C; Stubbings, 1964a, pp. 103-105, fig. 1; 1964b, pp. 328, 330-333, fig. 2; 1967, pp. 231, 241, 242, 309, 312; Wells, 1966, p. 89; Rosell, 1967, pp. 279, 393-394, pl. 6, figs. 1-9; Kujawa, 1971, pp. 285-286, fig. 3; Monod, 1974, p. 220, *pars.*

Octolasmis uncus Pearse, *fide* Newman, 1960c, p. 106; *fide* Causey, 1961, p. 51.

Octolasmis brevis Pearse, *fide* Newman, 1960c, p. 106; *fide* Causey, 1961, p. 51.

Octolasmis (Octolasmis) aymonini (Lessona and Tapparone-Canefri), *pars*, Newman, 1961b, p. 327; Hiro, 1938, pp. 465, 473, Utinomi, 1958, p. 307.

Darwin's original description of *Octolasmis lowei* is summarized as follows:

The capitulum, measuring about 2.7 mm in length and 1.7 mm in width, is triangular, much compressed, formed of a very thin membrane. The valves are thin and imperfectly calcified. The terga are broad, and have a deep embayment toward which the apex of the scutal occludent segment approaches. The carinal lobe of the terga is much broader than the occludent lobe, and the lower part of the terga is twice as broad as the occludent segment of the scuta. The scuta are composed of two narrow plates forming an angle of 50° to each other, and united at the umbo by a non-calcified flexible portion. The occludent segment of the scutum is about twice as wide and about one-fifth longer than the basal segment, which latter is pointed at the end. The occludent margin is slightly bowed, a little narrowed-in on the occludent margin close to the umbo. Close to the umbos on the under side of the basal segment there is a longitudinal calcified fold on each valve.

The carina is nearly the same width throughout, with the upper half rather the widest, and the apex blunt. The carina, which is convex within, extends up between three-fourths the length of the terga, terminating downward in a fork with sharp prongs at right angles to each other. The points of the prongs extend under about one-fourth the length of the basal segments of the scuta. The peduncle is narrow, somewhat longer than the capitulum, about two-tenths of an inch (5.1 mm) in length. The membrane of the peduncle is thin and structureless.

The labrum has a few distinct bead-like teeth on the crest; the palpi are small and moderately bristled. The mandibles have four teeth, plus the rudiment of a fifth. The first tooth is as far from the second as is this from the inferior angle. The second, third, and fourth teeth are blunt. The maxillae are small, with a small notch under the three upper spines, which are followed by five or six pair, nearly as large as the upper spines.

The first pair of cirri is remote from the second; their rami are nearly equal, and about one-third the length of the rami of the second cirrus, thickly clothed with bristles; the rami of the second cirrus are equal in thickness, but a little shorter than those of the sixth cirrus; the three or four basal segments of the anterior are thickly clothed with spines; the other segments and all the segments of the third pair resemble the segments of the posterior pair. These latter are elongated, not protuberant, and support eight pairs of spines with very minute intermediate spinules; those in the dorsal tufts are numerous and long.

The caudal appendages are nearly as long as the pedicels of the sixth cirrus; they are oval, moderately pointed, their sides thickly spinose for one-fourth their length.

Type locality. — Island of Madeira (32°45′N, 17°W), "attached to a rare Brachyourous Crab, discovered by the Rev. R. T. Lowe. Very rare."

Florida localities. — Gulf of Mexico at Dry Tortugas, near Fort Jefferson (24°40′N, 82°50′W); Alligator Harbor, Franklin County, from brachial chamber of the blue crab *Callinectes sapidus* Rathbun; St. Teresa, Franklin County, from the branchial chamber of the stone crab *Menippe mercenaria;* St. George's Sound, on gills of crabs.

Other localities. — Gulf of Mexico-Western Atlantic. — Texas Gulf Coast. Louisiana (Grand Isle, 30°N, 89°21′W). Mississippi Gulf Coast. South Carolina (Rockville Sea Buoy, on *Arenaeus cribrarius*). Off North Carolina. Brazil? ("St. Catharina", after Weltner, 1922), as *O. darwinii.*

Eastern Atlantic, Mediterranean, Africa. — Italy (off Naples 40°50′N, 14°15′W). Mediterranean Sea (as *O. darwinii*). Egypt (Suez, 30°56′N, 31°46′E), as *O. trigona* and *O. vaillanti.* Red Sea.

Persian Gulf. Cape Verde Islands (Ile de Sal, 3.7 meters, on *Panulirus regius*). Along west coast of Africa at Port Harcourt, Nigeria (4°43′N, 7°05′E). Ghana: Accra (5°33′N, 0°15′W). Mauritania: Cap Blanc (about 20°50′N, 17°W).

Indian Ocean. — South Africa: near Durban (29°43′S, 31°E). India, in Bay of Bengal and off the coast of Madras and Rayapuran.

Indonesia. — "Malay Archipelago". Java Sea, as *O. sinuata;* northeast of Salembu Besar Island at 5°20′S, 114°34′E, 33-35 meters.

Greater Pacific. — Australia: Sydney (33°55′S, 151°10′E); New South Wales, as *O. neptuni;* Hobart (42°54′S, 147°18′E), Tasmania. Philippine Islands: Iloilo (10°41′N, 122°33′E). Kapingmarangi Atoll (about 1°30′N, 155°E), in branchial chamber and on the gills of the slipper lobster *Parribacus antarcticus* (Lund). Hawaii, in Kanoehe Bay (approximately 21°25′N, 157°48′W), Oahu. Taiwan. Japan: Japanese waters as *O. aymonini;* vicinity of Seto Marine Biological Laboratory; Matsu Bay at Asamushi and Mourazima, and Nonai (40°51′N, 140°50′E) near Asamushi, on *Neptunus trituberculatus*.

Recapitulating, *Octolasmis lowei* (Darwin) and one or the other of the species included as synonymous by authors, range latitudinally from about 41° North (Japan) to 43° South (Tasmania), and longitudinally from perhaps 48° West to 155° East. I have not seen a report of *O. lowei* occurring in the Eastern Pacific along the west coast of the Americas, however. The depth range of the hosts within the known area was reported by Nilsson-Cantell to be from near shore to 457 meters.

Octolasmis mülleri (Coker) Pl. 6, figs. 9, 10

Dichelaspis mülleri Coker, 1902, pp. 401-412, figs. 1-14; Gruvel, 1905, p. 453; Nilsson-Cantell, *pars,* 1927, p. 766; Visscher, 1928, p. 237.

Octolasmis mülleri (Coker), Pilsbry, 1907, pp. 94, 95-96, fig. 32c; Humes, 1941, pp. 101-103; Behre, 1950, p. 17; Pearse, 1952a, p. 238; 1952b, p. 7; Hopkins, 1957, p. 425; Causey, *pars,* 1961, p. 52; Hulings, 1961, p. 216; Wells, 1966, *pars,* p. 89.

Octolasmis lowei mülleri (Coker), Pilsbry, 1953, p. 14.

Octolasmis mülleri (Coker) has been synonymized with, or has been considered one of the races of *Octolasmis lowei* (Darwin, 1851), by Nilsson-Cantell (1927, p. 766), Pilsbry (1953, p. 14), and Causey (1961, p. 52). Coker (p. 406) recognized "many points" of resemblance between *O. mülleri* and *O. lowei* (Darwin), but he also observed five important differences: (1) the shape of the capitulum; (2) the number of main spines on the segments of the posterior cirri (8 pairs in *O. lowei,* 6 pairs in *O. mülleri*); (3) the smaller plates of *O. mülleri;* (4) the angle separating the segments of the scuta; and (5) the character of the carina. These differences seem to me to be viable grounds for distinguishing the two species and suggest that the species in question should bear Coker's name of *Octolasmis mülleri.*

Coker's original description of *Dichelaspis mülleri* is summarized in part as follows:

> The capitulum is a little longer than broad and generally about half as thick as long, its measurements ranging from 3.5 mm to 4.5 mm in length and 3 mm to 3.5 mm in breadth. The five plates are small and well removed from one another.
>
> Each tergum* bears a notch on the occludent margin. The lower end of the tergum varies from one-third to three-fourths the length of the plate, and although the outline is generally smooth, it is sometimes a little jagged or with an embayment; the carinal margin of the tergum is slightly concave and also bears more or less of a notch; the upper end is blunt and rounded.
>
> Each scutum is composed of two unequal segments united at the umbone by an uncalified flexible portion. The occludent segment extends parallel with and close to the occludent margin of the capitulum, is widest in the middle, narrower near the umbone, and more or less pointed at the apex which is directed toward the notch in the tergum. The occludent segment and the basal segment form an angle of 70° to nearly 90°. The basal segment is narrower and about five-sixths as long as the occludent portion, is of more uniform width, and is usually bluntly pointed; the basal segment may not quite reach to the points of the carinal prongs, or may overlap them to as much as two-thirds their length. The carina is arched, convex within, terminating downward in a fork, and much widened at the base of the widely separated prongs; above the fork the carina is nearly uniform in width, and reaches to or slightly beyond the lower edges of the terga, where it ends bluntly; in some specimens, however, the carina extends up between the terga as much as halfway.

The peduncle is one-and-one-half to three times as long as the capitulum, but Coker examined one specimen with a peduncle 40 mm long and a capitulum only 4 mm long. The peduncle of mature individuals is commonly entirely, or in part, of a pink color, this color due to ova seen through the translucent integument of the peduncle.

Type locality. — North Carolina: Beaufort (32°44′N, 76° 41′W).

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*The two terga of the same specimen are not necessarily just alike, as shown on Plate 6, figures 9, 10.

Florida localities. — Off Palm Beach (26°41′N, 80°02′W), on gills of the crab *Cancer borealis* Stimpson, in about 60 ft.; Lake Worth (26°36′N, 80°04′W) Inlet; Alligator Harbor, Franklin County, on gills and mouth parts of the blue crab *Callinectes sapidus* Rathbun; off Panama City (30°10′N, 85°41′W), 30-100 ft.

Other localities. — South Carolina: North Inlet. Along the Texas Gulf Coast, common on the gills and to some extent on the mouth parts of the crustacean *Libinia dubia* Milne Edwards and the crab *Callinectes sapidus* Rathbun. Louisiana: Cameron (29°47′N, 93°19′W) and Grande Isle (30°09′N, 89°21′W), on gills of *Callinectes sapidus* Rathbun.

The barnacle *Octolasmis mülleri* has been recovered from waters up to 100 ft. in depth in the Western Atlantic and Gulf of Mexico, where it is restricted to shallow water crabs.

Octolasmis prototypus Pilsbry Pl. 6, figs. 11, 12

Octolasmis prototypus Pilsbry, 1911, pp. 171-172, figs. 2-3; Zullo, 1968, p. 215.

Pilsbry's description of this small species is summarized as follows:

> The capitulum, measuring 3.5 mm in length and 2.5 mm in width, is acutely ovate and almost entirely covered by white, dense, well-calcified plates. The tergum is about as long as the carina and nearly as long as the scutum; the lower end tapers and extends between the scutum and carina; the upper end is truncated, its scutal margin hollowed out to receive the apex of the scutum. The scutum is divided by an arcuate slit into a longer occludent and a shorter triangular lateral segment; the latter is acute above, rounded at the two basal angles, and nearly as high as wide. Like the tergum it has faint sculpture of concentric and radiating striae. The carina, which is somewhat separated from the other plates, is slightly arched and shortly forked at the base. The peduncle is finely annulated and often one and a half times longer than the capitulum, varying from 3.5 to 4 mm in length.
>
> *Type locality.* — Jamaica: Montego Bay. The holotype was found on a spider crab.

Dichelaspis sinuata Pearse, non Aurivillius, 1894

Dichelaspis sinuata Aurivillius, Pearse, 1932, p. 110, *not* Aurivillius, 1894, pp. 17-19, pl. 2, figs. 3-5.

The status of Pearse's *Dichelaspis sinuata* is not settled but the species is mentioned here because of its occurrence in Florida waters. This Florida form was originally identified by J. P. Visscher and listed, but not illustrated by Pearse, who reported its occurrence on the gills of the crab *Portunus spinicarpus* (Stimpson) in the Dry

Tortugas. However, Newman (1961a), who has done considerable work on the genus *Octolasmis,* questioned Visscher's identification and suggested that *Dichelaspis sinuata* Pearse might be the same as the prior-named *Paradolepas neptuni* Macdonald, 1869. The illustrations of the type of *Dichelaspis sinuata* Aurivillius from the Java Sea and of *Paradolepas neptuni* MacDonald from Australia are reproduced on Plate 7. Aurivillius recognized certain similarities between his *D. sinuata* and *P. neptuni* Macdonald but was reluctant to unite the two because of the differences in the form of the capitulum, the character and position of the carina, the acuteness of the basal angle of the scutum, and the great geographical distance separating the two taxa. It is my feeling that *Dichelaspis sinuata* Pearse may turn out to be a species other than *D. sinuata* Aurivillius or *Paradolepas neptuni* because the latter two occur far from the Tortugas.

Paradolepas neptuni MacDonald Pl. 7, figs. 4, 5-7

Paradolepas neptuni J. D. MacDonald, 1869, pp. 440-444, pls. 33-34, text-figs. a-d, 1-2; Whitelegge, 1889, p. 21.

Listed below is the synonymy of *Paradolepas neptuni* MacDonald with which, together with a number of other taxa, *Dichelaspis sinuata* Aurivillius has been united.

Dichelaspis neptuni (MacDonald), Hoek, 1883, pp. 32, 47, 48; Aurivillius, 1894, p. 19; Gruvel, 1900d, p. 110; 1905, pp. 127-128, fig. 147.

Dichelaspis sinuata Aurivillius, 1894, pp. 17-19, pl. 2, figs. 3-5 [See Pl. 7, figs. 1-3].

Dichelaspis vaillanti Gruvel, 1900c, p. 2 [*Fide* Newman, 1961a, p. 100]; 1900d, p. 109; 1905, pp. 128-129, fig. 148; Annandale, 1906b, p. 45; 1908, pl. 4, fig. 6.

Dichelaspis sinuata pars Annandale, 1909, p. 121 [*Fide* Newman, 1961a, p. 100].

Octolasmis neptuni (Macdonald), Barnard *pars,* 1924, pp. 57, 60, 61 [*Fide* Newman, 1961a, p. 100]; Newman, 1961a, pp. 100-102, pl. 21, as *Octolasmis (Octolasmis) neptuni neptuni;* Wu, 1967, p. 276, fig. 2; Utinomi, 1969, p. 82; 1970, p. 343, text-figs. 1a-b.

?Dichelaspis sinuata Aurivillius, Pearse, 1932, p. 110.

Octolasmis lowei (Darwin), Nilsson-Cantell *pars,* 1927, p. 766; 1938, p. 11; Broch, 1931, p. 129; Causey, 1961, p. 51 [*Fide* Newman, 1961a, p. 100.]

Octolasmis lowei forma *neptuni* Hiro, 1937, pp. 420, 466; 1939a, p. 206; Newman, 1960b, p. 10; 1960c, p. 108 [= *Octolasmis neptuni* (MacDonald), *fide* Utinomi, 1970, p. 343.]

Octolasmis (Octolasmis) neptuni hiroi Newman, 1961a, p. 102 [*Fide* Utinomi, 1970, p. 343.]

Type locality. — The type locality of *Octolasmis neptuni* is Moreton Bay, north of Brisbane (27°30′S, 153°E), Queensland, Australia, on the gills of *Neptunus pelagicus* (Linnaeus). In Australia the species is also recorded in abundance at Port Jackson and Sydney (33°55′S, 151°10′E).

Other localities. — MacDonald stated that *O. neptuni* occurs "amongst the islands of the Southwestern Pacific", including probably Nandi Bay (17°47′S, 177°29′E) in the Fiji Islands; South Africa, off Durban (29°53′S, 31°E); Egypt, at Suez (29°59′N, 32°23′E); South Korea, at Pusan (35°05′N, 129°02′E); Japan, in Mutu and Turuga Bay, where the species attached itself to the gills of the crab *Portunus trituberculatus.*

Octolasmis uncus Pearse Pl. 6, fig. 13

Octolasmis uncus Pearse, 1951, pp. 369-370, fig. 77,k.
Octolasmis uncus Pearse *pars*, Newman, 1960c, pp. 106, 108 [= *Octolasmis lowei* Darwin *fide* Newman, 1960c, pp. 106-108, fig. 4.]

Pearse's original description of *Octolasmis uncus* was as follows:

> The capitulum is compressed, triangular with basal angles rounded and the tip slightly bent toward the occludent side; about three-fourths as wide as long. The occludent margin is curved, but much less than the carinal margin.
>
> The scutum is calcified in two segments; occludent segment curved and pointed at both ends and gradually tapered; carinal segment bifid at the distal end but otherwise much like the occludent segment. Tergum large, stout and bent to form strong sharp hook on the carinal side, therefore the specific name *uncus*.
>
> The carina is moderately curved above, strongly so near the base.
>
> The peduncle is a little longer than the capitulum, cylindric, and wrinkled transversely.

Type locality. — Bahama Islands: Bimini. The coordinates of Bimini North Island are 25°46′N, 79°14′W, and of Bimini South Island 25°43′N, 79°15′W.

Six specimens of this species were collected by Pearse from the gill chambers of two stone crabs, *Menippe mercenaria* (Say), but no measurements were given. The distinguishing characters are the distally bifid carinal segment of the scutum and the strong sharp hook on the carinal side of the tergum. Newman (1960c, p. 108) was inclined to include *O. uncus* with the *O. lowei* series until the former was more fully described, but Pearse's name of *Octolasmis uncus* is retained here.

Pagurolepas conchicola atlantica Keeley and Newman Pl. 6, fig. 15

Pagurolepas conchicola atlantica Keeley and Newman, 1974, pp. 628-637, figs. 1,A-F; 2,A-H.

The capitulum of this small asymmetrical barnacle is composed of five reduced, calcified plates. The tergum is tripartite, the basal and occludent arms forming a notch to receive the occludent arm of the scutum. The scutum is about three times as long as wide, and is also notched to receive the medial arm of the tergum. The carina is less than one-half the length of the capitulum, with a basal fork, and is displaced toward the left side of the capitulum. The peduncle is sharply defined from the capitulum, is concentrically wrinkled, and is greatly expanded at the attachment area of the base. The caudal appendages are half the length of cirrus VI.

The capitular length of the holotype is 11 mm; of the small paratypes 1.3 and 2.5 mm; of juveniles 0.7 to 2.5 mm.

Type locality. — "Gerda" sta. 135 (24°29′N, 80°50′W), Florida Straits, 220 meters, in the gastropod *Bursa tenuisculpta* Dautzenberg and Fischer, inhabited by *Tomopagurus cokeri* (Hay).

Other localities. — Florida: "Anton Dohrn" sta., off Loggerhead Key, Tortugas, 16 miles south of No. 2 Red Buoy, 256 meters, in a buccinid gastropod, inhabited by *Tomopagurus cokeri* (Hay); "Anton Dohrn" sta., off Loggerhead Key, Tortugas, 15 miles south of No. 2 Red Buoy, 201 meters, soft gray mud.

Keeley and Newman (1974) have compared the Florida taxon with *Pagurolepas conchicola* s.s. from Zanzibar and Amakusa, Japan, and state that the Florida form "appears to differ sufficiently from those described from the Indo-West Pacific to be considered at least a distinct subspecies."

THE VERRUCIDAE

Many of the verrucid barnacles discussed in this work were first described and illustrated by Pilsbry (1907, 1916). Both the shell and internal organs were depicted. In his study of the latter in some fifteen of the verrucids, Pilsbry noted that the rami of cirri IV, V, and VI were very similar and not particularly diagnostic in differentiating species. However, the rami of cirrus I, II, and III were fairly distinct either in the number of segments of both rami or in the relative length of the anterior to posterior ramus.

Table 1 gives the relative length and number of segments of the cirri; Table 2 gives the absolute and relative lengths of the caudal appendages, and the lengths of the protopodite of cirrus V, and the complete Cirrus VI .

TABLE 1*

DIFFERENTIATION OF *Verruca* spp. BY MEASUREMENTS OF CIRRUS I, II, III

Species	Cirrus I		Cirrus II		Cirrus III
	Relative length of anterior to posterior rami	No. of segments of both rami	Relative length of anterior to posterior rami	No. of segments of both rami	Relative length of anterior to posterior rami
V. stroemia	Slightly unequal	7,9	<One-half	7,16	<One-half
V. alba	One-third	10,21	One-third	9,21;8,18	Three-fourths
V. nexa	Subequal	11,12	Two-thirds	10,15	Subequal
V. floridana	Three-fifths	11,14	Three-fourths	.....	Subequal
V. calotheca	Two-thirds	10,12	Slightly unequal	.....	Slightly unequal
V. c. flavidula	Three-fourths	9,14	Three-fourths	11,15	Subequal
V. c. heteropoma	...do...	12,13	...do...	11,14	Subequal
V. entobapta	Two-thirds	8,12	Subequal	15,16	
V. xanthia	Subequal	12,12	Three-fourths	10,15	Subequal
V. euglypta	Subequal	17,17	Three-fifths	8,18	Subequal
V. darwini	Subequal	8,8	Two-thirds	.....	Subequal
V. rathbuniana	Slightly unequal	10,11	Four-fifths	6,11	Subequal
V. hoeki	Subequal	10,12	Slightly unequal	15,15	Subequal
V. bicornuta	Subequal	10,11	Three-fourths	7,13	Subequal
V. halotheca	Equal	12,14	Three-fifths	9,22	Subequal

*from Pilsbry, 1916.

TABLE 2*

SPECIES DIFFERENTIATION AS INDICATED BY MEASUREMENTS OF CAUDAL APPENDAGES, OF PROTOPODITE OF CIRRUS V, AND OF CIRRUS VI

Species	Caudal appendages		Protopodite of Cirrus V (Length in mm.)	Cirrus VI (Length in mm.)
	Length in mm.	No. of segments		
V. alba	2.8	22	0.8 to 1	3.8 to 4.6
V. alba	2.5	28	1	3.8
V. floridana	3.2	23	1	5.5
V. entobapta	2.4	18	1.3	.....
V. calotheca	1.8	14	1.5	.....
V. c. flavidula	2.3	14	1.2	5+
V. c. heteropoma	1.6	14	1	5
V. xanthia	1	12	.....	.....
V. darwini	1.9	11	1.5	.....
V. hoeki	0.6	8	0.6	3
V. bicornuta	2.6	10	2.4	.....
V. euglypta	2	10	2.5	.....
V. halotheca	2	10	2.6	.....

*from Pilsbry, 1916.

Suborder VERRUCOMORPHA Pilsbry 1916

Family **VERRUCIDAE** Darwin 1854

Verruca alba Pilsbry Pl. 8, figs. 1-3

Verruca nexa alba Pilsbry, 1907, pp. 107-108, pl. 11, figs. 7-8; Pilsbry, 1911, p. 173; Zullo, 1968, p. 218.

Verruca alba Pilsbry, 1916, pp. 17, 18, 25-28, pl. 2, figs. 1-1b, 2; Pilsbry, 1953, p. 24; Henry, 1954, p. 444; Zullo, 1968, p. 218.

Pilsbry (1907) originally considered *V. alba* a subspecies of *V. nexa* Darwin but later (1916) decided it was a distinct species.

Descriptive details of the shell of the barnacle are abstracted from both of Pilsbry's accounts as follows:

The barnacle is white, not ruddy like that of *V. nexa,* and is flat topped, with steep or subvertical walls.

The movable tergum has four articular ridges, the second one very small in the type specimen, but nearly as large as the others in another specimen.

The fixed tergum has a conspicuous, stout, recurved beak densely marked with growth lines. It is callused within, and the basal edges of the wall are very obtuse and rather thick.

The movable scutum is strongly convex between the apex and basal margin, the apex depressed and twisted. There are three articular ridges and two (or sometimes three) longitudinal ridges on the occludent area.

The fixed scutum, like the fixed tergum, has a produced beak with conspicuous growth lines. In the interior of the fixed scutum there is a shallow adductor pit, bounded below by a curved adductor ridge.

The carina and rostrum interlock by one long and some small teeth in each, and both have several short curved ribs terminating on the hinge-line of the movable plates.

Measurements. — Holotype length 4 mm, breadth 2.7 mm, height 1.7 mm.

Type locality. — "Albatross" sta. 2317 (24°25′45″N, 81°46′45″W), 45 fathoms (83 meters), bottom temperature 75°F., seated on a sea urchin spine, about 36 statute miles south of Long Key, Monroe County, Florida.

Other localities. — Off Florida, in 195 fathoms (386 meters), "Blake" Expedition, Museum of Comparative Zoology; "Triton" sta., south of Sombrero Key Light (about 24°38′N, 81°07′W), 80 fathoms; 10 miles south of Key West, 125 fathoms, associated with *Scalpellum hendersoni* Pilsbry. North Carolina: "Albatross" sta. 2268 (35°10′40″N, 75°06′10″W), 68 fathoms, bottom temperature 71.3°F., about 31 miles southeast off Cape Hatteras; "Albatross" sta. 2269 (35°12′30″N, 75°05′W), 48 fathoms, bottom temperature 77°F., about 31 miles southeast of Cape Hatteras.

Distribution. — *Verruca alba* occurs in the Western Atlantic from about the latitudes of 24° North to 35° North and the longitudes of 75° West to 82° West. Depths range from 45 to 195 fathoms (83 to 386 meters).

Verruca alba barbadensis Pilsbry Pl. 8, figs. 4, 5

Verruca alba barbadensis Pilsbry, 1916, pp. 28-29, pl. 2, figs. 3, 3a; Zullo, 1968, p. 218.

Pilsbry's original description was the following:

The shape is more depressed than *V. alba.* The tergal area of the movable scutum is narrower, its ribs three or four in number are very narrow; the outer face is less convex, and the plate is not twisted toward the apex. The movable tergum is lengthened in the direction of the diagonal rib, and its articular ribs are unevenly spaced. The recurved beaks of the fixed scutum and tergum are very long. Rostrum and carina interlock by two very large and one small tooth in the rostrum, one very large and two or three small teeth in the carina. There are some very minute, granose ribs above the upper articulating rib of the rostrum, none above that of the carina. The rostrum is the largest and highest plate. It extends around the end of the barnacle as in *V. alba.* Basal margin of the wall is obtuse. Greatest carinorostral length 3.9 mm; height of fixed tergum 1 mm.

Type locality. — "Blake" Expedition, off Barbados, Caribbean Sea, in 106 fathoms (195 meters) on spine of the sea urchin *Dorocidaris bartletti* A. Agassiz.

Verruca alba caribbea Pilsbry Pl. 8, fig. 6

Verruca alba caribbea Pilsbry, 1916, p. 28, pl. 2, fig. 4; Zullo, 1968, p. 219.

This subspecies was described by Pilsbry from a colony of 23 individuals on one spine of the sea urchin *Cidaris affinis* Philippi. In 16 of the specimens the right scutum and right tergum were movable. On some individuals

the first articular ridge of the scutum is very weak and there is variation in the articulation of the carina and rostrum. As a rule each has three ribs and teeth. In a few examples the second rib and tooth of the carina are much broader than in others. The upper rib of the carina is always quite narrow, and the short ribs terminating on the tergal margin are either *extremely small,* never more than two in number, or, in a majority of the specimens, they are *absent or barely perceptible.* The basal edge of the wall is as obtuse as in the type form in some examples, thinner in others.

Measurements. — Greatest carinorostral length 4.1 mm, height of fixed tergum 2 mm.

Type locality. — "Blake" Expedition, off Grenada in the Caribbean Sea, in 92 fathoms (169 meters) on *Cidaris affinis* Philippi.

Other localities. — "Blake" Expendition, off Guadeloupe in the Caribbean Sea, in 150 fathoms (276 meters) also on *Cidaris affinis* Philippi. The three individuals from off Guadeloupe are similar, but larger than those from Grenada, the largest having a carinorostral length of 4.8 mm.

Verruca calotheca Pilsbry Pl. 8, figs. 7-11

Verruca calotheca Pilsbry, 1907, pp. 110-111, pl. 11, figs. 1-3; Pilsbry, 1916, pp. 17, 18, 33-34, pl. 4, figs. 4-4b; Broch, 1931, p. 130; Zullo, 1968, p. 219.

The following account is adapted from those of Pilsbry (1907, 1916).

The shell is white, depressed, slightly wider than long, with a subcircular base. The end walls are vertical, the carino-rostral wall sloping outward, the scutotergal wall overhanging. The movable tergum and scutum lie nearly parallel with the plane of the base.

The movable tergum is quadrangular, the upper margin shorter than the basal, the carinal margin arcuate. The surface is divided into two subequal areas, the carinal area transversely ribbed, the scutal area sculptured with four articular ribs, the first rib finely sculptured with thin, arcuate transverse lamellae, the other ribs transversely cut into tubercles which have the appearance of roof tiles; the second rib is the smallest, and hardly reaches to the apex, which is somewhat recurved. The furrow between the first and second ribs is wider than the others.

The fixed tergum is very regular in shape. The surface is radially divided into three areas; the middle area is triangular and raised, and without distinct sculpture; the scutal area is sunken, rather narrow, and very obliquely and finely costulate; the carinal area is wide, obliquely triangular, and sculptured transversely with rather widely spaced grooves which are waved downward near the sides of the area; the base of the carinal area is formed by the carina. The suture between the fixed tergum and the fixed scutum is a slit widening upward, occupied by an extension of the fixed scutum and above it an obliquely grooved aliform triangle for the fixed tergum.

The movable scutum is subtriangular, its surface divided into two areas of nearly equal size. The outer area is sculptured by wide transverse ribs parted by much narrower interstices. The tergal area has four arcuate articular ridges, the middle two deeply cut into transverse tubercles, the fourth rib narrower and less deeply sculptured, the first rib delicately striate transversely. The interior of the movable scutum is deeply concave, with a distinct raised adductor pit; near the basal margin there are two grooves. The scutotergal suture is markedly sinuous.

The surface of the carina is divided into two areas. The area below the beak is concave and weakly and irregularly wrinkled parallel with the base; the rostral area is marked with four slightly curved oblique ribs, the upper rib much the largest, the lower one very small. These ribs overlap a little and their ends interlock with those of the rostrum. The furrow between the first and second ribs is much wider than the other furrows. The apex of the carina is recurved and overhanging.

The rostrum is shaped much like a mirror image of the carina, but the wall below the beak is vertical, not concave, and there is a ledge above, with two beaded radial ribs curving toward the movable scutum. Below this ledge there is a very strong rib articulating at the end of the carina, and below it two minor ribs, all transversely grooved, the grooves narrow, the intervals slightly raised. The rest of the plate is irregularly wrinkled parallel with the base.

Measurements. — Holotype, greatest carino-rostral length 5.9 mm; width at right angles to length 4 mm; height from base to apex of fixed tergum 3 mm.

Type locality. — "Albatross" sta. 2415 (30°44′N, 79°26′W), 440 fathoms (809 meters), on the barnacle *Calantica superba* (Pilsbry), bottom of coral, coarse sand, shells, and Foraminiferida, about 130 statute miles east off Fernandina, Florida. *Verruca xanthia insculpta* Pilsbry was discovered at this same locality.

Other localities. — Broch (1931) reported this species from Indo-Malayan waters, and gave its depth range as 315 to 832 meters (172 to 452 fathoms).

Verruca calotheca flavidula Pilsbry Pl. 9, figs. 1, 2

Verruca calotheca flavidula Pilsbry, 1916, pp. 17, 18, 34-35, pl. 5, figs. 2, 2a; Krüger, 1940, p. 60; Zullo, 1968, p. 219; Bayer, Voss, and Robins, 1970, p. A43.

Verruca (Verruca) calotheca flavidula Pilsbry, Nilsson-Cantell, 1927, pp. 772-774, pl. 1, fig. 6, text-figs. 13a-e.

Pilsbry's diagnosis of this subspecies was as follows:

> The barnacle is very pale yellow or faintly brown outside, distinctly yellow within. The base is subcircular. The walls have simple, thin basal edges; interior without myophore or pit in the fixed scutum. Movable plates slope very steeply, about parallel to the plane of the adjacent carinorostral wall (or in some specimens approaching a horizontal position). Apices of the wall-plates project. Cirri I and II have rapidly tapering rami, the shorter ramus about three-fourths the length of the longer. Cirrus III is much more slender, with nearly equal rami, the inner one very profusely bristly. Terminal appendage has 14 joints, is three times the length of protopod, but less than half as long as cirrus VI.

The tergal valves are like those of *V. calotheca*.

The movable scutum also resembles *V. calotheca*, but the occludent area has two longitudinal furrows parted by three ribs which extend to the hinge margin. The interior is deeply concave, and the tergoscutal suture is nearly straight except near the apex where a small tooth of the tergum enters the scutum.

The carina is indistinctly double, and there is no area of short arcuate ribs above it. The interlocking teeth of the carina and rostrum are more regular than in *V. calotheca*, and the ribs running to them are stronger. Also in *V. calotheca* the upper ribs and teeth are decidedly larger than the lower ones. There are also slight differences in the scutotergal sutures in the fixed and movable valves.

The scutal area of the rostrum is sculptured with several narrow grooves curving toward and terminating on the scutal border.

A comparison of the cirri and caudal appendages of *V. calotheca* and *V. calotheca flavidula* is shown in Table 1 and 2.

Measurements. — Holotype, carinorostral length between apices 8 mm, height of fixed tergum 5.2 mm.

Type locality. — The material hauled from "Albatross" sta. 2415/2416 was placed together without specific identification. "Albatross" sta. 2415 (30°44′N, 79°26′W), 440 fathoms (809 meters), bottom temperature 45.6°F., bottom of coral, sand, shells, and Foraminiferida, lies about 130 statute miles east off Fernandina, Florida, the barnacles seated on coral branches. "Albatross" sta. 2416 (31°26′N, 79°07′W), 270 fathoms (496 meters), bottom temperature 53.8°F., bottom of coral and broken shells, lies about 130 statute miles east of Sapelo Island, Georgia.

Other localities. — Florida: "Albatross" sta. 2666 (30°47′30″N, 79°49′W), 270 fathoms (496 meters) bottom temperature 48.3°F., gray mud, lies about 116 statute miles east off St. Mary's River mouth, Western Atlantic, attached to the coral *Anisopsammia profunda* Pourtalès, with *Verruca xanthia* Pilsbry. Colombia: "Pillsbury" sta. 364 (9°28.7′N, 76°34.3′W to 9°21.2′N, 76°34.2′W), 933-961 meters, in Caribbean Sea about 90 kilometers northwest of Coveñas. Brazil: "St. Vincent-Pernambuco cable" (7°37′S, 34° 26′5″W), 50-150 fathoms (92-274 meters), in Western Atlantic about 50 kilometers east off Pta. de Pedra, Pernambuco.

Range and distribution. — All occurrences are in the Western Atlantic from approximately 32° North to 8° South at depths varying from 92 to 961 meters.

Verruca calotheca heteropoma Pilsbry Pl. 9, figs. 3, 4

Verruca calotheca heteropoma Pilsbry, 1916, pp. 17, 18, 35-36, pl. 5, figs. 1, 1a; Zullo, 1968, p. 219.

This barnacle, known by eight individuals from the type locality, resembles *V. calotheca* internally and in most details of external form. It differs, however, in the movable plates. The movable tergum of *V. calotheca heteropoma* has three articular ribs whereas in *V. calotheca* and *V. c. flavidula* there are four.

The movable scutum of *V. c. heteropoma* has two broad articular ribs (in *V. calotheca* and *V. c. flavidula* there are four articular ribs) and a much narrower though more prominent third crescentic rib terminating at the basitergal angle. There is also a minute rib under the apex, forming the upper border of the tergal edge.

The apex of the rostrum projects. The carinorostral sutural region is similar to that of *V. calotheca.*

The rami of cirri I and II are unequal, the anterior being about three-fourths the length of the posterior ramus. The terminal appendage of 14 segments is about one and one-half times the length of the protopod, and one-third that of cirrus VI. The penis is 2.4 mm. long, about half as long as cirrus VI.

Measurements. — Holotype, carinorostral length between apices

5.5 mm; greatest diameter at right angles to the length 5 mm; height of fixed tergum 2.6 mm.

Type locality. — "Albatross" sta. 2753 (13°34′N, 61°03′W), 281 fathoms (517 meters), bottom temperature 48°F., black sand, in St. Vincent Passage, between the islands of St. Vincent and St. Lucia, on spine of the sea urchin *Cidaris affinis* Philippi.

Verruca entobapta Pilsbry Pl. 9, figs. 5-7

Verruca entobapta Pilsbry, 1916, pp. 17, 18, 38-39, pl. 6, figs. 3-3b. Zullo, 1968, p. 219.

The following notes are from Pilsbry's original description:

> The barnacle is dull red within, tinted with lilac on the exterior. It is about as long as wide, with the movable plates nearly parallel with the plane of the base. The wall plates are rather thick, beveled to an obtuse basal edge; their parietal areas are sculptured by faint grooves roughly parallel with the basal borders.
>
> The movable tergum has a strong diagonal rib and three more articular ribs, the second one from the top a little smaller than the others. The beak is acute and curves upward.
>
> The fixed tergum is tripartite externally, with the beak produced and a little recurved. In the interior, the fixed tergum is calloused.
>
> The movable scutum is characterized by four beaded articular ribs and an extremely short and narrow rib forming the upper margin of the tergal edge of the apex. The rest of the plate has strong flat ribs separated by narrow grooves, parallel with the rostral margin. The beak is acute and is slightly curved upward. The inner face is plain, a little excavated near the beak.
>
> The fixed scutum is tripartite, the upper area sunken below the lower and more strongly sculptured. There is a very small radiiform area in the sutural furrow. In the interior there is an ample pit for the adductor, its lower border projecting shortly as a thick adductor ridge or low myophore, concave above. The apex of the fixed scutum projects strongly.
>
> The carina and rostrum interlock by teeth which terminate several scaly radial ribs in each valve, the upper rib of the rostrum being the largest. These ribs are flattened, somewhat imbricating upward, and are conspicuously scaly. There are no short curved ribs on the upper edge of the rostrum.

Measurements. — Holotype, carinorostral length of base 5 mm; length between apices 5.5 mm; diameter of base 5 mm; height of fixed tergum, apex to base, 3.9 mm.

Type locality. — "Albatross" sta. 2415 (30°44′N, 79°26′W), 440 fathoms (808 meters), bottom temperature 46.6°F., bottom of coral, coarse sand, shale, and Foraminiferida, about 130 statute miles east off Fernandina, Florida.

Other localities. — Georgia: "Albatross" sta. 2416 (31°26′N, 79°07′W), 276 fathoms (508 meters), bottom temperature 53.8°F., bottom of coral and broken shells, about 124 statute miles east off Sapelo Island.

According to Pilsbry, this species is close to *V. calotheca* Pilsbry, differing from it, among other criteria "by the deep pit, bounded below by a low adductor ridge or even a narrow myophore in the fixed scutum."

Verruca floridana Pilsbry Pl. 10, figs. 1-4

Verruca floridana Pilsbry, 1916, pp. 17, 18, 31-32, pl. 4, figs. 1-1c, 2-3; Pilsbry, 1953, pp. 23-24, pl. 1, figs. 2, 3, 9-13; Henry, 1954, p. 444; Zullo, 1968, p. 219.

The barnacle is white, about as wide as long, varying from square to approximately circular in outline; the opercular plates are quite flat and usually slope at a low angle with the plane of the base. The plates of the wall are rather thin, and are beveled to an edge at the base, with no trace of inflection.

The movable tergum is nearly square, the carinal border somewhat longer than the occludent border. Externally there are three strong, well-raised articular ribs, the rest of the plate sculptured with rather widely spaced sunken lineations parallel with the carinal margin. The interior face is smooth.

The fixed tergum is subquadrate, with four produced angles. The external surface is divided into four triangles by lines connecting basal extremities and the acute, recurved, and slightly projecting apex. The largest triangle has the basal margin as its base and is without special sculpture; the second triangle is small, radially ribbed, and concentrically striate toward the fixed scutum; the third triangle is lineolate and extends between the apices of the two terga; and the fourth triangle is long and lies between the carina and the movable tergum. The interior of this plate is rather heavily calloused in the middle.

The movable scutum has three articular ridges, the third or crescentic ridge extending to the basitergal angle. Between the articular ridges are two wide, shallow furrows. The rest of the surface is marked by rather widely spaced impressed lines parallel with the rostral border and cut by one (in the type), or sometimes by two or three curved radial furrows which do not extend to the apex of the plate (and therefore are not present in young individuals). The movable scutum has two low, wide teeth on the tergal border, between the apex and the rostro-tergal angle. Internally, the plate is quite smooth, gently concave in the middle.

The fixed scutum has a small recurved apex. The outer surface is divided into four triangles: a large one bounded by lines connecting the apex and basal extremities, with irregular sculpture consequent upon its base of support; a somewhat smaller triangle above the large one, with its base against the rostrum, bearing vertical, spaced lines, and sometimes some radial riblets near the rostrum; a small densely lineolate area between the apex and the movable scutum; and a very small, vertically lineolate, radiiform triangle toward the fixed tergum. In the interior of the fixed scutum there is a rather small adductor myophore, concave on its upper face, and situated rather high on the plate.

The carina has three wide radial ribs from the apex to the rostral suture, where they terminate in teeth interlocking with the teeth of the rostrum, producing a strongly zigzag suture. An inconspicuous, very narrow riblet along the tergal border lies parallel with the upper rib.

On the rostrum there are two principal ribs articulating with those of the carina. There is also a ledge along the scutal border, the ledge sculptured with several small, curved radial ribets, terminating on the scutal border.

Type. — Pilsbry designated as type, specimen ANSP No. 1901 and as cotype (paratype of Zullo), specimen USNM No. 48095.

Measurements. — Holotype (Pilsbry's pl. 4, figs. 1-1c), greatest carinolateral length 7.5 mm; length between apices 6 mm; greatest breadth at right angles to preceding measurement 7 mm; height from base to summit of movable scutum 4 mm.

Type locality. — "Eolis" Cruise, 1911, south of Key West, Florida, 90 fathoms, on dead shells of *Voluta dohrni* [*Scaphella dohrni* Sowerby], living *Pleurotoma albida* [*Polystira albida* Perry], and on *Dorocidaris* spines.

Other localities. — "Triton" sta. off Palm Beach, Florida, 75 fathoms on *Semicassis,* and in 100 and 150 fathoms on slag etc., gray mud bottom; Southwest of Sombrero Key Light, Florida in 40, 50, and 75 fathoms, on *Scaphella dohrni.*

As shown in a lot of 15 individuals taken by John B. Henderson, Jr. during the cruise of the "Eolis" in 1911, this species exhibits some variation depending on the irregularities of the supporting surface. According to Pilsbry most of the shells have spreading walls "but in some examples, hampered by a restricted base of support, the walls become steep, the tergo-scutal wall vertical or overhanging."

Verruca nexa Darwin Pl. 10, figs. 5, 6

Verruca nexa Darwin, 1854, pp. 522-525, pl. 21, fig. 5; Seguenza, 1876, p. 422; Hoek, 1883, pp. 30, 133, 134, 138; Weltner, 1897, p. 274; Gruvel, 1903, p. 102; 1905, pp. 179-180, fig. 197; Pilsbry, 1907, p. 107; 1916, pp. 17, 29-30, pl. 3, figs. 1-1c; Stubbings, 1940, p. 390.

The following notes are from Darwin's detailed description:

The shell is brownish red, tinted yellow, with almost perpendicular walls. The umbones of the compartments are prominent and sharp. The parietes are nearly smooth but the whole shell has a strongly ribbed appearance.

The movable tergum is rhomboidal, with the whole carinal portion marked only by lines of growth. There are three articular ridges, the upper of which is unusually distinct from the occludent margin.

The two arms of the fixed tergum are nearly equal in length. The internal transverse ledge is weakly developed.

The movable scutum is characterized by three prominent longitudinal ridges on the main part of the valve and two articular ridges on the tergal margin; of these latter the lower one extends down to about the middle of the tergal margin.

The fixed scutum is oblong and larger than the carina. Three or four rounded prominent longitudinal ribs extend from the apex to the basal margin, the extremities forming teeth which articulate with the rostrum. The upper articular ridge is the more prominent. On the under side there is a rounded hollow with a slightly prominent lower edge. The adductor plate is absent.

The carina is unusually small, about half the size of the rostrum.

The rostrum is patelliform with the umbo of growth subcentral. The valve is perpendicular, its upper part forming a ledge almost parallel with the orifice of the shell.

The labrum is bullate, triangular in section, with a row of minute bead-like teeth on the crest. The palpi are very narrow and short. The mandibles are provided with two or three main teeth, and their lower part is pectinated with sharp spines. Cirrus I is of moderate length, the rami with 11 and 12 segments. In cirrus II, the rami are unequal, the segments numbering 10 and 15. In cirrus III, the two rami are nearly equal, having 16 and 18 segments. The remaining cirri and the caudal appendages are as in the other species.

Measurements. — The diameter of Darwin's largest specimen was 0.2 of an inch, or 5.1 mm.

Type locality. — "West Indies, Mus. Brit; attached to a Gorgonia."

Other localities. — "Albatross" sta. 2324 (23°10′25″N, 82°20′24″W), 33 fathoms (61 meters), bottom temperature 79.1°F., coral bottom, off Habana, Cuba.

Verruca stroemia (Müller) Pl. 11, figs. 1-5

Lepas strömia Müller, 1776, p. 251, No. 3025; 1789, vol. 3, p. 21, pl. 94, figs. 1-4; Gmelin, 1791, pt. 6; Ranzani, 1818, vol. 2, pp. 66-67; Newman, Zullo, and Withers, 1969, p. R281, as *Verruca stroemia.*

Lepas striata Pennant, 1777, p. 73, pl. 38, fig. 7; Chemnitz, 1785, pp. 312-313, pl. 98, fig. 834; Montagu, 1803, *fide* Darwin, 1854, p. 518.

Lepas verruca Spengler, 1780, p. 101, pl. 5, figs. 1-3, 5; 1790, p. 194; Boys and Walker, 1784, pl. 3, fig. 87; Chemnitz, 1785, pp. 312-313, pl. 98, fig. 834; Gmelin, 1791, pt. 6; Wood, 1815, pl. 9, fig. 5.

Lepas dentata et *ferrata schroeteri* Chemnitz, 1785, pp. 312-313, pl. 98, fig. 834.

Balanus verruca Bruguière, 1789, p. 169.

Creusia verrucosa Bruguière, 1791, p. 144, pl. 164, figs. 16-17.

Balanus intertextus Pulteney, 1799 [*fide* Darwin, 1854, p. 518.]

Verruca strömia (O. F. Müller), Schumacher, 1817 [*fide* Darwin, 1854, p. 518.] The following are written as *Verruca strömia* or *Verruca stroemia* (O. F. Müller): Lamarck, 1818, vol. 5; Gray, 1825, p. 105; Darwin, 1854, pp. 518-520, pl. 21, figs. 1a-1f; Seguenza, 1869, p. 20; 1876, pp. 333-338, 365, 415, 423, 430, 432, 460-461, 473, pl. 5, figs. 2-2f; pl. 10, fig. 25 (variety?); Hoek, 1876, pp. 20, 46-49, 58; 1883, pp. 3, 4, 5, 30, 132, 133; Alessandri, 1894, pp. 254, 308-309, pl. II, fig. 11; 1906, pp. 232, 233, 273-275, pl. XIV(II), figs. 13-17; Weltner, 1897, p. 274; 1897a, pp. 438-444; 1898, pp. 6, 12, 15; 1900, vol. 1, pp. 290, 298, 303-304, 309; 1922, vol. 23, No. 2, p. 82; Gruvel, 1903, pp. 99, 100, 103; 1905, pp. 185, 188, fig. 206; 1920, pp. 50, 51, 75, 77, 83; Nordgaard, 1905, p. 183; Pilsbry, 1916, pp. 17, 24-25; *in* MacNeil, Mertie, and Pilsbry, 1943, p. 95; Schaper, 1922, pp. 214, 225-227, 243, 247, figs. 17-21; Broch, 1924b, pp. 8-12, 63-68, 72, 108, 109, figs. 22, 23; Krüger, 1927, pp. Xd3, 18, figs. 4, 27; 1940, pp. 59, 60, 256, fig. 60; Kolosváry, 1943, pp. 72-73, 91; 1947, pp. 4, 8, 10, 11, 36-37, 38, 50, 58, 59, 65, 66, 69, 72, pl. 2, figs. 4-6; 1963, p. 173; Withers, 1953, pp. 53, 60, 61, 62, 63, 95; Bishop, Crisp, Fischer-Piette, and Prenant, 1957, p. 10; Tarasov and Zevina, 1957, pp. 148, 149-151, fig. 48; Southward and Crisp, *in* Ray, 1963, pp. 15, 23, fig. 8.

Creusia strömia or *C. stroemia* (O. F. Müller), Lamarck, 1818, vol. 5; Philippi, 1844, vol. 2, p. 211.

Ochthosia stroemia (O. F. Müller), Ranzani, 1820, pp. 30-31; Philippi, 1836, vol. 1, p. 254; Bronn, 1848, p. 334; Sars, 1860, p. 410.

Clisia striata (Pennant), Leach, 1824, vol. 3, p. 171.

Creusia monstruosa Costa, 1844, p. 28 [*fide* Seguenza, 1876, p. 334.]

Oplosoma fimbriatum Costa, 1850-1853, pt. 2, No. 2, p. 349, pl. 28, figs. 2,a,A,B [*fide* Seguenza, 1876, p. 334.]

Verruca stroemia has not been reported from the Florida region but is discussed herein because it is the type species of the genus *Verruca,* is a well known fossil ranging from Miocene to Pleistocene in Europe, and is a widespread living form albeit generally in cold waters.

The barnacle is sturdy, small, depressed, and more or less circular in outline. When living it is white, dirty white, or yellowish brown in color. The shell is extremely asymmetrical, no two of the plates resembling the other. Generally, it is characterized (independently of the interfolding, oblique, articulating plates) by the presence of narrow, longitudinal ridges or folds and finer irregular, concentric growth striae. The top of the movable plates is flat and nearly parallel with the base. The basis is membranous.

The movable tergum is broad and rhomboidal, with three strong, longitudinal articular ridges on the scutal half of the valve. The longest ridge extends from the umbo to well beyond the base, the other two decreasing in length toward the scutum.

The fixed tergum has a transverse ledge on the under side, and there is considerable variation in the degree to which the ledge projects.

The fixed scutum is larger than the fixed tergum and has a strong protruding myophore.

The movable scutum is thick and about half the size of the fixed scutum. The movable scutum is narrowly subtriangular in form and tripartite, consisting of a longish central fold occupying the middle of the valve, and two smaller articular ribs on the tergal side, of which the innermost is the smallest.

The carina has an apical umbo and curves around the carinal margin of the fixed tergum. A variable number of ribs interlock with the grooves of the larger rostrum.

The rostrum is the largest plate of the shell and curves around the end of the occludent portion of the fixed scutum. The articulation is stronger than that of the carina.

Type locality. — I have seen no precise locality given for the type, but judging from Müller's title it is presumed to have been recovered in Norwegian or Danish waters.

Measurements. — The average maximum diameter is 5 mm. Broch stated that rarely it attains a maximum diameter of 10 mm.

Range and distribution. — *Verruca stroemia* does not occur in the Florida region but is abundant in northern waters. It has been reported from the Arctic Sea and U.S.S.R., the Greenland Sea, the Barents Sea, the Bering Sea, the White Sea, the Norwegian Sea, the North Sea, the North Atlantic Ocean, the coasts of northern Europe, the South Atlantic Ocean, the Gulf of Trieste, the Gulf of Naples, the Mediterranean Sea, and the Red Sea.

As a fossil, *Verruca stroemia* has been reported from the middle Miocene of Italy, from the Pliocene of Italy, and from the Pleistocene of Italy, Sicily, England, and Scotland.

Recent localities. — Arctic Sea — U.S.S.R.. Svalbard Archipelago (Spitzbergen) which extends from about 75° to 81° North and 10° to 28° East.

Greenland Sea: Off Greenland. Iceland, at and near Reykjavik (64°09′N, 21°58′W, and 65°41′N, 9°30′15″E).

Norwegian Sea, Finmark, and Norway: Common in all fjords. Drøbak (59°40′N, 10°40′E), 7-28 meters, on the polychaete *Tubularia indivisa;* Halangspollen; Drøbaksgrunnen; Kloasund; Storskjaer (59°35′N, 6°18′E); Stormedberget; Oljemøllen; Skipelle; Filtvet, 25-30 meters; northwest off Feisten Leuchtfeuer, 200 meters; Solsvik, Sotra on spine of the sea urchin *Dorocidaris papillata;* Raugnø-Sund, 35 meters, on the crustacean *Hyas coarctatum* and on *Tubularia indivisa;* Turøy-Knappen, 2-4 meters, on the mollusk *Laminaria;* Toftevåg, 10-20 meter; Rylandsvåg, 30-50 meters; Faerøya (61°12′N, 5°50′E), Hjeltfjord, 150-200 meters; Glesvaer, on *Lophophelia;* Røvaer, 80 meters; east side of Hustadøy, 10-15 meters; Flatnesgrunnen at Orlande (63°42′N, 9°40′E), on stones and on sponges of the genus *Phacellia;* Havnegrunnen at Garten, 200-300 meters; south of the island of Tautra, 70-150 meters; Trondheimsfjord; Heggdalen at Trondheim (63°36′N, 10°23′E); north of the island of Tautra, 80-200 meters; between Tautra and Leksvika (63°40′N, 10°40′E), 100-200 meters; Skarnsund, on *Lophophelia;* about 70 kilometers west off Vevelstad (65°41′N, 9°30′15″E), 440 meters, gray-blue mud; near Roelsøy, in Borgenfjord; Bergskanalen, Inntröndelag (subfossil); Röst, Lofoten (67°33′N, 12°10′E), on *Balanus hameri;* Lødingen, 40-200 meters (68°25′N, 16°E); Evenskjaer, 30-85 meters; Skagøsund, 75 meters, on *Tubularia;* Bjarkøy (69°N, 16°35′E), 0-145 meters, on *Hyas coarctatus;* Fisness, 50-70 meters, on the brachiopod *Waldheimia cranium;* Gibostad (69°22′N, 18°01′E), 35-70 meters; Tromsø (69°42°N, 19′E), 40-50 meters, on the pelecypod *Pecten islandicus* and on the brachiopod *Rhynchonella psittaca;* Porsangerfjord, with *Scalpellum stroemia* and *Tubularia* sp.; Karlsö (70°02′N, 19°50′E); Vardö Island (70°22′N, 31°06′E); Hjeltefjord; Fjolden-Fjord; Sumne.

North Sea: Schaper, 1922, pp. 246-247, listed *V. stroemia* at 63 stations in the North Sea between 53°36′N and 61°30′N and between 1°12′W to 8°3′E, at depths ranging from shore to 290 meters.

North Atlantic Ocean: Along the shores of Great Britain, Ireland, and the Shetland Islands. Shetland Islands: "Valdivia" sta. 4 (60°42′N, 3°10.8′W), 846 fathoms (1,556 meters), bottom temperature 5.9°C, on the sea urchin *Dorocidaris papillata,* about 78 statute miles west of Unst. Scotland: "Valdivia" sta. 10a (59°37.3′N, 8°49.8′W), 1326 fathoms (2,439 meters), bottom temperature 5.4°C, about 120 statute miles northwest of Butt of Lewis; station at 59°03′N, 1°47′45″W, 88 meters, about 30 statute miles east off Shapinsay, Orkney. England: Weymouth (50°36′N, 2°28′W), north shore of English Channel, and off Sandwich? (51°17′N, 1°2′E).

Northern Europe: Denmark. West Germany (Helgoland Island, 54°09′N, 7°52′E). Netherlands (Oost-Friesland). France: English Channel at Plouha (47°41′N, 20°55′W); Pointe de Lanvéoc (48°17′N, 4°28′W); Cap Lervily; Port Navale; St. Gildas-de-Rhuis (47°30′N, 2°50′W).

Mediterranean Sea and Balearic Islands.

Red Sea.

South Atlantic Ocean: Off Falkland Islands at 48°37′S, 55° 17′W.

Miscellaneous. Kolosváry (1947, p. 36) cited two localities that I have been unable to find: Sparre and Port Anger.

Fossil localities. — As a fossil, *Verruca stoemia* is reported as ranging from middle-upper Miocene through the Pleistocene. This represents a duration of some 10 million years, and is an unusually long range for a thoracic barnacle species. Other species of thoracic barnacles are short-lived geologically and are therefore excellent time markers. Nevertheless, *V. stroemia* has been identified by reliable taxonomists, at the following locations:

Middle-upper Miocene (Helvetian): Italy, in glauconitic marls and sands at Superga and Baldissero (Collini di Torino) east of Turin (40°04′N, 7°40′E).

Lower-middle Pliocene (Zanclean): White limestone of Sicily; Testa del Prato, Italy.

Middle-upper Pliocene (Plaisancian-Astian): England: Coralline Crag of Suffolk. Italy: Astigiano, Monteleoni-Calabro; Reggio di Calabria (38°06′N, 15°39′E); Teretri; Nasiti; Testa del Prato; Valle del Messinese near Gioisa-Ionica (38°20′N, 16°19′E); Gallina (38°05′N, 15°41′E). Sicily: Messina (38°13′N, 15°33′E); San Filippo (38°11′N, 15°17′E); Rometta (38°15′N, 15°25′E); Gravitelli; Ficarazzi (38°06′N, 13°28′E); near Palermo (38°08′N, 13°23′E).

Upper Pliocene (Astian): in Asti sands southeast of Torino (40°04′N, 7°40′E).

Pleistocene: Scotland: glacial deposits. England: Red Crag and Coralline Crag. Italy: Gravitelli; Salice (40°22′N, 17°58′E); Valle del Lamato (Prov. di Catanzaro); Reggio di Calabria (38°06′N, 15°39′E); Pezzo; Villa San Giovanni (38°13′N, 15°38′E); Monosterace; Archi (42°05′N, 14°24′E); Pantani; Bovetta; Ravagnese; and Musala. Sicily: Messina (38°13′N, 15°33′E); Milazzo; Ficarazzi (38°06′N, 13°28′E); Rometta (38°15′N, 15°25′E); San Filippo (38°11′N, 15°17′E). Norway: in the Killebo Formation at Rakkestad, elevation 400-440 ft., associated with numerous mollusks.

Verruca tarasovi Zevina Pl. 10, figs. 7, 8

Verruca tarasovi Zevina, 1971, pp. 439-441, figs. 1-10.

This species, which is far removed from the Florida area, is listed here to record the occurrence of a *Verruca* new in the western hemisphere.

According to Zevina the characteristic features of *V. tarasovi* are "fixed scutum and tergum with well-developed alae, thin myophore on the inner part of fixed scutum, and short caudal appendages."

Measurements. — Holotype, length of maximum diameter at base 8 mm; length between carina and rostrum 7.4 mm; height from base to apex of tergum 7.4 mm.

Type locality. — Eastern Pacific at 24°27.4′S, 70°42.2′W, 1230-1700 meters, just west off Blanco Encalada (24°25′S, 7°35′W), Chile, South America.

Also found at the same locality and depth was the cosmopolitan species *Verruca (Altiverruca) gibbosa* Hoek.

Verruca xanthia Pilsbry Pl. 11, figs. 6-7

Verruca xanthia Pilsbry, 1916, pp. 17, 18, 36-37, pl. 6, figs. 1, 1a, 1b; Zullo, 1968, p. 221.

The barnacle is pale yellow, depressed, about as wide as long, with the movable plates nearly parallel with the plane of the base. The basal edges of the wall are rather obtuse and simple.

The movable tergum has three articular ribs.

The fixed tergum is equilateral, with a large smooth paries bearing obliquely grooved aliform triangles on the scutal and carinal sides.

The movable scutum has three articular ribs, two broad and flattened, and a much narrower third, crescentic rib extending to the basitergal angle. Within, the movable scutum is hollowed out under the apical region. The suture between the scutum and tergum has two teeth projecting from the tergum, one near the apex, the other midway.

The fixed scutum has a concave upper face, is almost smooth externally, and has a small radiiform slip on the tergal side. The myophore is well developed.

The carina has five ribs, the upper much longer than the others, all articulating at their ends with those of the rostrum. The rostrum also has five ribs and a group of short arcuate ribs above, terminating on the scutal border. The apex of the rostrum is erect and marginal. Both the carina and the rostrum have a low submargin within.

Measurements. — Carinorostral length of the holotype between apices is 5 mm; greatest diameter at right angles to the length 5 mm; height of fixed tergum 3 mm.

Type locality. — "Albatross" sta. 2666 (30°47′30″N, 79°49′W), 270 fathoms, bottom temperature 48.3°F., bottom of gray sand, about 116 statute miles east off Fernandina, Florida. The type specimen was seated on the coral *Anisopoma profunda* Pourtalès, with the barnacle *Verruca calotheca flavidula* Pilsbry.

Other localities. — Pilsbry stated that one specimen somewhat smaller than the type was found in the dry material from one of the following stations:

"Albatross" sta. 2662 (29°24′30″N, 79°43′W), 434 fathoms, gray sand and broken shells, bottom temperature 43.7°F., about 87 statute miles east off Flagler Beach, Florida.

"Albatross" sta. 2663 (29°30′N, 79°49′W), 421 fathoms, brown sand, bottom temperature 42.8°F., about 84 statute miles east off Marineland, Florida.

"Albatross" sta. 2669 (31°09′N, 79°33′30″W), 352 fathoms, gray sand and dead coral, bottom temperature 43.7°F., about 108 statute miles east off Sea Island, Georgia.

"Albatross" sta. 2671 (31°20′N, 79°22′W), 280 fathoms, gray sand and dead coral, bottom temperature not recorded, about 93 statute miles east off Doboy Sound, Georgia.

"Albatross" sta. 2672 (31°31′N, 79°05′W), 277 fathoms, coarse brown sand, bottom temperature 54.3°F., about 125 statute miles east off Sapelo Sound, Georgia.

Verruca xanthia insculpta Pilsbry **Pl. 11, fig. 8**

Verruca xanthia insculpta Pilsbry, 1916, p. 37, pl. 6, fig. 2; Zullo, 1968, p. 220.

Pilsbry described this subspecies as follows:

> A variety or race of [*Verruca xanthia*], which may be called ***Verruca xanthia insculpta*** . . . is represented by one individual, Cat. No. 32925, U.S.N.M., taken at *Albatross* station 2415 or 2416 (the material from these two stations was not separated), both being very close to the type locality of ***V. xanthia.*** It has more pronounced sculpture than the type; the movable scutum being radially ribbed throughout, five ribs extending to the basal margin. The fixed scutum and tergum have strong, well-spaced growth lines parallel to the basal margin. The fixed scutum has a deep adductor pit within, situated in the upper half of the plate, but the lower margin of the pit does not project as a myophore. The fixed scutum occupies a smaller segment of the wall, and the rostrum a larger. The suture between movable scutum and tergum inside is almost straight, except near the apex.

Measurements. — Carinorostral length at base of holotype, 5 mm; carinorostral length between beaks, 6.5 mm; diameter at right angles to preceding, 6 mm; height of fixed tergum, 3.5 mm.

The single specimen "was seated with the carinorostral axis obliquely transverse to the supporting branch of white coral."

Type locality. — "Albatross" sta. 2415 or 2416, not separated. "Albatross" sta. 2415 (30°44′N, 79°26′W), 440 fathoms (809 meters), bottom temperature 45.6°F., coral, coarse sand, shells, and Foraminiferida, about 130 statute miles east of Fernandina, Florida. "Albatross" sta. 2416 (31°26′N, 79°07′W), 276 fathoms (508 meters), bottom temperature 53.8°F., coral and broken shells, about 124 statute miles due east off Sapelo Island, Georgia.

Verruca (Altiverruca) bicornuta Pilsbry **Pl. 11, figs. 9-12**

Verruca (Altiverruca) bicornuta Pilsbry, 1916, pp. 17, 18, 40, 43-44, pl. 7, figs. 1-1c; pl. 8, figs. 3-3b; pl. 9, fig. 1; Nilsson-Cantell, *pars,* 1928, pp. 25, 27, 28, 30; 1929b, *pars,* p. 473; 1955, p. 219; Zullo, 1963a, pp. 7, 30; 1968, p. 219; Newman and Ross, 1971, p. 136.

The following description of the single specimen (and holotype) is taken from Pilsbry.

The barnacle is cream-white, high, laterally compressed, with steeply sloping movable plates. The wall plates are not thick and have a narrow hemlike ledge around the base. The apices of the rostrum and carina are produced beyond the margins of the wall, forming short horns.

The movable tergum is rather thin, divided by a strongly raised diagonal ridge, above which there are two articular ridges, the median one low, and wide near the diagonal, the other one stronger with a concavity below it. The area below the diagonal has rib sculpture like the corresponding area of the scutum. The internal face is slightly concave. The internal suture between the tergum and the scutum is nearly straight, except near the occludent end where the tergum has a small projection.

The fixed tergum is the highest plate. It has a very narrow raised paries and rather large subequal scutal and carinal radiiform triangles.

The movable scutum is thick, with two contiguous, narrow, beaded, articular ribs, the lower one extending to the basitergal angle and defining a lunate sloping area. The tergal edge protrudes weakly near the apex below which there is a deep, narrow articular furrow that is seen when the scutum is isolated. The occludent area of the plate has regular, strong, flat, imbricating ribs. The inner face is deeply concave between the articular and outer raised borders.

The apices of the fixed scutum and tergum are prolonged slightly and curve toward each other. The paries of the fixed scutum is ridged parallel with the lines of growth. The tergal area or radius is very narrow, the rostral area larger than the paries. The interior is smooth, without pit or myophore.

The carina and rostrum are transversely ridged at the ends, but in front interlock by about four subequal teeth in each, these terminating as many strong, imbricate-sculptured radial ribs.

Measurements. — Holotype length between apices of rostrum and carina, 9 mm; height of fixed tergum, 8.3 mm.

Type locality. — "Albatross" sta. 2575 (41°07′N, 65°26′30″W), 1710 fathoms (3145 meters), bottom temperature 37°F., gray ooze, in Western Atlantic about 335 statute miles due east off Montauk Point, Long Island, New York.

Range and distribution. — The type locality of *Verruca (Altiverruca) bicornuta* s.s. is the only one reported for the species, and that lies some eleven degrees of parallel north of Florida waters. It is discussed in the present report, however, for the reason that Nilsson-Cantell (1928, 1929b) synonymized *V. bicornuta* with *V. gibbosa* Hoek which was found in the South Atlantic. In turn, Nilsson-Cantell united *V. sulcata* Hoek, *V. mitra* Hoek, *V. darwini* Pilsbry, *V. rathbuniana* Pilsbry, and *V. gibbosa somaliensis* Nilsson-Cantell with *V. gibbosa.* Newman and Ross (1971, p. 137) stated that this synonymy would give *V. gibbosa* "a worldwide distribution from depths of 500 to well over 3000 meters" and suggested that the synonymy be reviewed. Pilsbry himself recognized the similarities between *V. bicornuta* and *V. gibbosa* but because of small but significant differences he considered the two distinct.

Verruca (Altiverruca) darwini Pilsbry Pl. 12, figs. 1-3

Verruca darwini Pilsbry, 1907, pp. 111-113, pl. 10, figs. 4-8; Fowler, 1912, p. 498; Nilsson-Cantell, 1955, p. 219.

Verruca (Altiverruca) darwini Pilsbry, Pilsbry, 1916, p. 45; Zullo, 1963a, pp. 7, 31; 1968, p. 219.

The following account is from Pilsbry's original description:

> The shell is white, much elevated, attached lengthwise on the slender spine of a sea urchin. The base is long and narrow, partially clasping the spine, and the side walls overhang.
>
> The movable tergum slopes at an angle of about 45° with the base. It is quadrangular in outline, and divided into two areas by a raised, arcuate diagonal rib extending from the apex to the basiscutal angle. The tergal side is sculptured by wide, flat, transverse ribs with narrow interspaces. The scutal side has pleats at right angles to those of the tergal side. Near the upper margin there is a radial depression and a weak elevation, hardly to be called a rib, near the lower diagonal rib.
>
> The fixed tergum has two faces nearly at right angles, divided into three areas: the scutal area is triangular, does not reach the base, is marked with vertical pleats, and is separated from the median area by a narrow furrow; the median area consists of wide, flat pleats which are angulate or V-shaped except near the base where they are close and straight; the carinal area has oblique pleats, sinuated where they pass over the rounded ribs at the occludent margin.
>
> The movable scutum slopes at an angle of about 45° with the base. It is sculptured by wide, transverse pleats cut by an arcuate sulcus extending from the apex to the basitergal angle, cutting off an arcuate articular ridge. The small space between this rib and the tergal margin is closely sculptured with fine riblets parallel with the latter.
>
> The fixed scutum is irregularly subtriangular, with the apex curved strongly but not projecting toward the tergum, and is also divided into three areas: the median area is the widest and flat, with sculpture of wide, flat pleats weakly and irregularly striated parallel with the pleats; the rostral area is narrow, forming part of the rostral wall, sculptured with pleats deeper than those of the median area and at right angles to them; the tergal area is very narrow, not reaching the base, obliquely pleated, and separated from the median area by a ledge depressed below the base of the median area.
>
> The carina is quadrangular, with parallel tergal and basal margins, its surface divided by a weak diagonal groove into two triangular areas: the lower area is weakly sculptured into widely spaced grooves parallel with the basal margin; the rostral area has a strong, narrow rib along the upper margin followed by a deep furrow below which are two weak wide radial ribs, indicated more by the curvature of the pleats running over them than by actual elevation of the ribs themselves. The umbo of the carina projects a little.
>
> The rostrum is quadrangular with a slightly projecting umbo. It consists of two curved, radial articular ridges, the upper one strong, the lower one low and wide. Above the upper rib there is a narrow excavated area forming a ledge along the base of the movable scutum. In this area there are a few radiating riblets.
>
> The characteristic features of *V. darwini* are the "high compressed shape, wide pleat-like sculpture, and steeply sloping movable valves, with only one or two articular ridges . . .

Measurements. — The holotype is eleven mm in greatest carino-rostral length, 6 mm in greatest breadth, and 8.7 mm in height from base to apex of the fixed tergum. The topotype, shorter and wider than the type (see Pilsbry, pl. X, fig. 8), is 8.5 mm in greatest carino-rostral length, 6.7 mm in breadth, and 6.7 mm in height. The topotype also differs from the holotype in details of sculpture. Pilsbry stated

> These specimens seem to show that there may be considerable individual variation in *Verruca,* if, indeed, the differences between them are individual and not racial. In all other cases where I have been able to compare a number of examples they have proved to be very constant.

The topotype in this work is not illustrated because of the doubt that it is conspecific with the holotype.

Type locality. — "Albatross" sta. 2042 (39°33′N, 68°26′45″W), 1555 fathoms, *Globigerina* ooze, about 302 statute miles east off Beach Haven, New Jersey, in Gulf Stream.

Other localities. — "Albatross" sta. 2573 (40°34′N, 66°09′W), 1742 fathoms, gray mud and sand, about 400 statute miles east off Atlantic Highlands, New Jersey, in Gulf Stream.

Range and distribution. — Present records indicate that *V. darwini* is confined to a narrow swath in the Gulf Stream between 39° and 41° North and 66° to 69° West and at depths from 2844 to 3182 meters. Although not yet known, its occurrence in the Gulf Stream off the east coast of Florida may eventually be determined.

Verruca (Altiverruca) gibbosa Hoek Pl. 12, figs. 4-8

Verruca gibbosa Hoek, 1883, pp. 22, 27, 31, 134-138, pl. 6, figs. 17, 18; pl. 11, figs. 5-9; pl. 12, figs. 1-5; Weltner, 1895, p. 289; 1897, p. 274; 1898, pp. 6, 15; 1900, p. 305; Murray, 1896, pp. 386, 396; Gruvel, 1903, p. 102; 1905, pp. 178-179, fig. 195; Broch, 1931, p. 130; Nilsson-Cantell, 1938, p. 11; 1955, p. 219; Zevina, 1971, pp. 439, 441.

Verruca (Altiverruca) gibbosa Hoek, Pilsbry, 1916, pp. 41, 44; Nilsson-Cantell, 1928, pp. 25-30, figs. 12-13; 1929b, p. 470; Tarasov and Zevina, 1957, pp. 154-157, figs. 51-53; Newman and Ross, 1971, pp. 10, 14, 23, 124 (chart 9), 134-137, 189, 197.

Hoek's original diagnosis of this species follows:

> Shell white, surface smooth, with very prominent growth-ridges and furrows between the articulating ridges; walls almost perpendicular to the surface of attachment; base nearly triangular, not very narrow. Movable scutum rather large, with the upper articular ridge hardly distinguishable, and a very prominent third articular ridge, which is separated from the tergal margin by a rather broad interspace; apex pointed, not projecting freely; apex of the movable tergum almost pointed. Apex of the carina and rostrum recurved, and projecting freely beyond the surface of the shell. Rostrum and immovable scutum bulky.

Type locality. — "Challenger" sta. 317 (48°37′S, 55°17′W), 1035 fathoms, bottom temperature 1.7°C, bottom hard ground. This lies in the South Atlantic some 900 kilometers due east of Cabo Vigia, Argentina and roughly 400 kilometers northeast of Stanley (51°45′S, 57°56′W) in the East Falkland Islands.

The following species were synonymized with *Verruca gibbosa* by Nilsson-Cantell (1928, 1955):

Verruca sulcata Hoek, 1883, pp. 33, 139-140, pl. VI, figs. 19-20 (Pl. 12, figs. 9, 10). Holotype, "Challenger" sta. 170 (29°55′S, 178°14′W), 520 fathoms, bottom rocks, and 29°45′S, 178°11′W, 630 fathoms, bottom rocks. The specimens of *V. sulcata* were discovered in the South Pacific near Raoul in the Kermadec Islands, whereas *V. gibbosa* was discovered in the South Atlantic some 123 degrees of longitude west of *V. sulcata*. In addition to the vast distance separating them, the two types seem to me to be distinct when the illustrations of *V. sulcata* and *V. gibbosa* are compared.

Verruca mitra Hoek, 1907b, pp. 5-9, figs. 1-4 (Pl. 12, fig. 11). Holotype, "S. Y. Belgica" sta. (at about 70°S, 80°48′W), ± 555 meters in depth, in the Bellingshausen Sea, roughly 100 statute miles west of Charcot Island, Antarctica. Hoek, who described both *V. gibbosa* and *V. mitra*, thought they were different species, and judging from the illustrations of the types they are.

Verruca darwini Pilsbry, 1907, pp. 111-113, pl. X, figs. 4-8; 1916, pp. 17, 18, 45. Holotype, "Albatross" sta. 2042 (39°33′N, 68°26′45″W), 1555 fathoms, about 302 statute miles east off Beach Haven, New Jersey, in Gulf Stream of Western Atlantic. Aside from the great distance (about 82 degrees of latitude) between them there is a rather marked difference in the external sculpture of the two species as revealed in the illustrations of the types of *V. darwini* and *V. gibbosa*.

Verruca rathbuniana Pilsbry, 1916, pp. 17, 41-43, pl. 7, figs. 2, 2a, 2b. Holotype, "Albatross" sta. 2572 (40°29′N, 66°04′W), 1769 fathoms, gray ooze, bottom temperature 27.8°F., about 407 statute miles east off Atlantic Highlands, New Jersey. The illustrations of *V. rathbuniana* and *V. gibbosa* show considerable differences in external sculpture that support the validity of *V. rathbuniana*.

Verruca bicornuta Pilsbry, 1916, pp. 17, 18, 40, 43-44, pl. 7, figs. 1-1c; pl. 8, figs. 3-3b; pl. 9, fig. 1. Holotype, "Albatross" sta. 2575 (41°07′N, 65°26′30″W), 1710 fathoms, gray ooze, bottom temperature 37°F., about 335 statute miles due east of Montauk Point, Long Island, New York. *V. bicornuta* is indeed similar to *V. gibbosa*, but according to Pilsbry there are small but significant differences, and these together with the remoteness of one from the other are reasons for considering them distinct.

Verruca gibbosa Hoek is included here because of Nilsson-Cantell's statement that *Verruca bicornuta* "must be synonymous with *V. gibbosa*." The type of *V. bicornuta* was discovered at latitude 41°07′ North which is a little over ten degrees latitude north of Florida, and since other barnacles found around the 41° parallel also occur in waters off Florida, it is possible that *V. bicornuta* might be found there as well.

Confining our remarks to the *Verruca gibbosa* of Hoek and of those authors who have regarded it as the nominative species, the following observations may be added:

Measurements. — According to Hoek "The average size of four specimens was 8 mm in height and 9 mm in length from the apex of the rostrum to that of the carina."

Type locality. — "Challenger" sta. 317 (48°37′S, 55°17′W), depth 1873 meters, bottom temperature 1.7°C, bottom hard ground. This station is in the South Atlantic Ocean some 900 kilometers due east of Cabo Vigia, Argentina and roughly 400 kilometers northeast of Stanley (51°45′S, 57°56′W) in the East Falkland Islands.

Range and distribution. — South Atlantic Ocean: south of the Tropic of Capricorn, including the type locality (Murray, 1896). "Eltanin" sta. 1067, on the submerged Scotia Ridge (59°57′S, 34°41′W), 1098-1153 meters, in the Scotia Sea between South Orkney Island and South Sandwich Islands (Newman and Ross, 1971). Eastern Pacific Ocean: Chile: at 24°27.4′S, 70°42.2′W, 1230-1700 meters, just west off Blanco Encalada (24°25′S, 7°35′W); at 32°11.8′S, 71°50.5′W), 1375 meters, about 50 kilometers west off Logotoma (32°20′S, 17°19′W) (Zevina, 1971). Indian Ocean: near Crozet Islands (46°30′S, 51°E); Indo-Malayan waters, 38-1895 meters (Broch, 1931).

Verruca (Altiverruca) hoeki Pilsbry Pl. 13, figs. 1-3

Verruca hoeki Pilsbry, 1907, pp. 113-114, pl. 11, figs. 4-6.

Verruca (Altiverruca) hoeki Pilsbry, Pilsbry, 1916, pp. 17, 18, 41; Zullo, 1968, pp. 218, 219; Newman, Zullo, and Withers, 1969, p. R282.

The following description is adapted from Pilsbry's accounts of 1907 and 1916:

> The barnacle is small, gray-white, laterally much compressed, very tall, and conspicuously leaning. The base is chitinous, narrowly oval, and with what seems to be a calcareous lining. The movable plates lie parallel with the wall below them, and the basal edge of the wall is thin. The sculpture generally is very weak.
>
> The movable tergum is nearly square, the upper margin slightly shorter than the others. It is divided into two triangles by a diagonal rib extending from the apex to the basiscutal angle. The scutal triangle is marked by faint grooves parallel with the scutal margin, the remainder by faint vertical lines.
>
> The fixed tergum is five-sided, high and narrow, with a short basal margin from which the long side margins diverge upward. The upper margins converge to the pointed apex.
>
> The movable scutum is small and triangular, with a slightly curved apex. The occludent and tergal margins curve down, the plate thus being a little

convex at the sides and flat in the middle. Except for faint widely spaced grooves there is no sculpture.

The fixed scutum is quadrangular with straight margins. The side margins are vertical and at right angles with the base, and the upper margin slopes steeply. The apex is acute and projects a little. The surface is marked with weak growth lines and faint vertical striae.

The rostrum rises to an acute, slightly recurved apex from which radiate three weak ribs to the carinal margin. The rostrum is curved forming the rounded end of the wall.

The carina has an acute slightly projecting apex. A low rib along the upper margin terminates in a lobe indenting the suture with the rostrum, which elsewhere is an even line.

The four specimens collected from the type locality all had a narrow base not due to a narrow support, for all specimens were seated upon flat, frond-like polyzoan colonies, wider than the barnacle.

Measurements. — Holotype: length of base 3.6 mm; greatest width of base 1.9 mm; length of rostrum between apices of rostrum and carina 3.2 mm; oblique height from base to apex of fixed tergum 4 mm.

Type locality. — "Albatross" sta. 2750 (18°30′N, 63°31′W), Anegada Passage, 496 fathoms, bottom temperature 46.5°F., bottom of fine gray sand. This station is close to Sombrero Island (18°37′N, 63°26′W) in the Leeward Islands of the Caribbean Sea.

Verruca (Altiverruca) rathbuniana Pilsbry Pl. 13, figs. 4-6

Verruca (Altiverruca) rathbuniana Pilsbry, 1916, pp. 17, 41-43, pl. 7, figs. 2-2b; Nilsson-Cantell, 1927, pp. 776-778, text-fig. 15; 1955, p. 219; Zullo, 1963a, pp. 8, 30; 1968, p. 221.

The barnacle is cream-white, very high, compressed laterally, the movable plates approaching a vertical position. The apices of the carina and rostrum project. Plates of the wall are rather thin, and have a very narrow inflexed edge, like a hem, at the base.

The movable tergum is divided into two subequal areas by a diagonal beaded rib along which is a narrow groove. The scutal area is hollowed out above, and is sculptured with narrow, curved riblets parallel with the scutal suture. The other area is flat and sculptured by about 25 flat imbricating ribs which denticulate the carinal margin.

The fixed tergum is the highest plate. The paries, or median area is raised, narrow, and imbricated by shingle-like ribs parallel with the base, whereas the side areas are large and subequal, and are marked with steeply ascending ribs.

The movable scutum has a pair of beaded, contiguous articular ribs, the inner one of the pair the narrower and reaching the basitergal angle. The rest of the plate is flat with regular, imbricating transverse ribs. The tergal area is sunken and densely and finely striate. Within the movable scutum, the tergal and occludent borders are raised, the middle of the plate depressd. The suture between the scutum and tergum is straight except near the apices where the scutum projects.

The fixed scutum is tripartite, with a triangular wide median area, an almost equally large rostral area, and a very narrow, radiiform tergal area. The median area is sculptured by imbricating, shingle-like ribs parallel with the base. The side areas are marked by steeply ascending ribs. There is no internal myophore.

The carina curves around the carinal end of the wall. It has regular imbricating structure parallel with the basal margin, except on the rostral side, where there is a shallow radial sulcus bordered by vertically costate bands. There is also a very narrow rib running along the scutal border.

The rostrum is lower than the carina, with two radial sulci and three flat, costulate ribs. The carino-rostral suture is zigzagged by the interlocking of two conic teeth in each plate.

Measurements. — Holotype: greatest length of base 7.6 mm; length between apices of carina and rostrum 9.8 mm; greatest diameter of base 5.5 mm; height from base to apex of fixed tergum 10.5 mm.

Type locality. — "Albatross" sta. 2572 (40°29′N, 60°04′W), 1769 fathoms (3253 meters), gray ooze, bottom temperature 37.8°F., about 407 statute miles east off Atlantic Highlands, New Jersey.

Other localities. — Between San Tiago and São Vicente in the Cape Verde Islands (approximately 16°N, 24°W), 990 fathoms (1821 meters).

Nilsson-Cantell (1927) noted similarities between *V. rathbuniana* Pilsbry and *V. quadrangularis* Hoek (1883) but stated that "further finds are, however, necessary to decide whether there are one or two species here." The type locality of *V. quadrangularis* is "Challenger" sta. 323 (35°39′S, 50°47′W), 1900 fathoms (3494 meters), bottom temperature 0°C., bottom of grey mud, in the Western Atlantic about 375 kilometers southeast of Punta del Este, Uruguay (See type of *V. quadrangularis,* Pl. 14, figs. 7-11).

Verruca (Cameraverruca) euglypta Pilsbry Pl. 13, figs. 7-9

Verruca euglypta Pilsbry, 1907, pp. 108-110, pl. 10, figs. 1-3.
Verruca (Cameraverruca) euglypta, Pilsbry, Pilsbry, 1916, pp. 17, 18, 39-40, pl. 3, figs. 2, 2a; pl. 9, fig. 3; Zullo, 1968, p. 219; Newman, Zullo, and Withers, 1969, pp. R282-R283.

As described by Pilsbry the type is cream-white. It was seated transversely upon a branch of an *Oculina*-like coral much narrower than the barnacle, with the consequence that the base is contracted and the walls overhanging. The scuto-tergal wall is vertical and the rostrocarinal wall slopes steeply. The movable scutum and tergum lie at an angle of about 45° with the plane of the base. All of the plates are thin, deeply and closely ribbed in the direction of the growth lines, the riblets wider than the furrows separating them. The basal edge of the wall is thin and supple.

The movable tergum is quadrangular and much larger than the scutum. The occludent margin is somewhat shorter than the basal margin and parallel with it; the carinal margin is slightly arcuate, the articular margin coarsely zigzag. The surface is divided into two nearly equal areas by the slightly curved diagonal last articular ridge, the area below it being depressed, flat, and marked with transverse ribs only. There are four articular ridges, the third narrowest, the fourth widest and in bold relief. The second and third articular ridges unite near the apex so that on young specimens there are three articular ridges of about equal width. All of the ridges are marked with transverse riblets, those on the first ridge delicate and arching downward but on the others straight and wide. In the first articular furrow the transverse riblets are prominent, oblique, and lamellar.

The fixed tergum stands erect, surrounding two sides of the movable tergum, its scutal and carinal walls at right angles. The surface is divided into three areas: the scutal and carinal areas are triangular, reaching about halfway to the base, and sculptured by regular, obliquely transverse riblets; the middle area stands in high relief, extends to the base, and has wide, rather rude, flat transverse sculpture, with the interspaces linear and shallow. Along the carinal edge of the plate there is a poorly developed articular ridge. Within, the cavity of the fixed tergum has a partition like that of the rostrum.

The movable scutum is subtriangular and curved, with the surface divided into two areas. The larger occludent area is sculptured with transverse ridges, the smaller area with four arcuate articular ridges, the first of which is smooth and about one-third the length of the plate. The other ridges are cut by the transverse riblets, the second articular ridge being the narrowest and not quite reaching the apex, with the consequence that a young specimen would have but three articular ridges. The furrows between the ridges are smooth. "The movable scutum is smooth inside, with a shallow, oblong pit for the adductor muscle, and a narrow, well raised rim along the occludent side and apex."

The fixed scutum is divided into two nearly equal areas, and a third very narrow area next to the tergum. The rostral area is sculptured with plain transverse riblets; the middle area is triangular, raised above the others, sculptured transversely and irregularly, and interrupted by a number of irregular radial grooves. Near the base, the middle area is articulated with the rostrum by a single tooth. The tergal area is a very narrow, obliquely costulate segment not reaching the base and separated from the middle area by a deep furrow. Within, the fixed scutum has a "vertically depending plate, which from its position must be regarded as an enlarged adductor ridge or myophore; behind it is a deep narrow cavity."

The carina is bent so that its two faces stand at right angles. A broad rostral triangle is occupied by five radial ridges forming as many teeth articulating with the rostrum, the ridges crossed by transverse markings. Three of the ridges extend to the apex of the plate, the others being shorter and peripheral and therefore wanting in the young specimens. There is also a prominent radial ridge and furrow along the other margin of the carina articulating with the fixed tergum. The intermediate area, comprising a part of the surface of the plate, is rudely sculptured by wide, flat transverse plates separated by linear grooves. The carina has a very much narrower partition than the rostrum.

The rostrum is like the carina in general shape. On its carinal face there are five radial ridges, of which two or three arise at the apex, the second ridge being the widest. The rest of the plate has rude flat sculpture like that of the carina. Near the fixed scutum there are several radial grooves and furrows. The apex of the rostrum is enclosed by a partition within.

Measurements. — Greatest carino-rostral length 11.2 mm; greatest breadth (at right angles to length) 9.4 mm; height from base to apex of the fixed tergum 7.8 mm.

Type locality. — "Albatross" sta. 2415 (30°44′N, 79°26′W), 440 fathoms (809 meters), bottom temperature 45.6°F. About 130 statute miles east off Fernandina, Florida, bottom of coral, coarse sand, shells, and foraminifers.

Verruca (Metaverruca) coraliophila Pilsbry Pl. 13, figs. 10-12

Verruca (Metaverruca) coraliophila Pilsbry, 1916, pp. 21-23, pl. 1, figs. 1-5; Nilsson-Cantell, 1929b, pp. 461, 463, 464; 1938, p. 12 (as *V. coraliophora*); Southward and Southward, 1958, pp. 638, 639; Zullo, 1968, pp. 219, 220; Newman, Zullo, and Withers, 1969, p. R283; Bayer, Voss, and Robins, 1970, p. A43.

The following description is rearranged and adapted from Pilsbry's original:

> The barnacle is cream-white, attached to a branch of white coral. The carinorostral wall is somewhat sloping, the scutotergal wall usually vertical. The movable tergum and scutum lie parallel or nearly parallel with the plane of the base, each having three articular ribs. The plates of the wall are weakly sculptured or almost smooth, and their basal borders are broadly inflexed. Both movable valves have three flat ribs.
>
> The movable tergum has a deep recess in the middle of the scutal border at the termination of a median articular rib; above this there is a flat, wide, upper articular rib and below it a narrow diagonal rib. The exterior of the plate is transversely grooved and the internal face nearly flat.
>
> The fixed tergum is about as large as the fixed scutum and is similarly sculptured.
>
> The movable scutum has a crescentic rib, a broad, flat, strongly projecting median articular rib, and another very narrow one above it. The exterior of the plate is marked with well spaced, narrow, transverse grooves. In the interior there is a deep oblique articular furrow near the apex which receives the upper articular ridge of the scutum. This is bounded by a short elevated ridge the back of which is the deep pit of the scutal adductor muscle. Nearer the basal edge there are several low callosities variable in form and position.
>
> The fixed scutum is marked by faint growth lines on the exterior and occasionally with vertical grooves in the triangular area next to the occludent edge. The beak is not produced, lying in close proximity to that of the movable scutum. Below the tergal suture is a small ala. Within the fixed scutum there is a prominent adductor ridge or myophore, concave on the upper face.
>
> The carina and rostrum articulate by a suture which is weakly zigzag below. The carina has one large tooth above, between two small ones on the rostrum. The hinge margin is straight and simple, and the beaks are not produced.

Measurements. — Two dry specimens have the following dimensions: [1] Carinorostral length of base 8.5 mm, length between apices 6.3 mm, diameter of base 7.3 mm, height of fixed tergum 5.5 mm. [2] Carinorostral length of base 14 mm, length between apices 11.2 mm, diameter of base 8 mm, height of fixed tergum 8 mm.

Type specimen. — The specimen designated as "type" by Pilsbry (1916, plate 1, figs. 1, 1a) is stated by Zullo (1968) to be USNM 32928 of the U.S. National Museum (dry). The specific type locality is not known but according to Pilsbry and Zullo it is one of the following: "Albatross" sta. 2662 (29°24′30″N, 79°43′W), 434 fathoms (798 meters), bottom temperature, 43.7°F., gray sand and broken shells, about 87 statute miles east off Flagler Beach, Florida; "Albatross" sta. 2663 (29°39′N, 79°49′W), 421 fathoms (774 meters), bottom temperature 42.7°F., brown sand, about 84 statute miles east off Marineland, Florida; "Albatross" sta. 2669 (31°09′N, 79°33′30″W), 352 fathoms (647 meters), bottom temperature 43.7°F., gray sand and dead coral, about 108 statute miles east off Sea Island, Georgia; "Albatross" sta. 2671 (31°20′N, 79°22′W), 280 fathoms (515 meters), gray sand and dead coral, about 93 statute miles east off Doboy Sound, Georgia; and "Albatross" sta. 2672 (31°31′N, 79°05′W), 277 fathoms (509 meters), bottom temperature 54.3°F., coarse brown sand, about 125 statute miles east off Sapelo Sound, Georgia. The foregoing co-ordinates bracket the type locality of *Verruca coraliophila* in the Western Atlantic Ocean between the latitudes of 29°24′30″ and 31°31′ North and longitudes of 79°05′ and 79°49′ West.

Florida localities. — Off the east coast at "Albatross" stations 2662 and 2663.

Other localities. — Off the east coast of Georgia at "Albatross" stations 2669, 2671, and 2672; "Pillsbury" sta. P340 (9°13.5′N, 77°46′W), 307-366 meters, about 40 kilometers northeast of Sasardi Viejo, Panama, in the Gulf of Darien.

According to Nilsson-Cantell (1929b, pp. 461-465) and 1938 (p. 12), Pilsbry's *Verruca coraliophila* is synonymous with *Verruca sculpta* Aurivillius as well as with the following species united with *V. sculpta.*

Verruca recta? Aurivillius. 1898, pp. 195, 199; Gruvel, 1902a, p. 243; 1905, pp. 172, 181, fig. 189. Type locality: "Prince de Monaco" sta. 227 (38°23′N, 28°26′37″W), 1135 meters, northwest off Sta. Luzia, Pico, Azores.

Verruca sculpta Aurivilius, 1898, pp. 197-198-199; Gruvel, 1905, pp. 175-176; 1920, p. 41, pl. 5, figs. 26-27. Type locality: "Prince de Monaco" sta. 161 (46°04′40″N, 49°02′30″W), 1267 meters, North Atlantic, about 45 statute miles south of Cape Race (46°40′N, 53°08′W), Newfoundland.

Verruca linearis Gruvel, 1900b, p. 243; 1902b, pp. 31, 107-109, pl. 5, figs. 11-12; 1905, pp. 182-183, fig. 201. Type locality: "Talisman" sta. 128, 960-998 meters, Azores.

Verruca magna Gruvel, 1901, pp. 261-262; 1902b, pp. 31, 109-112, pl. 5, figs. 1-2; 1905, pp. 184-185, figs. 204-205. Type locality: "Travailleur/Talisman" dragage No. 141, Golfe de Gascogne, 1480 meters.

Verruca halotheca Pilsbry, 1906, p. 188, pl. 4, figs. 9-10; 1916, pp. 17, 18, 46-47, pl. 18, figs. 1, 1a. Type locality: "Albatross" sta. 4060, off northeast coast of Hawaii, on a volcanic pebble, 913 fathoms, bottom temperature 36.5°F.

Verruca capsula Hoek, 1913, pp. 130-134, pl. 12, figs. 1-3; pl. 13, figs. 1-4; Stubbings, 1936, p. 38. Type locality: Makassar Strait (0°34.6′N, 119°8.5′E), about 80 kilometers west off Munte, Celebes, Indonesia, depth 1301 meters, bottom of fine gray mud.

In comparing the Floridan *Verruca coraliophila* with the illustrations and descriptions of the types of the above-listed species, there does seem to be agreement in their relatively large size and general configuration. However, individual differences in morphology and sculpture may also be observed, and these in conjunction with the wide separation in habitat are persuasive reasons for considering, as did Pilsbry who had access to the pertinent literature and to a number of the barnacles themselves, that *V. coraliophila* is a distinct species.

ADDENDUM ON THE RHIZOCEPHALA

In my compendium on the Rhizocephala of Florida and surrounding waters (Weisbord, 1975) I failed to include the species contained in the important paper by Reinhard (1958) titled "Rhizocephala of the family Peltogastridae parasitic on West Indian species of Calatheidae". Reinhard described three new species of Peltogastridae (*Cyphosaccus chacei, Cyphosaccus cornutus,* and *Boschmaia mundicola*); noted new localities for *Tortugaster fistulatus* Reinhard and *Galatheascus minutus* Boschma; and pointed out the similarities between *Galatheascus minutus* Boschma 1933 and *Galatheascus striatus* Boschma 1933, collected near Plymouth, England. These six species, all of which save *Galatheascus striatus* should be added to the inventory of Rhizocephala listed in my 1975 work, are discussed in the following pages.

DESCRIPTION OF RHIZOCEPHALAN SPECIES

Family **PELTOGASTRIDAE** Lilljeborg, 1861b

Cyphosaccus chacei Reinhard Pl. 15, fig. 1

Cyphosaccus chacei Reinhard, 1958, pp. 296-299, 306, fig. 1, pl. 1 (1).

The sac is slender and V-shaped, with the stalk at the vertex of the angle. Each arm becomes broader toward the tip, the posterior arm equal to or a little longer than the anterior one. The anterior arm terminates in a nipple-like prominence, covered by a bulbous sheath which is a continuation of the external cuticle. The stalk is marked by three circular grooves. The external surface is covered by a thin cuticle beneath which are innumerable muscle fibers. The syntypes are approximately 5 mm in length, with the lesser diameter of the arms 0.5 to 0.75 mm, the greater diameter about 1 mm.

Type locality. — "Atlantis" sta. 3397 (22°34′30″N, 78°16′W), 180 fathoms (329 meters), on the crab *Munida irrasa* A. Milne Edwards, off Cayo Coco, Cuba.

Other localities. — Cuba: "Atlantis" sta. 3399 (22°35′N, 78° 2′W), 180 fathoms (329 meters), on *Munida irrasa,* off Cayo Coco. "Albatross" sta. 2337 (23°10′38″N, 82°20′21″W), 199 fathoms (364 meters), on *Munida irrasa.* Barbados: off Pelican Island, 80 fathoms (146 meters), on *Munida irrasa.*

Although not reported from Florida waters by Reinhard, it is anticipated that *Cyphosaccus chacei* will eventually be found there, as the host crab *Munida irrasa* occurs off Key West, Florida and ranges at least as far north as Cape Lookout, North Carolina.

Cyphosaccus cornutus Reinhard Pl. 15, fig. 2

Cyphosaccus cornutus Reinhard, 1958, pp. 299-300, 306, fig. 2, pl. 1 (2).

The body is approximately 8 mm in length and about 1 mm in thickness. It is broadly U-shaped, comparatively stout, uniform in thickness, with the stalk in the midregion. In shape the sac resembles an ox-bow, the anterior arm doubled over and bearing a nozzle-like prominence enclosing a blind canal. The external surface of the sac is covered with a thin cuticle through which the underlying network of delicate longitudinal and circular muscle fibers of the mantle are visible. The longitudinal fibers are more widely spaced than the longitudinal ones. The mesentery surface lies uppermost with the anterior arm to the observer's left. The testes are fused, occurring near the posterior end of the mesentery. The parasites are attached to the sternites of the third and fourth abdominal segments of the host crab *Munidopsis erinacea* (A. Milne Edwards).

Type locality. — "Atlantis" sta. 3305 (23°05′30″N, 82°35′W), 330 fathoms (604 meters), on *Munidopsis erinacea,* off Playa Baracoa, Habana, Cuba.

Reinhard did not report the parasite *C. cornutus* from Florida waters but its occurrence off Florida proper is not unlikely.

Boschmaia mundicola Reinhard Pl. 15, fig. 3

Boschmaia mundicola Reinhard, 1958, pp. 300-303, 306, fig. 3.

The animal has a somewhat hook-shaped appearance, each sac strongly bent, with the anterior arm nearly twice as long as the posterior. The basal portion of the sac tapers in the direction of the stalk. At the summit of the anterior arm there is a knob-like prominence formed by the mantle opening. The aperture, however, does not communicate with the exterior as it is covered by the external cuticle. The parasites are attached to the third and fourth abdominal segments of the host by means of a short thin stalk. The mesentery is broad and extends from one end of the sac to the other. The testes are exceedingly small, about 35 to 40 microns, and are set close to the stalk. The colleteric glands are located near the anterior end of the sac, with the left gland slightly in advance of the right. The syntypes are about 6 mm long and 1 to 1.5 mm thick.

Type locality. — "Fish Hawk" sta. 7302, off Cape Lookout, North Carolina (34°34′N, 76°34′W), 7.5 fathoms (14 meters), on the crab *Munida irrasa* A. Milne Edwards.

Florida locality. — "Fish Hawk" sta. 7279 (24°21′55″N, 81°58′25″W), 98 fathoms (183 meters), off Key West, on *Munida irrasa.*

Remarks. — The genus *Boschmaia* Reinhard is distinguished from the genus *Cyphosaccus* Reinhard by the orientation of the mesentery with respect to the stalk. In *Cyphosaccus* the mesentery lies uppermost when the animal is viewed in an upright position with the anterior arm to the observer's left, whereas in *Boschmaia* the mesentery lies on the far side of the animal when the sac is viewed in the same manner as above.

Tortugaster fistulatus Reinhard Pl. 15, fig. 4

Tortugaster fistulatus Reinhard, 1948, pp. 33-37, figs. 1-3; 1958, pp. 303-304, 306, fig. 4e; Weisbord, 1975, pp. 172, 183-184, pl. 25, figs. 7-8.

Tortugaster fistulatus was originally described and illustrated by Reinhard in 1948 from specimens collected off Tortugas, Florida, attached to the host crab *Munidopsis robusta* (Milne-Edwards). In his 1958 paper, Reinhard identified the same species from two new localities on two different hosts; one from the Straits of Florida on *Munidopsis bahamensis* Benedict and the other from the Western Atlantic off St. Augustine, Florida on *Munidopsis spinifer* (Milne-Edwards). Reinhard stated that "In their orientation and attachment with respect to the host and in their external appearance these examples of *T. fistulatus* agree with the type." The specimen measuring 6 mm in length and 3 mm in width (on the host *M. spinifer*), is illustrated here.

The localities from which *T. fistulatus* is now known are the following:

Type locality. — Gulf of Mexico, off Tortugas, Florida, 220 and 280 fathoms (402 and 512 meters), on *Munidopsis robusta* (Milne-Edwards).

Other localities. — Western Atlantic: "Atlantis" sta. 3780 (30° 27′N, 79°52′W), 250-265 fathoms (457-485 meters), on *Munidopsis bahamensis,* off St. Augustine, Florida; "Atlantis" sta. 2987 (23° 22′N, 79°53′W), 280-300 fathoms (512-549 meters), on *Munidopsis spinifer,* south of Cay Sal Island (23°41′N, 80°24′W), Straits of Florida.

Galatheascus minutus Boschma Pl. 15, figs. 5-7

Galatheascus minutus Boschma, 1933, pp. 476-478, figs. 1-3; 1947, pp. 2-4, fig. 1; Reinhard, 1958, pp. 304-306, figs. 4,a-d.

The syntypes are represented by two specimens differing in size and shape but undoubtedly belonging to the same species according to Boschma. One of the syntypes was recovered off Valentia, Ireland in 1870, attached to the crab *Galathea intermedia* Lilljeborg, and is 2.5 mm long, 2 mm high, and approximately 1.5 mm wide. The other syntype was recovered off Oban, Scotland in 1877, on *Galathea nexa* Embleton, and is 5 mm long, 3 mm high, and 2 mm wide. In the smaller specimen the mantle opening is a narrow pore which has not yet shifted toward the anterior end. In the larger specimen the mantle opening lies at the anterior end of the parasite, slightly turned toward the abdomen of the host, and is surrounded by a low ridge so that it projects a little above the surface of the mantle. Both specimens are more or less kidney-shaped, the smaller broadly oval, the larger subovate. The mantle opening is comparatively wide and situated at the dorsal part of the anterior region in adults, at the ventral part in young specimens. The stalk is situated in the median region of the body. The external cuticle of the mantle is smooth, without grooves, and very thin, approximately 4 microns in the adult. On the internal cuticle no retinacula were found by Boschma. The testes and colleteric glands are located near the stalk.

Five specimens of *G. minutus* were examined by Reinhard and all were oriented with their long axis perpendicular to the main axis of the host, and the site of attachment was on the second or third abdominal segment.

Type localities. — North Atlantic: Ireland: Off Valentia Island (51°55′N, 10°20′W), on *Galathea intermedia* Lilljeborg. Scotland: off Oban (56°25′N, 5°29′W), on *Galathea nexa.*

Florida localities. — "Combat" sta. 235 (27°27′N, 78°58′W), about 85 statute miles east off Fort Pierce, 180 fathoms (329 meters), on *Munida schroederi* Chase; "Blake" sta. 45 (25°33′N, 8°21′W), 101 fathoms (185 meters), in Gulf of Mexico, about 195 statute miles west off Highland Point, on *Munidopsis barbarae* (Boone) = *Galacantha barbarae* Boone.

Other localities. — North Carolina: "Fish Hawk" sta. 7302, off Cape Lookout (34°34′N, 76°34′W), 7.5 fathoms (14 meters), on *Munida irrasa* Milne-Edwards; Cuba: "Atlantis" collection, off Cayo Coco Island (22°30′N, 78°30′W), 180 fathoms (329 meters), on *Munida stimpsoni* Milne-Edwards.

Remarks. — Reinhard noted that *Galatheascus minutus* Boschma, 1933, was nearly identical with *Galatheascus striatus* Boschma, 1929, collected at the Loose-Eddystone Grounds near Plymouth, England, attached to the ventral surface of *Galathea strigosa* (Linnaeus). The only measureable difference Reinhard could discern between specimens from the type localities of each species was that the spindles of the retinacula of *G. minutus* were about 7 microns long and those of *G. striatus* 20 to 25 microns long.

The external appearance of both species are shown on plate 15.

Galatheascus striatus Boschma Pl. 15, figs. 8, 9

Galatheascus striatus Boschma, 1929, pp. 73-79, figs. 1-6; 1933, pp. 475-476; Reinhard, 1958, pp. 304, 306.

The body is elongate oviform, with a very broad mesentery extending from the anterior to the posterior. The stalk is slender, about 1 mm thick, and inserted in the anterior half of the body. The mantle opening is extremely narrow and so small (0.5 mm) that it escaped Boschma's notice until the parasite was examined in thin sections. The opening itself, however, and the narrow tube connecting the opening with the mantle cavity, are surrounded by a well-developed sphincter. The colleteric glands are simple, minute (about 0.5 mm), and near the stalk. They have a circular lumen flattened laterally. The external cuticle is comparatively thin (8-11 microns), and has a smooth surface with shallow grooves extending longitudinally. These grooves are 0.2 mm apart. The internal cuticle bears retinacula containing one to three spindles each, the spindles measuring 20-25 mm in length.

As measured from Boschma's illustration, the holotype is 19 mm long, and approximately 8.3 mm wide through the middle.

Type locality. — Loose-Eddystone Grounds near Plymouth (50°23′N, 4°10′W), England, on the crab *Galathea strigosa* (Linnaeus).

Remarks. — Although Reinhard discerned numerous similarities between this species and the later-described *Galatheascus minutus* Boschma from Irish and Scottish waters, it should be observed that adults of *G. striatus* are nearly four times larger, and the longitudinal grooves of the external cuticle considerably more pronounced than on *G. minutus*.

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PLATES

Explanation of Plate 1

Figure		Page
1-3.	**Heteralepas belli** (Gruvel) 1A. Holotype, about natural size, from Gruvel (1900a). 2. Holotype, drawn from nature. 3. External orifice of capitulum, view of face. Capitulum 25 × 16 mm, length of peduncle 32 mm, breadth 9.5 mm.	6, 9
4.	**Heteralepas cygnus** Pilsbry Holotype, natural size, from Pilsbry (1907). Measurements: capitulum 23 × 18 × 12.5 mm; peduncle length 70 mm, breadth near base 12.5 mm, near capitulum 8 mm.	6, 11
5.	**Heteralepas lankesteri** (Gruvel) Holotype, enlarged about 2.5 ×, from Gruvel (1900a). Measurements: capitulum of a very large specimen 25 mm × 16 mm; peduncle 32 mm × 9.5 mm (at base).	7, 11
6.	**Heteralepas cornuta** (Darwin, 1851) Holotype, magnified about 5 ×, from Darwin.	6, 9
7.	**Paralepas americana** Pilsbry 7a. Holotype, enlarged about 5 ×, from Pilsbry (1953). Measurements: capitulum length 4.5-5 mm; peduncle length 1.0 mm. 7b, maxilla; 7c, mandible; 7d, intermediate segment of outer ramus of cirrus V, left side anterior; 7e, protopodite, cirrus VI, with penis and caudal appendage.	7, 12
8.	**Lepas (Dosima) fascicularis** Ellis and Solander = **Lepas cygnea** Spengler "Type" of *Lepas cygnea* Spengler showing gas-filled float at base of peduncle. Specimen collected 2 August, 1788, about 9 miles west of Bergen, Norway.	7, 28

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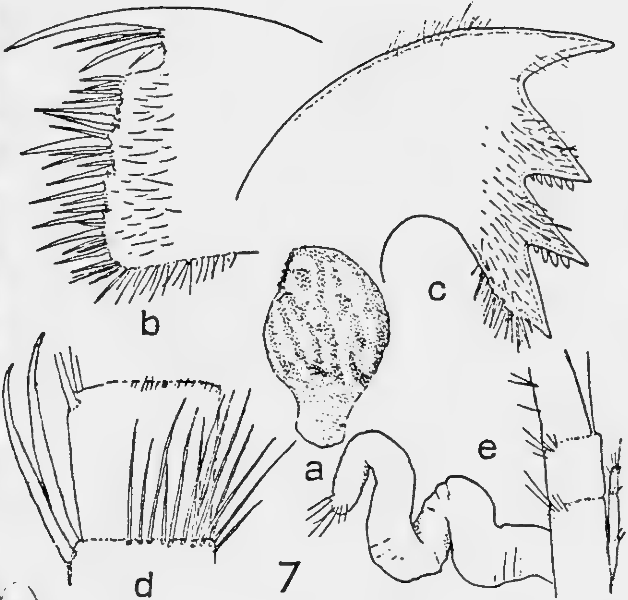

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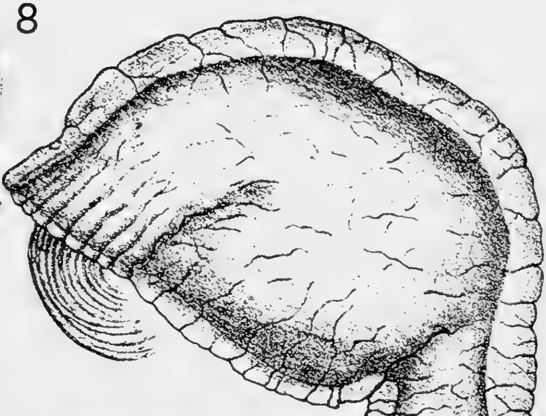

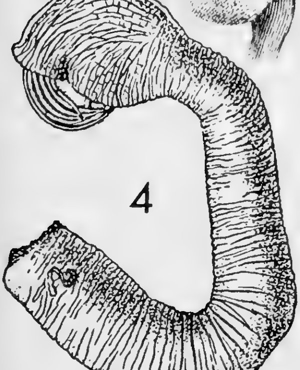

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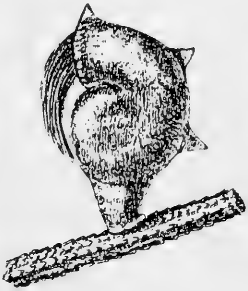

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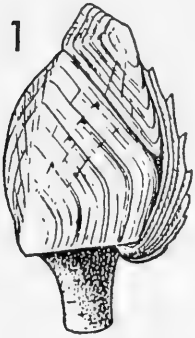
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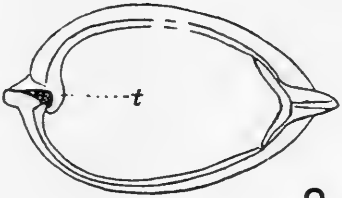

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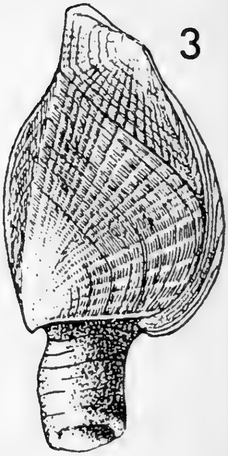
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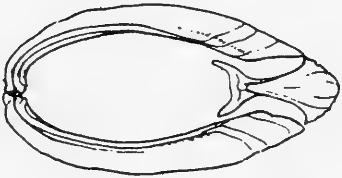
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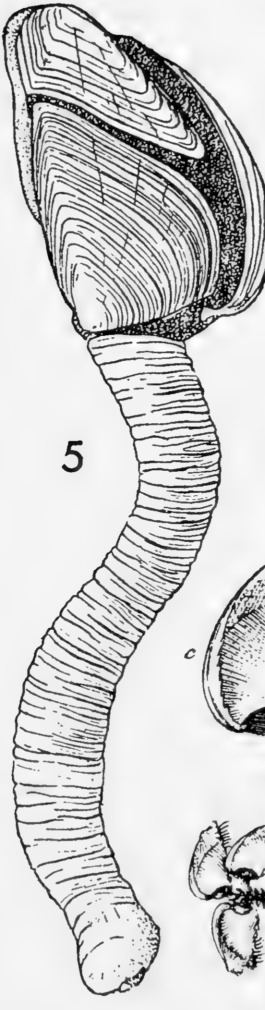
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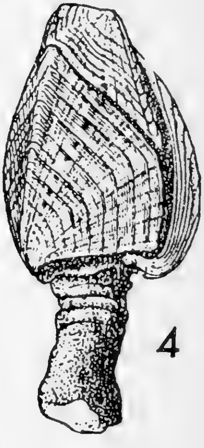
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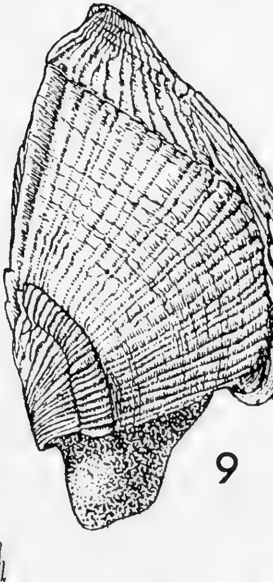
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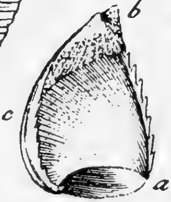

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Plate 2,

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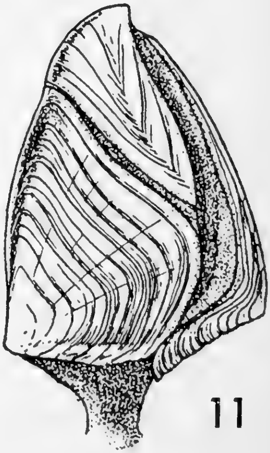
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EXPLANATION OF PLATE 2

Figure Page

1, 2. **Lepas anatifera** Linnaeus 7, 13

Figures from Pilsbry (1907). 1. Specimen from Boca Chica Bay, Florida, on driftwood; capitulum length 15 mm. 2. Diagram of base of capitulum showing umbonal tooth (*t*) of right scutum. Vineyard Sound, Massachusetts.

3, 4. **Lepas anserifera** Linnaeus 7, 18

Figures from Pilsbry (1907). 3. Specimen from Cherrystone, Virginia; capitulum length 27 mm. 4. Specimen from longitude 90°E, on equator; length of capitulum 19 mm.

5, 6. **Lepas hillii** (Leach) 7, 23

Figures from Pilsbry (1907). 5. Specimen from Menimsha, Martha's Vineyard, Massachusetts; capitulum length 35 mm. 6. Diagram of base of capitulum.

7-9. **Lepas pectinata** Spengler 7, 25

7. Holotype, from Spengler (1792), slightly enlarged. *a,* opening to peduncle with diaphragm; *b*, apex; *c*, carina. 8. Cluster of paratypes attached to *Fucus,* natural size. 9. Specimen from Vineyard Sound, Massachusetts, after Pilsbry (1907b); capitulum length 12 mm.

10, 11. **Lepas (Dosima) fascicularis** Ellis and Solander 7, 28

10. Holotype, from Ellis and Solander (1786). 11. Specimen from "Albatross" sta. 2425 (36°20′24″N, 74°46′30″W). Capitulum length 20 mm. From Pilsbry (1907).

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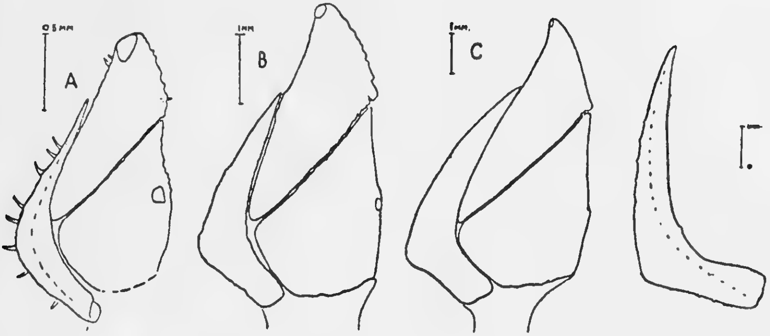
EXPLANATION OF PLATE 3

Figure		Page
1.	**Conchoderma auritum** (Linnaeus) Specimen from Cape Hatteras, North Carolina, on iron buoy. Length about 83 mm. From Pilsbry (1907).	7, 31
2.	**Conchoderma virgatum** (Spengler) Type specimen from near St. Barthélemy (17°55'N, 62°50'W). From Spengler (1790, 1792). Measurements of drawing: length 40 mm, width below aperture 14 mm.	7, 34
3.	**Oxynaspis celata hirtae** Totton Types. 3A. Capitulum length 1.9 mm, width 1 mm; 3B. Capitulum length 4.2 mm, width 2.6 mm; 3C. Capitulum length 7.4 mm, width 4.6 mm. Carina length 7.2 mm. Scale lengths: A, 0.5 mm; B, C, and carina, 1 mm.	7, 37
4.	**Oxynaspis floridana** Pilsbry Holotype × 6.4. Capitulum length 8 mm, width 4 mm; peduncle length about 2 mm.	7, 38
5.	**Oxynaspis gracilis** Totton Syntypes × 9. Average total length 5 mm; capitulum width across carinal elbow about 2 mm; peduncle length and width about 1 mm. Length of scale 1 mm.	7, 38
6-9.	**Oxynaspis patens** Aurivillius 6, 7. Holotype × 4.4. 6. Length of animal 14 mm; capitulum 8 mm × 4 mm. 7. View of capitulum from below. 8. Drawing of holotype by Totton (1940), × 7. 9. Portion of transverse section across peduncle showing spines, greatly enlarged, from Aurivillius (1892).	7, 39



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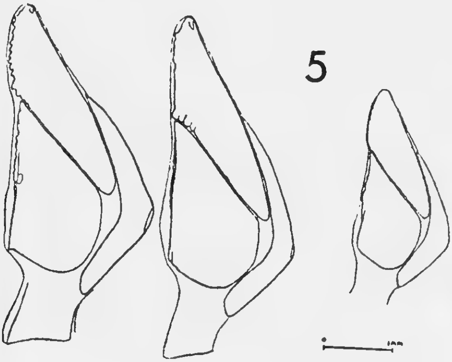

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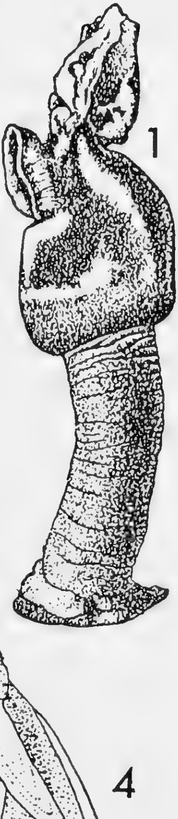

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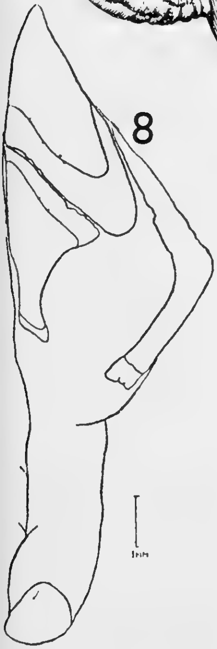

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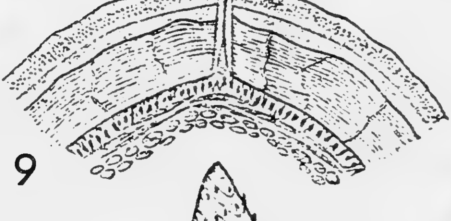

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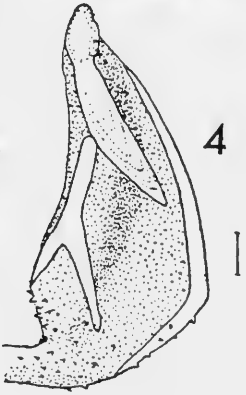

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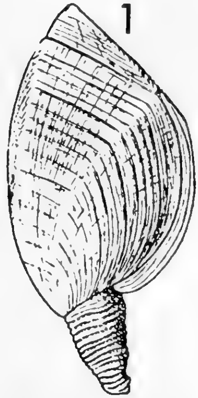
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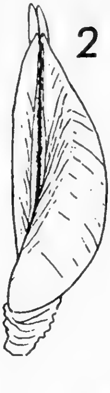
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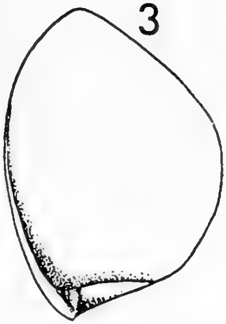
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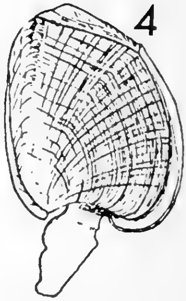
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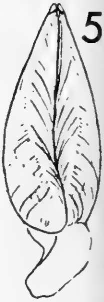
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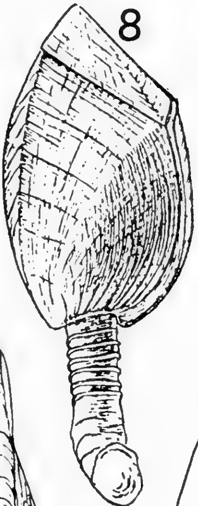
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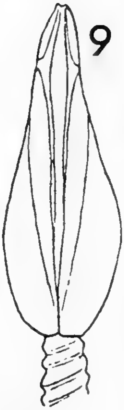
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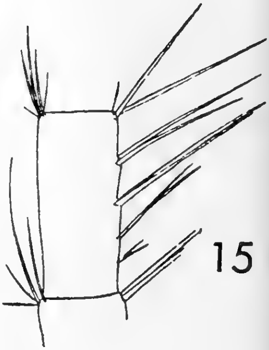
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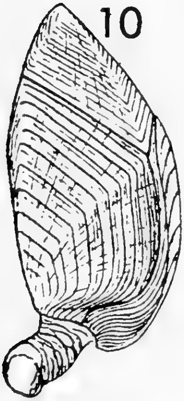
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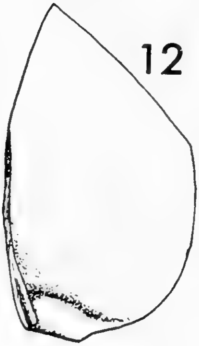
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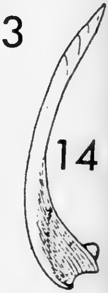
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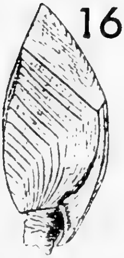
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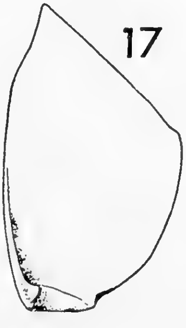
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EXPLANATION OF PLATE 4

(Figures rearranged from Pilsbry (1907); same size as originals)

Figure Page

1-3. **Poecilasma inaequilaterale** Pilsbry 7, 40

1, 2. Holotype, lateral and ventral views. Measurements: capitulum 11.5 × 7 × 3.2 mm. 3. Interior of specimen from off Key West, Florida, enlarged.

4, 5. **Poecilasma inaequilaterale breve** Pilsbry 7, 42

Holotype, lateral and ventral views, enlarged about 4 ×. Measurements: capitulum 7.5 × 5.3 × 3 mm.

6, 7. **Poecilasma kaempferi litum** Pilsbry 7, 44

Holotype, lateral and ventral views, enlarged about 2.6 ×. Measurements: capitulum 12 × 6.8 × 3.3 mm; carina length 7.8 mm; peduncle length 5 mm.

8, 9. **Poecilasma kaempferi novaeangliae** Pilsbry 7, 45

Holotype, lateral and ventral views, enlarged about 2.4 ×. Measurements: capitulum 17 × 9.7 × 5.75 mm; carina length 12 mm; peduncle length 9 mm.

10-15. **Megalasma (Glyptelasma) annandalei** Pilsbry 7, 45

10, 11. Holotype, lateral and ventral views, enlarged about 2.4 ×. Measurements: capitulum, 19 × 9 × 5.5 mm; carina length 13 mm. 12. Interior of scutum, enlarged. 13, 14. Interior and lateral views of carina, enlarged. 15. Intermediate segment from cirrus VI, anterior side on right side of figure.

16-20. **Megalasma (Glyptelasma) gracilius** Pilsbry 7, 47

16. Holotype, lateral view, enlarged about 2.7 ×. Measurements: capitulum (measured to the umbo of the carina), 11.8 × 5 × 3 mm; carina length 7.75 mm. 17. Interior of scutum, enlarged. 18, 19. Interior and lateral views of carina. 20. Maxilla.

EXPLANATION OF PLATE 5

Figure | Page

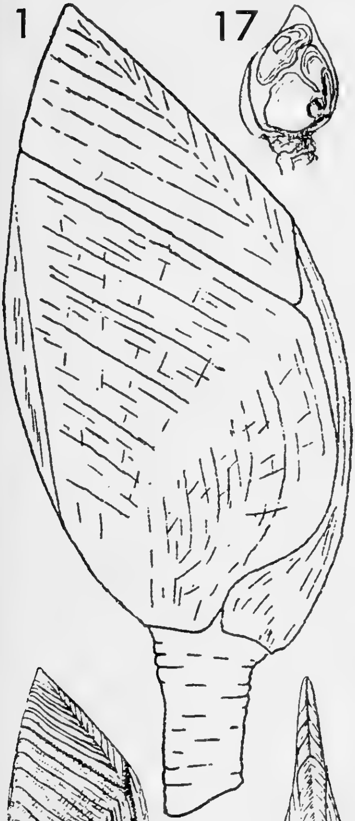
1, 2. **Megalasma (Glyptelasma) hamatum** Calman 7, 48
Holotype, × 3.5. 1. Lateral view; 2. Carina, inner surface. Measurements: capitulum length to middle of basal margin 24 mm; breadth 12.5 mm. From Victoria-Tasmania cables. Compare with specimen from Cuba, *in* Calman (1919, text-fig. 7).

3-7. **Megalasma (Glyptelasma) subcarinatum** Pilsbry 7, 50
3, 4. Lateral and dorsal views of holotype, × 2.6. Measurements: capitulum 19 × 10 × 5 mm; carina length 12 mm. 5. Interior of scutum, enlarged. 6, 7. Interior and lateral views of the carina.

8-12. **Megalasma (Glyptelasma) rectum** Pilsbry 7, 51
8, 9. Lateral and dorsal views of holotype, × 2.4. Measurements: capitulum 15.5 × 7.5 × 4 mm; carina length 10 mm; peduncle length about 2 mm. 10. Interior of scutum, enlarged. 11, 12. Interior and lateral views of the carina.

13-15. **Octolasmis americanum** Pilsbry 7, 52
Holotype. 13. Lateral view, × 4. Measurements: capitulum length 8 mm, width 3.6 mm. 14, 15. Carinal and basal views, enlarged.

16-18. **Octolasmis antiguae** (Stebbing) 7, 53
16. Lateral view of holotype, × 14. Measurements: length 3.81 mm, maximum width of capitulum 2.54 mm. 17. Young specimen, enlarged. 18. Same as fig. 17, showing tergum and scutum more highly magnified.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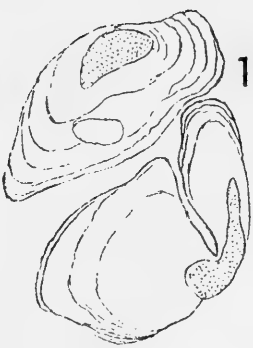
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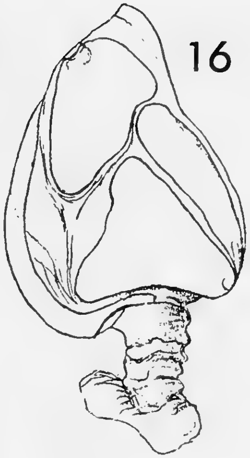
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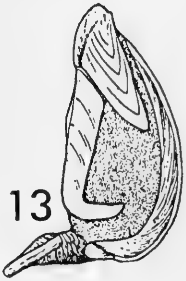
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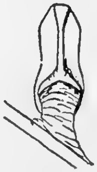
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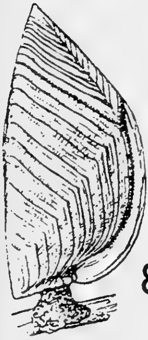
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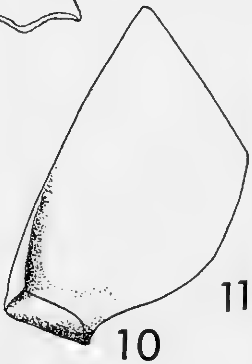
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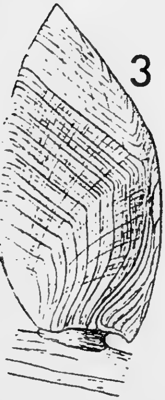
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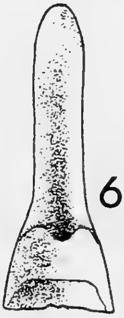
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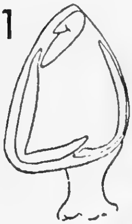

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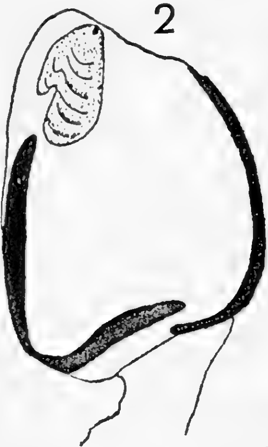

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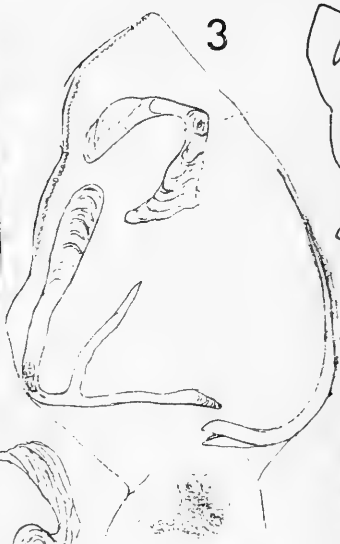

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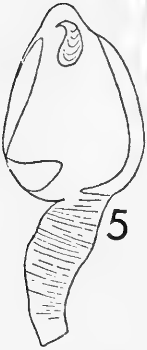

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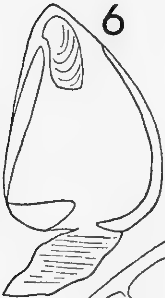

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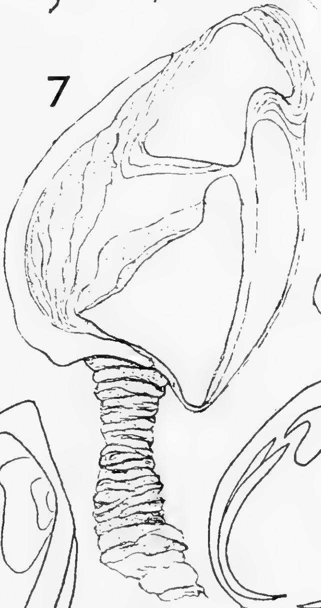

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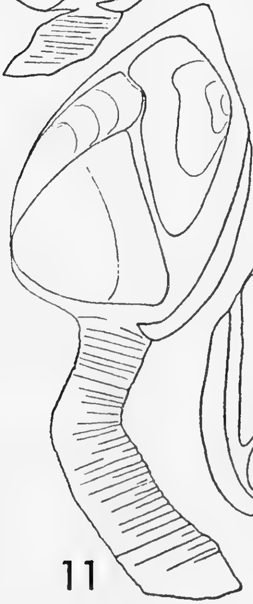

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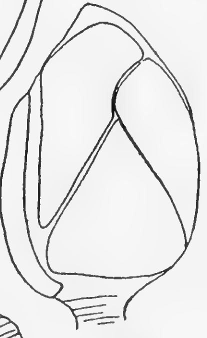

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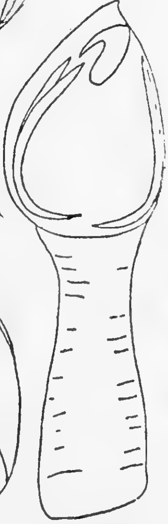

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EXPLANATION OF PLATE 6

(Figures same as on original plate of responsible author)

Figure Page

1. **Octolasmis brevis** Pearse 7, 54
Holotype, × 10. Capitulum 2.0-2.4 mm × 1.6 mm; peduncle length 1.2 mm.

2. **Octolasmis dawsoni** Causey 7, 55
Holotype, × 35. Average capitulum length 1.42 mm.

3, 4. **Octolasmis forresti** (Stebbing) 7, 56
3. Holotype, × 23. Measurements: Length of specimen approximately 5.5 mm of which the peduncle (removed from figure 3) occupies the larger portion. 4. Specimen illustrated by Pilsbry (1907, p. 94).

5, 6. **Octolasmis geryonphila** Pilsbry 8, 58
Types, × 8. Capitulum length 3.5 mm, breadth 2.5 mm; peduncle length 2.5-3 mm.

7, 8. **Octolasmis hoeki** (Stebbing) 8, 59
7. Holotype, × 20. Natural size about 3.2 mm in length, 1.8 mm maximum width of capitulum. 8. Tergum of another specimen, enlarged.

9, 10. **Octolasmis mülleri** (Coker) 8, 63
9. Holotype, × 8, from Coker (1902). Measurements: capitulum length 3.5-4.5 mm, width 3.5-4.0 mm; peduncle one to ten times length of capitulum. 10. Another specimen, from Pilsbry (1907), × 8, Lake Worth Inlet, Florida.

11, 12. **Octolasmis prototypus** Pilsbry 8, 65
Holotype, × 12, showing both faces of capitulum. Measurements: capitulum length 3.6 mm, width 2.5 mm; peduncle length 3.5-4.0 mm.

13. **Octolasmis uncus** Pearse 8, 67
Holotype. Pearse's drawing is greatly enlarged.

14. **Octolasmis lowei** (Darwin) 8, 60
Holotype, × 9. Capitulum length 2.8 mm, width 1.7 mm; peduncle length 5.1 mm.

15. **Pagurolepas conchicola atlantica** Keeley and Newman 8, 67
Holotype, right side, × 4. Capitulum length 11 mm.

EXPLANATION OF PLATE 7

Figure — Page

1-3. **Dichelaspis sinuata** Aurivillius 66

Holotype. 1, lateral view, × 8. Length of animal 5 mm; length of capitulum 2.5 mm, breadth 1.5 mm. 2, capitulum from below, × 8. 3, capitulum from above, × 8.

4. **Paradolepas neptuni** MacDonald 66

Holotype, × 21. Capitulum length 3.1 mm. *a,* pedicle; *b,* scutum; *c,* tergum; *d,* carina. Moreton Bay, Australia.

5-7. **Paradolepas neptuni** MacDonald 66

5, 6. Group of specimens from Moreton Bay, Australia. 5, attached to gills of *Neptunus pelagicus* (Linnaeus). 6, attached to one of the gill flappers of *Neptunus pelagicus,* considerably enlarged. 7. Specimen from Nandi Bay, Fiji Islands. a, palp; b, mandible; c, maxilla; d, external maxilla; e, anterior branch of first pair of cirri.

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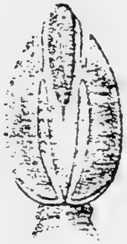

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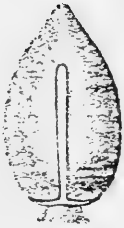

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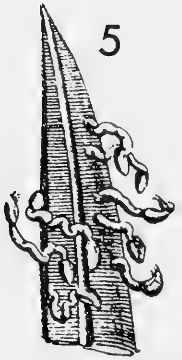

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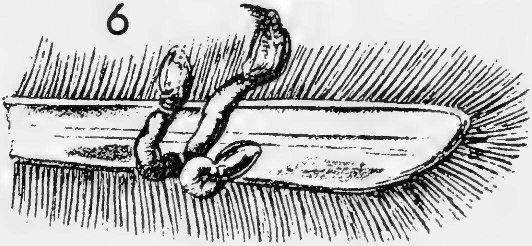

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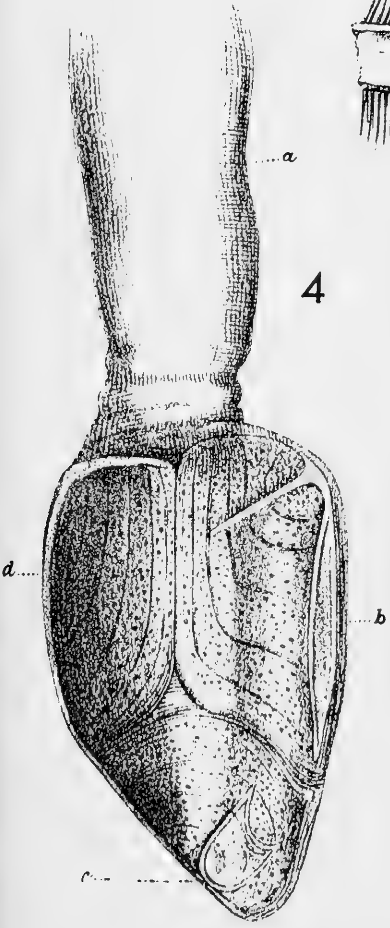

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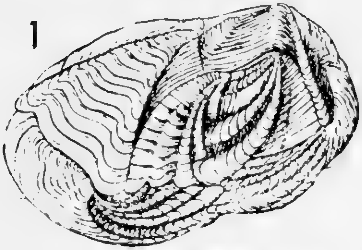

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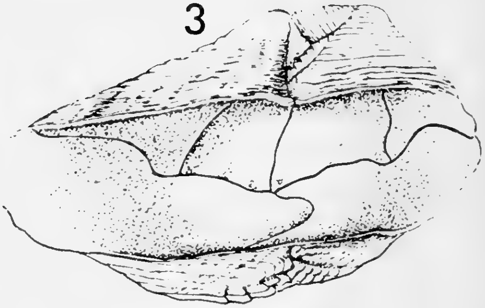

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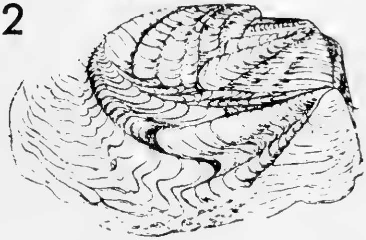

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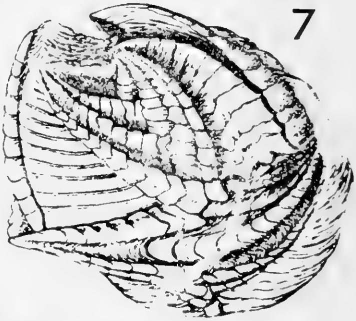

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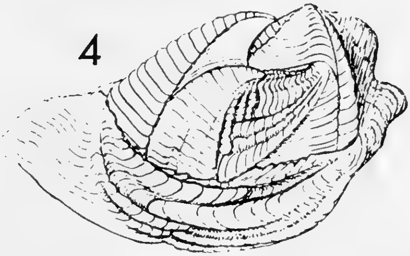

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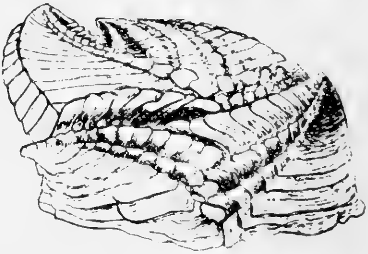

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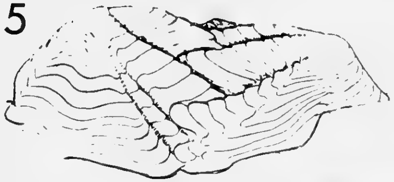

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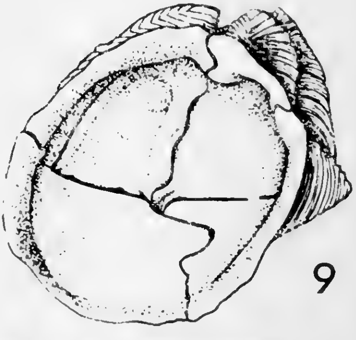

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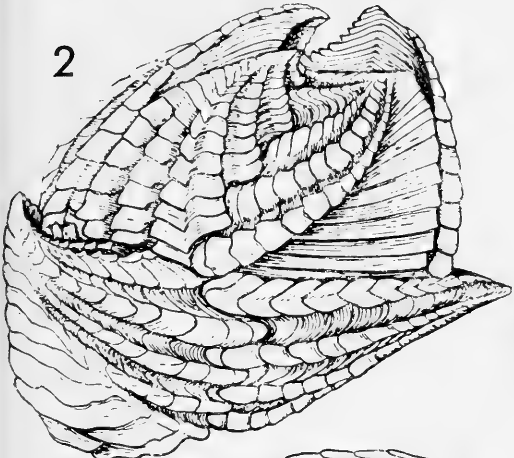
EXPLANATION OF PLATE 8

Figure		Page
1-3.	**Verruca alba** Pilsbry 1, 2. Holotype, top and carinorostral views, × 11. Measurements: length 4 mm, breadth 2.7 mm, altitude 1.7 mm. 3. Specimen from Pourtalès Plateau, near Key West, Florida, view of base, enlarged.	8, 69, 70
4, 5.	**Verruca alba barbadensis** Pilsbry Holotype, × 14, top and rostrocarinal views. Length 3.9 mm, height of fixed tergum 1 mm.	8, 71
6.	**Verruca alba caribbea** Pilsbry "Types" on *Cidaris affinis* Philippi, × 2. Greatest carinorostral length of individual barnacle 4.1 mm, height of fixed tergum 2 mm.	8, 72
7-11.	**Verruca calotheca** Pilsbry Holotype. 7, 8, top and carinorostral views, × 9. Greatest carinorostral length 5.9 mm, width at right angles to length 4 mm, height of fixed tergum 3 mm. 9, base of shell, × 6, length about 5.25 mm, width 4.8 mm. 10, interior of movable scutum, × 3, height 3 mm. 11, interior of movable tergum, × 3, height about 3 mm, width at base about 2.6 mm.	8, 69, 70, 72

EXPLANATION OF PLATE 9

Figure		Page
1, 2.	**Verruca calotheca flavidula** Pilsbry Holotype. Carinal and top views, × 8. Carinorostral length between apices 5.2 mm. On fig. 1, the movable tergum is top left, the fixed tergum top right.	8, 69, 70, 74
3, 4.	**Verruca calotheca heteropoma** Pilsbry Holotype. Top and carinorostral walls, × 5. Carinorostral length between apices 5.5 mm, greatest diameter at right angles to length 5 mm, height of fixed tergum 2.6 mm.	8, 69, 70, 75
5-7.	**Verruca entobapta** Pilsbry Holotype. Basal (× 10), rostrocarinal (× 10), and top (× 9) views. Carinorostral length between apices 5.5 mm, long diameter of base 5 mm, height of fixed tergum, apex to base 3.9 mm.	8, 69, 70, 76



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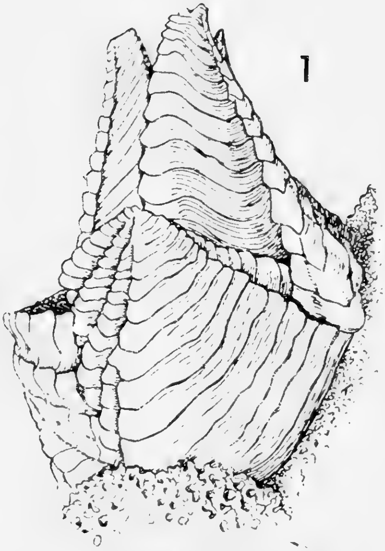

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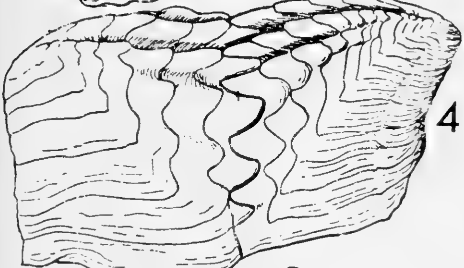

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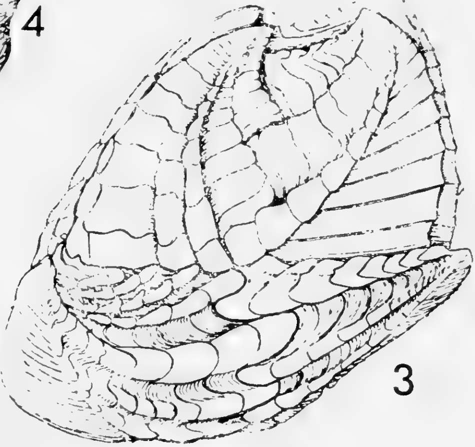

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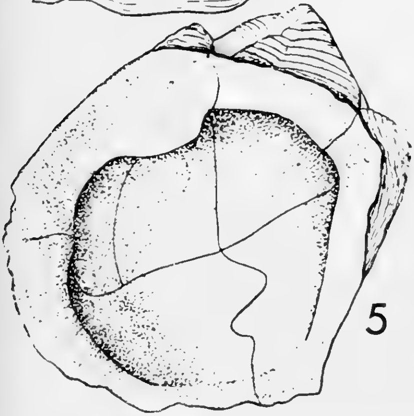

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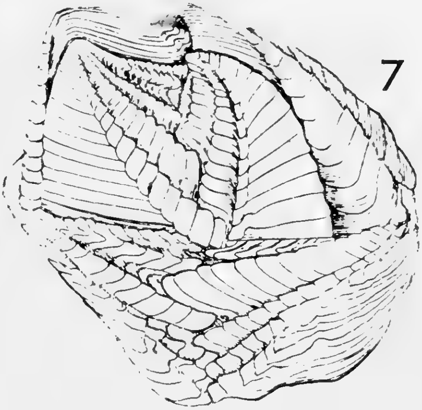

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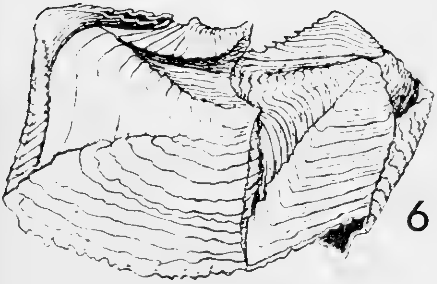

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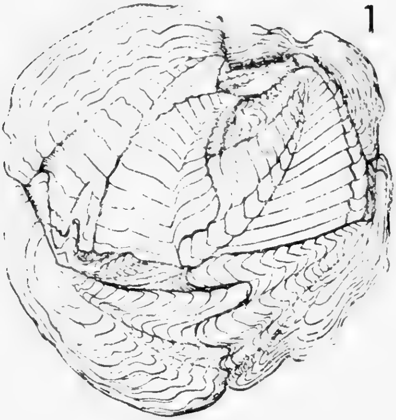

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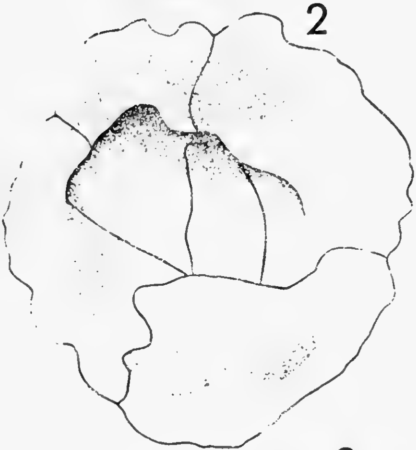

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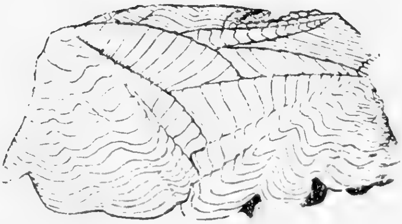

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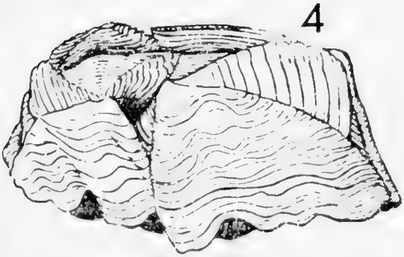

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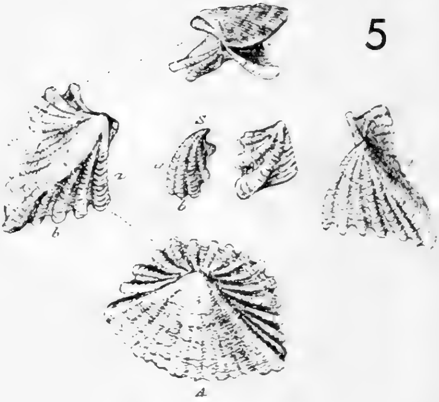

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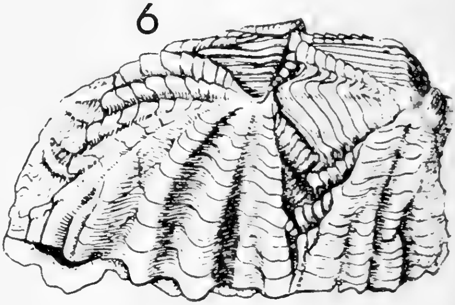

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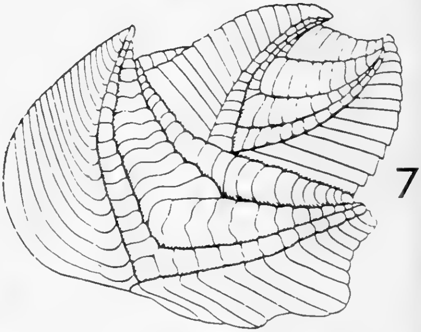

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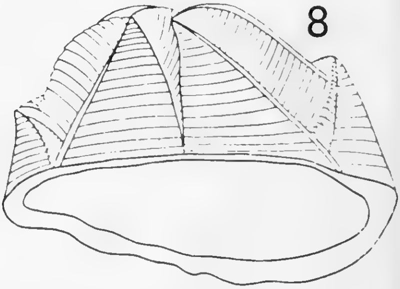


EXPLANATION OF PLATE 10

Figure Page

1-4. **Verruca floridana** Pilsbry 8, 69, 70, 77

Holotype, × 7, showing top (1), base (2), rostrocarinal walls (3), and scutotergal walls (4). Greatest carinorostral length 7.5 mm, length between apices 6 mm, greatest breadth at right angles to preceding 7 mm, height from base to summit of movable scutum 4 mm.

5, 6. **Verruca nexa** Darwin 8, 69, 79

5. Holotype, valves separated, enlarged. Legend: *A* — rostrum; *B* — carina; *S* — movable scutum; *S'* — fixed scutum; *a* — occludent margin of scuta; *b* — basal margin of scuta. The diameter of Darwin's largest specimen was 5.1 mm. 6. Lateral view of specimen from off Habana, Cuba, × 10. Carinorostral length 4.7 mm, height of fixed tergum 2.1 mm.

7, 8. **Verruca tarasovi** Zevina 8, 84

Holotype, × 8, showing top (7) and basilateral view (8). Maximum diameter at base 8 mm, length between carina and rostrum 7.4 mm, height from base to apex of tergum 7.4 mm.

EXPLANATION OF PLATE 11

Figure Page

1-5. **Verruca stroemia** (O. F. Müller) 8, 69, 79

Specimen from Trondheimsfjord, Norway (after Broch, 1924b). 1, common form of shell, × 5. 2, 3, exterior and interior of movable tergum, × 8. 4, 5, exterior and interior of movable scutum, × 8.

6, 7. **Verruca xanthia** Pilsbry 8, 69, 70, 84

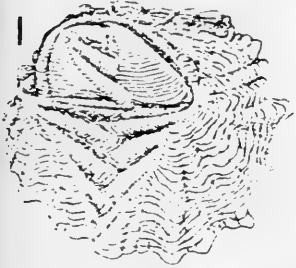
Holotype. 6, top view, × 5. 7, basal view, × 5. Measurements: carinorostral length 5 mm, greatest diameter at right angles to length 5 mm, height of fixed tergum 3 mm.

8. **Verruca xanthia insculpta** Pilsbry 8, 86

Holotype, × 6. Carinorostral length at base 5 mm, carinorostral length between apices 6.5 mm, diameters at right angles to preceding 6 mm, height of fixed tergum 3.5 mm.

9-12. **Verruca (Altiverruca) bicornuta** Pilsbry 8, 69, 70, 86

Holotype. 9-11, rostrocarinal, tergoscutal, and rostral views, × 5. 12, interior of scutum and tergum, × 3.2. Measurements: length between apices of rostrum and carina 9 mm, height of fixed tergum 8.3 mm.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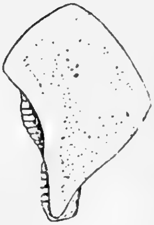
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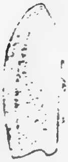
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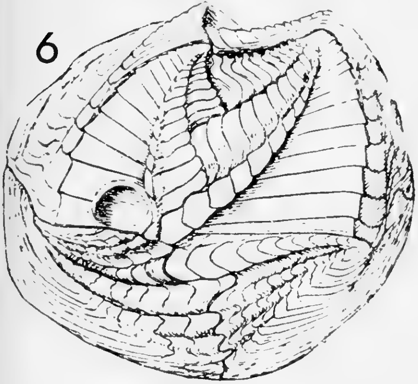
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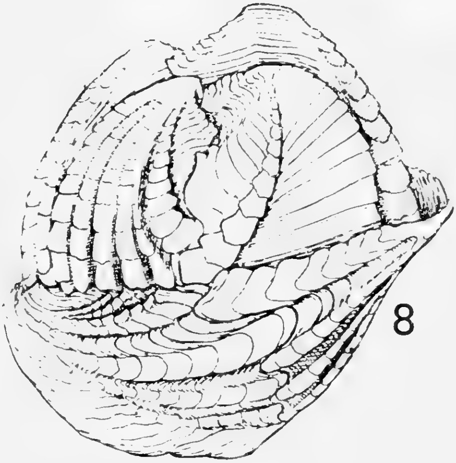
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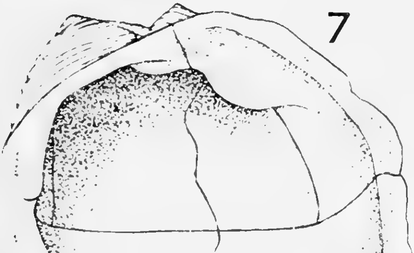
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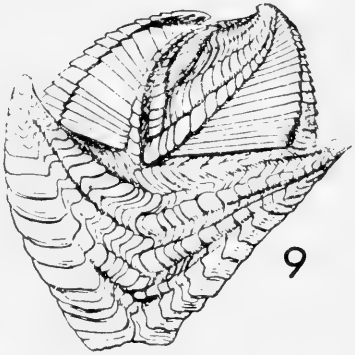
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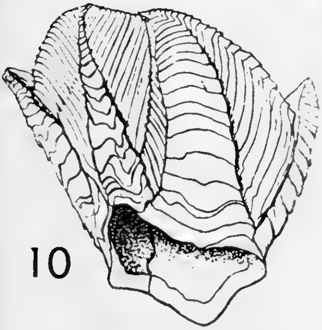
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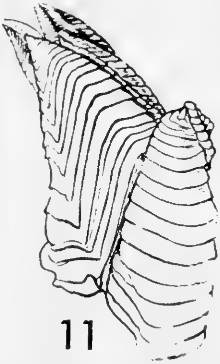
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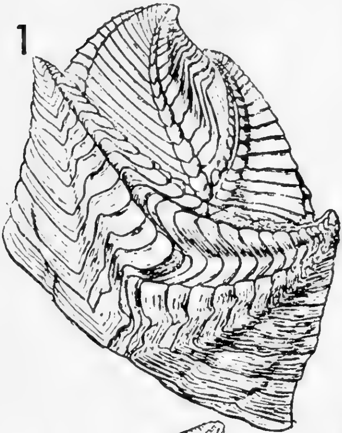
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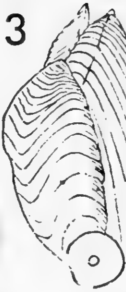
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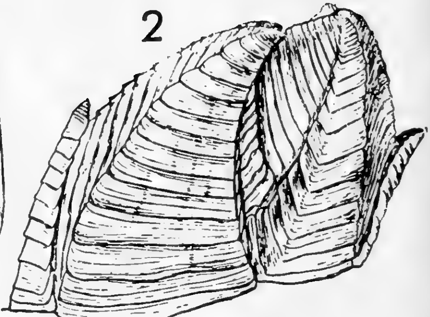
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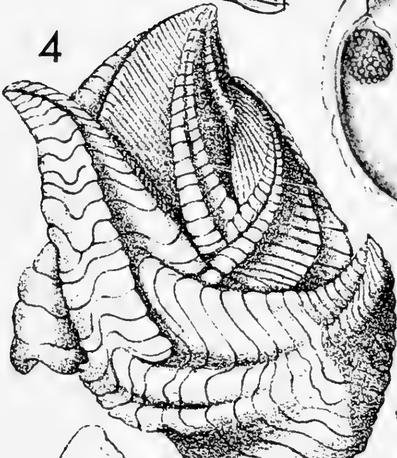
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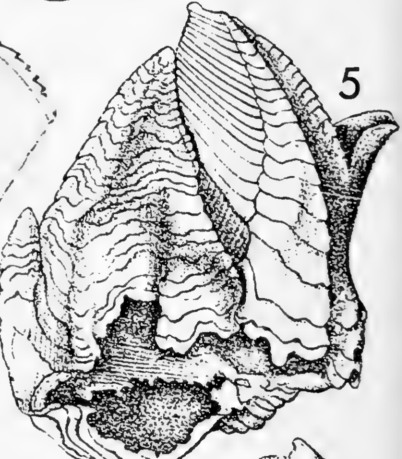
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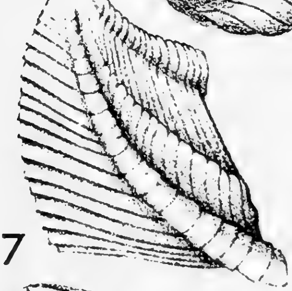
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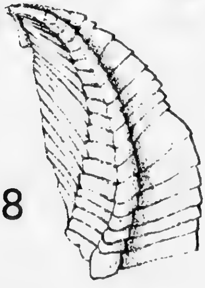
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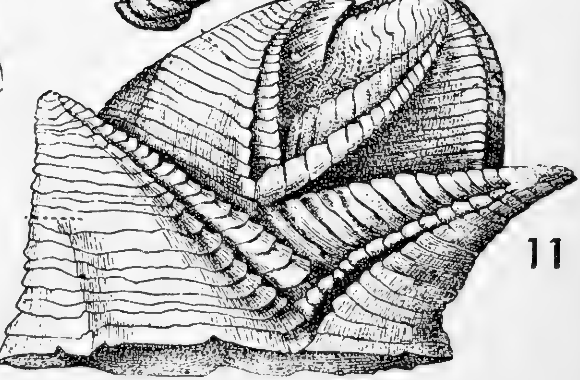
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EXPLANATION OF PLATE 12

Figure Page

1-3. **Verruca (Altiverruca) darwini** Pilsbry 8, 69, 70, 88

Holotype. 1, lateral view showing movable valves, × 4; 2, lateral view showing fixed valves, × 4; 3, rostral end, × 4. Greatest carinorostral length 11 mm, greatest breadth 6 mm, height from base to apex of fixed tergum 8.7 mm.

4-8. **Verruca (Altiverruca) gibbosa** Hoek 8, 89

Holotype. 4, lateral view showing movable scutum and tergum, × 6.5; 5, lateral view showing immovable scutum and tergum, × 6.5; 6, interior of scutum and tergum attached to each other, × 5.5; 7, exterior of tergum, × 7.5; 8, exterior of scutum, × 7.2. According to Hoek, "The average size of four specimens was 8 mm in height and 9 mm in length from the apex of the rostrum to that of the carina."

9, 10. **Verruca (Altiverruca) sulcata** Hoek 90

Holotype. 9, lateral view showing movable scutum and tergum, × 6.5; 10, lateral view showing immovable scutum and tergum, × 6.5. Measurements: height of shell 5.5 mm, length from apex of carina to that of rostrum not quite 5 mm. Illustrated to compare with holotype of *V. gibbosa.*

11. **Verruca (Altiverruca) mitra** Hoek 90

Holotype. Lateral view showing movable scutum and tergum, × 10. "The greatest diameter of the shell at the base is, in the largest specimen, not quite 6 mm, the height of the shell is nearly 5 mm." (Hoek, 1907b, p. 8). Illustrated to compare with holotype of *V. gibbosa* Hoek.

EXPLANATION OF PLATE 13

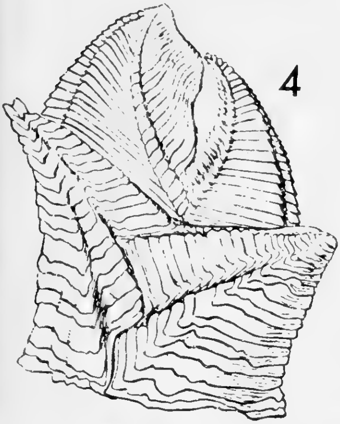
Figure Page

1-3. **Verruca (Altiverruca) hoeki** Pilsbry 8, 69, 70, 91
Holotype. Carinorostral (1), rostral (2), and tergoscutal (3) views, × 10. Length of base 3.6 mm, greatest width of base 1.9 mm, length from apex to rostrum to that of carina 3.2 mm, oblique height from base to apex of fixed tergum 4 mm.

4-6. **Verruca (Altiverruca) rathbuniana** Pilsbry 8, 69, 92
Holotype. Carinorostral (4), scutotergal (5), and rostral (6) views, × 5. Greatest length of base 7.6 mm, greatest diameter of base 5.5 mm, length between apices of carina and rostrum 9.8 mm, height from base to apex of fixed tergum, 10.5 mm. Compare with *V. quadrangularis* Hoek, Pl. 14, figs. 7-11.

7-9. **Verruca (Cameraverruca) euglypta** Pilsbry 8, 69, 70, 94
7, 8, holotype, × 4.2. Oblique view from side of movable valves (7) and view from side of fixed scutum and tergum (8). Greatest carinorostral length 11.2 mm, greatest breadth at right angles to length 9.4 mm, height from base to apex of fixed scutum 7.8 mm. 9, interior of rostrum of another specimen, × 11. Height about 11 mm, width about 8.5 mm.

10-12. **Verruca (Metaverruca) coraliophila** Pilsbry 8, 96
10, top view of holotype, × 9.6. Long diameter 9.6 mm, transverse diameter 7.4 mm. 11, interior view of fixed scutum and tergum, × 5, width of combined valves 9.5 mm. 12, interior view of movable scutum and tergum, detached and enlarged. Height of tergum 3.5 mm, length at base 3.75 mm; height of scutum from apex to middle of base 3.5 mm, length of base 2.75 mm.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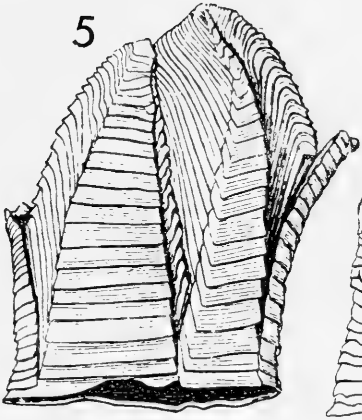
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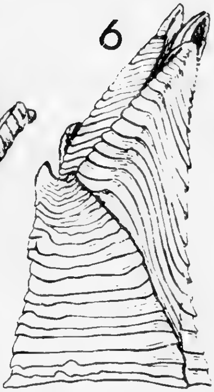
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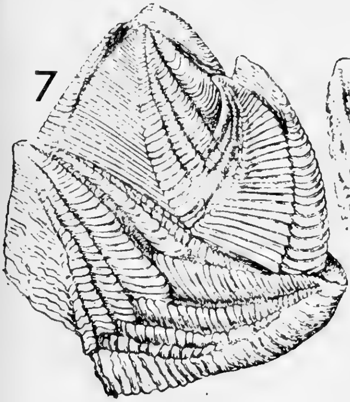
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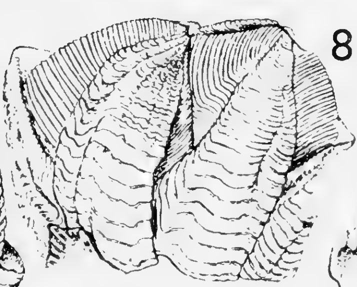
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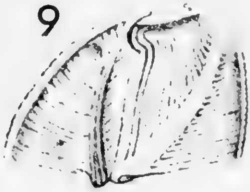

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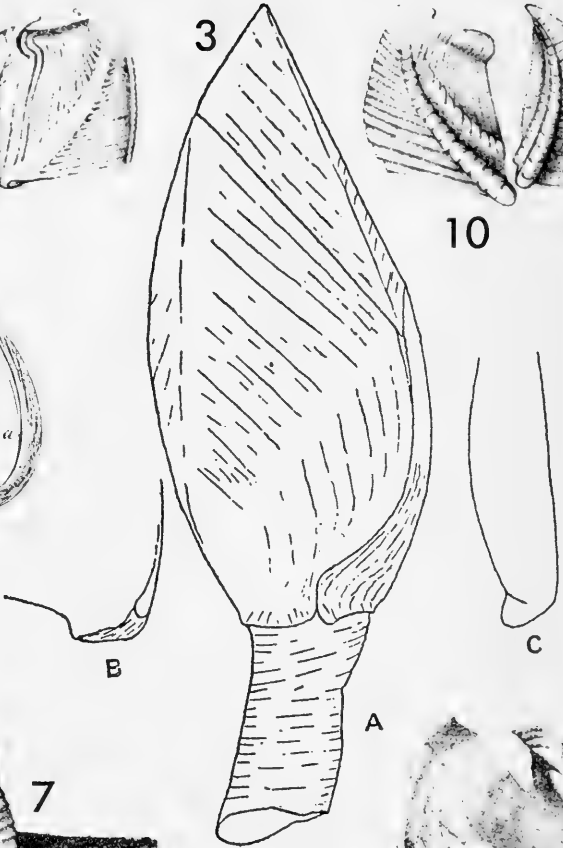

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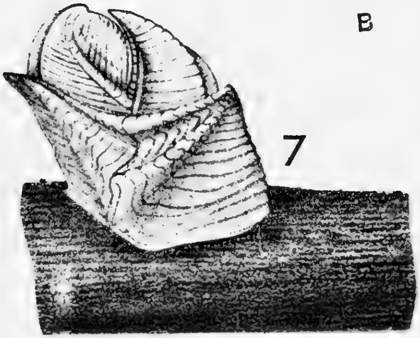

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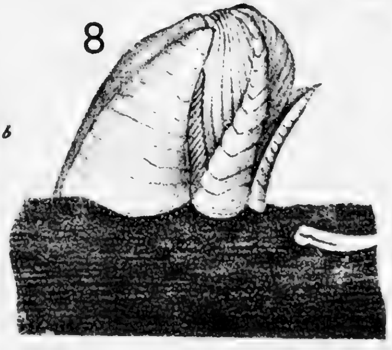


8

5

Explanation of Plate 14

Figure		Page
1.	**Poecilasma crassa** Darwin Holotype. Lateral view of complete individual, × 2. (a), carina. Length of capitulum 10.2 mm.	43
2.	**Anatifa ovalis** Gray Named and drawn by Gray (1848), but described presumably under the name *Anatifa crassa*. Probably represents *Poecilasma crassum* Darwin.	43
3.	**Megalasma (Glyptelasma) hamatum** Calman Specimen from coast of Cuba, greatly enlarged. A, lateral view. B, basal angle of scutum. C, scutum from occludent aspect, to show eversion of basal margin. Capitulum length 24 mm, breadth 12.5 mm.	48
4.	**Octolasmis darwinii** (Filippi) Holotype of *Dichelaspis darwinii* Filippi. a, tergum; b, scutum; b′, occludent segment; b″, basal segment; c, carina. Reproduced from Filippi (1861a) who did not give its dimensions save to indicate its "smallness." According to Gruvel (1905, p. 131) a capitulum of one example of the species had a length of 3 mm, breadth 2.5 mm, peduncle 1 mm.	61
5, 6.	**Octolasmis aymonini** (Lessona and Tapparone-Canefri) 5. Holotype of *Dichelapsis* [sic] *aymonini* Lessona and Tapparone-Canefri, greatly enlarged. 6. Cluster of four individuals. Length of capitulum 3 to 8 mm, peduncle of largest specimen 20 mm.	61
7-11.	**Verruca (Altiverruca) quadrangularis** Hoek Holotype. 7. Animal, seen from the side of the movable scutum and tergum, × 7.5. 8. Animal, seen from the sides of the immovable scutum and tergum, × 7.5. 9. Scutum and tergum, interior view, × 9. 10. Tergum, exterior view, × 9. 11. Scutum, exterior view, × 9. Compare with *Verruca (Altiverruca) rathbuniana* Pilsbry, Pl. 13, figs. 4-6.	93

EXPLANATION OF PLATE 15

(Illustrations of Rhizocephala from Reinhard, 1958, and Boschma, 1929, 1933)

Figure Page

1. **Cyphosaccus chasei** Reinhard 99

External appearance of two of the syntype specimens, enlarged. Length 5 mm, diameters of arms 0.5 to 1 mm.

2. **Cyphosaccus cornutus** Reinhard 99

External appearance of the syntype, enlarged. Length 8 mm, thickness 1 mm.

3. **Boschmaia mundicola** Reinhard 100

External appearance of syntype, enlarged. Length 5 mm, thickness 0.5 mm to 0.75 mm.

4. **Tortugaster fistulatus** Reinhard 101

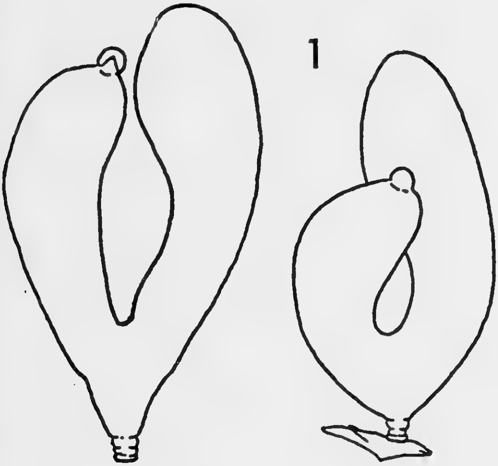
External appearance of specimen on *Munidopsis spinifer,* enlarged. Length 6 mm, width 3 mm.

5-7. **Galatheascus minutus** Boschma 101

5. Syntype, on *Galathea intermedia* Lilljeborg, recovered off Valentia, Ireland, enlarged. Length 2.5 mm, height 2 mm, breadth 1.5 mm. 6. Syntype on *Galathea nexa,* recovered off Oban, Scotland, enlarged. Length 5 mm, height 3 mm, breadth 2 mm. 7. External appearance of specimen on *Munidopsis barbarae,* enlarged. Length 3 mm, breadth 2 mm, thickness 1.5 mm, recovered in Gulf of Mexico, about 195 statute miles west of Highland Point, Florida.

8, 9. **Galatheascus striatus** Boschma 103

8. External appearance of holotype viewed from left side, enlarged 3 ×. Length 19 mm, breadth through middle 8.3 mm. 9. Semi-diagrammatic longitudinal section in which the genital organs of one side are shown also. *mo,* mantle opening; *c,* colleteric gland; *s,* stalk; *t,* testis; *vm,* visceral mass; *mc,* mantle cavity.



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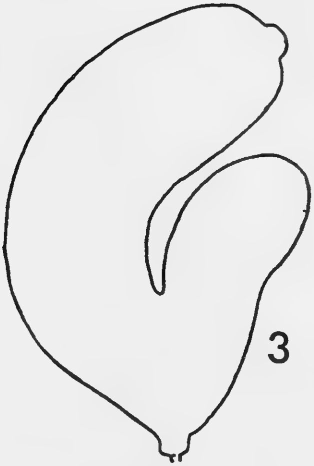

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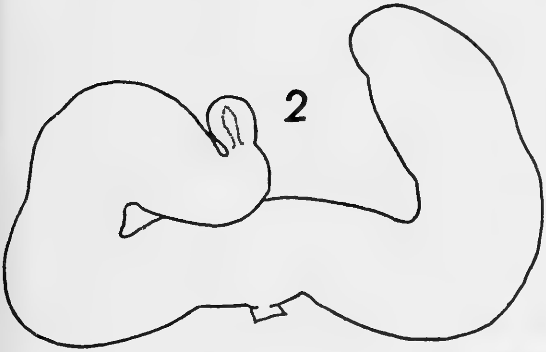

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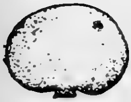

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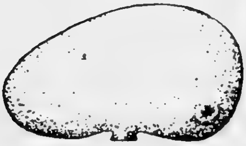

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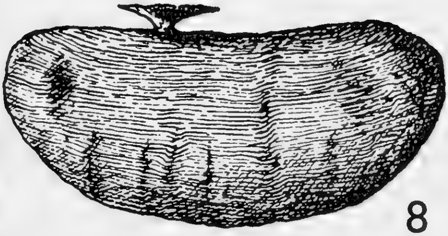

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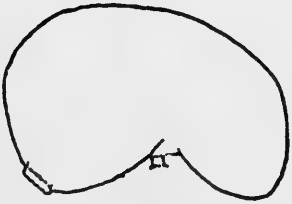

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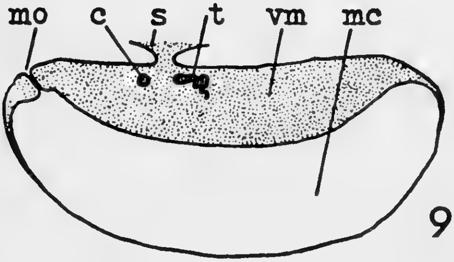

9

INDEX

NUMBER 306

Note: Page numbers in light face; plate numbers in **bold face** type.

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

PREPARATION OF MANUSCRIPTS

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Authors are requested to enclose $10 with each manuscript submitted, to cover costs of postage during the review process.

Collinson, J.
1962. *Size of lettering for text-figures.* Jour. Paleont., v. 36, p. 1402.


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By

Raman J. Singh
Northern Kentucky University
Highland Heights, Kentucky 41076

1979

Paleontological Research Institution
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CONTENTS

LIST OF TABLES

TREPOSTOMATOUS BRYOZOAN FAUNA FROM THE BELLEVUE LIMESTONE, UPPER ORDOVICIAN, IN THE TRI-STATE AREA OF OHIO, INDIANA AND KENTUCKY

RAMAN J. SINGH
Northern Kentucky University
Highland Heights, Kentucky 41076

ABSTRACT

Ten genera of trepostomatous Bryozoa, of which one (*Parvohallopora*: type species *Monticulipora ramosa* d'Orbigny), is new, are described and illustrated. The 16 species included, of which one is new, are: *Amplexopora cingulata* Ulrich, *A. robusta* Ulrich; *Batostomella gracilis* (Nicholson); *Bythopora dendrina* (James); *Dekayia aspera* Milne-Edwards and Haime, *D. pelliculata* Ulrich; *Heterotrypa frondosa* (d'Orbigny), *H. solitaria* Ulrich; *Homotrypa curvata* Ulrich, *H. obliqua* Ulrich; *Monticulipora mammulata* d'Orbigny; *Parvohallopora ramosa* (d'Orbigny), *P. laevigata,* n. sp.; *Peronopora decipiens* Rominger, *P. dubia* Cumings and Galloway and *Amplexopora* (?) *filiasa* (d'Orbigny). An attempt is made to establish the morphological concept of *Batostomella gracilis,* the type species of *Batostomella,* and *Monticulipora ramosa,* because the type material is not available. The generic assignment of *Amplexopora* (?) *filiasa* is tentative; forms referred to this species are peculiar in the absence of zooecial bend and presence of many cycles (non-overgrowth) of endozone and exozone within a zoarium; a new generic name for the species would be in order but is deferred because the original types have not been traced.

A description format is suggested for the qualitative features of the trepostomes. This gives a three-dimensional picture of a zoarium and should be understood better than the separate descriptions of the tangential and longitudinal orientations given by many contemporary workers.

Monticules, including maculae of some authors, are composed of zooecia, megazooecia, mesopores, thicker walls and irregular wall laminae, either singly or in various combinations. Monticules are here suggested to be polymorphic in the trepostomes.

The integrate and amalgamate concept as used morphologically in the trepostomes is confusing and unnecessary. Nature of the wall laminae in longitudinal orientations is described as: (1) convex; (2) angular; (3) convex or angular with concentrations of darker material, either in zooecial boundary zone or proximal parts of laminae; or (4) abutting at sharp angles along a thin, dark, granular layer. Forms with the last laminar arrangement may be genetically distinct. The dark layer is not, as has been commonly supposed, an optical effect produced by sharply-bending laminae. In many instances, laminae are darker where they are not bent sharply. Microchemical analysis and electron-probe investigations are needed to further evaluate the morphology of the wall.

An analysis of the original definition by Nickles and subsequent authors validates the Bellevue Limestone as a rock-stratigraphic unit. Other alleged biostratigraphic units of the Cincinnatian need to be similarly analysed before they are replaced. The section in the Bellevue Hill Park, Cincinnati, Ohio, is the type section. Nickles, in characterizing the Bellevue as "*Monticulipora molesta* beds" probably erred by misidentifying the abundant *Heterotrypa frondosa*: *M. molesta* Nicholson is actually a *Peronopora.*

INTRODUCTION

The classic exposures of Upper Ordovician rocks around Cincinnati, Ohio and into southeastern Indiana and northern Kentucky, have been the subject of intensive investigations for over a century.

The abundant well-preserved and diverse fauna of brachiopods, predominantly trepostome bryozoans, cephalopods, pelecypods and others have been the target of many workers. The steady refinement of taxonomic procedures and methods of investigation and illustration has been applied to some of the above groups in many recent works.

Ironically, trepostome bryozoans, second in abundance only to the brachiopods, have been neglected by most recent workers. Perhaps this is because of the time-consuming study they require.

The discriminating use of acetate replicas ("peels"), which can be prepared several times faster than thin-sections, should give more impetus to the study of trepostome bryozoans (See Boardman and Utgaard, 1964, for details on peel preparation).

The stratigraphic relationships of the monotonous-appearing, flat-lying limestones and shales that make up the Cincinnatian Series are far from clear. The nomenclature seems to have progressed from the original "Blue Lime" for the entire series through the creation of many subdivisions to a more recent lumping trend. The validity of many new formational and lower category names that seem to follow state lines has not been demonstrated. Facies relationships are still poorly understood throughout the Cincinnati Arch region.

This work is a comprehensive study of the trepostomatous bryozoan fauna of a small stratigraphic interval. The Bellevue Limestone is ideal because of its easy identification and consistent nature in the field.

Ten genera, one new, and 16 species, one new, are described from a study of over 2,000 "peeled" (acetate replicas) and thin-sectioned zoaria. High interzoarial variability in both qualitative and quantitative features is noteworthy.

Parvohallopora ramosa and *Batostomella gracilis* are the predominant ramose forms: *Heterotrypa frondosa* is the predominant frondose form. *Monticulipora mammulata* represented by both frondose and ramose zoaria is rare at all localities. Both conspecific and interspecific incrustations are common; as many as four conspecific overgrowths have been observed in *Homotrypa*.

Many incrustations are separated by detrital material that covered the patches of dead zooids on a zoarium; in some cases this material covers the entire zoarium. This clearly indicates a slow deposition rate. The remarkable preservation of the external features of all zoaria suggests minimal transport from their life habitat, and qualifies the fauna as an autochothonous assemblage.

The total stratigraphic range for species described here can be determined only by further work in the Cincinnatian.

ACKNOWLEDGMENTS

Most of the work towards this paper was done at the Division of Invertebrate Paleontology, Department of Paleobiology, Smithsonian Institution, Washington, D.C. Complete access to the facilities and collections of the U.S. National Museum of Natural History is gratefully acknowledged. Financial assistance in the form of a NDEA Predoctoral Fellowship was provided by the Department of Geology, University of Cincinnati, to support the author at the Smithsonian Institution from June 1968 to June 1969.

The present study was supervised by Richard S. Boardman (Smithsonian Institution) and Kenneth E. Caster (University of Cincinnati). Dr. Boardman, with whom I was associated at the Smithsonian initiated me into the study of trepostome bryozoans and was easily and at all times accessible for impromptu "seminars". Boardman and Caster also read the manuscript critically and made many technical suggestions. To both Drs. Boardman and Caster, my sincerest appreciation for their continual interest.

An informal Bryozoan Seminar Group at the Smithsonian during 1968-69, was also the testing forum for the discussion and refinement of the the ideas of its members: R. S. Boardman and A. H. Cheetham (Smithsonian Institution), Helen Duncan and O. L. Karklins (United States Geological Survey), Miss P. L. Cook (British Museum of Natural History), T. G. Gautier (currently at the National Museum of Natural History), R. J. Hinds (currently at Slippery Rock State College) and O. B. Nye, Jr. (currently at Syracuse University).

This publication was made possible by a generous grant from the Northern Kentucky University Foundation, Inc.

Traditionally last to be mentioned but not so in contribution towards the completion of this work, I wish to record here the efforts of my wife, Sharon. She prepared the final typed manuscript

and helped in the layout of plates, while pursuing her own graduate studies.

Despite all the help which I have received, I alone must take responsibility for the accuracy of what follows.

COLLECTING LOCALITIES

1. Bellevue Hill Park, Cincinnati, Ohio. The bluffs on the south side of the park are accessible from the entrance to the park on Ohio Avenue and also from the sharp bend in Clifton Avenue. Fairview, Bellevue (22 feet thick [6.7 m]), and Corryville.
2. Fairview Park, Cincinnati, Ohio. The bluffs on the southwest side of the park are accessible from the main entrance to the park on McMillan Street. Fairview, Bellevue (20 feet thick [6.1 m]), and Corryville.
3. Muddy Creek, Cincinnati, Ohio. Outcrops along the creek. Accessible from Muddy Creek Road which runs alongside the creek. Addyston, Ohio-Kentucky Quadrangle. Fairview, Bellevue (18 feet thick [5.5 m]), and Corryville.
4. Harrison Road, Cincinnati, Ohio. Road cut on the northeast side, about 0.25 mile [0.4 km] northwest from junction with Simonson Road. (Near 9103 Harrison Road.) Addyston Quadrangle. Fairview, Bellevue (about 10 feet thick [3.1 m]).
5. Buell Road, Fairfield, Ohio. Road cut about 0.75 miles [1.2 km] south of junction of Buell and Crest Roads. This locality is about 8 miles [12.8 km] south of Hamilton, Ohio. Greenhills Quadrangle. Bellevue (approx. 5 feet thick [1.5 m]).
6. Tanner's Creek, Weisberg, Indiana. About 32 miles [51.5 km] west of Cincinnati, Ohio, between Manchester and Harmon's Station. Cuts also along the road that for short distance parallels the railroad tracks. Locality as described by Cumings and Galloway (1913).
7. Rising Sun, Indiana. Cuts along Highway 56, 3 miles [4.8 km] southwest of Rising Sun. Bellevue is badly weathered; its estimated thickness is about 8 feet [2.5 m].
8. Florence, Kentucky. Near the Florence exit from Interstate Route 75; the road-cut is along Pleasant Valley Road, about 2,000 feet [0.6 km] northwest of Sugartit, south of the radio tower. Bellevue (about 12 feet thick [3.7 m]).
9. Bedford, Kentucky. Road-cuts on U.S. 42, road ascends west bluff of Kentucky River valley. 2.3 miles [3.7 km] east of Bedford, Trimble County, southwest of Carrollton, Kentucky; just across Hardy Creek. Bellevue (about 22 feet thick [6.7 m]).
10. Maysville, Kentucky. Road-cuts on U.S. 62-68, 1.5 miles [2.4 km] southwest of Maysville, Mason County. Locality is Stop 6 in GSA Guidebook for Cincinnati meeting (Schmidt *et al.*, 1961, p. 276, fig. 13). For more details, see Peck, 1966.
11. Georgetown, Ohio. Road-cuts on Highway 125, just south of its junction with 221. A rather complete section of the Cincinnatian series is exposed here. Bellevue (about 32 feet thick [9.8 m]).
12. Stonelick Creek, Owensville, Ohio. Stream exposures off Highway 131, three miles [4.8 km] north of Owensville, Clermont County. This is a famous locality for some rare Upper Ordovician fossils. Bellevue (about 18 feet thick [5.6 m]).

ABBREVIATIONS OF REPOSITORIES

MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.
UC	University of Chicago, Chicago, Illinois.
UCM	Department of Geology Museum, University of Cincinnati, Cincinnati, Ohio.
UMMP	University of Michigan Museum of Paleontology, Ann Arbor, Michigan.
USNM	National Museum of Natural History (formerly United States National Museum), Smithsonian Institution, Washington, D.C.

CINCINNATIAN STRATIGRAPHY

The Cincinnatian strata exposed so well in and around Cincinnati, Ohio, have become established as the North American standard section of the Upper Ordovician. These strata superficially appear as a monotonous sequence of alternating shales and limestones, but bear a diverse, well-preserved fauna. Because of this, they have traditionally been studied more extensively paleontologically than lithologically. The names of several formations and members recognized in the area were applied by earlier workers to supposedly equivalent rocks in Indiana, Kentucky, and even Tennessee.

Renewed interest in the tri-state area is resulting in reevaluation of traditional concepts. The major impetus has been given by the reports by the American Commission on Stratigraphic Nomenclature and ultimately its Code (A.C.S.N., 1961). The major emphasis has been on the acquisition of previously-neglected "non-paleontologic" information. The application of the concepts of lithostratigraphy to these strata, until recently allegedly divided on the basis of fossils alone (hence biostratigraphic units of the modern usage), was inevitable.

For a pre-Commission summary of the Upper Ordovician stratigraphy see Nickles (1902, pp. 52-60), Cumings (1908, 1922), Cumings and Galloway (1913), and Fenneman (1916). Weiss and Norman (1960b) tabulated the complete history of the Cincinnatian stratigraphy.

Gustadt (1958) was perhaps the first post-Commission worker to re-evaluate the Upper Ordovician stratigraphy of the area. He summarized the Cincinnatian stratigraphy in the eastern interior region and concluded that the formations assigned to the Cincinnatian Series are "actually biostratigraphic zones" (p. 513). Weiss and Norman (1960a), Weiss (1961), Weiss and Sweet (1962, 1964), Weiss, *et al.* (1966), Scotford (1965), Ford (1967, 1968) and Osborne (1968) in Ohio; Weir, *et al.* (1965), Peck (1966) in Kentucky; and Brown and Lineback (1966), Brown and Anstey (1968) and Anstey and Fowler (1969) in Indiana, are some of the works concerned with lithostratigraphic reappraisals.

Contrary to the general misconception, the original definitions of the Cincinnatian members and formations are not solely based on faunal descriptions; lithologic characters of each member were also described (*e.g.*, Nickles, 1902). Admittedly, in some, there is a discrepancy of a few feet between lithologically-determined boundaries and the range of "diagnostic" fossils, in some Cincinnatian stratigraphic units. Clearly for a lithologically-based stratigraphy some redefinition is in order. Current stratigraphic revisionist activity, in an attempt to map these rocks in the tri-state area solely using lithologic criteria for formational identifications, has in some instances disregarded the traditional Cincinnati-based names, discounting them as wholly biologically determined and hence not acceptable. Hence a series of largely duplicate names in the stratigraphic literature and the long-standing standard Cincinnati column is being supplanted by type sections elsewhere. In one strange example, the Bellevue Limestone was redefined as a lithostratigraphic unit and assigned a new type section on a steep hill near the extant original type section in Bellevue Hill Park. Less confusion would result if refinement and redefinition of the long-standing "formations" and "members", rather than their arbitrary abandonment, had occurred.

The relationships of the many new formations and members being introduced in the tri-state area are rather unclear. Some of these units are: Grant Lake Limestone, Bull Fork Formation, (Peck, 1966, in the Maysville, Kentucky area), Calloway Creek Limestone, Ashlock Formation, and Drakes Formation (Weir, *et al.,* 1965, in the south-central Kentucky area), and Dillsboro Formation (Brown and

Lineback, 1966, in Indiana; as defined this unit includes most of the Maysville Group).

The stratigraphic framework for the Upper Ordovician in the tri-state area neither universally comprehensible nor accepted. A clearer understanding of the stratigraphy of the Cincinnatian must await syntheses designed to clarify the temporal and spatial relationships of the strata. These studies require lithologic and paleontologic data. The resulting meaningful and tested facies model is yet to come.

THE BELLEVUE LIMESTONE

Nickles (1902, p. 82) chose an old quarry site in the bluff at the bend in Clifton Avenue, Cincinnati, Ohio (just under the Bellevue House, a one-time landmark, now the site of Bellevue Hill Park) to define the Bellevue or "*Monticulipora molesta*" beds, as follows:

> Overlying the quarry layers Fairmount limestone, or "Hill Quarry Beds" is a small series of beds of rather shelly limestone, thinner than those below and harder, which the eye readily distinguishes as quite different from the layers below . . . . these layers project out boldly near the top of the bluff, above the strata of the Fairmount beds. The beds are almost a mass of bryozoa and hence contain few other fossils. The *Monticulipora molesta* which, if not restricted to these beds, at least here attains its maximum development in size and number, is one of the most characteristic of these bryozoa and has been chosen for the faunal designation. The thickness of these beds is about 15 feet.

He went on to say:

> . . . immediately above are about five feet considerably different lithologically and somewhat faunally, which we include in this subdivision. These upper layers are largely composed of single valves of and broken fragments of *Rafinesquina alternata* variety, though entire specimens are not common. The *M. molesta* occurs also in these layers, but has not been found in the next division.

Evidently, Nickles did not define the lithologic limits of the "member" precisely. Later attempts to define the top and bottom of the Bellevue on a lithologic basis have resulted in various interpretations because of the latitude offered by the original definition.

The confusion in defining the base of the Bellevue arises because of the presence of a 2-3′ zone of fossil hash with thin irregular limestone beds overlain by a zone of calcareous shale about 6 feet thick. Whether or not to include these two zones in the Bellevue has been debated by later workers.

Kerr (1951, p. 102) expressed prevailing opinion about the base of the Bellevue beds:

> What is usually taken as the base of the Bellevue (and of the McMillan) is a coquinite bed comprised of the cemented valves of the brachiopod *Rafinesquina alternata* which are usually shingled in arrangement.

Hyde (1959), noting the lack of persistence of the shingle zone and the fact that weathering of the overlying shale unit tends to cause the shingle zone to be covered, suggested that the "operational contact" between the Fairmount and overlying Bellevue be placed at the top of the shale unit.

Caster, Dalvé, and Pope (1961) considered the base of the hash zone to be the contact between the Fairmount and the Bellevue and named this unit as the "Shingled *Rafinesquina* Zone."

Ford (1967, pp. 932-934) accepted the boundary proposed by Hyde. Although he realized that "the name Bellevue has both priority and currency", he noted that "it is undefined as a rock unit." With this basis he defined the new name, Bellevue Limestone, essentially in the concept of Hyde. He designated its type section in the cliff at the intersection of Rice and Gage Streets, Cincinnati, Ohio. Osborne (1968, p. 2142) in his study of the bedrock geology of eastern Hamilton County, Ohio, accepted this new rock unit and its new type section designation.

Ford's new rock stratigraphic unit and his new type section designation are unacceptable, for the following reasons:

Nickles (1902) introduced the name Bellevue or "*Monticuliport molesta*" beds as one of the six subdivisions of the Lorraine Group (Maysville). Each of these subdivisions had a geographic name and a fossil species name. For each subdivision he gave the distinctive lithologic features, including the much-used modern character of bedding properties. The diagnostic fossil commonly was an abundant species of trepostome bryozoan.

The subdivision "Bellevue beds" was not meant to be only a biostratigraphic unit in the modern usage. A "bed" as used by Nickles is a rock-stratigraphic term in the modern usage. This character is emphasized by Nickles' use of a geographic name as a prefix.

The characterization of the Bellevue beds by the abundance of the trepostome bryozoan *Monticulipora molesta* is erroneous. Ironically, the species name applies to a *Peronopora (Monticulipora molesta* Nicholson 1881, is not a *Monticulipora)*. The monticuliporas of the Bellevue are referrable to *M. mammulata* (*q.v.*). But this species is not abundant in the Bellevue, in the original type area or elsewhere. Nickles relied on characters of external morphology to identify bryozoan specimens (1905), and in identifying *Monticulipora* was probably misidentifying *Heterotrypa frondosa*. Homeomorphy in the trepostomes is well documented. My studies of internal morphology revealed only a few specimens of *M. mammulata*, compared to the abundance of *Heterotrypa frondosa*. It may be that a large number of specimens of *M. mammulata* in the United States National Museum (National Museum of Natural History), allegedly collected from the Bellevue by early workers, came from the overlying Corryville or the underlying Fairmount beds. Because all three are exposed at Fairview Park, Cincinnati, where most of the collections were made, and because the combined faunas mingle in talus, mislabelling of the horizon is possible.

According to the Code of Stratigraphic Nomenclature (A.C.S.N., 1961, Art. 13, Remark h) the original type section cannot be changed. Ford, in his redefinition of the unit, did not demonstrate that the boundaries of his Bellevue Limestone were significantly different (he followed Hyde in eliminating the shale bed and the shingle zone from the base) from the original definition. The top of the Bellevue is gradational. The Code (Art. 19, Remark e) allows the same boundaries for the rock-stratigraphic and biostratigraphic units. It follows that a type section for a rock-stratigraphic unit should suffice, since the Code does not specify type sections for biostratigraphic units.

Therefore, the type section of the Bellevue Member (*sensu* Hyde) in Bellevue Hill Park, as designated by Nickles, is reinstated. The section chosen by Ford, about a mile from the original section, is on a steep bluff not as accessible for collecting.

DISTRIBUTION OF THE BELLEVUE BEDS

The Bellevue is typically developed in the immediate vicinity of Cincinnati. Isolated outliers on the higher hilltops are more common than continuous outcrops. The base of the Bellevue lies in the escarpment on the north side of the Cincinnati Basin, between 720 and 730 feet above sea level, and rises eastward and southwestward to about 800 feet above sea level. The Bellevue overlies the Miamitown shale (Ford, 1967, p. 931) which ranges in thickness from five feet in the vicinity of Clifton Hill, Cincinnati to 15+ feet near Miamitown, Ohio, thickening northwesterly. The base of the Bellevue is considered to be the first massive, fairly even-bedded gastropod (*Lophospira, Cyclonema*) limestone, commonly six or more inches thick. None of the limestone beds in the Miamitown shale exceed 3-4 inches in thickness.

The upper boundary of the Bellevue is gradational but seen only in rare complete sections. Some of these are Bellevue Hill Park (the type section), Rice and Gage Streets, Muddy Creek, and Hamilton and Ashby Roads (an abandoned quarry in an area now being rapidly built over). The Bellevue is gradational into the overlying shales that comprise the Corryville beds of Nickles. The boundary is usually covered, and where the comparatively resistant Bellevue forms the tops of the hills, boundary definition is problematic. Perhaps the remnant Bellevue is devoid of its easily erodable upper component in the outliers.

The Bellevue Limestone is about 22-25 feet thick around Cincinnati. In the type section in Bellevue Hill Park, 22 feet of Bellevue strata were measured. Ford (1967) and Osborn (1968) measured 25 feet of Bellevue strata in the Rice and Gage Street cut. The northernmost Bellevue outcrop measured and collected is exposed on Buell Road (locality 5) where it is about 6-8 feet in thickness. Ulrich and Bassler (1914) noted that no strata referable to Bellevue were traced around Hamilton, Ohio, which is about eight miles north of the Buell Road locality. The unit is about 50+ feet thick to the west, in the vicinity of Madison, Indiana. Foerste (1904, p. 89) measured 20-24 feet of Bellevue or "*Platystrophia lynx* beds," near Madison, Indiana. Across the Ohio River in northern Kentucky, a maximum of 28 feet of Bellevue was measured and collected. The unit seems to disappear further westward in Indiana.

Eastward and southeastward the Bellevue is traceable through the famous Stonelick Creek cuts, into the Georgetown, Ohio area and across the river around Maysville, Kentucky. In the Maysville area the typical lithology of the Bellevue is included in the Grant

Lake Limestone Formation (Peck, 1966). This formation is about 114 feet thick in its type locality and is characterized by thin, irregular, and rubbly-weathering beds which are resistant to erosion and form steep slopes. Peck (1966, p. B16, fig. 5) regarded its contact with the underlying Fairview Formation as transitional. The latter, as in Cincinnati, is composed of alternating planar beds of limestones and shales. The contact of the Grant Lake with the overlying Bull Fork Formation, which consists of alternating limestones and shales, is sharp in places (Peck, 1966, fig. 6). It may be that the Bellevue is a northwest tongue of the much thicker Grant Lake Limestone, as suggested by Ford, although Peck made no such suggestion. The descriptions of the Grant Lake Limestone by Peck do not clearly distinguish it from the Bellevue. Those two rubbly units with similar lithology are not duplicated elsewhere in the Cincinnatian section. It would seem most reasonable to give priority to the type area and the nomenclature applied there. Thus, the name Bellevue would be preferred to the Grant Lake Limestone of Peck. The Bellevue should not be abandoned solely because its thickest expression is not at its type section.

The Bellevue Limestone was traced southward to a section near Pleasant Valley Road, Florence, Kentucky. Beyond this point the typical lithology is absent. Foerste's extensive mapping in the region supports this observation. Foerste (1904) named supposedly equivalent strata as the Gilbert Member. This convention has been accepted by Weir, *et al.* (1965), who have included the Gilbert in a new unit, the Ashlock Formation. The Gilbert appears to be a southern facies replacement of the Bellevue.

NATURE OF THE BELLEVUE LIMESTONE

The Bellevue Limestone is made up of predominantly organoclastic particles and minor amounts of terrigenous clastics. Whole or broken fragments of bryozoans and brachipods make up about 90% of the total fossil content. This composition accounts for the names, "*Monticulipora molesta* beds" (Nickles, 1902), "*Platystrophia* zone" (Cumings, 1901; Foerste, 1904), and "*Rafinesquina ponderosa* zone" (Cumings and Galloway, 1913), that have been given to the unit. The Bellevue has the ill-deserved name of the

"*Rafinesquina fracta* zone," on the assumption that the basal shingled zone of the unit is comprised solely of *R. fracta.* Actually *R. fracta* is common in shingled layers in the Fairview Limestone; other rafinesquinas are similarly emplaced in the Bellevue but *R. fracta* is only questionably present there. Cephalopods, gastropods, pelecypods, echinoderms, and trilobites (in order of decreasing abundance) contribute a smaller faunal percentage, but are locally conspicuous in patches. The clastic material is distributed erratically within the lime matrix, or as separate, thin layers. Insoluble residue values obtained for some random limestone samples range from less than 5% to more than 35%.

The individual units are thin- to medium-bedded (*sensu* Ingram, 1954: thin = 2.5 - 10 cm; medium = 10 - 30 cm; and thick = 30 cm or more). Bedding characteristics for the Bellevue can be somewhat misleading because thin layers of clastic material, under variable weathering conditions, may change from one to another bedding division. Most of the massive medium beds, after differential removal of the softer clastics, appear thin-bedded.

The abundance of robust, convex shells of the brachiopods *Rafinesquina, Platystrophia,* and *Hebertella,* and bryozoan zoaria of various sizes revealed by differential weathering imparts a characteristic "rubbly" appearance to the Bellevue. This makes Bellevue lithologically distinctive, and easily recognized in the field. Ford (1967, p. 921) described these limestones as having "crenulated bedding", a misleading and incorrect designation.

The limestones are grouped under "Class 3" of Weiss and Norman (1960a, p. 295), distinguished by "whole, broken fossils, either oriented or randomly arranged, insoluble fraction large." Many of the limestones of the Bellevue actually are referable to both "Class 3" and "Class 1" of Weiss and Norman, the latter distinguished by "whole or broken fossils, randomly arranged; insoluble fraction small and localized."

The shells and bryozoan colonies are remarkably free from abrasion or rounding. Even the sharp monticules of bryozoans are complete, especially if these were covered by clastic matrix (see Pl. 43, fig. 3). Most of the broken shells can be attributed to postdepositional changes, especially breakage by compaction. This indicates that the fossils were deposited in the immediate vicinity of their life position. Deposition must have been in quiet waters, contrary to the first impression gained by examining outcrops and hand-specimens. Movement of the clastics must have been mainly by currents, but this movement had to be such that the water did not remain muddy for any appreciable length of time, because both brachiopods and bryozoans are lophophorates and their economy required relatively clear water.

Very slow accumulation of sediments is suggested by the numerous conspecific and non-conspecific overgrowths in many bryozoan assemblages. As many as five overgrowths have been noted. In addition, many Bellevue specimens of brachiopods and cephalopods show similar bryozoan overgrowths. Abundant borings, ranging in size from 0.4 to 0.15 mm in diameter, seen on many ramose and non-ramose zoaria also indicate a rather slow rate of accumulation of sediments. The sedimentation rate apparently was not much different from that of a typical modern carbonate bank.

Published lists of fossils in various Cincinnatian members reveal fewer species in the Bellevue than in the underlying Fairmount and overlying Corryville. This may be partly due to the lesser thickness of the Bellevue, but a detailed analysis of these lists and experience in the field show that many species were not carried over to the Bellevue from the underlying strata. The environment of the Bellevue seems to have been restricted in the sense that a lesser number of species existed, but those which did live in this setting were abundant.

This may be explained by one of three "basic biocoenotic principles", outlined by Thienemann (1954), that show the variability of environment resulting in the development stages of the community: (translated by Hedgepeth, 1957, p. 42)

1. The variety of a species is greater under more diverse conditions.
2. The variety of species is reduced, but the individual members are increased in a community as the environmental conditions depart from the normal or optimum for most of the species concerned.
3. The variety of species, balance and stability of the community are greater as the conditions in a given environment become more stable and continuous.

The second principle of Thienemann thus seems to be applicable to the Bellevue Limestone, which suggests a departure from the "optimum" environmental conditions which existed during the deposition of overlying and underlying strata. In addition to the increased number of individuals postulated by the above principle, lack of inter-species competition could result in larger-sized individuals. The Bellevue is known for this — species names like *ponderosa, magna,* are characteristic of the Bellevue.

The number of ecological niches may have been reduced by a decline in the amount of terrigenous sediments, thus providing more uniform substrate characteristics.

THE INTEGRATE AND AMALGAMATE WALL IN TREPOSTOMES

Ulrich and Bassler (1904, pp. 15, 40) introduced the terms Integrata and Amalgamata to divide the Order Trepostomata into Suborders. This classification was expanded and adopted by Bassler for the *Treatise on Invertebrate Paleontology* (1953). The validity of this taxonomic hierarchy has been questioned and rejected by many (Lee, 1912; Duncan, 1939; Boardman, 1960a). Cumings and Galloway (1915) and Boardman (1960a) found integrate and amalgamate wall types displayed in a single zoarium. As presently understood this characteristic of the wall, although routinely mentioned for different taxa, has no usefulness. I suggest that descriptions and diagnoses based on tangential sections only produce inadequate and misleading results. I also suggest that the presence of a dark median layer (see *Observations on the Median "Line"*) makes the wall distinct. Laminae are not necessarily darker at the point or zone of maximum bend, as was suggested by Cumings and Galloway (1915) and accepted by later authors.

Clarification of wall types in trepostomes should provide additional information on the mode of growth of the skeleton, on the lines of work begun by Borg (1926) on cyclostomes, and Boardman (*in* Boardman and Cheetham, 1969) on trepostomes. A review of studies of trepostome wall structure will aid in understanding the original concept and its subsequent interpretation.

Nicholson (1876) initiated the use of thin-sections for documenting the internal morphology of bryozoans. Dybowski (1877) first discerned the laminated nature of the wall and classified the "chaetetids" from the Silurian of the Baltic on this character (pp. 13, 14; transl. from German):

A. Wall of the polypide thin and structureless
B. Wall of the polypide thick and of lamellar structure
  1. Adjacent polypides share a common wall; "coenenchyms" (mesopores) absent
    a. line in the wall (*Wandstränge*) present
    b. line in the wall (*Wandstränge*) absent
  2. Lamellae of the polypide wall merge directly with the mesh of "coenenchyms"

Dybowski illustrated forms with (pl. 2, figs. 8-10) and without (pl. 3, figs. 1-3) the dark line (*Wandstränge*) in the middle of the zooecial wall, in both longitudinal and tangential section. He showed that the dark line is either continuous or composed of scattered granular material (*Körniger*). It seems that Dybowski's classification was the forerunner of the Integrate and Amalgamate divisions of trepostomes.

Nicholson (1881, pp. 36-42), in his comprehensive monograph on the monticuliporids, discussed the microstructure of the wall. His thesis was that each zooecium (*corallite* of Nicholson, who considered monticuliporids to be corals) has its own wall and if no distinct boundary was discernable between two zooecia, it was due to "apparent amalgamation." He recognized three types of wall.

1. Forms in which

> each tube possesses a perfectly independent and complete wall. . . . Hence, in thin tangential or longitudinal sections of such forms, the visceral chamber of each corallite is seen to be surrounded by its own investment of light-colored sclerenchyma [Nicholson considered this secondary], and to be separated from the corresponding investment of all the tubes in immediate contiguity with it by a clearly-marked dark line [Nicholson considered this primordial], which is often thickened into larger or smaller nodes at the angles of junction of the corallites.

2. Apparent amalgamate forms with very thin walls and indivisible wall boundaries. Nicholson (1881, pp. 38, 39) ascribed this to imperfect observation. He argued that "rough fractures" always display zooecia with complete walls showing the outer and the inner part of the wall, and hence the apparent amalgamation seen in thin sections did not make the actual wall single;

3. Forms which are thick-walled and do not have a dark line in the center of the zooecial wall. He observed that in these,

> . . . each visceral chamber is enclosed by a distinct dark line or marginal ring, usually circular or oval in outline, marking the original boundary of the tube, and the interspaces between the dark lines are filled in by sclerenchyma of a different texture and much lighter colour.

The dark lines referred to by Nicholson in his type 3 are actually the boundaries between the zooecial lining and the cortex (Pl. 43, fig. 1b). He included *Monticulipora ramosa* and *M. rugosa* (here assigned to *Parvohallopora*), among others, in this division.

Ulrich (1890, pp. 308-312) with similar arguments reiterated Nicholson's philosophy under the title "Independence of the Zooecia walls." His examples included both trepostome and cryptostome bryozoans. Like Nicholson, Ulrich recognized three main conditions of the wall:

1. Forms in which "the visceral chamber is seen to be surrounded by its own calcareous investment, and to be separated from its immediate neighbors by a more or less clearly marked *dark or light line*" [Italics by RJS].

2. Forms in which the duplex character of the wall is not apparent because of the thinness of the wall. Here, Ulrich invoked Lonsdale's and Nicholson's reliance on rough fractures to demonstrate the real duplex character of the walls.

3. Forms in which the wall appeared amalgamated because of the lack of a distinct divisional line. According to Ulrich there is no real fusion of the walls, and this appearance can be ascribed to imperfect preservation, or slight irregularities in the deposition of the internal laminae of the sclerenchyme. Ulrich (1890, p. 310) thought the latter condition occurred

> only in forms having the partition rounded at the surface . . . When observed in longitudinal sections, the partitions between the zooecia are seen to be composed of a succession of superimposed conical layers [laminae] which are deposited one upon the other as the growing margin of the wall is carried upwards. When the centre of the partition is carinate at the surface then a more or less distinct straight line passes through the apices of the conical laminae, but in those forms that have the superficial termination of the partitions rounded, the separating line or primitive wall [*primordial* of Nicholson] is often made slightly zigzag by the alternate overlapping of the deposit on each side. This peculiarity sufficiently explains the fact that while the divisional line may be quite distinct at one point of the tangential section, it is scarcely or not at all perceptible in other portions of the section.

It is apparent from the preceding discussion that these authors recognized two types of wall condition; one with a distinct divisional line (Nicholson — only dark in color; Ulrich — dark or light in color) and the other with no distinct divisional line, although to these authors the lack of a line indicated only apparent amalgamation of the walls. This concept culminated in a classification of the trepostomes (Ulrich and Bassler, 1904) that stressed the importance of the wall microstructure:

> The classificatory value of the structure of the walls separating neighboring zooids, especially the degree in which the calcareous investment of adjoining zooids is either amalgamated or maintains for each its integrity, continues to impress us more and more favorably. According as the walls are amalgamated or retain their duplex characters, the seven families recognized under the Trepostomata in the latest classification of Paleozoic Bryozoa, fall four into the first and three into the second division, as follows: (1) (*Amalgamata*) Monticuliporidae, Heterotrypidae, Constellariidae, and Batostomellidae; (2) (*Integrata*) Amplexoporidae, Calloporidae, and Trematoporidae.

Amalgamata were defined (p. 15) as

> Trepostomata in which the boundaries of adjacent zooecia are obscured by the more or less complete amalgamation of their walls.

Integrata were defined (p. 40) as

> Trepostomata in which the boundaries of adjacent zooecia are sharply defined by a black divisional line.

Bassler (1911, p. 177) observed that the black divisional line characteristic of the Division *Integrata*

> . . . in all probability represents the fossilized remains of animal matter which filled this space during the life of the organism. Occasionally this narrow, intervening area is occupied by a light-colored tissue, and in this case the outer boundaries of the walls of each zooecium can be seen.

It is interesting to note that Bassler, like Nicholson, confused the boundary between the zooecial lining and the zone of curved laminae with the boundary between adjacent zooecia. Thus, the light-colored tissue which he thought occupied the intervening area between two adjacent zooecia is actually the wall. (See Pls. 41, 42, 43.)

Bassler, like Ulrich (1890, p. 309) suggested that either a dark line, or a light line in the form of tissue, (as seen in tangential section) was the criterion for differentiation of the Integrata and Amalgamata. He elevated these two divisions to formal subordinal taxonomic rank and defined Integrata (1953, pp. 107, 108) as having

> walls of adjacent zooecial tubes not coalesced but separated by a dark divisional line or a light-colored tissue, with individual wall boundaries distinctly visible.

Lee (1912, p. 145) was the first to try to classify British Carboniferous trepostomes within the framework of the Integrata and Amalgamata divisions. He noted that

> In the British fauna, so far as examined, a black line is occasionally exhibited in forms which are otherwise referable to the division Amalgamata. Its adoption as a classificatory character in the case of material considered here would lead to an inconsistent grouping of the species and is therefore deferred pending further investigation.

Cumings and Galloway (1915) summarized and added to the existing knowledge on the morphology of the trepostomes. Under "Histology of the Walls and the Median Line" (pp. 359-361), they discussed wall microstructure in detail. They cited several species with integrate walls that were assigned to the Amalgamata, and vice versa. These observations were made not only in the tangential sections, commonly used for identifying the wall type, but also in longitudinal section. This led them to remark (p. 359) that

> These two types of structure certainly appear to be very distinct; nevertheless both may and do occur in the same species, and indeed in a single specimen... It is very rarely indeed that the apparently sharp divisional line of the wall is not resolved by high magnification into an irregular zone . . . .

Cumings and Galloway (1915, p. 360) considered that differences in the thickness of the growing edge explained the formation of the two types of wall. For the Integrata

> . . . the growing edge of the wall is very thin, and the wall becomes gradually thicker farther in . . . Because of this method of growth the laminae of the wall have a very steep pitch, and the bend they make in the axis of the wall is sharp.

and for the Amalgamata:

> . . . the growing edge of the wall in *Dekayia* is smoothly rounded, and the laminae pass across from zooecium to zooecium with a regular curve.

They further explained the formation of the two types of walls, as follows:

> For some reason, whenever the wall laminae of the trepostomes are sharply bent the material appears dark. This is true also of sharp bends of diaphragms.

They did make another statement that is important here:

> In the Integrata commonly, and occasionally in the Amalgamata, they [granules] are more closely concentrated in the axial region of the wall, and when bands of granules from either side of the wall are present they are often offset instead of continuing uninterruptedly across the median region of the wall.

Duncan (1939) found that genera that otherwise seemed to display homogeneous characters were referable to both Integrata and Amalgamata. To surmount this difficulty she proposed the family Atactotoechidae to accommodate genera in which the wall condition was either amalgamate or integrate.

Boardman (1960a, p. 26) followed Cumings' and Galloway's (1915) identification of the microstructure of the walls using both longitudinal and tangential sections because he found that

> . . . some genera cannot be placed in suborder and family categories as presently defined. Several species of both *Atactotoechus* and *Leptotrypella* show both amalgamate and integrate wall structure in tangential section. . . . Such variation within a species, and even within a zoarium, conflicts with the degree of constancy expected for usable subordinal characters.

To be consistent with existing literature, Boardman continued to describe the integrate and amalgamate condition of the wall as observed in tangential orientation. Boardman (p. 28) synthesized observations made in longitudinal and tangential orientations to explain the integrate and amalgamate wall in terms of the inclination of the laminae:

> If the plane of the thin section cuts the skeletal material at right angles to the plane of the laminae, the laminae will obviously be seen in transverse view, one lamina upon the other. If the plane of a thin section cuts the skeletal material parallel to the plane of the laminae, the plane of the thin section will lie within a very few laminae, the laminated structure will not be apparent, and a hyaline or granular appearance will result, depending on the texture of the laminated material.

His explanation for the amalgamate wall was that

> The curving laminae intersect the plane of the tangential section at varying angles. Near the margin of the wall adjacent to the zooecial chamber, the laminae are approximately at right angles to the tangential section. Therefore, these laminae are cut transversely and appear as laminated areas in tangential section. As the laminae approach the zooecial boundaries, however, they gradually curve through an arc of 90 degrees. Finally the laminae are parallel to the plane of the tangential section, and that area of the tangential slide appears to be non-laminated and hyaline.

He described the apparent integrate wall observed in tangential section as follows:

> . . . laminae, as seen in longitudinal section never curve enough to become parallel to the plane of the tangential section over an appreciable distance. Thus, a tangential section intersects nearly all the wall laminae at high angles resulting in the laminated nature of the wall material being displayed throughout the thickness of the wall. At the narrow zooecial boundary zone the laminae terminate or bend sharply and are parallel to the plane of the tangential section only at the line of junction of zooecia. The zooecial boundary thus appears in tangential section as a line or narrow light-shaded hyaline zone differentiated from the typical laminated structure on either side of the boundary.

Ross (1964, pp. 936-937) recognized three wall types in Chazyan ectoprocts from New York and Vermont. She observed that

> In many radial and some laminate colonies the calcite laminae of the zooecia in the peripheral exozone part of the colony are inclined where they line the inner part of the zooecial tube. Near the outer part of the zooecial walls, laminae or adjacent zooecia may abut abruptly at a steep angle in a narrow irregular dark band, or the laminae of adjacent zooecia may curve convexly and intertongue in a wide band that also has some dark material included in it. The calcitic material between two adjacent zooecial tubes may thus appear to be longitudinally divided into two or three parts, depending on the orientation of the laminae.

According to Ross (p. 937) the walls composed of a single unit always produced an amalgamate appearance in tangential section, and two- or three-part walls could produce either an amalgamate or an integrate appearance in tangential orientation (*amalgamate* and *integrate* sensu Ulrich and Bassler, 1904).

INTEGRATE AND AMALGAMATE APPEARANCE

From the foregoing summary it is evident that the subordinal division of trepostomes into Integrata and Amalgamata is taxonomically unnatural and difficult to use. Thus while many workers doubt and others reject the validity of such a division, generic and specific descriptions still refer to a broad or narrow, integrate or amalgamate wall observed in tangential orientation. A "line", under different magnifications, becomes a quantitative rather than a qualitative entity.

In addition to different arrangements of laminae (as seen in longitudinal orientation), distribution of dark material in the laminae, and (of lesser importance) the position of a section relative to the laminae, all control the integrate or amalgamate appearance.

Laminae in the zone of curved laminae (ZCL) may be (as seen in longitudinal orientation):

1) convex — laminae rounded distally
2) angular — laminae subrounded to pointed distally
3) convex or angular
    a. distinct concentration of darker material in the zooecial boundary zone

b. distinct concentration of darker material only in proximal parts of laminae, making the light colored, narrow zooecial boundary zone prominent.

4) conjoined at sharp angles along a thin, dark, irregular, granular layer.

Laminae are continuous across the ZCL in all but the last situation.

The first two conditions of the laminae will respectively result in an amalgamate and integrate (light colored "line" or narrow "zone") or gradational integrate-amalgamate appearance in tangential orientation. This agrees with the explanation given by Boardman (1960a). Walls in situation one always appear amalgamate (see Pls. 28, 29; *Heterotrypa frondosa*), but situation two, seen tangentially, may produce an integrate or a gradational integrate-amalgamate appearance (see Pls. 19-22; *Batostomella gracilis*).

Situation 3a will appear either or both amalgamate and integrate in tangential orientation, but the boundary is always darker colored (*Eridotrypa mutabilis* is a representative case).

Situation 3b always produces a light-colored gradational integrate to amalgamate condition. The "line" or "zone", seen tangentially is always surrounded by darker laminae. These laminae are darker proximally in longitudinal section (see Pl. 43, figs. 1b, 1c; *Parvohallopora ramosa*).

Situation 4 nearly always produces a dark narrow "zone" or "line", depending on the thickness of the layer and the inclination of laminae. Longitudinally discontinuous portions of the surface, if intersected tangentially, will produce a light colored appearance (see Pls. 16, 17 — *Amplexopora cingulata;* Pls. 17, 18 — *A. robusta*; Pl. 32, 33 — *Homotrypa curvata*; Pls. 34, 35 — *H. obliqua*).

Therefore, even a consistent laminar arrangement within a zoarium could produce an integrate, amalgamate, or a gradational appearance. In taxa with laminae that appear V- to U-shaped in longitudinal orientation, appearance in tangential orientation will be correspondingly variable. Laminae in *Batostomella gracilis* can range from V- to U-shaped within a single zoarium.

Morphologically, the concept of integrate — amalgamate walls, seen in tangential orientation, is confusing and unnecessary. Emphasis should instead be placed on description of the laminae in the zooecial boundary as seen in both longitudinal and transverse orientations.

NATURE OF THE LAMINAE

Cumings' and Galloway's suggestion, accepted by later authors, that the laminae are darker in color whenever they are sharply bent is not confirmed here. It is obvious that laminae are optically distinguishable from each other because of alignment of crystal edges and perhaps due to minor differences in chemical composition. Without such closely-spaced differences, acetate replicas made from polished and etched specimens will not show the laminate nature of the wall.

If sharp bends in laminae produced a darker appearance, then all trepostomes that have angular laminae as seen longitudinally should have a dark "line" or a narrow zone in the ZCL, or in the case of convex laminae a wider dark zone in the ZCL. This is not a routine observation. Laminae in many specimens are distinctly darker in zones where they are only slightly or not at all bent. In *P. ramosa* (Pl. 41, fig. 4C), the zooecial lining is more clearly seen because the light-colored laminae are sharply demarcated from distinctly darker portions of wall laminae. Laminae in both cases are not bent. Similarly, the diaphragm laminae commonly are no darker where they bend sharply into the wall. Instead the laminae of many diaphragms are darker only partially. Such discontinuities in the color of the laminae may be attributed to changes in chemical composition. Detailed microanalyses of these structures should pinpoint the cause for these changes and provide data towards an understanding of the mode of growth of the trepostome skeleton.

OBSERVATIONS ON THE MEDIAN "LINE"

The median "line" of Cumings and Galloway, as seen in longitudinal orientation, was first observed by Dybowski (1878). He called it *Wandstränge,* and used its presence or absence in his classification of the Baltic chaetetids. The median "line" is actually a layer, and lies between adjacent zooecia. It is seen in many species of *Amplexopora* (Pl. 16-18), *Homotrypa* (Pls. 32-35) and many other genera. It is irregular and in longitudinal section may be discontinuous. Under high magnification (more than ×100) it is seen to be composed of rounded to subrounded almost opaque granules.* The black material may be organic in origin or a concentration of

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*Similar granules are present in Recent bryozoans, such as *Diaperoecia californica* (d'Orbigny) [Pl. 23, figs. 3, 4].

minerals determined by original differences in wall composition. It extends the length of the exozone, but because the wall loses its laminar nature and thins in its transition from the exozone to endozone, the present longitudinal limits assigned to this layer may be restricted by inadequate observation. Within the limits of their resolution (about ×1000), the laminae appear discontinuous, being offset along the layer.

These characteristics make this kind of wall genetically quite distinct and further evaluations are needed to test its significance in suprageneric systematics. Microchemical analysis and electron probe investigation may provide additional information. In terms of application of the Borgian concept of colonial control of the skeletal secretion to trepostomes (Boardman *in* Boardman and Cheetham, 1969), this type of wall needs to be investigated further.

MONTICULES — POLYMORPHS IN TREPOSTOMES

Among bryozoans, only the cheilostomes have been cited traditionally as possessing full development of polymorphism (Hyman, 1959). Many authors have attempted to show the homologous relationship of trepostome acanthopores with vibraculae (kenozooids) of the cheilostomes. Mesopores are uniquely developed in trepostomes and in spite of the lack of evidence of a complete or reduced living individual in their spaces, interpretive terms such as "mesozooid" (Hyman, 1959, p. 393) and "mesozooecium" (Ross, 1964, p. 940; Ross considered these to be heterozooids) have been applied. Maculae (clusters of larger than average zooecia that appear as flat or depressed surfaces on the zoarium) have been interpreted as brood chambers by some workers. Astrova (1973, p. 4) considered the presence of larger than average zooecia in macules (= monticules of this report) to be a manifestation of polymorphism.

Whether mesopores and acanthopores are heterozooids or kenozooids will be determined by well-documented studies of interpretive morphology, but there is little doubt that these structures are an expression of polymorphism in trepostomes.

Monticules in the trepostomes are the most prominent zoarial feature. Although their function is a matter of conjecture, it is suggested here that the monticules represent parts of a zoarium whose function was at least different from the remainder. Discontinuous variation in morphology of the monticules and the remainder of a zoarium would qualify these to be considered as polymorphic entities.

Monticules may or may not be regularly spaced on the zoarium. *Batostomella gracilis* is characterized by smooth zoarial surface. Out of many hundred zoaria studied, only one cluster of mesopores was seen (Pl. 21, fig. 1a). Similarly, only scattered examples of a few megazooecia were observed in *B. gracilis* (Pl. 21, fig. 1a) and in *Parvohallopora ramosa* (Pl. 43, fig. 2). The latter is additionally characterized by regular development of monticules.

The most readily observable expression of monticules is a protuberance. An examination of large surfaces of smooth, non-monticulate zoaria and their tangential orientations reveals apparent polymorphic differences. Monticules as understood here may be composed (singly or in various combinations) of zooecia, megazooecia, mesopores, acanthopores, thickenings of wall and irregular laminae arrangement.

Based on the study of species discussed here the following variations in monticules may represent the existence of polymorphic zooids:

1. Monticules as prominent protuberances on the zoarial surface, showing definite morphologic differences:
   a. Clusters of megazooecia, mesopores, acanthopores in many arrangements and combinations, e.g., *Heterotrypa frondosa;* common in many other trepostomes
   b. Clusters of megazooecia, e.g., *Amplexopora cingulata*
   c. Zooecial size indistinguishable in cross-section, but development of either or both differences in wall thickenings and arrangement of laminae, e.g., *Parvohallopora ramosa, P. laevigata* (zoarial surface may be smooth in latter).
2. No external protuberance
   a. Clusters of megazooecia, e.g., *Homotrypa curvata, Amplexopora robusta*
   b. Megazooecia occurring as irregularly distributed, isolated entities, e.g., *Batostomella gracilis, P. ramosa*
   c. Clusters of mesopores irregularly distributed, e.g., *Batostomella gracilis, Amplexopora cingulata.*

GLOSSARY

Terms are as precise as the level of understanding about the morphological components to which they are applied. Various interpretations naturally lead to different usages of a single term, or various terms may be used for the same morphological component. This situation is not uncommon in the trepostome literature. A definition of the morphological terms used here is presented to remove potential ambiguity. None of the terms themselves is new and only one, *Diaphragm-Zooecial Lining Unit,* is a new combination. Bassler (1953, pp. G7-G16) reviewed various definitions and morphological terms used in the study of Bryozoa.

Axial Ratio. — Ratio between the endozone diameter (width in frondose forms) and total zoarial diameter, measured at the same location on the zoarium. Cuffey (1967, p. 31) used the formula:

$$AR = \frac{\text{diameter of axial region}}{\text{total diameter}} \times 100$$

Cystiphragm. — Skeletal partition extending from the zooecial wall into the zooecial tube and recurved proximally to form a closed compartment by abutting against the zooecial wall or adjacent cystiphragm or diaphragm. Cystiphragms either partly or completely encircle the zooecial tube to form a hollow ring. They commonly occur in closely packed or overlapping series lining the zooecial wall. Cystiphragms do not extend completely across the zooecial tube.

Cystoidal Diaphragm. — A tranverse structure formed by two diaphragms in contact only part way across the zooecial tube, forming a completely enclosed compartment between them. One of the diaphragms is always complete across the zooecial tube.

Diaphragm. — Skeletal partition structure across the zooecial and mesopore tubes. Diaphragms can be transverse, oblique, concave, or convex to the direction of growth of the tube. The diaphragm is a component of the integrated Diaphragm-Wall Unit or the Diaphragm-Zooecial Lining Unit.

Diaphragm-Wall Unit. — An integrated skeletal unit consisting of the diaphragm and part of the distal wall that is in continuity with the diaphragm. The laminae of the wall component are considerably thicker than those of the diaphragm and merge into the Zone of Curved Laminae in a short distance.

Diaphragm-Zooecial Lining Unit (new combination). — An integrated skeletal unit consisting of the diaphragm and zooecial lining of the distal wall that is in continuity with the diaphragm. The laminae of the lining are approximately the same thickness as in the diaphragm and run parallel to the direction of growth of the zooecium for a considerable distance before merging into the Zone of Curved Laminae. A proximal unit can onlap a distal unit for some distance. [Zooecial lining = Cingulum of some modern authors. Utgaard and Perry (1964, p. 102, expl. of pl. 22) use the two terms interchangeably.]

Endozone. — Inner part of the zoarial skeleton. It is basal in encrusting and massive forms and axial in others. It is composed of proximal parts of zooecia that trend approximately parallel to the direction of growth of the zoarium. The zooecial walls are commonly thin and typically there are no mesopores. Diaphragms are absent or widely spaced.

This term, proposed by Boardman (1960a), is favored over *immature region, neanic zone,* or *axial region* of other authors, because no degree of ontogenetic development is implied and because the term is applicable to all growth habits without ambiguity.

Exozone. — Outer part of the zoarial skeleton, extending from the outer surface of the zoarium to the endozone. In this zone the zooecia are commonly approximately at right angles to the zoarial surface and zooecial walls are characteristically thicker. Mesopores are commonly restricted to this zone. Diaphragms and acanthopores, if present, are more abundant than in the endozone.

This term, proposed by Boardman (1960b), is favored over *mature region, ephebic zone, cortical region,* or *peripheral region* of other authors, because no degree of ontogenetic development is implied and because the term is applicable to all growth habits without any ambiguity.

Independent Wall Unit. — A segment of the zooecial wall that is not connected to the laminae of the diaphragm. It can be continuous or discontinuous across the zooecial tube.

Longitudinal Section. — Section exposing the zooecia parallel to the direction of growth.

Megazooecium. — A polymorphic zooecium distinctly larger in cross-section than average. Commonly developed in monticules, and also in the central part of the endozone of some genera (e.g., *Batostomella*).

Mesopore. — Skeletal tube parallel to zooecia but appreciably smaller in diameter and extremely variable in transverse outline. Initiated in the vicinity of zooecial bend in most genera. In lower Paleozoic genera, mesopore diaphragms are commonly more numerous, closely spaced, and thicker than in associated zooecia. I consider mesopores to be space-fillers if a number of these, of variable angular shape in cross-section, occur between adjacent zooecia. Others are circular in shape. Because mesopores are poorly understood, interpretive terms such as *mesozooid* (Hyman, 1959, p. 393) and *mesozooecia* (Ross, 1964, p. 940) are not used.

Monticule. — Cluster of megazooecia, zooecia, mesopores, and acanthopores in varying arrangements and combinations. Sometimes expressed as only slight wall thickenings. Monticules are regularly spaced and may be expressed on the zoarial surface as small protuberances or depressions. Includes macula of other authors.

Mural Lacuna. — Minute equidimensional space in the zooecial walls.

Overgrowth. — Conspecific growth incrusting a zoarium and separated from it by a basal laminae.

Space Filler — See *Mesopore*

Tangential Section. — Section parallel to and just under the zoarial surface. The section commonly cuts the zooecia, mesopores, and acanthopores in the exozone transversely.

Transverse Section. — Section at right angles to the direction of zoarial growth.

Zoarium. — The skeleton of a bryozoan colony.

Zone of Curved Laminae (ZCL). — The outermost zones of adjacent zooecial or mesopore walls in which the laminae are convex in the direction of zooecial growth. The laminae may be continuous or may abut in the middle to make the zooecial boundary visible.

Zooecial Bend. — Relatively sharp bend in the zooecium generally located either at the boundary between the endozone and exozone or in the early exozone. The concave side of the bend is always toward the proximal direction of the zoarium.

Zooecial Surface Angle. — The angle at which the zooecia intersect the surface of the zoarium.

Zooecium. — The skeletal tube that contained successive generations of zooids.

SYSTEMATIC PALEONTOLOGY

Too often the modern literature on trepostomes contains generic and specific diagnoses and descriptions that are merely observations based on tangential and longitudinal sections. The arrangement of the structural features of the trepostomes are seldom reconstructed in three dimensions.

For clarity and succinctness, the following description format is employed in characterizing species and genera. This arrangement allows a better comprehension and comparison of the qualitative details because a given anatomical part, *e.g.*, a zooecium, is described completely in one place in the description (in endozone, exozone, in tangential and longitudinal orientations, etc.).

In addition, details that are not characteristic of a particular taxonomic level, but rather pertain to all trepostomes, are omitted. Much contemporary trepostome literature contains considerable dross of this sort. For example, the fact that the mesopores have closely spaced and thicker diaphragms is unnecessary for all specific and many generic descriptions, because, at least in Lower Paleozoic trepostomes, all mesopores have this characteristic. Similarly, almost all trepostomes have a distinctly laminated wall structure and have the walls in the endozone; these are obvious features that need not be repeated in specific descriptions. Lack of clear concepts of some trepostome genera will obviously result in some deviations from the above plan.

Cross-checks have hopefully eliminated redundancy of detail from descriptions at different taxonomic levels. It would enormously facilitate and clarify trepostome taxonomy if some such procedure were common. Accumulation of such information should ultimately provide a basis for diagnoses in the trepostomes.

DESCRIPTION FORMAT

External

1. Mode of growth
   Ramose, Encrusting, Frondose, Massive, Bilaminate, etc.
2. Branching characteristics
   shape of branches
   angle of bifurcation
   distance between bifurcations
3. Surface characteristics
   smooth, monticules

Internal

1. Zooecia
   A. Zooecial wall
      1. Wall characteristics in endozone and exozone, e.g., irregular thickenings of wall in zooecial bend zone.
      2. Endozone
         length, parallel-sided, irregular, proximally irregular or conical, etc.
         shape in transverse cross-section.
         arrangement, e.g., megazooecia in center of endozone
      3. Exozone
         length — whether new zooecia initiated in later endozone or most endozone zooecia continue into exozone or new zooecia in early exozone give rise to another set of shorter zooecia, etc.
         shape in tangential section
   B. Intrazooecial features
      1. Diaphragms
         orientation — planar, inclined, convex, concave
         thickness variation and spatial distribution
      2. Cystiphragms
         orientation proximal or distal sides of zooecia, etc.
      3. Cystose diaphragms
      4. Zooecial lining — nature of overlap — how far do the units overlap before merging with the wall, etc.
      5. Cysts
      6. Spines
      7. Others
2. Interzooecial features — Mesopores
   point of origin and termination
   longitudinal shape — tapering on one or both ends or 'beaded'
   shape in tangential section
   arrangement — whether fill spaces between 2 or more zooecia or one to several between adjacent zooecia, etc.
3. Other — Acanthopores
   point of intiation
   configuration
   rejuvenation
   size variation — due to variation of clear or laminated component
4. Wall microstructure
   nature of individual wall units — thickness variation
   long or short diaphragm-wall units
   mural lacunae
   nature of laminae — continuous or discontinuous; angle of curvature
   distribution of dark material in laminae, in the center or proximal zone
   presence or absence of dark granular surface along which laminae abut

5. Monticules
    arrangement of zooecia or megazooecia, mesopores, acanthopores; orientation of cystiphragms
    correlation with external appearances

SYSTEMATICS

Sixteen species of trepostomes have been identified from the Bellevue Limestone. Their geographic distribution and abundance in the tri-state area are shown in Table 1.

Only "descriptions" are given for the species because comparative information necessary for "diagnoses" is not yet available for known species.

The qualitative data are presented in an abbreviated style and tabular quantitative data are presented for each species.

Genus **AMPLEXOPORA** Ulrich

Type species.—*Atactopora septosa* Ulrich, 1879; subsequent designation by Boardman, 1960b, pp. 16, 17.

Ulrich (1882a, p. 154) defined the new genus *Amplexopora* without any type species designation. Ulrich (1882b, p. 254) described and illustrated as new "*Amplexopora cingulata,* n. gen. et n. sp.," which he considered as the type of the genus, although he (1882a) had already cited four species of *Amplexopora.* As the first reviser, Boardman (1960b, pp. 16, 17) selected one of the four species, *Atactopora septosa,* to be the type species of *Amplexopora.* The concept of the genus here also follows Boardman (1960b).

Amplexopora cingulata Ulrich, 1882b Pl. 16, figs. 1a-1e; Pl. 17, figs. 1a-1c

1882b. *Amplexopora cingulata* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, p. 254, pl. 11, figs. 5-5b.
1908. *Amplexopora cingulata* Ulrich, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 758, pl. 6, figs. 1, 1a.
1915. *Amplexopora cingulata* Ulrich, Bassler, U.S. Natl. Mus., Bull., vol. 92, No. 1521, p. 36.
1953. *Amplexopora cingulata* Ulrich, Bassler, Treatise Inv. Paleont., Part G., Bryozoa, p. G108, fig. 73, 1a-d.

Description.—Zoaria ramose to frondo-ramose; conspecific incrustation common; corresponding branch circular to elliptical in cross-section; zoarial surface smooth to covered by low broad monticules.

Zooecia in endozone even-sided, all more or less proximally sharply conical; attain maximum width in less than 1 mm. from

Table 1. — Distribution and Abundance* of Trepostome Species in the Bellevue.

Localities Species	1	2	3	4	5	6	7	8	9	10	11	12
Amplexopora cingulata	A_5	C_5	R_2	R_1	—	—	C_5	R_1	—	—	—	—
A. robusta	A_2	C_2	C_2	R_2	R_1	R_2	C_2	C_2	R_2	R_2	C_3	A_2
Bythopora dendrina	R_2	R_1	R_3	—	—	—	—	—	—	—	R	—
Batostomella gracilis	AA_{10}	AA_5	AA_5	AA_5	A_5	A_5	—	C_5	R_1	AA_5	AA_5	AA_5
Dekayia aspera	C_2	A_2	R_2	R_1	C_2	R_2	R_1	R_2	R_1	C_2	R_3	C_2
D. pelliculata	—	C_2	A_3	C_2	—	R_2	—	—	—	—	—	R_1
Heterotrypa frondosa	AA_2	AA_2	AA_2	C_2	C_1	C_1	R_1	AA_2	—	C_2	AA_3	R_2
H. solitaria	C_2	A_2	A_2	R_2	R_2	C	R	C	A_1	R	C	C_1
Homotrypa curvata	C_1	C_2	—	R_2	R_1	—	—	C_2	C_2	R_1	—	C_2
H. obliqua	C_2	R_2	—	—	R_1	R	—	R	—	C_2	R_1	R_2
Monticulipora mammulata	R_2	R_3	R_2	—	—	R_1	R_1	C_3	A_2	R_1	—	R_1
Parvohallopora ramosa	AA_2	AA_2	AA_2	AA_2	AA_2	AA_2	AA_2	AA_2	A_3	AA_2	AA_2	AA_2
P. laevigata, n. sp.	AA_2	A_2	A_2	A_2	A_1	A_2	A_1	AA_2	R	AA_2	A_1	A_2
Peronopora decipiens	C_2	AA_2	A_2	C_2	R_2	A	AA	A_2	R_1	AA_1	A_1	C_1
P. dubia	C_1	—	R_1	—	—	—	R_2	C	R_2	—	A_2	C_1
Amplexopora (?) filiasa	R_1	—	—	R_1	C_4	—	C	—	—	R	—	—

very abundant — AA (20-25); abundant — A (15-20); common — C (15-5); rare — R ($<$ 5).
*Rough approximation based on sectioned and unsectioned zoaria.
Numeral subscript = number of zoaria measured. See Tables 2-17 for quantitative data.

Table 2. — Quantitative data, *Amplexopora cingulata* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.14-.25	.178	.00041	.020	11.5	20	200
	(b)	.15-.21	.178	.00025	.016	8.88	20	200
Max. dimension of mesopores	(a)	.03-.16	.084	.0012	.034	41.3	20	165
	(b)	.07-.14	.088	.0003	.018	20.7	20	165
Max. dimension of megazooecia in exozone	(a)	.20-.35	.255	.001	.036	13.9	20	100
	(b)	.22-.32	.255	.001	.032	12.6	20	100
Number of acanthopores in 1 mm square	(a)	0-31	13.0	32.19	5.67	42.8	20	100
	(b)	9-27	13.0	21.94	4.68	35.3	20	100
Width of zoaria		3.5-9.7	—	—	—	—	18	22

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

inception; erratic irregularities in wall; zooecial openings polygonal in cross-section.

Zooecia in exozone initiated primarily in outer endozone, secondarily in zone of zooecial bend; zooecial openings rounded to polygonal in cross-section.

Diaphragms uniformly planar throughout; inequidistantly placed in endozone; uniformly spaced in exozone; longitudinal alignment of diaphragms in exozone also consistent.

Zooecial lining moderate to thick, fairly uniform in thickness within a zoarium; diaphragm-zooecial lining unit distinct to indistinct.

Mesopores lacking.

Acanthopores abundant, rarely circular in cross-section, restricted to zooecial corners; minute; lumen inconspicuous to visible at magnifications of more than 100; laminated material irregularly dispersed.

Wall indistinctly laminate, apparently granular; laminae sharp V-shaped, abutting in the central zone of ZCL along a highly irregular surface, latter always distinctly dark in color.

Monticules composed of megazooecia and thicker walls.

Remarks. — See Table 2 for quantitative data and Table 1 for distribution and abundance data. Ulrich described the species from McKinney's Station (Kentucky) on the line of the Cincinnati Southern RR. Ulrich considered the exposure at that locality to be stratigraphically equivalent to those near the tops of the hills in and around Cincinnati, Ohio. These according to modern usage would include the Fairview Formation and the McMillan (composed of Bellevue, Corryville and Mt. Auburn Members) Formation.

See *Remarks* under *A. robusta* for comparison with other species.

Amplexopora robusta Ulrich Pl. 17, figs. 2a-2b; Pl. 18, figs. 1a-1c, 2a-2b

1883. *Amplexopora robusta* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 6, p. 82, pl. 1, figs. 1-16.

1889. *Amplexopora robusta* Ulrich, Miller, North American Geol. Paleont., p. 292, fig. 450.

1890. *Amplexopora robusta* Ulrich, Ulrich, Geol. Sur. Illinois, vol. 8, p. 318, fig. 7d.

1908. *Amplexopora robusta* Ulrich, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 762, pl. 6, figs. 5-5b.

Description. — Zoaria ramose, frondo-ramose, conspecific incrustations uncommon, corresponding branch circular to elliptical in cross-section; zoarial surface smooth.

Zooecia in endozone even-sided to slightly wavy, proximally sharply conical; attain maximum width in less than 1 mm length; distally irregularly tapering; zooecial openings polygonal in cross-section.

Zooecia in exozone initiated primarily in mid-endozone, secondarily in zone of zooecial bend; zooecial openings always polygonal in cross-section.

Diaphragms present throughout; inequidistant in endozone, irregularly and closely spaced in exozone; not aligned longitudinally in exozone; planar, curved, inclined.

Cystose diaphragms common throughout exozone.

Mesopores lacking.

Acanthopores indistinct, few, commonly in zooecial corners.

Wall indistinctly laminate; laminae narrowly V-shaped; most abut in the central zone of ZCL along a thin irregular surface; occasionally laminae continuous across ZCL; diaphragm-wall units distinct to indistinct. Wall thickening in exozone not appreciable.

Monticules irregularly developed, composed of megazooecia.

Remarks. — See Table 3 for quantitative data and Table 1 for distribution and abundance data. Ulrich described this species as "rather rare near the tops of the hills about Cincinnati, Ohio." Cumings (1908) simply re-copied the figures given by Ulrich, perhaps because of his doubts about the presence of the species in his material from Indiana.

A. robusta differs from *A. cingulata* in having noticeably thinner zooecial walls and abundant cystose diaphragms throughout the exozone. Zooecial lining is developed only in *A. cingulata.*

Ulrich also mentioned that funnel-shaped diaphragms (also called infundibular diaphragms) were distinctly abundant in *A. robusta.* Based on my study of large collections of trepostomes, the presence, absence, or abundance of these features is not of taxonomic importance at species or even higher levels, but is a fundamental morphological feature of the trepostomes, although developed throughout or sporadically within only a few zoaria of any species. These diaphragms may represent polymorphic zooids in the trepostomes.

Table 3. — Quantitative data, *Amplexopora robusta* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.18-.35	.249	.0025	.05	20.1	24	240
	(b)	.19-.30	.254	.0012	.034	13.5	24	240
Max. dimension of mesopores	(a)	.04-.18	.102	.0018	.04	42.0	24	136
	(b)	.08-.13	.10	.0005	.022	22.3	24	136
Number of acanthopores in 1 mm square	(a)	2-20	8.44	55.7	7.47	88.5	24	120
	(b)	4-16	7.77	8.80	2.96	38.1	24	120
Width of zoaria		5.3-9.1	—	—	—	—	22	22

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

A. septosa, the type species of the genus, differs from both *A. robusta* and *A. cingulata* in possessing abundant exacanthopores that prominently offset and inflect zooecial walls between zooecial corners. Cystose diaphragms are present in *A. septosa.* The primary types of *A. septosa* are from the Mount Hope Member of the Fairview Formation (Maysville group), of the Upper Ordovician at Covington, Kentucky (Boardman, 1960b, p. 20).

Genus **BATOSTOMELLA** Ulrich

1882a. *Batostomella* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, pt. 1, pp. 140, 141, 154.
1889. *Batostomella* Ulrich, Miller, North American Geol. Paleont., p. 294.
1890. *Batostomella* Ulrich, Ulrich, Geol. Surv. Illinois, vol. 8, pp. 375, 432.
1915. *Batostomella* Ulrich, Bassler, U.S. Natl. Mus., Bull. 92, vol. 1, p. 111.
1920. *Batostomella* Ulrich, Vinassa de Regny, Soc. Italiana de Sci. Nat., vol. 59, p. 227.
1953. *Batostomella* Ulrich, Bassler, Treatise on Inv. Paleont., Pt. G., Bryozoa, p. G99.
Bythopora (part) of authors

Type species. — *Chaetetes gracilis* Nicholson, 1874; subsequent designation by Miller, 1889, p. 294. It is likely that the type material was collected from the Corryville Shale Member of the McMillan Formation, Maysville Group, Cincinnati. See *Remarks* under *Batostomella gracilis.*

Emended definition. — Zoaria ramose, distinctly bifurcating at small angles; characteristic smooth zoarial surface due to thickened zooecial walls and small zooecial openings. Broad exozone and thickened zooecial walls preserving original circular cross-section of branches.

Zooecia in endozone polygonal in cross-section. One to several megazooecia in central part of endozone. In exozone, zooecial openings polygonal, subcircular to oblong. In exozone zooecial walls of broad U- to V-shaped laminae, continuous across ZCL. Zooecial walls progressively thicker towards zoarial surface. Diaphragms rare to absent in zooecia, thin, planar to slightly curved. Zooecial openings aligned in longitudinal ranges, rarely in oblique ranges.

Mesopores rare to abundant, most initiated in early exozone, openings commonly constricted where walls meet diaphragms. Diaphragms restricted to earlier ontogenetic stages; in some species extending to later stages; closely spaced, thicker than zooecial diaphragms, planar.

Mural lacunae present in some species in single row in zone of curved laminae on either side of zooecial boundaries.

Acanthopores rare to abundant, small, restricted to exozone; lumen minute, not always visible; apparently flush with zoarial surface.

Minimum Geological range. — Maysville to Richmond Groups of Cincinnatian (Upper Ordovician) Series.

Remarks. — Duncan (1949, p. 124) summarized the nomenclatorial problems with the type species designation of *Batostomella.* Ulrich (1882a, p. 154) did not designate a type species when he named *Batostomella* although he emphasized and described the characters of *Chaetetes gracilis* Nicholson, and listed five other species he assigned to the genus. In 1890, Ulrich designated both *C. gracilis* and *B. spinulosa* (a Mississippian species) as the types of *Batostomella;* in subsequent years he considered *B. spinulosa* as the type species. Miller (1889) designated *C. gracilis* as the type species of *Batostomella.* As the first reviser, Miller's designation is both legally appropriate and conforms to Ulrich's (1882a) concept of *Batostomella.* This designation was overlooked and consequently many workers subsequently referred to *B. spinulosa* as the type species. Crockford (1947, pp. 33-34), unaware of Miller's designation, questioned the validity of *B. spinulosa* as the type species, and considered *Batostomella* to be the junior synonym of *Bythopora,* as in Nickles' and Bassler's (1900) synonymy.

Both *Batostomella* and *Bythopora* lack diaphragms in the endozone, have relatively thick zooecial walls and wall laminae continuous across the zone of curved laminae. But *Batostomella* includes robust forms that have zooecial openings constricted in the exozone by thickening of zooecial walls, while *Bythopora* has only slightly flared zooecial openings. The exozone in *Bythopora* is characteristically thin. Megazooecia in the central part of the endozone have also been identified in *Eridotrypa* Ulrich, *Lamottopora* Ross, and *Newportopora* Ross.

Batostomella gracilis (Nicholson) Pl. 19, figs. 1, 2a-2c; Pl. 20, figs. 1a-1c, 2, 3; Pl. 21, figs. 1a-1b, 2a-2b, 3; Pl. 22, figs. 1, 2

1871. *Chaetetes gracilis* James, Cat. Lower Sil. Fossils Cincinnati Group, p. 3 (*nom. nudum*).

1874. *Chaetetes gracilis* James, Nicholson, Geol. Soc. London, Quart. Jour., vol. 30, p. 504, pl. 29, figs. 7, 7a.

1875. *Chaetetes gracilis* James, Nicholson, Geol. Surv. Ohio, Pal., vol. 2, pt. 2, p. 198, pl. 21, figs. 8, 8b.
1878a. *Chaetetes meeki* James, Paleontologist, No. 1, p. 1.
1881. *Monticulipora (Chaetetes) meeki* (James), James, Paleontologist, No. 5, pp. 35, 36.
1881. *Monticulipora (Heterotrypa) gracilis* (James), Nicholson, Genus *Monticulipora,* p. 125, fig. 20, pl. 2, figs. 1-16.
1883. *Monticulipora gracilis* (James), Hall, Indiana Dept. Geol. Nat. Res., 12th Ann. Rept., p. 248, pl. 10, figs. 1-3; pl. 11, fig. 11.
1889. *Batostomella gracilis* (James), Miller, North American Geol. Paleont., p. 294, fig. 458.
1890. *Batostomella gracilis* (Nicholson), Ulrich, Geol. Surv. Illinois, vol. 8, p. 432, pl. 35, fig. 2.
1895. *Homotrypella gracilis* (Nicholson), Ulrich, Geol. Minnesota, vol. 3, p. 228.
1900. *Bythopora gracilis* (Nicholson), Nickles and Bassler, U.S. Geol. Surv., Bull. 173, p. 185.
1906. *Bythopora gracilis* (Nicholson), Bassler, U.S. Natl. Mus., Proc., vol. 30, pp. 20, 21.
1906. *Bythopora meeki* (James), Bassler, U.S. Natl. Mus., Proc., vol. 30, p. 21, 22.
1908. *Bythopora gracilis,* Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 782, pl. 8, figs. 6, 6b; pl. 27, figs. 2, 29.
1915. *Bythopora gracilis,* Bassler, U.S. Natl. Mus., Bull. 92, pp. 151, 152.
1925. *Bythopora meeki* (James), Dyer, Ontario Dept. Mines, 32nd Ann. Rept., pt. 7, p. 51, pl. 5, figs. 4, 5.
1953. *Batostomella gracilis* Nicholson, Bassler, Treatise on Inv. Paleont., pt. G (Bryozoa), p. G99, fig. 63, 1a-d.
1961. *Bythopora gracilis,* Caster, Dalvé and Pope, Cincinnati Mus. Nat. Hist., pl. 4, figs. 12, 13.
1961. *Bythopora meeki,* Caster, Dalvé and Pope, Cincinnati Mus. Nat. Hist., pl. 6, figs. 19, 20.
1964. *Batostomella gracilis,* Utgaard, and Perry, Indiana Dept. Cons. Geol. Surv., Bull. 33, p. 87, 88, pl. 17, figs. 1-7.

Description. — Zoaria ramose, conspecific incrustations uncommon. Zoarial branches typically circular in cross-section, rarely compressed producing slightly elliptical outline. Branches bifurcate 40-60°, at short intervals. Zoarial surface smooth.

Walls even to slightly wavy in endozone, abruptly thickening in early exozone, variable in thickness in exozone, commonly attaining maximum thickness in outer exozone.

Zooecia in middle of endozone distinctly large (megazooecia); parallel, even-sided; characteristically long, proximally sharply conical, gradually increasing in diameter, attaining maximum diameter in less than 1 mm length. Zooecia in outer endozone distinctly smaller in diameter, commonly showing irregularly wavy walls; usually budding one or more zooecia into exozone before themselves bending into exozone.

Zooecia in zooecial bend zone constricted compared to those in endozone and exozone; rarely budded in exozone; zooecial openings rounded, circular to slightly elongated in outline.

Diaphragms lacking in endozone; present in some zooecia near zooecial bend, rare in outer exozone; planar, optical laminae thick.

Mesopores abundant, most initiated in vicinity of zooecial bends; commonly terminated below zoarial surface by thickened wall; one to several between zooecia; rarely in clusters (polymorphs); rounded to slightly irregular in outline.

Acanthopores few to numerous, fairly uniform in diameter, lumen characteristically minute and constant in diameter; almost all centered between zooecial openings; never inflecting walls.

Wall laminae continuous across ZCL, broad U- to V-shaped in direction of growth; independent walls, indistinct even in presence of diaphragms.

Remarks. — See Table 4 for quantitative data and Table 1 for distribution and abundance data. James (1871, p. 3) introduced the name *Chaetetes gracilis* in the catalogue of Lower Silurian fossils of the Cincinnati group, with no description or illustration. According to Nicholson (1874, p. 504) James sent him a collection of specimens identified as *C. gracilis*. Nicholson described and illustrated the species for the first time, thereby inadvertently becoming the author of the species. He described it as:

> Corallum dendroid, the branches cylindrical from less than 1 line to 2 lines or more in diameter, dividing dichotomously at short intervals. Corallites very small and crowded from 10-12 in the space of 1 line, thick-walled, opening obliquely on the surface by oval or circular calices, between which are placed excessively minute circular tubuli. The surface exhibits no elevations or tubercles, but is entirely smooth, and there are also no groups of larger sized corallites, the ordinary corallites being all nearly of a size.

He indicated its locality and formation data as "Cincinnati group, near Cincinnati, Ohio."

Since the type material used by Nicholson has not been located, no clear-cut concept of *C. gracilis* and consequently *Batostomella* exists. This is reflected by the long synonymies in the literature; the general feeling was summarized by Ross (1967, p. 641):

> . . . since the types of this species have not been available for study the generic concept of *Batostomella* remains unknown and the name belongs to the list of unrecognizable generic names of ectoprocts.

Nicholson (1874, pl. 29, figs. 7, 7a; 1881, pl. 2, figs. 1, 1b, 2a)

Table 4. — Quantitative data, *Batostomella gracilis* (Nicholson)

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.10-.25	.19	.018	.034	15.3	55	550
	(b)	.12-.22	.17	.006	.025	12.4	55	550
Max. dimension of mesopores	(a)	.02-.11	.06	—	—	—	55	550
	(b)	.04-.09	.06	.0002	.012	20	55	550
Max. dimension of megazooecia in endozone		.21-.40	.28	.003	.06	22	55	550
Number of acanthopores in 1 mm square	(a)	0-60	16	236	15.4	96	51	255
	(b)	2-41	16	94.7	9.7	63.7	51	255
Diameter of zoaria		1.4-10	4.2	—	—	—	89	101

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

illustrated the external and internal characters of *Chaetetes gracilis.* Ulrich (1882a, p. 141) considered *C. gracilis* [*sensu* Nicholson] to be typical of *Batostomella;* this consideration was used by Miller (1889) in designating *C. gracilis* the type species of *Batostomella.* Subsequent referral of *C. gracilis* to genera other than *Batostomella* (mainly *Bythopora*) has led to the present absence of a clear-cut concept of *Batostomella.* This was complicated by the lack of understanding of *Bythopora* and its type species *Helopora dendrina* James, the type specimens of which were thought to be lost until recently. Ross (1967) traced and restudied the type specimens of *Helopora dendrina* James. This information is helpful in establishing *Bythopora* and subsequently differentiating it from *Batostomella.*

The robust, externally smooth zoaria, thick exozone and thickened zooecial walls of *Chaetetes gracilis* (James), Nicholson, are distinctive of Ordovician trepostomes and do not fit the concept of *Bythopora* which is characterized by delicate, slender forms with an extremely thin exozone. The specimens here referred to *Batostomella gracilis* are abundant in the Bellevue Limestone and elsewhere. Hence, in spite of the fact that the types of *C. gracilis* are unavailable for study, the concept of *C. gracilis* is re-established here. No useful purpose would be served by placing *Batostomella* in a list of unrecognized genera, as this would necessitate erection of a new genus and species.

According to Nicholson (1874, p. 505) James sent him a part of his collection of *C. gracilis* James (*nom. nudum*). The James collection was deposited at the Field Museum, Chicago, and a suite of 70 specimens, entered in its catalogue as the syntypes of *C. gracilis* Nicholson, has not been located. It is debatable whether these specimens were used by James as well as Nicholson for introducing the name *C. gracilis.* The specimens listed in the Field Museum catalogue may represent only the James collection and the material used by Nicholson (the "legal" type) is still untraceable, as is part of his other type material.

Incidentally, in the Field Museum the name *Bythopora gracilis* was substituted for the original entry of *Chaetetes gracilis,* probably to conform with Bassler's (1906) assignment in the restudy of the James types.

Geological occurrence of the types. — One non-type specimen

(UC 1877) from the James collection (labelled *Bythopora gracilis*) was loaned to the National Museum of Natural History. The original entry in the catalogue was *Monticulipora gracilis* (see the synonymy for the chronology of generic shifts). The data accompanying the specimen indicate that it came from the Corryville beds, "Lorraine group." This specimen apparently is a typical *C. gracilis* and compares well with the descriptions and illustrations of Nicholson (*fide* R. S. Boardman, pers. comm.).

Bassler (1906, pp. 20, 21), who restudied the James types, mentioned that *Bythopora gracilis* (= *C. gracilis* Nicholson) was abundant in the Fairview and McMillan Formations throughout the "Ohio Basin," and especially abundant in the Corryville shales where many slabs are covered with its white, narrow, smooth branches. *C. meeki,* according to James (1878a), came from higher horizons of the Cincinnati Group. Bassler (1906) specifically mentions the *C. meeki* horizon as the Waynesville formation, Richmond Group. Under the circumstances it is safe to say that the Corryville Shale Member of the McMillan Formation was the source of original types of *C. gracilis* collected by James for himself and Nicholson.

Comparison with other species. — *B. gracilis* differs from *B. granosa* Ulrich in having numerous mesopores, most of which reach the zoarial surface; all mesopores have diaphragms along their entire lengths. James (1878a) proposed the name *C. meeki* to include larger diameter forms that he collected from horizons higher than those of *B. gracilis.* In 1881, James reported that *B. gracilis* had thinner walls and that *B. meeki* was characterized by maculae. Neither of these observations are substantiated here. Bassler (1906, pp. 20, 21) noted that

> the various species of *Bythopora* are so much alike in internal structures that it is not strange that Nicholson (1881) considered the species under discussion [*B. meeki*] only a variety of his *Monticulipora gracilis.* However, the fact that it occupies and is characteristic of a different geological horizon, and always forms a considerable larger zoarium, seems to be reason enough for its rank as a distinct species . . . *B. gracilis* stems seldom over 3 mm in diameter . . . *B. meeki* seldom less than 6-7 mm.

The range in zoarial diameter of Bellevue specimens of *B. gracilis* (1.4-10 mm) more than covers the size ranges observed by James and Bassler. This is seen in collections even from small stratigraphic intervals in the Bellevue Limestone. The internal anatomical details of the collection are the result of allometric growth, rather than characters that would be considered to be of specific rank. Hence, *Batostomella meeki* is here considered to be synonymous with *B. gracilis*. Utgaard and Perry (1964, p. 89) noticed a similar range in size in their collection of *B. gracilis* from the upper part of Whitewater Formation, Richmond group.

Genus **BYTHOPORA** Miller and Dyer

1878. *Bythopora* Miller & Dyer, Contr. Paleont., No. 2, p. 6.
1889. *Bythopora* Miller & Dyer, Miller, North American Geol. Paleont., p. 295.
1890. *Bythopora* Miller & Dyer, Ulrich, Geol. Surv. Illinois, vol. 8, p. 376.
1900. *Bythopora* Miller & Dyer, Nickles & Bassler, U.S. Geol. Surv., Bull., vol. 173, p. 32.
1906. *Bythopora* Miller & Dyer, Bassler, U.S. Natl. Mus., Proc., vol. 30, pp. 20-22.
1908. *Bythopora* Miller & Dyer, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 741.
1915. *Bythopora* Miller & Dyer, Bassler, U.S. Natl. Mus., Bull. 92, vol. 1, p. 150.
1920. *Leptotrypella (Leptotrypellina)* Vinassa de Regny, Soc. Italiana Sci. Nat., vol. 59, p. 222.
1934b. *Bythopora* Miller & Dyer, Bassler, Fossilium Cat., Animalia, pars 67.
1953. *Bythopora* Miller & Dyer, Bassler, Treatise Inv. Paleont., part G (Bryozoa), p. G99.
1967. *Bythopora* Miller & Dyer, Ross, Jour. Paleont., vol. 41, pp. 641-642.
Batostomella (part) of authors.

Type species. — *Helopora dendrina* James, 1878a (= *Bythopora fruticosa* Miller and Dyer, 1878; a junior objective synonym.) Probably the type material came from the Fairview Formation (Maysville Group) at Cincinnati, Ohio.

Definition. — Slender, frequently dichotomously branching zoaria. Exozone extremely thin. Zooecia polygonal in cross-section in endozone, rounded in exozone, enlarged in cross-section towards zoarial surface. Zooecial walls composed of V-shaped laminae. Diaphragms lacking in endozone, rare to absent in exozone. Mesopores lacking. Aconthopores few, with clear lumen surrounded by laminated material.

Remarks. — *Bythopora* differs strikingly from otherwise similar-looking genera *Aisenvergia* Dunaeva, *Lamottopora* Ross, *Newportopora* Ross, *Polycylindricus* Boardman and *Volnovachia* Dunaeva of the family Aisenvargiidae Dunaeva, 1964, in its widening of the zooecial openings towards the zoarial surface. A marked constriction in the zooecial openings, characteristic of the above-mentioned genera, is also typical of *Batostomella*. *Bythopora* differs from *Batostomella* in that the megazooecia are not developed in its endozone.

Ross (1967, p. 641) regarded *Bythopora* to be sufficiently distinct in itself to warrant its inclusion in the monogeneric family Bythoporidae Miller, 1889. Ulrich (1890) and Bassler (1953) considered it to be related to *Batostomella* and included it in the family Batostomellidae Ulrich (*in* Miller, 1889).

Bythopora dendrina (James) Pl. 22, figs. 3-5; Pl. 23, figs. 1a-1c, 2

1878. *Helopora dendrina* James, Paleontologist, No. 1, p. 3 (July 2).
1878. *Bythopora fruticosa* Miller & Dyer, Contr. Paleont., No. 2, p. 6, pl. 4, figs. 6, 6a (July 22).
1878b. *Helopora dendrina* James, James, Paleontologist, No. 2, pp. 14, 15 (September 14).
1889. *Bythopora fruticosa* Miller & Dyer, Miller, North American Geol. Paleont., p. 245, fig. 461.
1890. *Bythopora fruticosa* Miller & Dyer, Ulrich, Geol. Surv. Illinois, vol. 8, p. 376.
1900. *Bythopora dendrina* (James), Nickles and Bassler, United States Geol. Surv., Bull., vol. 173, p. 185.
1906. *Bythopora dendrina* (James), Bassler, United States Natl. Mus., Proc., vol. 30, p. 20.
1953. *Bythopora dendrina* (James), Bassler, Treatise Inv. Paleont., Pt. G (Bryozoa), p. G99.
1960. *Bythopora fruticosa* Miller & Dyer, Orlov (Ed.), Principles of Paleont. (Russian Treatise), Bryozoa, Brachiopoda vol., p. 65.
1967. *Bythopora dendrina* (James), Ross, Jour. Paleont., vol. 41, pp. 642-644, pl. 67, figs. 1-8, 10-13; pl. 69, fig. 4; pl. 72, fig. 3.

Type. — The holotype was re-discovered and described by Ross (1967, p. 641): the original zoarium is approximately 3.5 cm in diameter (pl. 67, fig. 11) and fragments of it sectioned by her (pl. 67, figs. 1, 2, 6) are also described by Ross. Collected from the "Top of Mount Adams, Cincinnati, Ohio." (James, 1878b, pp. 14, 15). The geographical data suggest the stratigraphical horizon is the Fairmount Limestone Member of the Fairview Formation (Maysville Group).

Description. — Zoaria delicate; branch cross-section subcircular to slightly compressed; surface rough. Exozone width characteristically smaller than endozone. Endozone composed of 10 to 15 zooecia; polygonal in cross-section; zooecial tubes straight to slightly irregular in profile; individual tubes widen abruptly at zooecial bends, or widen gradually in exozone. Zooecia oval in cross-section in exozone, becoming oblong; elongated parallel to direction of zoarial growth at zoarial surface. Zooecial tubes in outer endozone budding 0 to 2 shorter zooecial tubes before bending into exozone.

Zooecial walls in endozone thin, gradually thickened from zooecial bends; retaining maximum thickness in about middle of exozone and tapering slightly towards zoarial surface. Individual wall units variable in thickness. Wall composed of broad V-shaped laminae, these continuous across the zone of curved laminae.

Diaphragms lacking in endozone; rare to absent in exozone; planar to slightly curved; randomly distributed.

Mesopores absent. Acanthopores few, restricted to exozone; minute; lumen distinct, surrounded by non-laminated material.

Remarks. — See Table 5 for quantitative data and Table 1 for distribution and abundance data. Naming of the type species of *Bythopora* is complex and deserves a brief summary (see Bassler [1906, p. 20] and Ross [1967, p. 641] for additional details). It appears that Dr. Charles Schuchert collected a zoarium from the top of Mount Adams, Cincinnati, Ohio. This specimen was first studied by Mr. U. P. James who named it *Helopora dendriana.* James first reported orally on it at the August, 1876 meeting of the Cincinnati Society of Natural History and later published its description in 1878 (July 2). According to James, [1878b (September), pp. 14, 15] the same zoarium was illustrated and described by Miller and Dyer (1878, July 22) as *Bythopora fruticosa,* the type of the new genus *Bythopora.* Bassler (1906) was the first author to accept James' explanation, consequently considering *B. fruticosa* to be the junior objective synonym of *H. dendrina.* This interpretation has been accepted by most later workers, a notable exception being the Russian Treatise (Bryozoa, Brachiopoda Volume, Orlov (ed.), 1960).

Ross (1967, p. 641) identified a zoarium of *B. dendrina* from the Dyer Collection (MCZ 2144), as the specimen figured by Miller and Dyer, and hence the holotype. A zoarium in the collection of the Department of Geology, University of Cincinnati (UCM 1321) had previously been considered the holotype. Ross (1967) considered the zoaria conspecific, but the UCM zoarium differs from the illustration by Miller and Dyer in that it encloses thicker branches of *Calopora* (= *Hallopora;* see Singh, 1970). The localities given by James (1878a; "Top of Mount Adams") and Miller and Dyer (1878; "Middle part of the Cincinnati Group") are helpful to the extent that the "Hill Quarry beds" which are the Fairmount Member of the Fairview Formation are known to have been exposed

Table 5 — Quantitative data, *Bythopora dendrina* (James)

Character	Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings; c.s. shape in tangential orientation	.10-.18	.12	.0006	.025	19.9	1	10
Min. dimension of zooecial openings; c.s. shape in tangential orientation	.06-.10	.08	.0002	.012	14.5	1	10
Max. width of zooecia in endozone; longitudinal orientation	.9-.13	.11	.0002	.011	9.8	2	13
Diameter of zoaria	.7-3.2	1.5	—	—	—	6	10

S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

at the Mt. Adams locality. In the absence of more precise stratigraphic location, the holotype is considered to have been collected from the Fairmount beds.

A restudy of the holotype of *Bythopora dendrina* by Ross (1967) has been helpful not only in the understanding of *Bythopora* but has also clarified the concept of *Batostomella gracilis,* the type species of *Batostomella* (frequently been referred to *Bythopora*).

Both the holotype and the zoarium from the University of Cincinnati collection sectioned by Ross (1967) compare well with Bellevue material and are here considered to be conspecific. Additional material at the National Museum of Natural History from the Fairview Formation, Cincinnati, is here considered conspecific with the Bellevue material. "Pustules" reported in *B. dendrina* from the Trenton of New York by Ross (1967, p. 634, pl. 67, fig. 10) seem to be restricted to that material. Ross also described the presence of 1-2 mesopores per zooecia in a tangential section of a holotype fragment. Longitudinal orientations do not show mesopores. In tangential sections, small openings are common in cuts that are slightly deeper than usual and oblique. These are obtained when zooecia are cut at the zone of constriction. The appearance of the deeper tangential sections is mostly a reflection of the narrow exozone characteristic of this species.

The Bellevue material is assigned to this species solely on the basis of comparison with the type material, the only species studied in detail. Bassler (1915) listed 12 species of *Bythopora,* of which *B. gracilis* and *B. meeki* are here assigned to *Batostomella* (see synonymy under *Batostomella gracilis*). The remainder of the species were first introduced in the literature with quite generalized and inadequate morphological information, and have not subsequently been restudied. For this reason any meaningful comparison of the Bellevue material with other described species must await comprehensive re-evaluation of the genus.

Genus **DEKAYIA** Milne-Edwards & Haime, 1851

Type species.—*Dekayia aspera* Milne-Edwards and Haime, 1851, by original designation.

The concept of the genus as followed here is after Boardman and Utgaard (1966, pp. 1103-1104).

Dekayia aspera Milne-Edwards and Haime Pl. 24, figs. 1a-1e; Pl. 25, figs. 1a-1b, 2a-2d

1851. *Dekayia aspera* Milne-Edwards & Haime, Mono. Polyp. Foss. Terra. Paleont., p. 278, pl. 16, figs. 2, 2a.
1908. *Dekayia aspera* Milne-Edwards & Haime, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., pp. 810-811, pl. 13, figs. 5-5e; pl. 27, fig. 20.
1913. *Dekayia aspera* Milne-Edwards & Haime, Cumings & Galloway, Indiana Dept. Geol. Nat. Res., 37th Ann. Rept., pp. 63, 64.
1953. *Dekayia aspera* Milne-Edwards & Haime, Bassler, Treatise Inv. Paleont., pt. G., p. G98, figs. 60/1a-1c.
1966. *Dekayia aspera* Milne-Edwards & Haime, Boardman & Utgaard, Jour. Paleont., vol. 40, p. 1104, pl. 138, figs. 1-4.

Description. — Zoaria ramose, frondo-ramose and incrusting; branches circular to elliptical in cross-section; zoarial surface smooth.

Wall characteristically uniform in thickness in endozone and exozone.

Zooecia in endozone long, uniform in width, proximal end broadly conical; attaining maximum width in less than 1 mm length; uniformly polygonal in cross-section; distinctly smaller zooecia observed in cross-section represent proximal ends of normal-sized zooecia.

Zooecia in exozone long; most initiated in mid- to late-endozone, rarely in mid-exozone; zooecial openings uniformly polygonal in cross-section.

Diaphragms entirely lacking in endozone, rarely one or two in exozone, resultant living chamber small; thin, planar.

Mesopores entirely lacking. Constriction of crenulate wall simulating mesopores in some sections.

Acanthopores variable in size; variation in both lumen and laminated material. Lumen of large acanthopores commonly larger than in small complete acanthopores. Both end-acanthopores and exacanthopores present.

Wall crenulate in both endozone and exozone; most proximal parts of zooecia also distinctly crenulate. Wall indistinctly laminate; laminae continuous across ZCL.

Monticules commonly composed of megazooecia and zones of thickened wall; rarely by a radial arrangement of megazooecia and zooecia around a large acanthopore.

Remarks. — See Table 6 for quantitative data and Table 1 for distribution and abundance data.

The concept of the species follows Boardman and Utgaard (1966), since the type material used by Milne-Edwards and Haime

Table 6. — Quantitative data, *Dekayia aspera* Milne-Edwards and Haime

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.18-.27	.227	.0017	.041	18.1	21	210
	(b)	.19-.26	.223	.0003	.017	7.58	21	210
Max. dimension of megazooecia in exozone	(a)	.25-.41	.31	.0026	.051	16.5	21	105
	(b)	.25-.39	.31	.0013	.036	11.5	21	105
Number of acanthopores in 1 mm square	(a)	0-19	6.28	18.18	4.26	67.9	21	105
	(b)	3-16	6.17	11.41	3.38	54.8	21	105
Width of zoaria		2.5-9.1	—	—	—	—	17	17

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

is not traceable. Ulrich (1883, p. 6, fig. 5) figured a portion of a tangential section showing the characteristic large and small acanthopores of the species. Ulrich gave the following information on the distribution of this and other species of *Dekayia*:

> Like the other species of the genus, *D. aspera* is restricted in its vertical range, which is from 300-325 feet above low water mark in the Ohio River, at Cincinnati, Ohio. At this height the fragments are quite common.

This range (according to Bassler, 1906, p. 8) corresponds to the Mt. Hope Member of the Fairview Formation. Nickles (1902, p. 75) apparently found this species diagnostic of the younger beds he named the *Dekayia aspera* or Fairmount beds.

See *Remarks* under *D. pelliculata* for comparisons.

Dekayia pelliculata Ulrich Pl. 26, figs. 1a-1f; Pl. 27, figs. 1a-1e

1883. *Dekayia pelliculata* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 6, p. 150; pl. 6, figs. 9, 9a.
1908. *Dekayia pelliculata* Ulrich, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 818, pl. 13, figs. 4, 4a.

Description. — Zoaria frondo-ramose, incrusting; conspecific incrustations common. Branches smooth at extremities. Zoarial surface smooth or covered by low broad monticules distinguished by wall thickenings only.

Wall thicker in exozone.

Zooecia in endozone even-sided, sharply conical at proximal ends; attaining maximum width in less than 1 mm length; four- or more-sided in cross-section.

Zooecia in exozone long; initiated in late endozone, secondary zooecia budding in zooecial bend zone; zooecial openings in cross-section characteristically polygonal in thin-walled segments and polygonal to slightly rounded or subrounded in thicker-walled segments. Diaphragms present in a few zooecia of endozone and exozone; irregularly placed in exozone; planar, thick; forming short diaphragm-wall units.

Mesopores commonly initiated in late endozone, most reaching zoarial surface; rapidly attaining maximum width, this maintained with minor irregularities. Diaphragms in mesopores distinct, indistinguishable in thickness from those in endozone or exozone; polygonal; from distribution and shape appear as spacefillers; commonly one between adjacent zooecia; in cross-section may appear on more than one side of zooecia.

Acanthopores abundant, variable in size; lumen and laminated material both variable in diameter; in large acanthopores lumen commonly elliptical in cross-section; both endacanthopores and exacanthopores present.

Wall gently and irregularly crenulate in endozone; regularly and strongly so in exozone; distinctly laminate; laminae narrowly convex, continuous across ZCL; appearing uniformly dark.

Monticules composed of zooecia, thickened wall and abundant acanthopore or only megazooecia with thin walls and acanthopores.

Remarks. — See Table 7 for quantitative data and Table 1 for distribution and abundance data. Ulrich provided the following formation and locality information:

> Cincinnati group. Rather rare on the hills back of Cincinnati, Ohio and Covington, Kentucky at an elevation of from 300 to 350 feet above the low water mark in the Ohio River.

This vertical range, according to Bassler (1906, p. 8) would approximately encompass the Fairview Formation of modern usage.

D. pelliculata differs from *D. aspera* in possessing mesopores, diaphragms, and thicker walls in the exozone. *D. appressa,* a form with thin walls, has only a few small acanthopores. *D. aspera* has distinct, abundant large and small acanthopores.

Genus **HETEROTRYPA** Nicholson, 1879

Type species. — *Monticulipora frondosa* d'Orbigny, 1850; subsequent designation by Utgaard and Boardman, 1965. Designated under Plenary Powers by the I.C.Z.N. (1968, Opinion 838).

The concept of the genus as followed here is after Boardman and Utgaard (1966, pp. 1105-1107).

Heterotrypa frondosa (d'Orbigny) Pl. 28, figs. 1a-1f; Pl. 29, figs. 1a-1b, 2a-2b, 3a-3b

1850. *Monticulipora frondosa* d'Orbigny, Prodr. de Paleont., vol. 1, p. 25.
1966. *Heterotrypa frondosa* (d'Orbigny), Boardman and Utgaard, Jour. Paleont., vol. 40, pl. 140, figs. 1a-1d, 2a-2b.

Description. — Zoaria frondose, proximal ramose shaft and ramose protrusions elsewhere; conspecific overgrowths rare. Zoarial surface covered by sharp broad uniformly-spaced monticules.

Zooecia in endozone even-sided with minor irregular thicken-

Table 7. — Quantitative data, *Dekayia pelliculata* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.18-.30	.23	.0042	.065	28.2	10	100
	(b)	.19-.29	.24	.0007	.026	10.7	10	100
Max. dimension of mesopores	(a)	.03-.18	.093	.0016	.034	42.5	10	91
	(b)	.09-.13	.098	.00018	.013	13.7	10	91
Number of acanthopores in 1 mm square	(a)	0-18	7.64	17.54	4.19	54.8	10	50
	(b)	6-13	7.92	5.14	2.27	28.6	10	50
Width of zoaria		2.2-10.9	—	—	—	—	10	10

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

ings; conical at proximal zones; gradually expanding to maximum width in less than 1 mm length, this width maintained until its termination; polygonal in cross-section; small zooecia interspersed with more abundant larger zooecia that represent proximal ends of larger zooecia.

Zooecia in exozone commonly initiated in mid-endozone, rarely in late endozone; rare secondary zooecia initiated in exozone; in cross-section, zooecial openings commonly circular; rarely otherwise.

Diaphragms irregularly distributed in endozone, abundant in exozone; apparently uniform in thickness; planar; cystose in outer exozone. Diaphragm-zooecial lining unit distinct, weak or absent. Distal components of zooecial lining may overlap proximal components making this zone thicker. Few laminae of zooecial lining merging with wall.

Mesopores abundant; may be initiated in mid-endozone; more commonly in zone of zooecial bend; rounded to subangular in outline; because of shape and size do not appear as space-fillers. Diaphragms in mesopores seldom cystose.

Acanthopores abundant to common; exacanthopores and endacanthopores commonly of same size; offset acanthopores slightly inflecting zooecial walls, producing zooecial openings that are not rounded; 0 - 4 around each zooecium; lumen distinct, relatively large.

Occasional cyst present, rounded in outline.

Walls gradually thickening into exozone, with local, irregular thinnings and thickenings. Some diaphragm-zooecial lining units thickening in distal parts of zooecium; laminae sharply convex and continuous across ZCL; laminae thick and dark in color; irregularly light in color across ZCL; proximal zones of laminae overlapping tightly, permitting few laminae from zooecial lining to merge.

Monticules composed of megazooecia, mesopores, acanthopores, and thicker, darker walls. Clusters of mesopores or megazooecia and mesopores occur singly or in combination on a zoarium.

Remarks. — See Table 8 for quantitative data and Table 1 for distribution and abundance data. Boardman and Utgaard (1966, p. 1106) designated a lectotype (USNM 55879, pl. 140, fig. 1) and two paralectotypes (USNM 144231, pl. 140, fig. 2) from the type material obtained by Ulrich and Bassler (1904, p. 25) from the

Table 8. — Quantitative data, *Heterotrypa frondosa* (d'Orbigny)

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.15-.21	.185	.00036	.019	10.2	20	200
	(b)	.17-.20	.186	.0001	.01	5.24	20	200
Max. dimension of mesopores	(a)	.02-.17	.090	.0043	.065	72.6	20	200
	(b)	.07-.11	.087	.00015	.012	14.1	20	200
Max. dimension of megazooecia in exozone	(a)	.22-.35	.269	.00072	.027	10.0	20	100
	(b)	.24-.30	.269	.00034	.019	6.85	20	100
Number of acanthopores in 1 mm square	(a)	4-35	13.3	50.41	7.10	53.4	20	100
	(b)	7-23	12.5	27.27	5.22	41.8	20	100
Width of zoaria		3.6-7.8	—	—	—	—	16	16

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

d'Orbigny collection in the Museum national d'Histoire naturelle of Paris. According to Ulrich and Bassler these specimens probably came from the Fairmount Member (Fairview Fm.) of the Maysville Group at Cincinnati, Ohio.

Boardman and Utgaard found the lectotype of *H. frondosa* to be qualitatively more

> comparable in many respects to specimens of *H. prolifica* from the Waynesville Formation of the Richmond Group, than to the subsequently identified specimens known to come from the Fairmount Member of the subjacent Maysville Group. Comparable characters include an unusually broadly amalgamate appearance with thick zooecial linings and walls and correspondingly small zooecial voids, acanthopores of small diameter and comparable arrangement, and closely spaced zooecial diaphragms.

Consequently they suggested that Ulrich and Bassler may have erred in their stratigraphic determination.

Bellevue material is remarkedly similar to the type material. The features noted above are consistently developed in all the zoaria referred to *H. frondosa.*

Heterotrypa solitaria Ulrich Pl. 30, figs. 1a-1b, 2a-2d; Pl. 31, figs. 1a-1b, 2a-2c

1883. *Heterotrypa solitaria* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 6, p. 88, pl. 1, figs. 3, 3a, 3b.

Description. — Zoaria frondose, conspecific overgrowths infrequent; branch margins smoothly rounded. Zoarial surface covered by low broad monticules, commonly almost flush with surface.

Wall irregularly thick in exozone, may be wavy to slightly crenulate in endozone and zooecial bend zone.

Zooecia in endozone uneven sided, broadly conical at proximal end, with gradual increase in width; maximum width attained in about 1 mm; commonly polygonal, rarely quadrangular in cross-section.

Zooecia in exozone commonly initiated in zooecial bend zone; more than one may be budded from an endozonal zooecium; zooecial openings typically polygonal in outline, many subrounded.

Diaphragms absent to rare in endozone; absent in most zooecia; abundant in exozone; typically aligned at an almost constant distance from zoarial surface. Most planar; few slightly curved concave to zoarial surface; rarely cystose; forming well-defined short diaphragm-wall units.

Cysts common in many zoaria, restricted, without any pattern, to a few zooecia; rounded in outline; projecting slightly into zooecial opening.

Mesopores abundant, most initiated near zooecial bend; irregularly terminated in exozone; many reach zoarial surface; typically moniliform; uniform in width; rounded to subrounded in cross-section; due to shape and outline appear as space-fillers.

Both end- and exacanthopores; lumen distinct in both; size variation of acanthopores reflects variations in both lumen and surrounding laminate material.

Wall indistinct, composed of laminae continuous across ZCL; laminae narrowly convex. Wall composed of short diaphragm-wall and independent wall units; irregular thickenings in wall contributed by either.

Monticules composed of megazooecia, thickened walls, and larger acanthopores.

Remarks. — See Table 9 for quantitative data and Table 1 for distribution and abundance data. Ulrich (1883, p. 89) gave the formation and locality information as:

> Cincinnati group. Rare near the tops of the hills west of Covington, Ky., at a height of about 300 feet above low water mark in the Ohio River.

This vertical range corresponds approximately to the Mt. Hope Member of the Fairview Formation (Bassler, 1903, p. 8).

H. solitaria differs markedly from *H. frondosa* in possessing thinner walls and a consistently thinner exozone, lacking a zooecial lining, and having diaphragms aligned equidistant from the zoarial surface. In cross-section, the thinner wall of *H. solitaria* produces distinct polygonal zooecial openings.

Genus **HOMOTRYPA** Ulrich, 1882b

Type species. — *Homotrypa curvata* Ulrich, 1882, by original designation.

Definition. — Bassler (1953, p. G96) is followed here. It should be pointed out that a re-evaluation of the concepts of the closely related genera, *Gortanipora* Vinassa de Regny, 1920 and *Homotrypella* Ulrich, 1886 may result in reassignment of some species assigned to the three genera.

Table 9. — Quantitative data, *Heterotrypa solitaria* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.15-.21	.192	.00025	.016	8.27	12	120
	(b)	.18-.20	.192	.00003	.006	3.06	12	120
Max. dimension of mesopores	(a)	.03-.20	.097	.0017	.041	43.0	12	120
	(b)	.07-.12	.097	.00015	.012	12.7	12	120
Max. dimension of megazooecia in exozone	(a)	.23-.35	.269	.0010	.032	12.1	12	60
	(b)	.25-.34	.269	.0007	.026	9.70	12	60
Number of acanthopores in 1 mm square	(a)	4-27	11.1	18.18	4.26	38.4	12	56
	(b)	7-15	11.1	7.75	2.78	25.2	12	56
Width of zoaria		2.0-4.2	—	—	—	—	11	11

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Homotrypa curvata Ulrich Pl. 32, figs. 1a-1b, 2a-2d. Pl. 33, figs. 1a-1b, 2a-2c

1882b. *Homotrypa curvata* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, pp. 242-243, pl. 10, figs. 7-7d.
1903. *Homotrypa curvata* Ulrich, Bassler, U.S. Natl. Mus., Proc., vol. 26, p. 575.
1908. *Homotrypa curvata* Ulrich, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., pp. 840-841, pl. 17, figs. 3-36; pl. 29, fig. 13.

Description. — Zoaria frondo-ramose; proximal branches rounded, distal ones compressed; corresponding branch shape circular to subcircular or elliptical in cross-section; zoarial surface smooth.

Wall uniformly even, distinctly thickened in exozone.

Zooecia in endozone even-sided, rarely irregularly wavy; proximally sharply conical; maximum width attained in less than 1 mm length; regular in width; polygonal in cross-section.

Zooecia in exozone primarily initiated in well-defined zooecial bend zone; zooecial openings polygonal to subcircular in cross-section.

Diaphragms present throughout; planar, slightly curved to inclined; spaced uniformly in endozone; irregularly spaced in exozone, length of living chamber variable.

Cystiphragms present in almost all zooecia; projecting one-half or more into zooecial cavity; occurring in continuously overlapping series.

Mesopores absent.

Acanthopores abundant, uniform in size; lumen and laminated material distinct; mostly concentrated between zooecial corners.

Wall laminae sharply V-shaped; abutting in central zone of wall along an irregular surface; wall laminae continuous with those of diaphragms and cystiphragms.

Monticules composed of irregularly aligned megazooecia and laminae thus different from those in intermonticular zones.

Remarks. — See Table 10 for quantitative data and Table 1 for distribution and abundance data. Ulrich's (1882b) formation and locality information was:

> Cincinnati Group. An abundant species on the hills surrounding the city of Cincinnati, but very limited in range, being apparently restricted to a few feet of strata at the 300 feet equivalent to Mt. Hope beds of Fairview Fm. level.

Table 10.—Quantitative data, *Homotrypa curvata* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.10-.20	.151	.0007	.027	17.6	14	140
	(b)	.12-.18	.151	.0005	.021	14.8	14	140
Max. dimension of megazooecia in exozone	(a)	.20-.35	.237	.0018	.043	18.3	14	70
	(b)	.21-.30	.240	.0006	.024	10.1	14	70
Width of zoaria		4.8-11.4	—	—	—	—	14	14

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Bassler (1953) in his study of *Homotrypa* mentioned that the species characterized the Fairmount beds at Cincinnati, Ohio, and in that vicinity.

For comparison with other species, see *Remarks* under *H. obliqua.*

Homotrypa obliqua Ulrich Pl. 34, figs. 1a-1e; Pl. 35, figs. 1a-1e

1882b. *Homotrypa obliqua* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, pp. 243-244, pl. 10, figs. 6-6b.
1903. *Homotrypa obliqua* Ulrich, Bassler, U.S. Natl. Mus., Proc., vol. 26, p. 575, pl. 23, figs. 12-14.
1908. *Homotrypa obliqua* Ulrich, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., pp. 848-849, pl. 19, figs. 1-16; pl. 30, fig. 6.

Description. — Zoaria ramose, branches circular to elliptical in cross-section; zoarial surface covered with sharp conical monticules.

Zooecia in endozone even-sided or slightly wavy; sharply conical in proximal zone; attaining maximum width in more than 1 mm length; slight irregularities in width; polygonal in cross-section.

Proximal parts of some zooecia in exozone primarily initiating several zooecia; others initiated secondarily in weakly-defined zooecial bend zone; zooecial openings polygonal to subcircular in cross-section.

Diaphragms common in exozone, less common in outer endozone, and rare to absent in endozone; planar; convex in distal part of zooecia.

Cystiphragms present in almost all zooecia; projecting about one-half to one-third into zooecial cavity; occurring in continuously overlapping series; uniform in size.

Mesopores absent.

Acanthopores abundant, mostly restricted to zooecial corners. Lumen indistinct; typical structure of laminated material not developed.

Wall laminae sharply V-shaped; abutting in central zone of wall along an irregular surface; diaphragms apparently abutting sharply against wall.

Monticules composed of megazooecia.

Remarks. — See Table 11 for quantitative data and Table 1 for distribution and abundance data. Ulrich's (1882b) information on distribution was: "rather common near the tops of the hills at

Table 11. — Quantitative data, *Homotrypa obliqua* Ulrich

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.10-.24	.168	.0011	.033	19.4	10	100
	(b)	.14-.22	.171	.00055	.023	13.7	10	100
Max. dimension of mesopores	(a)	.02-.15	.063	.0013	.036	56.7	10	100
	(b)	.06-.11	.080	.00027	.016	20.6	10	100
Max. dimension of megazooecia in exozone	(a)	.19-.39	.265	.0022	.046	17.5	10	50
	(b)	.21-.30	.265	.0013	.037	13.8	10	50
Number of acanthopores in 1 mm square	(a)	6-23	14.4	43.95	6.62	46.0	2	7
	(b)	10.5-19.6	15.0	41.40	6.43	42.9	2	7
Width of zoaria		3.9-9.0	—	—	—	—	7	7

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Cincinnati, Ohio." Bassler (1903) found it abundant in the Fairview and McMillan Formations.

H. obliqua differs from *H. curvata* in having no diaphragms in the endozone, possessing slightly wavy walls in early exozone and late endozone, and a thinner exozone, and showing monticules on the external surface. Zoaria in *H. curvata* are externally smooth and branches commonly are subcircular to elliptical in cross-section.

Genus **MONTICULIPORA** d'Orbigny

1849. *Monticulipora* d'Orbigny, Rev. Mag. Zoology, ser. 2, vol. 1, p. 503.
1850. *Monticulipora* d'Orbigny, d'Orbigny, Prodr. Paleont., vol. 1, p. 25.
1854. *Monticulipora,* d'Orbigny, Milne-Edwards & Haime, Palaeontogra. Soc., Mon., p. 264 (only a footnote).
1879. *Monticulipora* d'Orbigny, (part), Nicholson, Tabulate Corals, Paleozoic Period, p. 269.
1881. *Monticulipora* d'Orbigny, (part), Nicholson, Genus *Monticulipora,* pp. 1, 99-102.
1882a. *Monticulipora* d'Orbigny, Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, pp. 153.
1882b. *Monticulipora* d'Orbigny, Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, p. 232.
1904. *Monticulipora* d'Orbigny, Ulrich & Bassler, Smith. Misc. Coll., vol. 47, p. 15.
1908. *Monticulipora* d'Orbigny, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 750.
1911. *Monticulipora* d'Orbigny, Bassler, U.S. Natl. Mus., Bull., vol. 77, p. 179.
1934a. *Monticuliporella* Bassler, Washington Acad. Sci., Jour., vol. 24, p. 408.
1953. *Monticulipora* d'Orbigny, Bassler, Treatise Inv. Paleont., part G. (Bryozoa), pp. G94-95.
1966. *Monticulipora* d'Orbigny, Boardman & Utgaard, Jour. Paleont., vol. 40, p. 1093.

Type species.—*Monticulipora mammulata* d'Orbigny, 1850. A subsequent designation by Bassler and Duncan (1955; ICZN, 1957, Opinion 443). D'Orbigny (1849, p. 503) proposed the genus *Monticulipora* and designated *M. frustulosa,* (a non-trepostome from the Jurassic of France) as the type species. This designation was not discovered until later. In 1850 d'Orbigny added two new species from the Cincinnatian strata, *M. mammulata* and *M. frondosa,* and four Jurassic species.

In 1934(a), Bassler, after the discovery of the Jurassic type nomination, contrary to the commonly accepted usage of *M. mammulata* as the type species of the genus, attempted to revalidate *M. frustulosa* as the type species. To achieve this he proposed a new generic name, *Monticuliporella,* having *M. mammulata* as its type species. But Bassler and Duncan (1955), by a petition successfully sought to suppress the name *Monticuliporella* (now officially rejected and invalid), and designated *M. mammulata* as the type species of *Monticulipora.*

Monticulipora mammulata d'Orbigny — Pl. 36, figs. 1a-1b, 2a-2c; Pl. 37, figs. 1, 2, 3a-3b

1850. *Monticulipora mammulata* d'Orbigny, Prodr. Paleont., p. 25.
1851. *Chaetetes mammulatus* (d'Orbigny), Milne-Edwards & Haime, Hist. Nat. des. Corall., vol. 3, p. 267, pl. 19, figs. 1, 1a.
1854. *Monticulipora mammulata* d'Orbigny, Milne-Edwards & Haime, Palaeontogr. Soc., Mon., p. 265.
1874. non *Chaetetes mammulatus* (d'Orbigny), Nicholson, Geol. Soc. London, Quart. Jour., vol. 30, p. 508, pl. 130, figs. 3, 3a.
1879. non *Monticulipora (Heterotrypa) mammulata* (d'Orbigny), Nicholson, Tabulate Corals Paleozoic Period. p. 294, pl. 13, figs. 1-1b.
1881. non *Monticulipora (Heterotrypa) mammulata* (d'Orbigny), Nicholson, Genus *Monticulipora,* pp. 104-110, pl. 6, figs. 1-1g.
1881. non *Monticulipora (Peronopora) molesta* Nicholson, Genus *Monticulipora,* pp. 224-226, pl. 6, figs. 2-2d.
1882b. *Monticulipora mammulata* d'Orbigny, Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, pp. 234-36, pl. 10, figs. 5, 5a.
1882b. *Monticulipora mammulata* d'Orbigny var. *molesta* Ulrich, Cincinnati Soc. Nat. Hist., Jour., vol. 5, p. 236.
1904. *Monticulipora mammulata* d'Orbigny, Ulrich and Bassler, Smith. Misc. Coll., vol. 47, p. 16, pl. 6, figs. 1-3.
1906. *Monticulipora mammulata* d'Orbigny, Thevenin, *in* Boule, Types du Prodr. de Paleont., p. 165, pl. 8, figs. 10, 11; pl. 9, fig. 1.
1908. *Monticulipora mammulata* d'Orbigny, Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., pp. 859-862, pl. 21, figs. 1-1c; pl. 31, figs. 1, 1a.
1953. *Monticulipora mammulata* d'Orbigny, Bassler, Treatise Inv. Paleont., part G (Bryozoa), pp. G94-95, figs. 55/1a-d.
1966. *Monticulipora mammulata* d'Orbigny, Boardman & Utgaard, Jour. Paleont., pp. 1093-1096, pl. 133, figs. 1-3; pl. 134, figs 1-3.

Description. — Zoaria massive, frondose or frondo-ramose; rare branches on massive proximal ends of frondose zoaria circular to subcircular in cross-section. Zoarial surface covered by sharply conical to blunt monticules, closely spaced; some adjacent monticules coalesced.

Wall in endozone and exozone indistinct; endozone-exozone boundary obscure.

Zooecia in endozone even-sided, flaring distally and continuing for appreciable lengths before budding new zooecia; sub-rounded to slightly elliptical in cross-section.

Zooecia in exozone commonly initiated considerable distance proximally from zooecial bend; a few zooecia bud within mid-exozone; zooecial openings polygonal to sub-rounded in cross-section.

Diaphragms abundant in endozone as well as exozone; closely spaced, planar, very thin.

Cystiphragms present in many zooecia in both endozone and exozone; occurring as overlapping series; diaphragms commonly connect the cystiphragm to opposite walls; most distal relative to zoarium.

Mesopores commonly initiated in zone of zooecial bend; many continue to increase in diameter until crowded out by zooecia near zoarial surface; a few short mesopores initiated and terminated in mid-exozone.

Acanthopores rare to common, small in diameter; lumen distinct to obscure; size variation mainly due to lumen component.

Wall indistinctly laminate; dark granular material irregularly distributed; diaphragm-wall units obscure.

Monticules composed of clusters of mesopores and distinct darker and thicker walls; laminae in thicker walls also obscured; cystiphragms commonly oriented with zooecial opening away from center of monticule. Megazooecia immediately around cluster of mesopores larger than intermonticular zooecia.

Remarks. — See Table 12 for quantitative data and Table 1 for distribution and abundance data. Nicholson (1874, 1879, 1881) and Ulrich (1882a) presented conflicting interpretations of *Monticulipora mammulata* d'Orbigny and *Chaetetes decipiens* Röminger. One reason for this was the unavailability of the primary type material. Hence *M. mammulata* was based on comparisons of secondary material with published external characters. Ulrich's (1882a, pp. 130-134) careful analysis showed that Nicholson consistently misidentified *Monticulipora (Heterotrypa) mammulata* Nicholson (= *Monticulipora frondosa* d'Orbigny) and *Monticulipora (Peronopora) frondosa* Nicholson (= *Chaetetes decipiens* Röminger).

Utgaard and Boardman (1965, p. 118) summarized the history of generic and specific assignments used by Nicholson and Ulrich. These authors' petition to ICZN (answered in ICZN, 1968, Opinion 838) fixed the generic concepts through establishment of *Monticulipora frondosa* d'Orbigny as the type species of *Heterotrypa,* and *Chaetetes decipiens* Röminger as the type species of *Peronopora,* both now accepted usage.

My work shows that *Monticulipora (Peronopora) molesta* [*sensu* Nicholson] is not a *Monticulipora* but a *Peronopora* [*sensu* Ulrich and of modern usage].

Table 12. — Quantitative data, *Monticulipora mammulata* d'Orbigny

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.16-.25	.187	.0004	.02	10.7	15	150
	(b)	.18-.22	.187	.00021	.015	7.75	15	150
Max. dimension of mesopores	(a)	.03-.12	.08	.0076	.087	111	15	75
	(b)	.04-.11	.08	.00027	.016	20.6	15	75
Max. dimension of megazooecia in exozone	(a)	.21-.38	.232	.0036	.05	25.8	15	75
	(b)	.22-.32	.246	.00074	.027	11.1	15	75

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Ulrich (1882b, pp. 234-236) accepted Nicholson's assignment of the new species *Monticulipora (Peronopora) molesta,* to the genus *Monticulipora.* At the same time, Ulrich seemed to be impressed by differences in the growth habit and consequently suggested that

> Nicholson's name *molesta* be retained as a varietal designation for the frondescent examples of this species, *Monticulipora mammulata,* as some title by means of which it may be distinguished from the massive and lobate examples.

Nickles (1902) apparently chose to recognize *M. molesta* Nicholson as a distinct species and designated one of his new stratigraphic members, the Bellevue, as the *M. molesta* beds because of the alleged abundance of this species. He apparently misidentified *Heterotrypa frondosa* (see Nature of the Bellevue Limestone).

Cumings (1908, p. 802), referring to a thin-section photograph of d'Orbigny's type of *M. mammulata,* commented:

> The type as figured is the ramose form, to which, according to Ulrich's suggestion, we should apply the varietal name *molesta.* In view of this last fact it would seem to be best to either discard the name *molesta* or apply it rather to the massive form.

Nicholson (1881, p. 224) characterized *M. molesta* as "frondescent and undulating lobed or palmate expansions . . . rarely the corallum is massive."

That Nicholson was alluding to what is today assigned to *Peronopora* is clearly indicated by his statement that

> The normal mode of growth in *M. molesta* is certainly that of an expanded frond, composed of two strata of corallites, which diverge in opposite directions from an imaginary mesial plane to open on the two flat surfaces of the expansions.

The accompanying illustrations (pl. 6, figs. 2-2d) show two exteriors and additional internal characters. His figure 2 is of a large frondose zoarium showing a distinct, though discontinuous, median layer. This layer is not unlike that of *Monticulipora (Peronopora) frondosa* (= *Chaetetes decipiens* Röminger; now also referred to *Peronopora*) shown on plate 5, figure 5a. It may be, as is not uncommon in the species, that Nicholson's specimen actually showed a discontinuous median layer.

The external morphology of *M. mammulata* d'Orbigny has been variously and erroneously interpreted by many authors. In addition Nicholson misidentified as *Monticulipora (Peronopora)* *molesta* a *Peronopora* of modern usage. This observation needs to be checked and confirmed if and when Nicholson's type material is located.

The Bellevue monticuliporas, both frondose and ramose forms, are here referred to *M. mammulata* because the two habits intergrade. The Bellevue beds are not typified by *M. molesta.* Even supposing this name could apply to frondescent forms, these are not especially characteristic of the unit.

PARVOHALLOPORA, n. gen.

Type species. — *Monticulipora ramosa* d'Orbigny, 1850.

This species is chosen as the type of the genus because it is most familiar and perhaps the most abundant of all the species. The long species synonymy attests to this.

Definition. — Zoaria ramose. Zoarial surface smooth or with regularly spaced monticules. Exozone well developed. Zooecial surface-angle sharp. Zooecia in endozone polygonal in cross-section, in exozone polygonal or circular to subcircular. Diaphragm-zooecial lining unit present in many species. Laminae in ZCL merging, broad U- to V-shaped, distinctly dark at their proximal parts. Diaphragms in zooecia in endozone, absent in exozone of some species. Diaphragms planar or curved but rarely cystose. Mesopores abundant between most zooecia, rounded to subrounded, rarely polygonal in cross-section, always less than half the diameter of zooecial openings. Diaphragms in mesopores, planar to curved, forming short diaphragm-wall units.

Minimum geological range. — Upper Ordovician.

Remarks. — The genus *Hallopora* of authors (e.g., Bassler, 1953, p. G112) includes a morphologically heterogeneous group of species that range in age from Ordovician through Devonian. This halloporoid complex can be characterized by the presence of diaphragms both in the endozone and exozone, closely-spaced diaphragms in the early part of the zooecia and fewer in the distal part in the endozone, numerous mesopores, rounded cross-sectional shape of the zooecia in the exozone, and the absence of acanthopores.

Bassler (1911, pp. 334, 335) characterized the type species of *Hallopora, Chaetetes elegantula,* by the presence of "ornamental covers that close the diaphragms" (fig. 210f), features that Hall thought taxonomically unimportant in his original definition of the species. Bassler (1953, p. G112, fig. 741e) used these as characters to define *Hallopora,* as follows:

> Ramose, intertwined branches may form clumps 30 cm wide. Zooecial apertures commonly closed by ornamental perforate covers which become diaphragms when left behind during growth.

Ross (1969) mentioned this as a valid character but did not illustrate its presence in the type material that she studied. An examination of a *C. elegantula* collection from Rochester, NY, in the National Museum of Natural History, showed that only a few specimens possess this structure. Another one of the two specimens from Lockport, New York (at Northern Kentucky University, supplied by Ward's Natural Science Establishment, Rochester, New York) showed this structure also. But because it is present in only a few zoaria this character does not seem to be of taxonomic value even at the species level. Determination of its biological significance awaits further study. A study of sectioned topotype material of *C. elegantula* and related forms in the National Museum of Natural History collections from the Waldron Shale (Middle Silurian) of Ohio, suggests that this group is distinctive, and is unrelated generically to the Bellevue material and most of the Upper Ordovician forms now referred to the genus *Hallopora.* Hence, the new genus *Parvohallopora* is proposed here to accommodate the Upper Ordovician halloporas.

A literature analysis and study of the collections in the National Museum of Natural History indicates that most of the Ordovician species of *Hallopora* are referrable to *Parvohallopora.* A notable exception is an undescribed halloporid species from Wilmington, Illinois (Richmond), that appears intermediate between the two genera.

Parvohallopora is easily distinguished from *Hallopora* by the following characteristics:

1. Zooecia of smaller diameter than in *Hallopora.*
2. Absence of mural spines in the zooecia. *H. elegantula* has numerous mural spines in the zooecia.
3. Numerous small mesopores between most zooecia, that commonly are less than half the diameter of the zooecia. *Hallopora* is characterized by large polygonal mesopores.
4. Zooecia that in the endozone are polygonal in cross-section. In *Hallopora* the zooecia in the endozone are circular to subcircular in cross-section.

5. Cystose diaphragms are rare to absent in the zooecia and absent in the mesopores of *Parvohallopora*. Both mesopores and zooecia in *Hallopora* are characterized by numerous cystose diaphragms.
6. Laminae in the ZCL of adjacent zooecia are broadly U - V shaped. Laminae in *Hallopora* are generally distinctly V-shaped.

Parvohallopora ramosa (d'Orbigny) Pl. 41. figs. 1-3, 4a-4c; Pl. 42, figs. 1, 2, 3a-3c; Pl. 43, figs. 1a-1c, 2, 3

1850. *Monticulipora ramosa* d'Orbigny, Prodr. de Paleont., vol. 1, p. 25.
1851. *Chaetetes ramosus* (d'Orbigny), Milne-Edwards & Haime, Mono. Pol. Foss. Terr. Palaeozoiques, vol. 5, p. 266, pl. 19, figs. 2, 29.
1851. *Chaetetes rugosus* Milne-Edwards & Haime, Mono. Pol. Foss. Terr. Palaeozoiques, vol. 5, p. 268, pl. 20, figs. 6, 6a.
1851. *(non) Chaetetes dalii* Milne-Edwards & Haime, Mono. Pol. Foss. Terr. Palaeozoiques, vol. 5, p. 266, pl. 19, figs. 6, 6a.
1874. *Chaetetes dalei* Nicholson, Geol. Soc. London, Quart. Jour., vol. 30, p. 503, pl. 29, figs. 5, 5b.
1874. *Chaetetes rugosus* Milne-Edwards & Haime, Nicholson, Geol. Soc. London, Quart. Jour., vol. 30, p. 502, pl. 29, fig. 2.
1874. *Chaetetes pulchellus* Nicholson, Geol. Soc. London, Quart. Jour., vol. 30, p. 502, pl. 29, fig. 2.
1875. *Chaetetes pulchellus* Nicholson, Nicholson, Pal. Ohio, vol. 2, p. 195, pl. 21, figs. 5, 5a.
1875. *Chaetetes rugosus* Milne-Edwards & Haime, Nicholson, Pal. Ohio, vol. 2, p. 193, pl. 21, fig. 2.
1875. *Chaetetes dalei* Nicholson, Nicholson, Pal. Ohio, vol. 2, p. 192, pl. 21, fig. 1a.
1876. *Chaetetus rugosus* Milne-Edwards & Haime, Nicholson, Ann. Mag. Nat. Hist., ser. 4, vol. 18, p. 87, pl. 15, fig. 4.
1878. *Monticulipora rugosa* (Milne-Edwards & Haime), Dybowski, Chaetetiden der Silur- Formation, p. 92, pl. 3, fig. 1.
1879. *Monticulipora ramosa* d'Orbigny, Nicholson, Tabulate Corals Paleozoic Period, p. 274, fig. 35b.
1879. *Monticulipora (Heterotrypa) ramosa* (d'Orbigny), Nicholson, Tabulate Corals Paleozoic Period, p. 296, pl. 13, figs. 2, 2a.
1881. *Monticulipora (Heterotrypa) ramosa* (d'Orbigny), Nicholson, Genus *Monticulipora,* p. 110, fig. 18, pl. 2, figs. 2, 2a.
1881. *Monticulipora ramosa* d'Orbigny var. *rugosa* (Milne-Edwards & Haime), Nicholson, Genus *Monticulipora,* pp. 113-115, figs. 19a-b, pl. 2, fig. 3.
1881. *Monticulipora (Heterotrypa) andrewsi* Nicholson, Genus *Monticulipora,* pp. 128-131, figs. 21a-d, pl. 5, figs. 1, 1a.
1883. *Chaetetes dalei* Nicholson, Hall, Indiana Geol. Nat. Hist., 12th Ann. Rept., p. 249, pl. 11, fig. 2.
1889. *Callopora? (Heterotrypa) rugosa* (Milne-Edwards & Haime), Nicholson, Manual Paleont., p. 347, fig. 224b.
1889. *Monticulipora ramosa* d'Orbigny, Miller, North American Geol. Paleontology, p. 197, fig. 198.
1890. *Callopora ramosa* (d'Orbigny), Ulrich, Geol. Surv. Illinois, vol. 8, pp. 3, 15, fig. 5b.
1906. *Monticulipora ramosa* d'Orbigny, Thevenin *in* Boule, Ann. de Paleont., vol. 1, p. 166, pl. 9, figs. 5-8.
1908. *Callopora ramosa* (d'Orbigny) var. *rugosa* (Milne-Edwards & Haime), Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., pp. 793-795, pl. 10, fig. 2, pl. 2; pl. 27, figs. 14, 14a.
1912. *Callopora ramosa* (d'Orbigny), Cumings, Geol. Soc. America, Bull. 23, pl. 20, fig. 16; pl. 22, fig. 28.

1913. *Hallopora ramosa* (d'Orbigny), Bassler *in* Zittel-Eastman, Textbook Paleont., p. 337, fig. 490.
1915. *Hallopora ramosa* (d'Orbigny), Cumings & Galloway, Geol. Soc. America, Bull. 26, pl. 14, fig. 44.
1931. *Hallopora ramosa* (d'Orbigny), McFarlan, Geology of Kentucky, p. 107, pl. 13, fig. 3.
1931. *Hallopora rugosa* (Milne-Edwards & Haime), McFarlan, Geology of Kentucky, p. 108, pl. 13, fig. 2.
1944. *Hallopora rugosa* (Milne-Edwards & Haime), Shimer and Shrock, Index Fossils North America, p. 261, pl. 99, fig. 5.
1953. *Hallopora ramosa* (d'Orbigny), Bassler, Treatise Inv. Paleont., pt. G (Bryozoa), fig. G742.
1961. *Hallopora ramosa* (d'Orbigny), Caster, Dalvé & Pope, Cincinnati Mus. Nat. Hist., pl. 4, figs. 14, 15.
1961. *Hallopora rugosa* (Milne-Edwards & Haime), Caster, Dalvé & Pope, Cincinnati Mus. Nat. Hist., pl. 4, fig. 16.

Description.—Zoaria ramose, only conspecific incrustations. Branches circular to subcircular in cross-section; bifurcating at 60-75°, at intervals of 1-4 cm. Zoarial surface completely covered by monticules. Monticules show gradation between isolated, regularly spaced conical protuberances that are rounded or blunt at their tips, to transversely oriented ridges, partly or completely encircling zoarial branches.

Wall commonly attains maximum thickness in early exozone; irregular thickenings in exozone common.

Zooecia in endozone parallel-sided, proximally gradually expanding conical, attaining maximum width within a distance of less than 1.5 mm; walls even, except near zooecial bend, may be slightly wavy; polygonal outline in cross-section; smaller zooecia representing proximal portions.

Zooecia in exozone usually initiated only slightly proximal to zooecial bend; zooecial openings circular to subcircular in cross-section.

Diaphragms common in endozone, closely-spaced in exozone (resultant living chamber short), usually absent in zooecial bend zone; planar, rarely slightly inclined or curved.

Mesopores initiated from almost mid-endozone to early exozone; most terminate in mid-exozone; circular to subciricular in cross-section; slightly elongated mesopores have rounded outline; one to several mesopores between adjacent zooecia which, due to shape and distribution, do not give appearance of space-fillers.

Walls composed of diaphragm-zooecial lining units; zooecial lining approximately equal in thickness to diaphragms, distally becoming slightly thicker because lining from proximal units may continue distally for some distance before merging with ZCL. Laminae U- to V-shaped; proximal zone of laminae darker in color. Abutting of proximal zones of lamina, seen in longitudinal and transverse orientation, resulting in formation of almost continuous irregular black line or narrow zone with occasional breaks where laminae from zooecial lining interfinger.

Monticules variably composed: wall thickening with irregular wall lamina most common; clusters of mesopores and slightly larger (size in cross-section same as zooecia in intermonticular areas) zooecia less common.

Remarks. — See Table 13 for quantitative data and Table 1 for distribution and abundance data. Since the types of *M. ramosa* have never been adequately studied, it has been necessary to re-examine the concept of the species described by d'Orbigny (1850, p. 25) as:

> *Ceriopora ramosa* Readle (envoye sous ce nom). Espece remeuse dont les branches sont rondes. Etats Unis, Cincinnati, Ohio (Blue lime).

Apparently Readle never published the species as all attempts to locate such a publication have been unsuccessful. Thevenin (1906, p. 166) reported that Readle introduced the name in a manuscript that was never published.

Thevenin (1906) in a restudy of d'Orbigny's collection in the Muséum national d'Histoire naturelle (Paris), figured one specimen of *M. ramosa.* Two illustrations are external views (pl. 9, fig. 5, natural size, and fig. 7, enlarged). The only other illustration is a transverse section made from this specimen. These illustrations clearly show the gross superficial nature of the specimen. Monticules are regularly spaced on the zoarial surface. A slight transverse elongation of the monticules results in what authors have termed "rugosity."

Milne-Edwards and Haime (1851) redescribed the species as a *Chaetetes* but again illustrated only the external morphology. These authors also introduced a new species, *Chaetetes rugosus,* also illustrated only by its external morphology. This species showed transverse fusion of the monticules resulting in almost complete encirclement of the zoarial surface by the monticules.

Ever since, this monticular character has been the sole criterion by which many authors have separated the two species. Except

Table 13. — Quantitative data, *Parvohallopora ramosa* (d'Orbigny)

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.12-.25	.19	.0007	.027	14.2	24	240
	(b)	.15-.22	.19	.00026	.016	8.53	24	240
Max. dimension of mesopores	(a)	.02-.15	.07	.00098	.031	44.8	24	240
	(b)	.06-.10	.07	.00022	.015	21.3	24	240
Diameter of zoaria		3.3-9.2	—	—	—	—	24	24

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Nicholson (1881) and Cumings (1908), most workers have considered the two species "natural." These authors considered *C. rugosa* to be a variety of *C. ramosa.* Both Nicholson (pl. 2, figs. 2, 2a, 3) and Cumings (pl. 27, figs. 13, 13a, 14, 14a) showed the extremes in the development of the monticules to illustrate the two forms, realizing that intermediate forms occurred.

A large collection from the Bellevue shows that the monticules grade from simple cones to transverse ridges with all stages in between. Not uncommonly this gradation can be seen on a single zoarium (Pl. 41, fig. 2). In fact it is a rare zoarium of any completeness that does not show some elongation of the monticules. The internal morphology is consistent and unrelated to the configuration of monticules. Moreover, the monticular zooecia in either species are quantitatively indistinguishable from intermonticular zooecia, in cross-sectional shape or other morphological features.

In collections which probably came from the Corryville shale, some comparatively complete colonies show uniform development of "rugosity." Since they show no astogenetic progression it would seem that the "rugosity" was probably environmentally controlled. Conditions favorable to the development of rugose monticulation must have been spatially random or restricted, because the completely rugose forms occur in an approximately 1:25 ratio in museum collections.

Slight elongation of monticules is not uncommon in associated *Heterotrypa frondosa.*

Therefore, *C. rugosus* appears to be an ecotypic expression of a single species for which the valid name is *C. ramosus.*

As is evident from the synonymy, the external characters of the species have been illustrated satisfactorily. As *C. ramosus* is abundant and distinctive, confusion with other forms is unlikely. In spite of the absence of type material for comparison, the concept of the species as commonly used is clear.

Monticulipora andrewsi seems to be a junior subjective synonym. Nicholson's original description of this form is highly generalized and in spite of his assertion that this species can be distinguished from *P. ramosa,*

> not only by the marked difference in their external characters, but also by numerous more or less important features in their internal structure,

it is impossible to do so. Particularly so, because the only external features that Nicholson thought distinctive (poorly developed monticules) were completely gradational with the regular conical monticules typically developed in *P. ramosa.*

Parvohallopora laevigata, n. sp. Pl. 38, figs. 1a-1f; Pl. 39, figs. 1a-1e; Pl. 40, figs. 1a-1d, 2

Etymology. — The species name reflects the paucity of diaphragms in the exozone.

Description. — Zoaria ramose, only conspecific incrustations. Branches circular to subcircular in cross-section, bifurcating at 60-70° at intervals of 1-3 cms. Zoarial surface smooth or covered by short knobby monticules. Wall thickenings clearly seen in center of monticules; rarely noticeable elsewhere.

Wall commonly attaining maximum thickness in mid-exozone; irregular thickenings rare in exozone.

Zooecia in endozone parallel-sided, proximally rapidly expanding conical; attaining maximum width within a distance of less than 0.5 mm; walls even; polygonal in outline in cross-section; smaller zooecia representing proximal portions.

Zooecia in exozone usually initiated some distance proximal to zooecial bend; zooecial openings circular to subcircular in cross-section.

Diaphragms rare in zooecia, commonly absent in a zooecium, but up to three may be present in exozone so that last living chamber is long; proximally several closely spaced diaphragms may be present.

Mesopores initiated in endozone; most continue to or near zoarial surface; attaining maximum width near zone of initiation and usually maintaining this width; circular to subcircular, rarely slightly polygonal in cross-section, one to several between adjacent zooecia; due to shape and distribution do not give appearance of space-fillers.

Wall composed of diaphragm-wall and independent wall units. Laminae broad to narrow, convex; continuous across ZCL; darker proximally, making central part of ZCL light-colored.

Monticules in longitudinal orientation composed of short zooecia; laminar arrangement irregular; walls usually thicker and darker. In tangential orientation monticules distinguished only by slight thickening of wall and irregular laminae arrangement.

Remarks. — See Table 14 for quantitative data and Table 1 for distribution and abundance data.

UCM 40351 is here designated the holotype (Pl. 38, figs. 1a-1f) and UCM 40352-40354 are designated the paratypes (Pls. 39, 40).

P. laevigata is distinguished from *P. ramosa* by its normal lack of diaphragms and diaphragm-zooecial lining units in the exozone, and its fewer and more erratically-spaced diaphragms in the distal portion of the zooecia in the endozone. Individual wall units in *P. laevigata* are also thinner and uniform in thickness. *P. laevigata* is known only from the Bellevue limestone.

Genus **PERONOPORA** Nicholson, 1881

Type species. — *Chaetetes decipiens* Röminger, 1866; subsequent designation by Utgaard and Boardman, 1965. Designated by the ICZN (1968, Opinion 838).

The definition of the genus as given by Boardman and Utgaard (1966, p. 1096) is accepted and followed here.

Peronopora decipiens (Röminger) Pl. 44, figs. 1a-1d, 2; Pl. 45, figs. 1a-1e

1866. *Chaetetes decipiens* Röminger, Acad. Nat. Sci., Philadelphia, Proc., p. 115.
1881. *Monticulipora (Peronopora) frondosa* Nicholson, Genus *Monticulipora,* p. 216, figs. 46, 47; pl. 5, figs. 4, 4a, 5, 5a.
1966. *Peronopora decipiens* (Röminger), Boardman & Utgaard, Jour. Paleont., vol. 40, pp. 1097-1099, pl. 135, fig. 1; pl. 136, figs. 1, 2.

Description. — Zoaria frondo-bilaminate, conspecific incrustations common; fronds irregularly developed, diverging from 70-90°; width of fronds ranges from 1.5 to 3 cm, thickness from 1 to 7 mm. Zoarial surface smooth to uniformly covered by low broad monticules.

Median layer distinctly developed, dark, variable in thickness, locally absent; short minute, discontinuous tubes aligned in direction of growth locally separate median layer into two dark, thick laminae.

Zooecia in endozone typically polygonal in cross-section; budding commonly opposite, on either side of median layer; most zooecia continuing to zoarial surface without budding of subsequent zooecia; zooecial opening circular to subcircular in cross-section.

Table 14. — Quantitative data, *Parvohallopora laevigata* n. sp.

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.15-.29	.197	.0014	.038	19.1	20	200
	(b)	.18-.23	.199	.0003	.017	8.46	20	200
Max. dimension of mesopores	(a)	.03-.18	.079	.0011	.034	42.7	20	200
	(b)	.06-.13	.078	.00045	.021	27.2	20	200
Diameter of zoaria		3.7-8.3	—	—	—	—	19	19

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Diaphragms rare (0-5), commonly restricted to early exozone (living chamber long); occasional diaphragm in outer exozone; planar, uniform in thickness.

Cystiphragms in continuous overlapping series, extending uninterruptedly from near junction with median layer to near zoarial surface; uniform in size, usually less than half-width of zooecia; invariably restricted to distal (of zoarium) parts of zooecia; connecting diaphragms not at junction of cystiphragms.

Mesopores commonly initiated in zones of zooecial bend, close to median layer, rarely in mid-exozone; most attain maximum width near zone of initiation, rarely pinched out in mid-exozone; cystose diaphragms commonly developed in outer exozone; polygonal in outline, 0-2 between adjacent zooecia; shape and distribution giving attributes of space-fillers.

Acanthopores numerous, variable in size, mainly due to variation in thickness of laminated material; lumen uniformly minute, slightly inflecting walls.

Wall indistinctly laminate; in thicker wall units, laminae continuous across ZCL; broadly rounded to slightly angular in curvature; dark granular material in central part of wall.

Monticules variable in size and in arrangement of mesopores, megazooecia, acanthopores, and wall thickness; wall in center always thicker than in intermonticular areas; megazooecia always present.

Remarks. — See Table 15 for quantitative data and Table 1 for distribution and abundance data. The concept of this species follows that of Boardman and Utgaard (1966). They have sectioned, described, and illustrated the syntype suite (UMMP 6676) labelled, "Corryville Member of the McMillan Formation, Maysville Group, Upper Ordovician, at Cincinnati, Ohio." This label obviously is not the original made by Röminger, because these stratigraphic names were introduced much later. The stratigraphic assignment of the zoaria seems accurate, because a topotype suite (USNM 2014) from the Corryville beds in Cincinnati is considered to be conspecific by Boardman and Utgaard (1966, p. 1097) and is used as a basis for their species description.

For comparison with other species of *Peronopora* see *Remarks* under *P. dubia.*

Table 15. — Quantitative data, *Peronopora decipiens* Röminger

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.14-.22	.18	.0004	.02	10.6	16	160
	(b)	.16-.20	.18	.00018	.013	7.36	16	160
Max. dimension of mesopores	(a)	.03-.15	.08	.0011	.033	38.0	16	160
	(b)	.06-.10	.08	.00013	.011	14.2	16	160
Max. dimension of megazooecia in exozone	(a)	.20-.29	.25	.0011	.033	13.7	16	80
	(b)	.22-.27	.25	.00032	.018	7.14	16	80
Number of acanthopores in 1 mm square	(a)	14-44	23.4	46.10	6.79	29.0	16	80
	(b)	16-39	23.4	30.69	5.54	23.7	16	80
Width of zoaria		1.0-5.0	—	—	—	—	16	16

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Peronopora dubia (Cumings & Galloway) Pl. 46, figs. 1a-1e, 2a-2b

1913. *Peronoporella dubia* Cumings & Galloway, Indiana Dept. Geol. Nat. Res., 37th Ann. Rept., pp. 434-436, pl. 15, figs. 1-1f; pl. 16, figs. 1-1e; pl. 17, figs. 1-1c.

1966. *Peronopora dubia,* Boardman & Utgaard, Jour. Paleont., vol. 40, pp. 1100-1102, pl. 137, figs. 1-4.

Description. — Zoaria frondose-bilaminate, incrusting, including commonly conspecific overgrowths. Fronds irregularly developed, diverging from 70-90°; several mm in width; 0.9-6 mm in thickness. Zoarial surface smooth to uniformly covered by sharp, low monticules.

Median layer distinct, dark, uniformly thin; locally absent.

Zooecia in endozone four-sided to polygonal in cross-section; alternate budding on either side of median layer common; additional budding in zone of zooecial bend or later. Zooecial openings highly irregular in cross-section, amoeboid in shape.

Diaphragms restricted to endozone, 1-5, closely spaced (living chamber unusually long); planar, usually connecting wall with opposing cystiphragm.

Cystiphragms in continuous overlapping series, spatial distribution variable; can be absent in outer exozone; apparently uniform in size; invariably restricted to distal (of zoarium) parts of zooecia; connecting diaphragms joining junction of or any position on cystiphragms.

Mesopores commonly initiated near subsequent zooecial buds some distance from median layer; rarely initiated in mid-exozone; most attaining maximum width near zone of initiation, slightly wider towards zoarial surface; most reach zoarial surface; rounded, irregular in cross-section; unlike zooecia.

Acanthopores numerous, uniform in size; lumen distinctly minute; laminated zone slightly variable in size; not inflecting walls. Broken zooecia with distal hooked ends apparently rejuvenated.

Wall laminae apparently continuous across ZCL; laminae narrowly convex.

Monticules commonly composed of clusters of mesopores; rarely distinct megazooecia in center of mesopores.

Remarks. — See Table 16 for quantitative data and Table 1 for distribution and abundance data. Cumings and Galloway (1913) reported the species common in the Tanner's Creek railroad and borrow cuts, Indiana.

Table 16. — Quantitative data, *Peronopora dubia* (Cumings and Galloway)

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.15-.22	.19	.0007	.026	13.7	10	100
	(b)	.17-.20	.19	.00008	.009	4.75	10	100
Max. dimension of mesopores	(a)	.03-.15	.081	.0011	.033	40.8	9	90
	(b)	.07-.09	.082	.00009	.009	11.3	9	90
Max. dimension of megazooecia in exozone	(a)	.21-.32	.264	.0008	.028	10.6	10	50
	(b)	.23-.30	.262	.0007	.025	9.83	10	50
Number of acanthopores in 1 mm square	(a)	14-65	32.5	217.7	14.8	45.4	10	48
	(b)	17.4-54	32.5	201	14.2	43.6	10	48
Width of zoaria		1.6-6.0	—	—	—	—	9	9

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Cumings and Galloway erected the monotypic genus *Peronoporella* based on *P. dubia,* because of the supposedly consistent absence of a median lamina. Boardman and Utgaard (1966, p. 1097) did not consider the genus well conceived and assigned *Peronoporella* to *Peronopora.* As shown in illustrations in Boardman and Utgaard (pl. 137) and this report, the median lamina can be thin and locally may be absent.

P. dubia lacks tubes in the median planes of the median layer whereas *P. decipiens* shows local development of these tubes. *P. dubia* also has a thicker endozone and abundant acanthopores.

Genus **AMPLEXOPORA (?)** Ulrich

Amplexopora (?) filiasa (d'Orbigny) Pl. 47, figs. 1a-1d, 2; Pl. 48, figs. 1a-1e

1850. ?*Monticulipora filiasa* d'Orbigny, Prodr. de Paleont., vol. 1, p. 25.
1851. ?*Chaetetes filiasa* (d'Orbigny), Milne-Edwards & Haime, Mono. Pol. Foss. Terr. Palaeozoiques, vol. 5, p. 261.
1875. ?*Chaetetes filiasa* (d'Orbigny), Nicholson, Paleontology Ohio, vol. 2, p. 206.
1890. *Leptotrypa filiosa,* Ulrich, Geol. Surv. Illinois, vol. 8, p. 456, pl. 36, figs. 7, 7a.
1906. *Amplexopora filiosa* (Ulrich), Bassler, U.S. Nat. Mus., Proc., vol. 30, p. 12-13, pl. 3, figs. 1-3.
1908. *Amplexopora filiasa* (Ulrich "and other American authors") [not d'Orbigny], Cumings, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rept., p. 765, pl. 5, fig. 2; pl. 7, figs. 1-1b.

Description.—Zoaria massive, incrusting. Zoarial surface covered by regularly spaced, prominent monticules.

Zooecia progressing from endozone into exozone without any angular change. Exozone distinguishable from endozone by slightly thicker walls and closer spacing of diaphragms. Many endozones and exozones developed in a zoarium.

Zooecia uniformly even-sided throughout, unusually long compared to other Ordovician trepostomes; new zooecia budded irregularly throughout; zooecial openings distinctly polygonal in cross-section, subrounded in thicker wall zones.

Diaphragms abundant throughout, uniformly spaced within each zooecium and more or less uniformly aligned in zooecia; about three times as many per unit length in exozone as in endozone; spacing in different zones remarkably uniform; diaphragms uniformly thick, planar, rarely inclined; forming commonly indistinct diaphragm-zooecial lining units; cystose diaphragms rare.

Mesopores absent.

Acanthopores abundant, mostly developed at zooecial corners; uncommon between zooecial corners; uniform in size; lumen rarely distinct.

Wall laminae distinct, sharply to broadly V-shaped, continuous across ZCL; darker in central part of ZCL.

Monticules composed of clusters of megazooecia with wall laminae of a distinctly different orientation; some acanthopores between zooecial corners.

Remarks. — See Table 17 for quantitative data and Table 1 for distribution and abundance data. The species is doubtfully referred to *Amplexopora* pending further work on the original types. A new generic name would eventually be appropriate for this unusual species.

The species was originally described by d'Orbigny (1850, p. 25) as:

> *Monticulipora filiasa,* d'Orb., 1848 [*sic.*] *Favosites filiasa,* Readle (envoyee ce nom) Etats-Unis, Kentucky Frankfort, Cincinnati, Ohio (Blue Lime).

As indicated above (under *Monticulipora mammulata*) many of the names which Readle had employed in labeling his collection (examined by d'Orbigny) were never published.

Subsequent descriptions of the species by Milne-Edwards and Haime (1851) and Nicholson (1875) are also too generalized to aid in establishing the morphologic basis of the species.

It was not until Ulrich's (1890) documentation of the internal and external morphological characteristics that the species as is known presently was recognized. Whether Ulrich's material was conspecific or even congeneric with d'Orbigny's material must await discovery and re-evaluation of the types. Ulrich altered the spelling of the species name without explanation. Ulrich alluded to the massive nature of the large colonies. He also pointed out the most important distinguishing characters of the species:

> Many successive mature and immature exozone and endozone regions may be observed upon some specimens, the tubes usually being continuous without zooecial bend throughout the zoarium.

Bassler (1906) and Cumings (1908) similarly identified their material and the latter author specifically attributed the authorship of the species to Ulrich.

Table 17. — Quantitative data, *Amplexopora* (?) *filiasa* (d'Orbigny)

Character		Range	Mean	S^2	S	V	Zoaria measured	Total Measurements
Max. dimension of zooecial openings	(a)	.15-.26	.208	.0016	.04	19.3	7	70
	(b)	.16-.24	.21	.00087	.030	14.1	7	70
Max. dimension of megazooecia in exozone	(a)	.19-.42	.302	.0025	.05	16.7	7	35
	(b)	.22-.38	.308	.0023	.048	15.7	7	35
Number of acanthopores in 1 mm square	(a)	0-30	12.4	46.60	6.83	54.9	7	35
	(b)	4.6-22	13.6	31.89	5.65	41.6	7	35

(a) data from all zoaria; (b) data from zoarial means.
S^2 = Variance; S = Standard deviation; V = Coefficient of variation.
All measurements are in mm. See Table 1 for number of zoaria measured from each locality.

Bassler assigned the species to *Amplexopora* because of the presence of a central black line separating the walls of adjoining zooecia. Thus he differentiated it from the closely related *Cyphotrypa,* that Bassler characterized as having amalgamate zooecial walls. The forms here referred to *A. (?) filiasa* show laminae that are continuous across the ZCL, whereas laminae in *Amplexopora* abut along a dark surface in the ZCL. It may be that the Bellevue material described here is not conspecific with all the material studied by Bassler from the Fairmount, Bellevue, and Corryville Members. Under the circumstances the generic assignment and the authorship of the species is in doubt.

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PLATES

Thin-sections, "peels" and unprepared zoaria illustrated in the following plates are deposited in the Department of Geology Museum, University of Cincinnati; herein abbreviated to UCM. Separate UCM numbers are assigned to all zoaria; all thin-sections made from a single zoarium are given one UCM number.

Illustrations from each zoarium are identified by separate numbers in plates and plate descriptions.

Stated magnifications in the following section should be multiplied by 0.88 to produce true magnifications.

EXPLANATION OF PLATE 16

Figure		Page
1.	**Amplexopora cingulata** Ulrich	189

Thin-sections of zoarium (monticules low on zoarial surface); Loc. 7; UCM 40313.

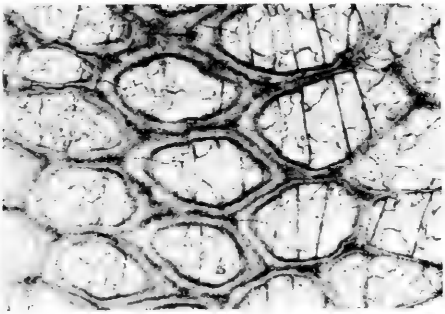
1a. Oblique longitudinal view of exozone showing continuous median layer, locally not developed; closely spaced thin diaphragms; × 40.

1b. Transverse view of exozone showing continuous median layer, infrequent cystose diaphragms; × 40.

1c. Tangential view showing cluster of megazooecia forming a monticule, in upper portion. Acanthopores are angular in cross-section; dark median wall layer is only locally continuous; × 40.

1d. Longitudinal view of wall with a continuous irregular and granular median layer. Diaphragm-zooecial lining unit developed on right side and absent distally. The diaphragms are dark in color along their planar extent and for some distance distally; × 250.

1e. Tangential view of single zooecium showing minute lumen of acanthopores at corners, and the discontinuous dark median wall layer. Distinct but thin zooecial lining developed; × 250.



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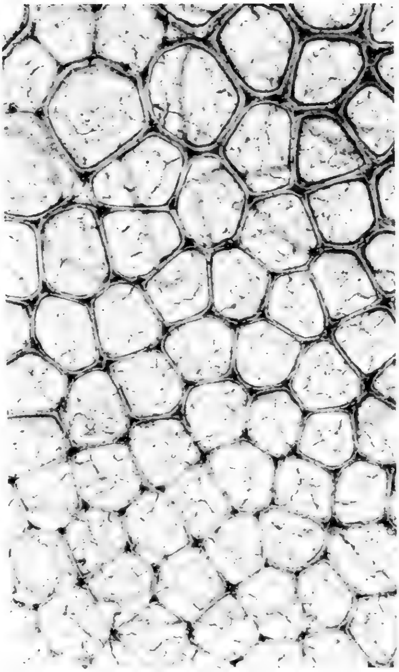

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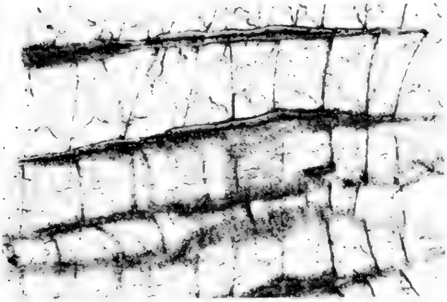

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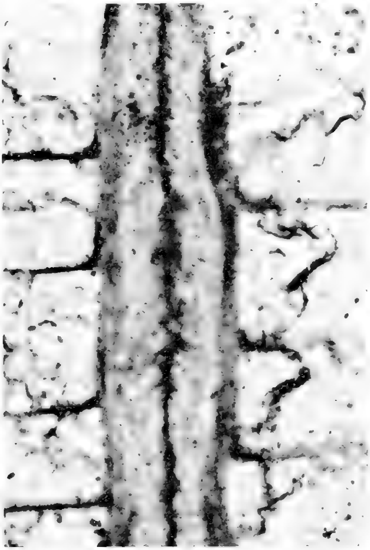

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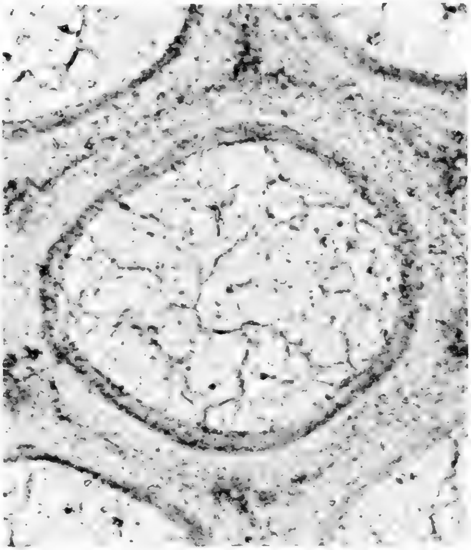

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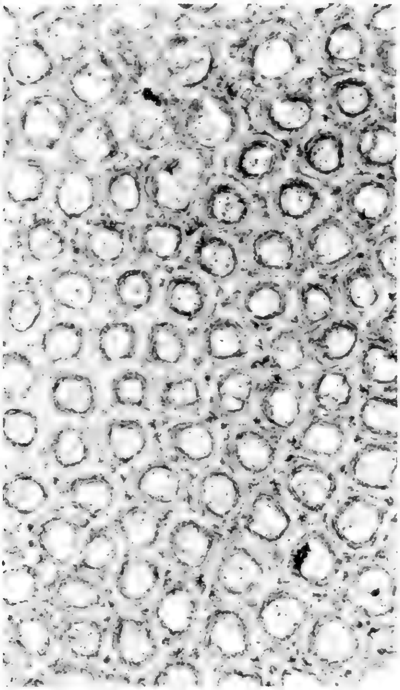

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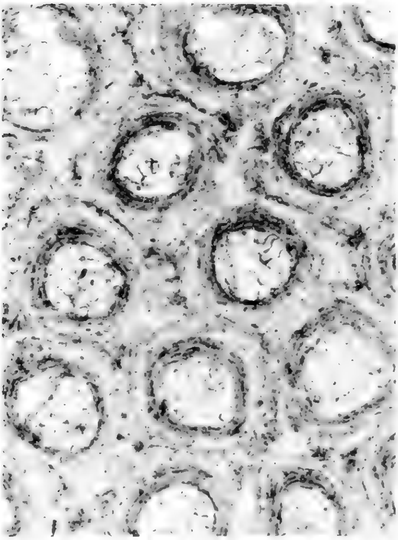

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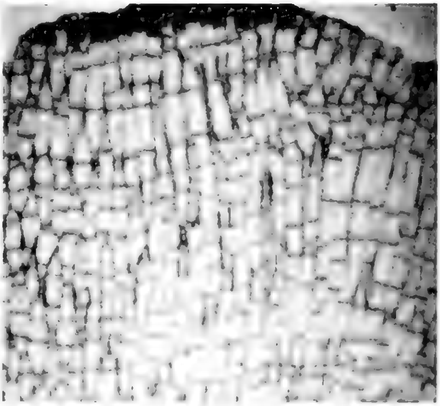

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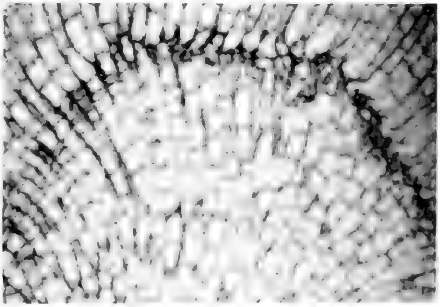

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EXPLANATION OF PLATE 17

Figure		Page
1.	**Amplexopora cingulata** Ulrich	189

Thin-sections of zoarium (monticules low on zoarial surface); Loc. 12; UCM 40314.

1a. Tangential view showing thick walls, locally continuous median layer, cluster of megazooecia in upper portion; × 40.

1b. Tangential view showing development of zooecial lining; × 100.

1c. Transverse view of wall showing irregular, locally discontinuous and granular nature of dark median wall layer. Wall darker adjacent to zooecial openings where laminae are not bent; × 400.

2.	**Amplexopora robusta** Ulrich	192

Thin-sections of zorium (zoarial surface smooth); Loc. 1; UCM 40315.

2a. Longitudinal view of distal growing zone; × 10.

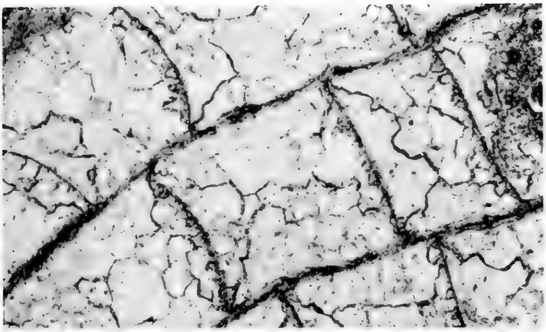
2b. Longitudinal view of proximal portion showing abandoned discontinuous growing zone. Several zooecia on left side pass on uninterruptedly, whereas on right side new zooecia appear to bud off the growing surface. The endozone shows the typical development of abundant diaphragms; × 10.

EXPLANATION OF PLATE 18

Figure		Page
1, 2.	**Amplexopora robusta** Ulrich	192

Thin-section of zoarium (zoarial surface smooth).

1. Loc. 1; UCM 40315.
    - 1a. Tangential view showing thick walls below and thin walls above. Some zooecia four-sided; × 40.
    - 1b. Longitudinal view of part of exozone showing thin walls; discontinuous but prominent dark median wall layer; × 100.
    - 1c. Tangential view showing mostly continuous dark median wall layer; × 100.
2. Loc. 12; UCM 40316.
    - 2a. Longitudinal view of exozone (left) and endozone. Diaphragms closely spaced in exozone; many cystose diaphragms developed; × 40.
    - 2b. Longitudinal view of wall showing both diaphragm wall and independent wall units. Dark median wall layer is irregular but well-developed. Laminae are locally convex and continuous across zone of curved laminae (ZCL); × 250.



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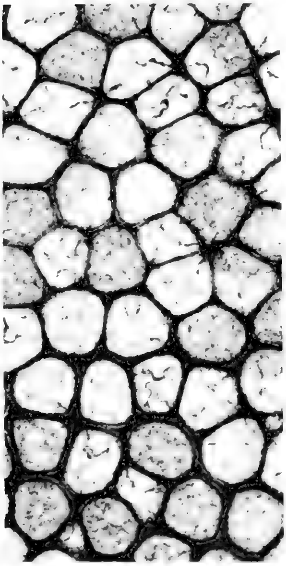

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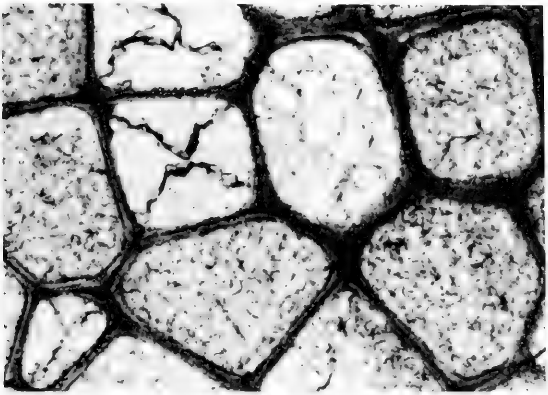

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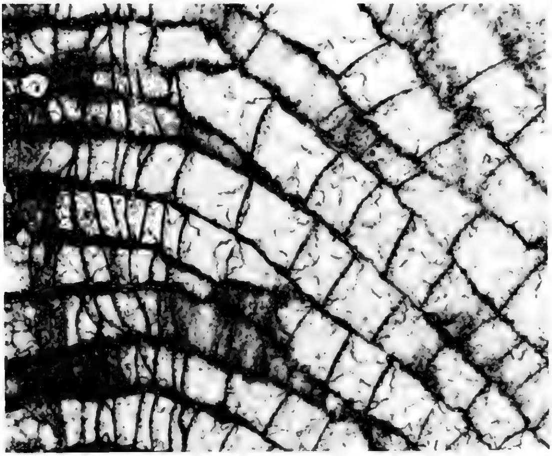

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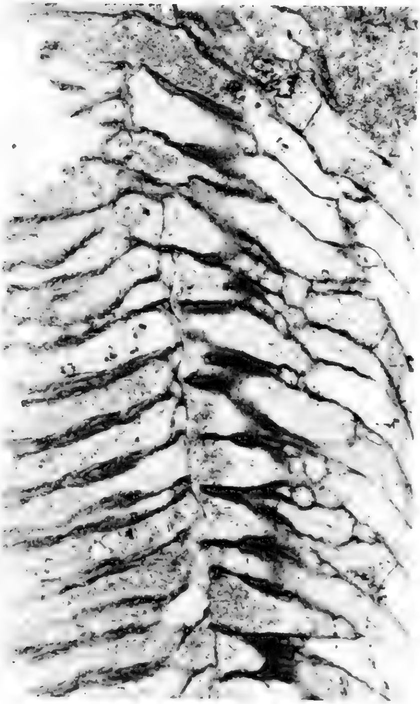

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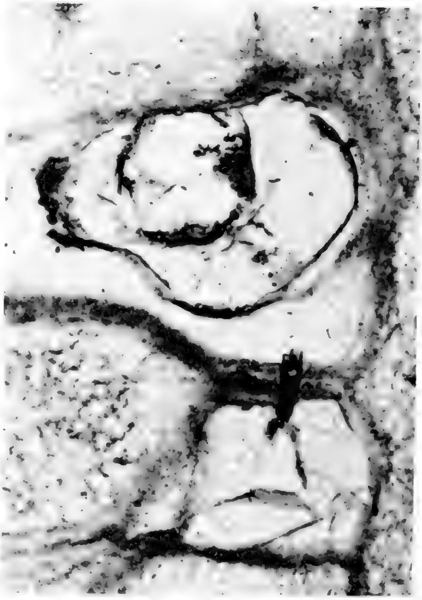

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EXPLANATION OF PLATE 19

Figure Page

1, 2. **Batostomella gracilis** (Nicholson) 196

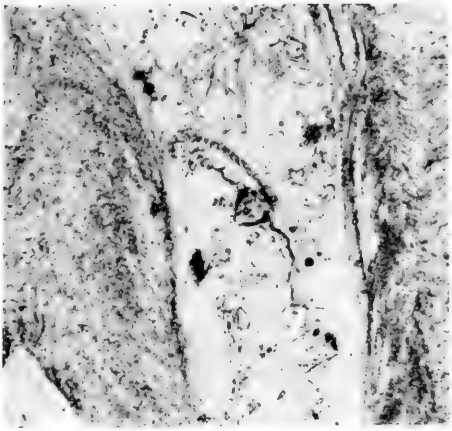
1. Loc. 2; UCM 40317.
   External view of proximally partly complete zoarium. Base is almost circular in outline. Zoarial surface is extremely smooth because of thick zooecial walls and small zooecial openings. Cross-section of branches circular except near bifurcation zone; × 4.
2. Thin-sections of zoarium. Loc. 5; UCM 40318.
   - 2a. Longitudinal view showing conspecific incrustation. Note uniformity of exozone width in zone of incrustation and elsewhere apparently indicating regeneration of partially dead portions; × 10.
   - 2b. Longitudinal view showing details of basal layer. In the center the basal layer is not in contact with zooecia, suggesting presence of uncalcified tissue below calcified basal layer; × 40.
   - 2c. Longitudinal view just above basal layer appearing on right, showing brown bodies encased in two organic membranes. The distal end (at left of photograph) of outer membrane appears narrow and open; × 250.

EXPLANATION OF PLATE 20

Figure		Page
1-3.	**Batostomella gracilis** (Nicholson)	196

Thin-sections of zoarium.

1. Loc. 5; UCM 40318.
    - 1a. Longitudinal view showing part of funnel (= infundibular) diaphragm continuous with wall on left side; × 250.
    - 1b. Tangential view showing abundant acanthopores. Few zooecia show irregular outlines; × 40.
    - 1c. Tangential view showing distinct lumen of acanthopores. Irregularity in zooecial opening outline does not seem to be wholly caused by acanthopores, because nearly all acanthopores are in middle of wall; × 100.
2. Loc. 3; UCM 40319.
   Transverse view showing thick exozone, megazooecia in endozone; × 10.
3. Loc. 1; UCM 40320.
   Transverse view showing exozone and endozone. Note megazooecia in central portion of endozone and constriction of zooecia near exozone.



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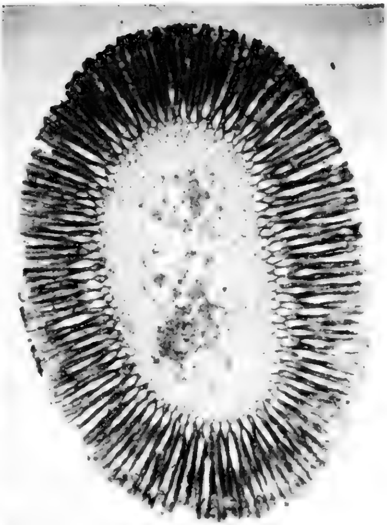

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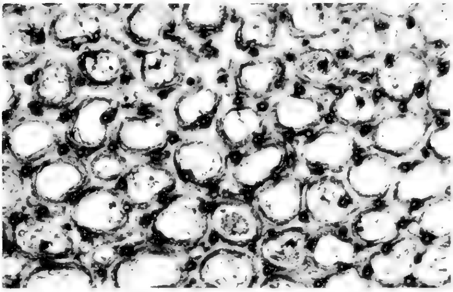

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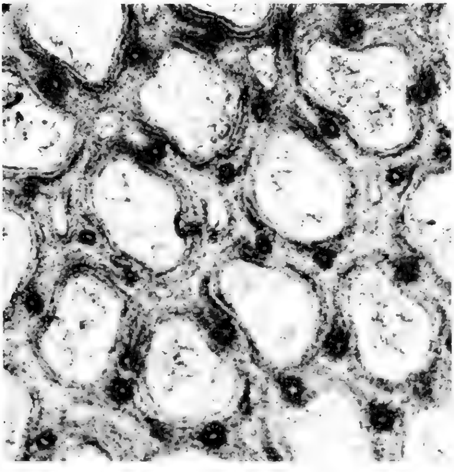

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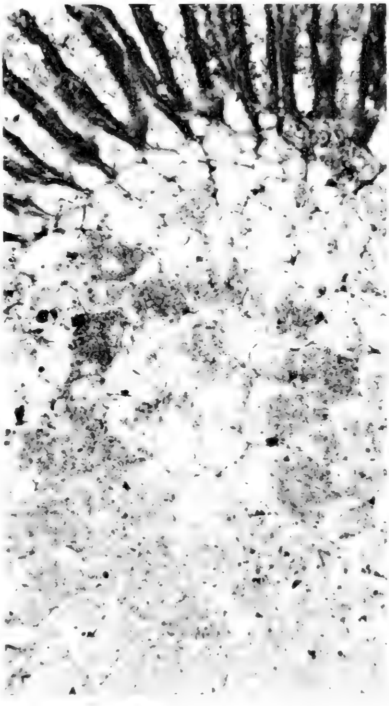

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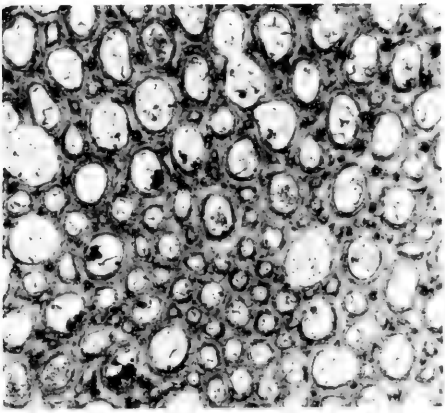

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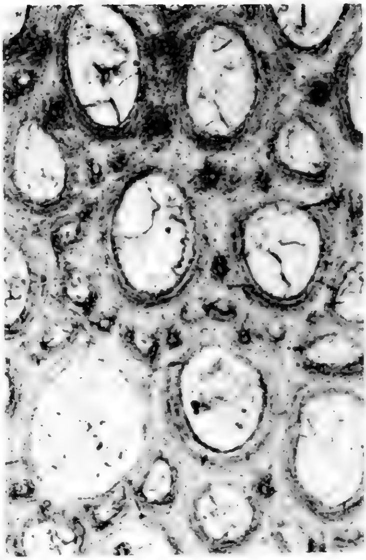

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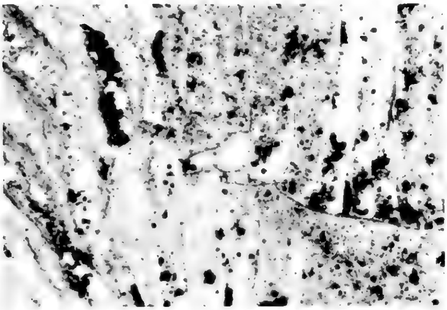

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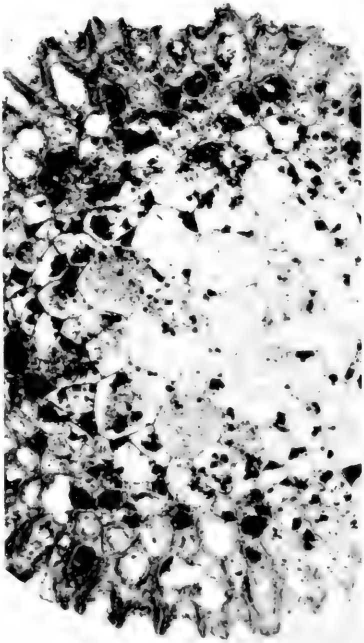

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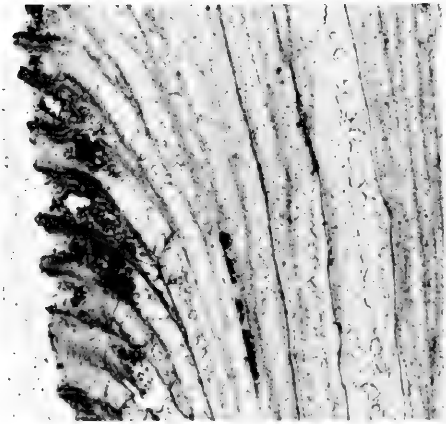

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EXPLANATION OF PLATE 21

Figure Page

1-3. Batostomella gracilis (Nicholson) 196

Thin-sections of zoarium.

1. Loc. 10; UCM 40321.
    - 1a. Tangential view showing a cluster of mesopores and a few megazooecia among normal zooecia. These probably represent polymorphs within the species that have smooth zoarial surfaces; × 40.
    - 1b. Tangential view showing a megazooecium at lower left, and many mesopores of rather uniform size around zooecia, suggesting that these may not be space fillers; × 100.
2. Loc. 1; UCM 40322.
    - 2a. Longitudinal view of parts of exozone on the left, and endozone; zooecial surface angle is small; zooecia in endozone rejuvenated by repair; filled with dark, opaque, spherical grains; × 40.
    - 2b. Transverse view showing thin exozone and endozone; megazooecia in central portion of endozone; small zooecial openings in center surrounded by megazooecia represent the proximal portion of megazooecia; × 40.
3. Loc. 1; UCM 40323.
   Longitudinal view showing thin exozone, long megazooecia in central portion of endozone. Note buds in endozone and almost midexozone; × 40.

EXPLANATION OF PLATE 22

Figure Page

1, 2. **Batostomella gracilis** (Nicholson) 196

Thin-section of zoarium.

1. Loc. 3; UCM 40324.
   Longitudinal view of wall in exozone showing convex laminae continuous across ZCL; diaphragm-wall units of mesopores. The laminae appear to be lighter in color where they are most sharply bent; × 100.
2. Loc. 1; UCM 40325.
   Longitudinal view of wall in exozone; zooecial opening with a thin diaphragm in lower part; × 250.

3-5. **Bythopora dendrina** (James) 203

3. Thin-section of zoarium. Loc. 3; UCM 40326.
   Longitudinal view showing exozone and endozone; narrow exozone and small zooecial surface angle; × 40.
4. Acetate replica of zoarium. Loc. 3; UCM 40327.
   Transverse view of section from acetate replica, showing thick exozone; zooecia in endozone are uniform in size; × 40.
5. Acetate replica of zoarium. Loc. 3; UCM 40328.
   Transverse view of section from acetate replica showing thinner exozone; × 40.

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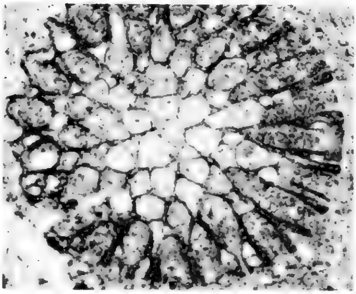

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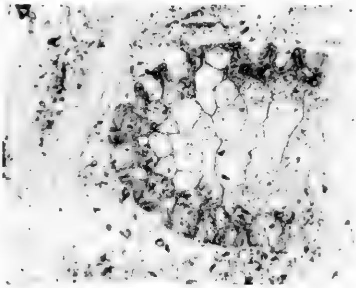

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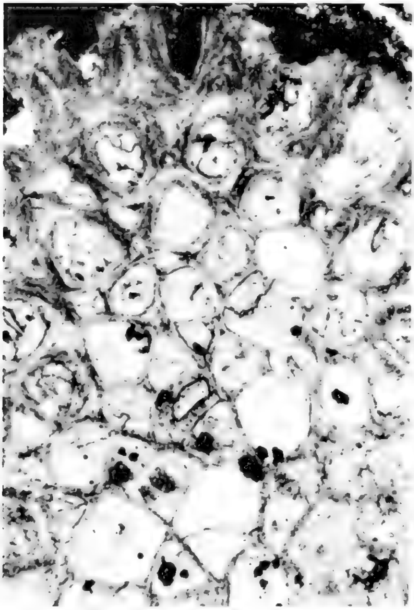

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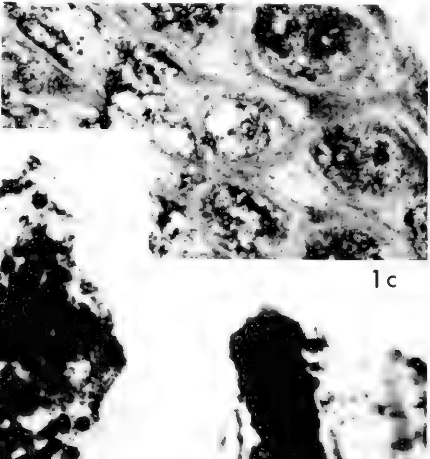

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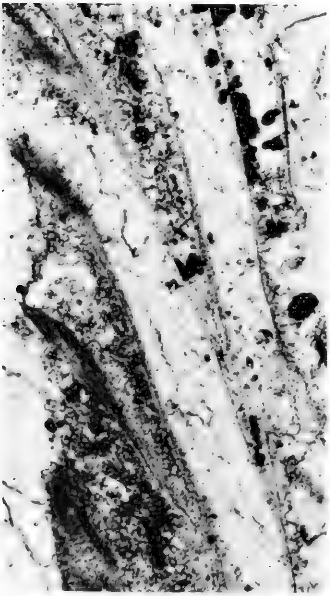

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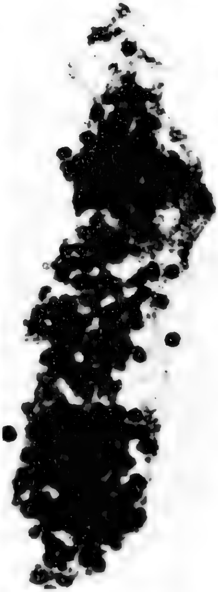

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EXPLANATION OF PLATE 23

Figure		Page
1, 2.	**Bythopora dendrina** (James)	203

Thin-sections of zoarium.

1. Loc. 1; UCM 40329.
    - 1a. Transverse view of exozone and part of endozone; × 100.
    - 1b. Longitudinal view of wall in exozone; the three cylindrical structures distinctly made up of spherical, dark, opaque granules may represent disintegrating products of polypide(s). Laminae in wall are continuous across ZCL; note that laminae appear darker in color where they are not sharply bent; × 250.
    - 1c. Tangential view; note light zones in middle of ZCL that correspond to zones shown in fig. 1b; × 100.
2. Loc. 2; UCM 40330.
    Longitudinal view showing exozone and spherical, dark, opaque granules that were probably derived from structures shown in fig. 1b. Note similar granules in endozone and exozone of many species illustrated in this report; × 100.

Figure		Page
3, 4.	**Diaperoecia californica** (d'Orbigny)	182, 258, 265

Locality: 1889 cruise of the "Albatross". United States Fish and Game Commission Station #2938. Pacific Ocean, off the coast of S. California; UCM 40331.

3. Stained specimen (Recent) of broken polypide showing abundant spherical, dark granules; × 100.
4. Stained specimen of a complete polypide in zooecium; note few scattered spherical granules in zooecium at right; × 100.

EXPLANATION OF PLATE 24

Figure Page

1. **Dekayia aspera** Milne-Edwards and Haime **207**

Thin-sections of zoarium (zoarial surface smooth).

Loc. 6; UCM 40332.

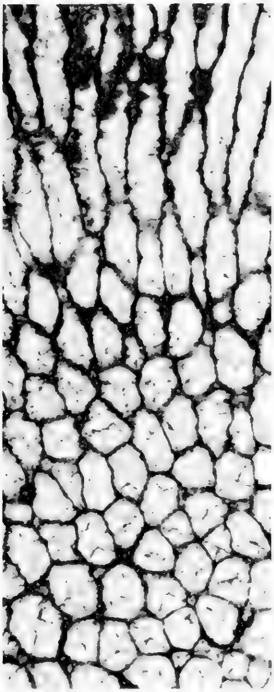
1a. Transverse view of zoarium showing oblique sections of exozone and endozone; note acanthopores in endozone; thick and wavy walls in exozone; × 25.

1b. Longitudinal view of endozone showing wavy walls even at proximal tips of zooecia; note elongate dark body at left (see fig. 1c) ; × 25.

1c. Magnified view of elongate dark body showing opaque, spherical granules. Photographed under polarized light. Compare with Pl. 23, fig. 3; × 100.

1d. Longitudinal view of acanthopore with dark material that seems to follow the outline of lumen; × 250.

1e. Tangential view showing cluster of megazooecia at center left; × 40.



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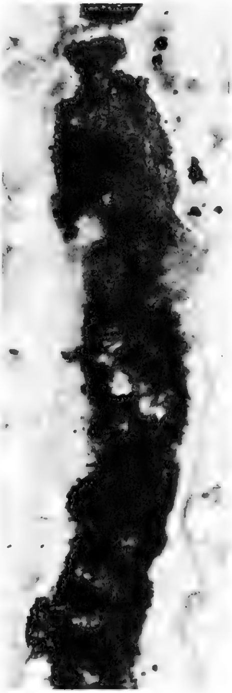

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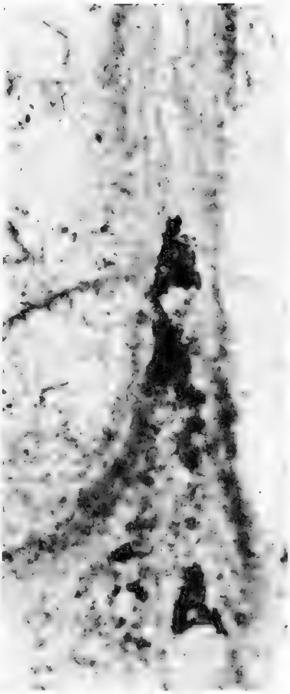

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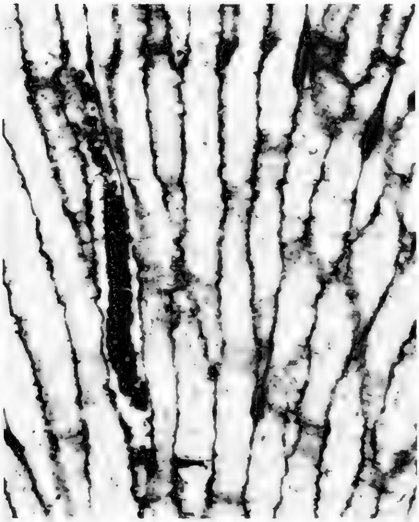

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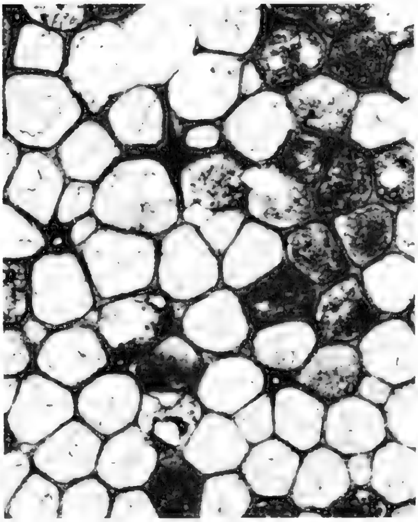

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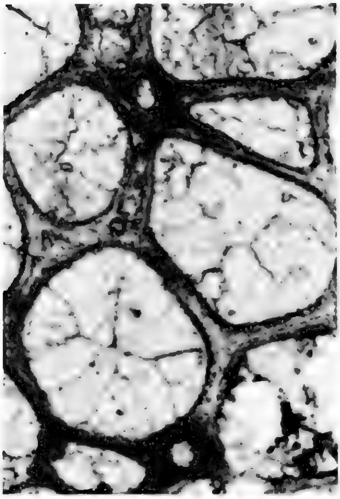

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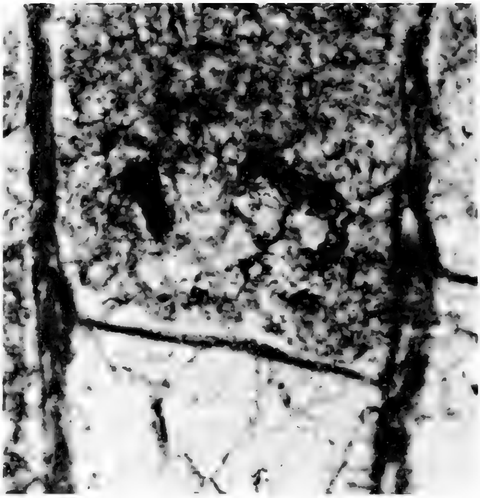

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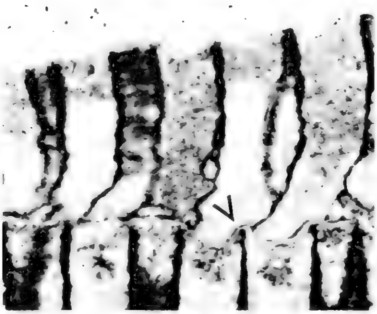

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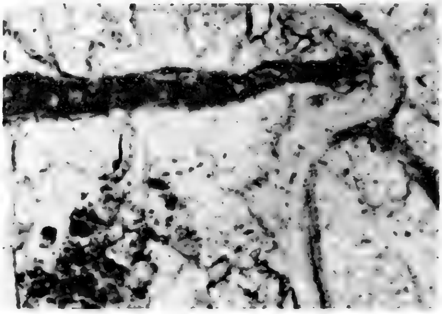

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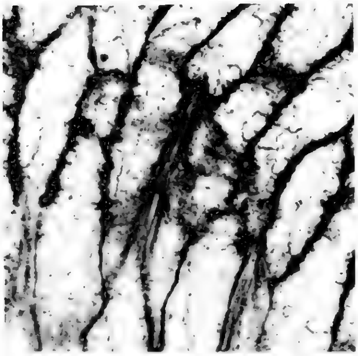

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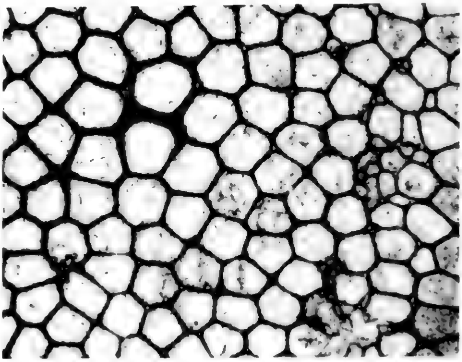

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EXPLANATION OF PLATE 25

Figure		Page
1, 2.	**Dekayia aspera** Milne-Edwards and Haime	207

Thin-sections of zoarium (zoarial surface smooth).

1. Loc. 6; UCM 40332.
    - 1a. Tangential view showing large endacanthopore and correspondingly large lumen; × 100.
    - 1b. Longitudinal view of wall in exozone showing rare thick diaphragm; laminae sharply convex but continuous across ZCL. Variations in position of dark and light zones of laminae can be matched with fig. 1a; × 250.
2. Loc. 12; UCM 40333.
    - 2a. Longitudinal view of primary exozone and secondary conspecific incrustation. Note light colored zone below basal layer of secondary zone. Arrow points to basal layer detail shown in fig. 2b.
    - 2b. Detail of basal layer and wall (zoarial surface to the right); note thin diaphragms (barely visible in 2a) just below mass of brown bodies; × 250.
    - 2c. Longitudinal view of endozone showing endacanthopores; × 40.
    - 2d. Tangential view showing cluster of megazooecia with thicker walls, at upper left, and small openings, at right, that are the proximal ends of zooecia; × 25.

EXPLANATION OF PLATE 26

Figure Page

1. **Dekayia pelliculata** Ulrich 209

Thin-sections of zoarium (zoarial surface smooth); Loc. 2; UCM 40334.

1a. Longitudinal view showing exozone and endozone; true mesopores in exozone; and exacanthopores; × 40.

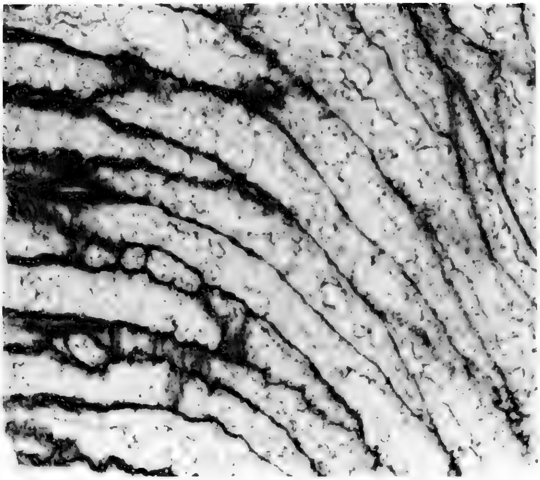
1b. Longitudinal view, proximal portion showing *Peronopora* being incrusted by two conspecific overgrowths of *D. pelliculata*; × 25.

1c. Tangential view showing thick and thin wall zones; × 40.

1d. Transverse view of exozone and endozone. Endacanthopores in endozone; × 40.

1e. Tangential view of thicker wall zone; note variation in size of acanthopore lumina; × 100.

1f. Longitudinal view of exozone wall; laminae are narrowly convex but continue across ZCL. Light zones also seen in fig. 1e. Mesopores (lower left) with distinct diaphragms; × 100.



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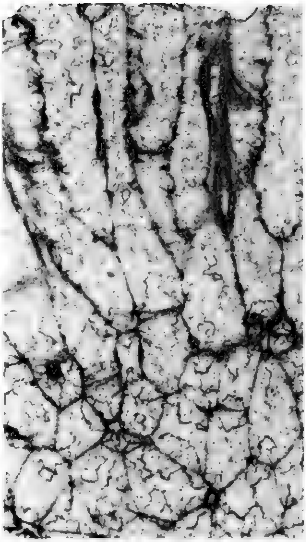

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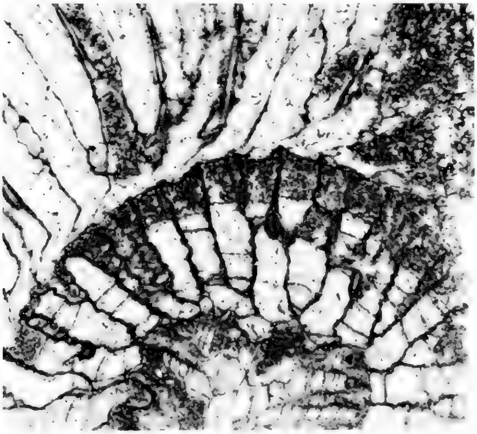

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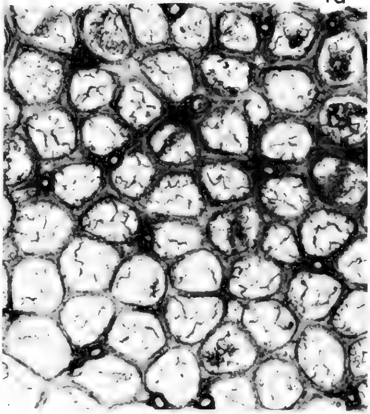

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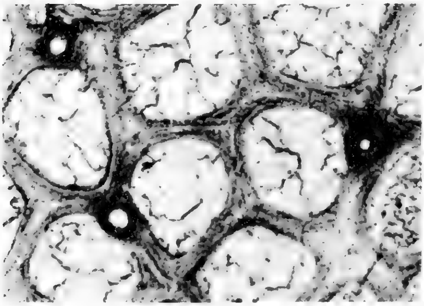

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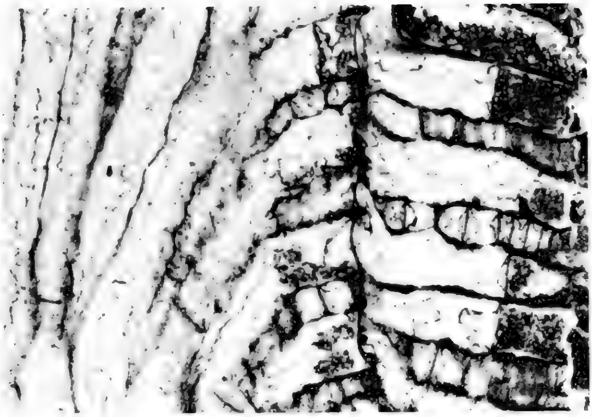

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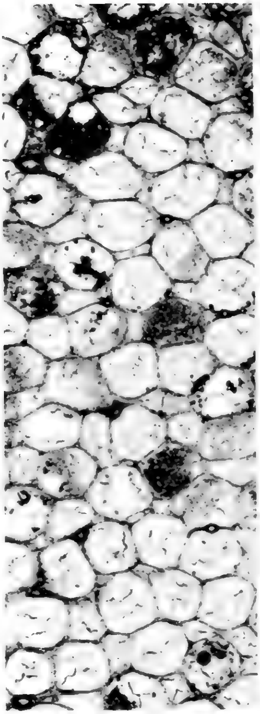

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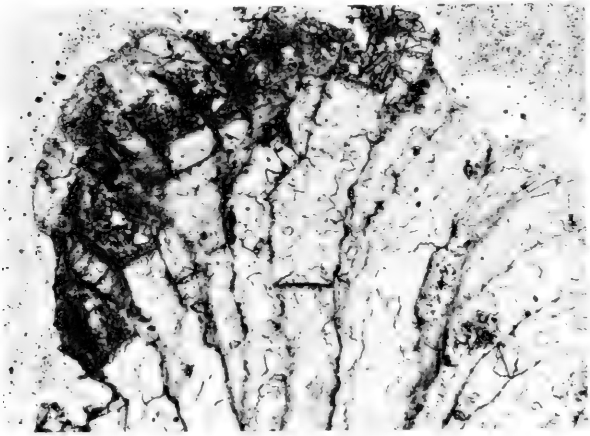

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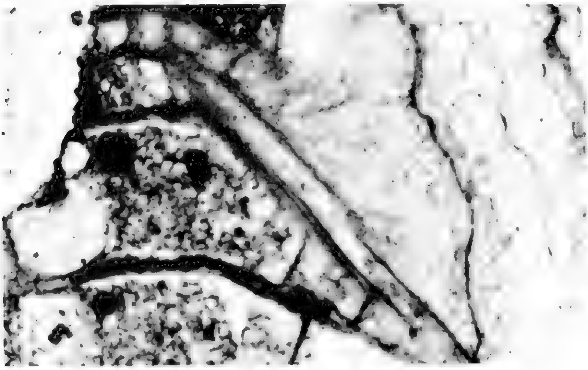

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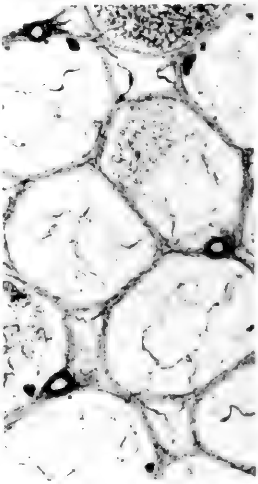

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EXPLANATION OF PLATE 27

Figure		Page
1.	**Dekayia pelliculata** Ulrich	209

Thin-sections of zoarium (zoarial surface smooth); Loc. 2; UCM 40335.

1a. Longitudinal view showing conspecific incrustation, and endozone. Mesopores have distinct diaphragms; × 40.

1b. Tangential view showing uniform size of zooecia and uniform wall thickness; acanthopores almost uniform in size. Presence of only single mesopores between adjacent zooecia suggests that these were typically space fillers; × 40.

1c. Longitudinal view of distal growing zone; × 40.

1d. Longitudinal view of exozone showing a large endacanthopore oblique to zooecial axis. It appears that the diaphragm-wall unit at proximal end of acanthopores overlaps onto it, suggesting the acanthopore is solid; × 100.

1e. Tangential view of zooecia and quadrate mesopores; × 100.

EXPLANATION OF PLATE 28

Figure | Page
1. **Heterotrypa frondosa** (d'Orbigny) **210**

Thin-sections of zoarium (monticules distinct on zoarial surface); Loc. 1; UCM 40336.

1a. Longitudinal view of exozone with conspecific incrustation seen at lower portion maintaining exozone width; note cystiphragms near zoarial surface, funnel diaphragms, and exacanthopores; × 25.

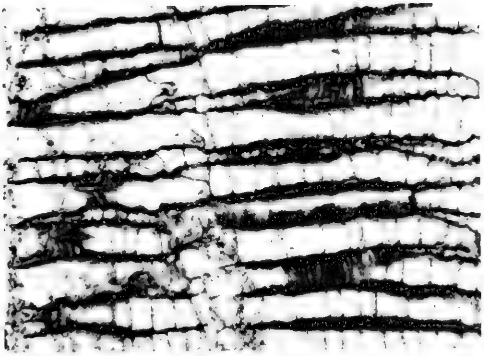
1b. Tangential section showing cluster of megazooecia and mesopores (polymorph); × 40.

1c. Longitudinal view of endozone; × 40.

1d. Longitudinal view of exozone; endacanthopore, oblique to zooecial axis, appears to be overlapped by dark material continuous with diaphragm, suggesting solid lumen; thick zooecial lining; × 100.

1e. Longitudinal view of wall in exozone showing exacanthopore with distinct breaks due to slight displacement of adjacent segments and subsequent repair; × 100.

1f. Longitudinal view of wall in exozone; laminae are continuous across ZCL; laminae uniformly dark in color regardless of the angle of curvature; zooecial lining is not fully developed distally; × 100.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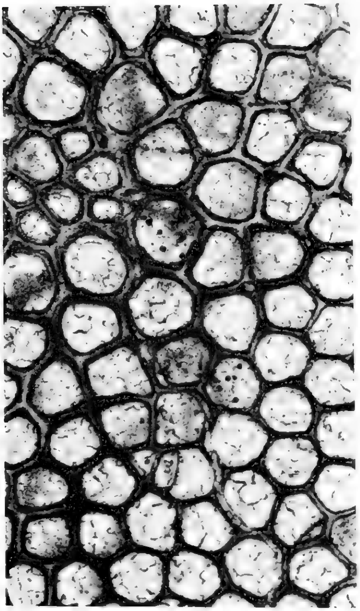
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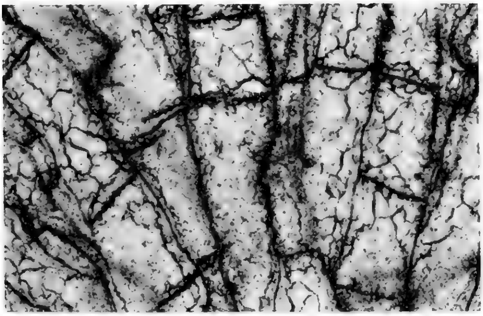
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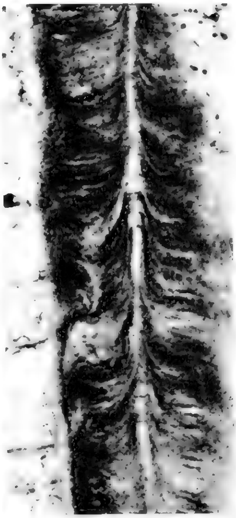
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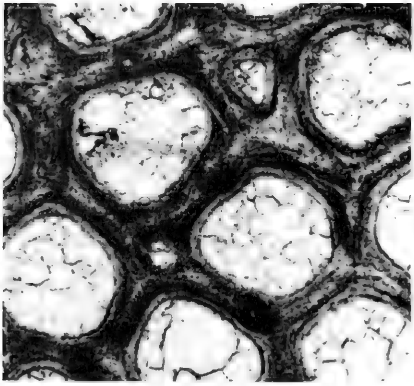
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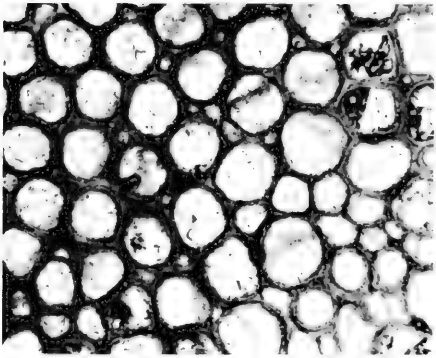
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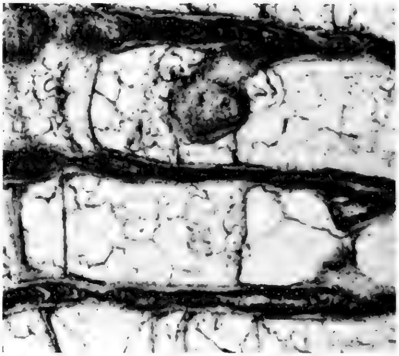
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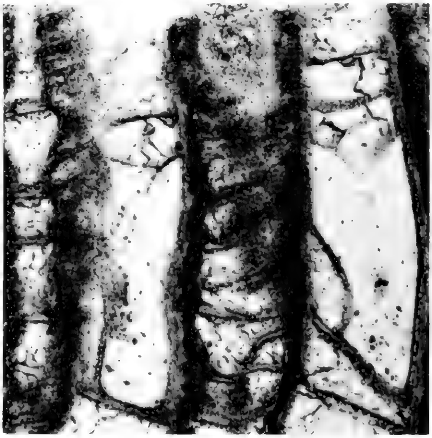
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EXPLANATION OF PLATE 29

Figure | Page
1-3. **Heterotrypa frondosa** (d'Orbigny) 210
- 1. Thin-sections of zoarium; Loc. 2; UCM 40336.
  - 1a. Tangential view showing minute lumen of acanthopores and zooecial lining; × 100.
  - 1b. Longitudinal view of wall in exozone; laminae are distinctly dark in middle of ZCL and are dark in color regardless of the angle of curvature of the laminae; × 250.
- 2. Thin-sections of zoarium (monticules distinct on zoarial surface); Loc. 2; UCM 40337.
  - 2a. Tangential view showing numerous cysts; × 40.
  - 2b. Longitudinal view of exozone showing cysts; thin zooecial lining; × 100.
- 3. Thin-sections of zoarium (zoarial surface smooth); Loc. 12; UCM 40338.
  - 3a. Longitudinal view of distal growing zone; × 40.
  - 3b. Longitudinal view of wall in exozone to show cystiphragm. funnel diaphragm and brown bodies; × 100.

EXPLANATION OF PLATE 30

Figure — Page

1, 2. **Heterotrypa solitaria** Ulrich **214**

Thin-sections of zoarium (monticules distinct on zoarial surface).

- 1. Loc. 4; UCM 40339.
  - 1a. Longitudinal view of exozone and endozone; diaphragms in zooecia are aligned; mesopores are moniliform; × 25.
  - 1b. Tangential view showing cluster of megazooecia in center; × 40.
- 2. Loc. 4; UCM 40340.
  - 2a. Longitudinal view of exozone and part of endozone; beaded mesopores and aligned diaphragms; × 40.
  - 2b. Transverse view showing diversely polygonal zooecia in the endozone; × 40.
  - 2c. Longitudinal view of endozone showing proximal zones of zooecia and few diaphragms; × 40.
  - 2d. Longitudinal view of exozone showing endacanthopore oblique to zooecial axis; diaphragm clearly overlaps the acanthopore, suggesting solid and protruding acanthopore during life; × 100.

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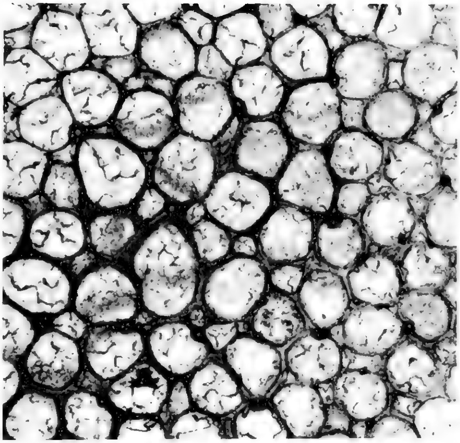

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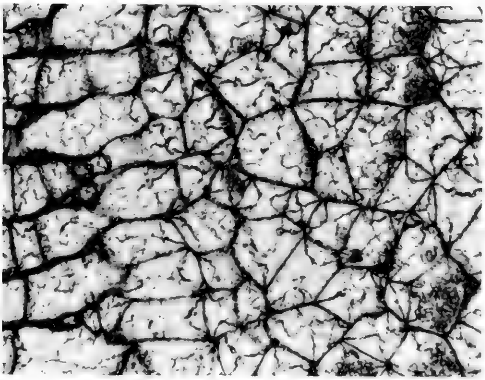

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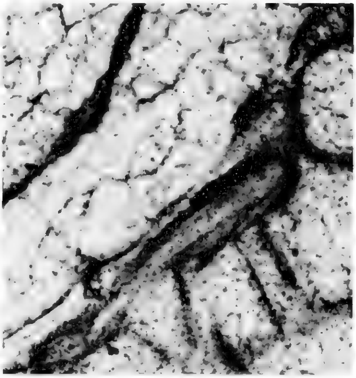

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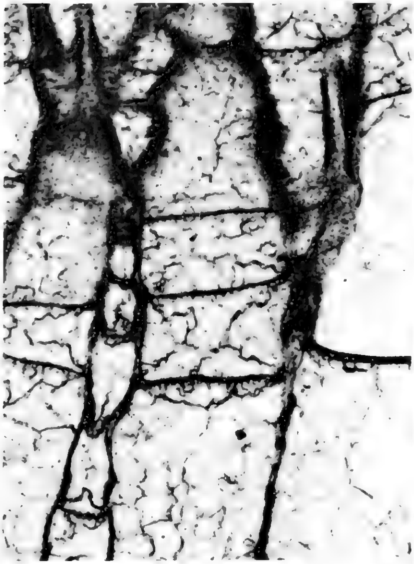

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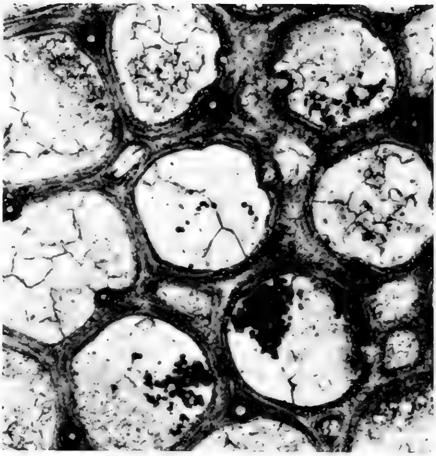

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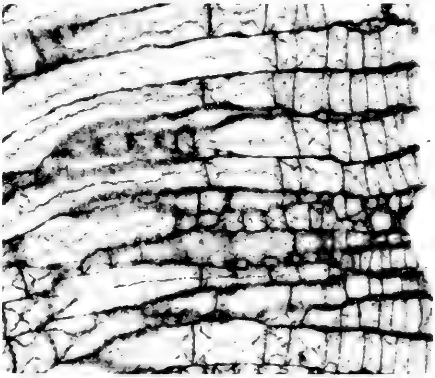

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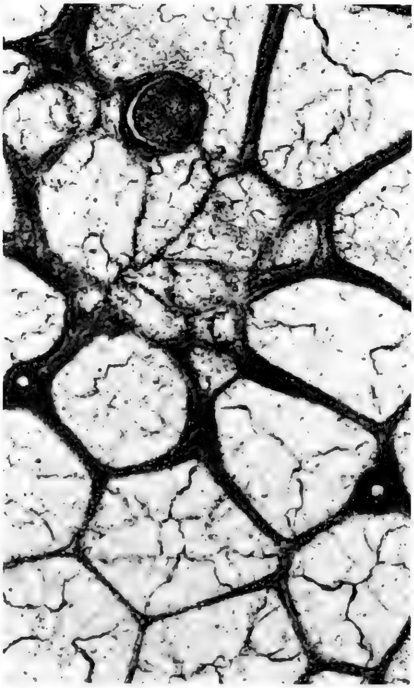

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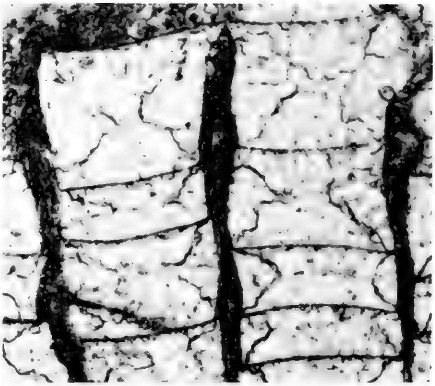

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EXPLANATION OF PLATE 31

Figure Page

1, 2. **Heterotrypa solitaria** Ulrich 214

Thin-sections of zoarium (monticules distinct on zoarial surface).

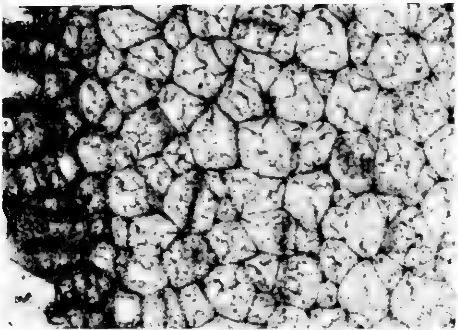
1. Loc. 4; UCM 40340.
    - 1a. Longitudinal view of exozone showing beaded mesopores, exacanthopores. In the lower part of photograph one diaphragm in mesopore is in form of a funnel (in zooecia similar structures are called infundubilar diaphragms and usually suggest the presence of a normal zooid in life); × 100.
    - 1b. Tangential view showing acanthopores; dark, opaque, spherical granules within zooecia (See Plate 23); cysts; × 100.
2. Loc. 7; UCM 40341.
    - 2a. Longitudinal view of exozone showing aligned diaphragms; beaded mesopores; thin walls; × 25.
    - 2b. Tangential section showing rare stellate arrangement of zooecia, mesopores; cyst in upper portion; × 100.
    - 2c. Longitudinal section of exozone showing relatively thin walls and very thin diaphragms; × 100.

EXPLANATION OF PLATE 32

Figure		Page
1, 2.	**Homotrypa curvata** Ulrich	217

Thin-sections of zoarium (zoarial surface smooth).

1. Loc. 4; UCM 40342.
    - 1a. Transverse view through exozone and endozone; × 40.
    - 1b. Longitudinal view showing exozone and endozone in the distal zoarium (most cystiphragms are located in the distal region of the zoarium); abundant diaphragms in endozone; distinct dark median wall layer (see fig. 2c); × 40.
2. Loc. 2; UCM 43043.
    - 2a. Longitudinal view of endozone and exozone; × 40.
    - 2b. Tangential view showing cluster of megazooecia at center; note continuity of median layer and abundance of acanthopores around megazooecia (See also Pl. 18, figs. 1a, 1b); × 40.
    - 2c. Longitudinal view of exozone, showing distinct dark median wall layer; × 100.
    - 2d. Longitudinal view of wall in exozone showing irregular, granular nature of dark median wall layer; × 250.



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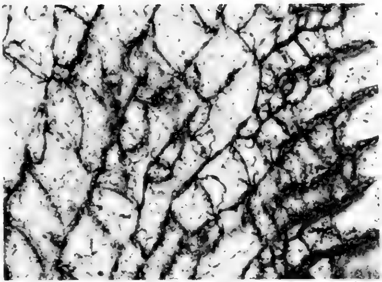

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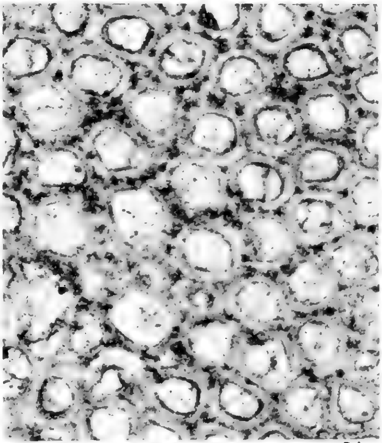

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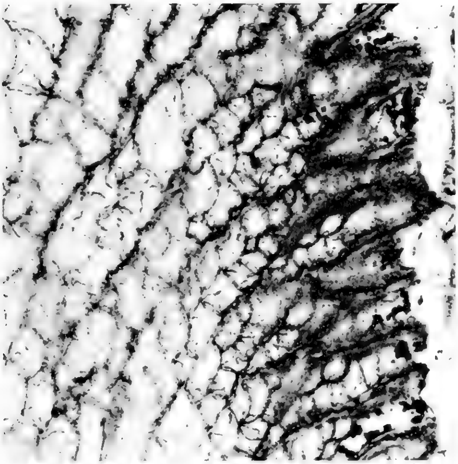

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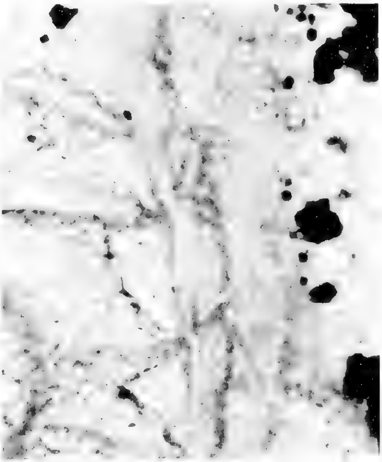

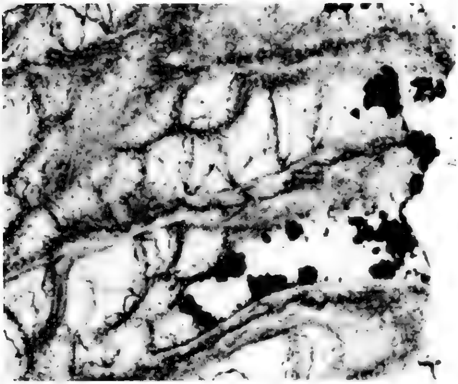

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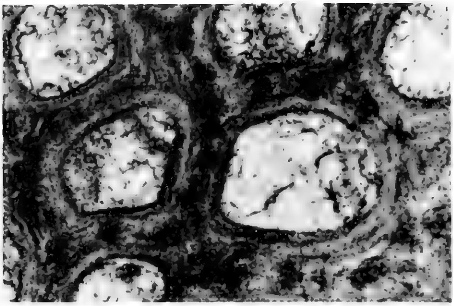
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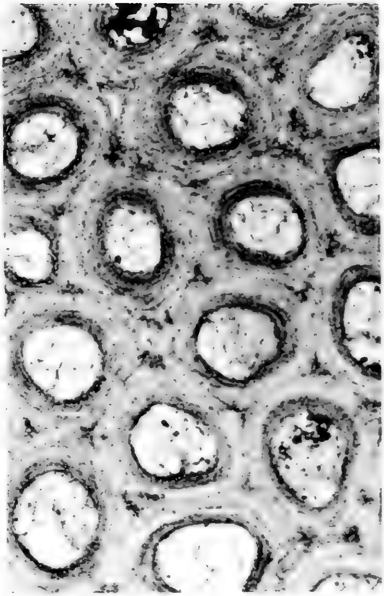
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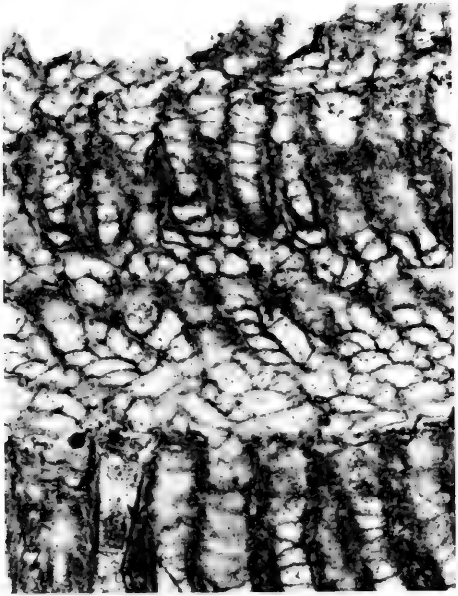
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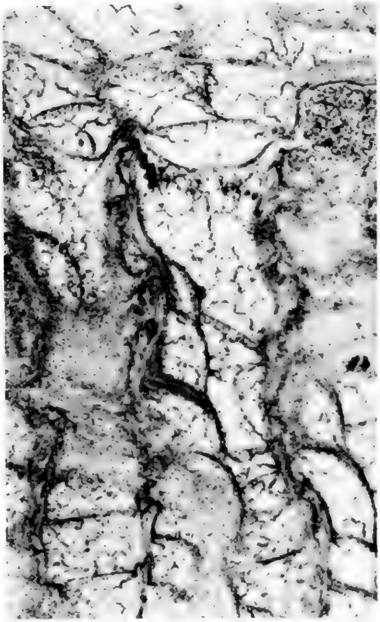
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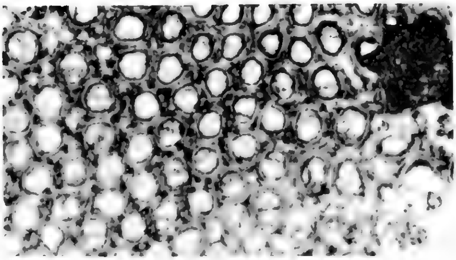
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EXPLANATION OF PLATE 33

Figure — Page

1, 2. **Homotrypa curvata** Ulrich 217

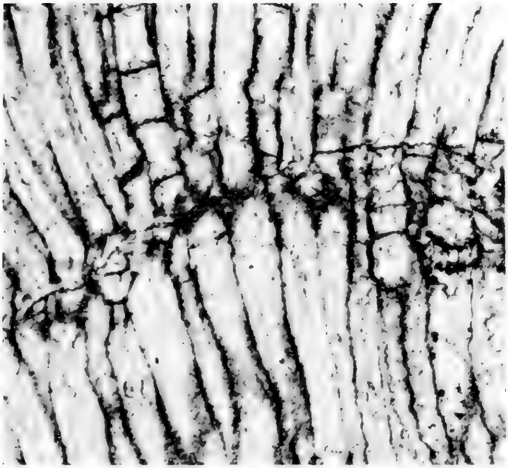
- 1. 1a, 1b are enlargements of Plate 32, fig. 2b; Loc. 2; UCM 43043.
  - 1a. Tangential view of megazooecia; note concentrations of acanthopores; × 100.
  - 1b. Tangential view of regular sized zooecia; × 100.
- 2. Thin-sections of zoarium (monticules low, indistinct on zoarial surface); Loc. 12; UCM 40344.
  - 2a. Longitudinal view of exozone showing three original conspecific incrustations; detrital material below all basal layers suggests time lapse between mortality of colony and next incrustation; × 40.
  - 2b. Longitudinal view of one of the basal layers seen in upper portion; note its contact with basal skeleton of zoarium and detrital material; × 100.
  - 2c. Tangential view showing borings of unknown origin at right, upper one filled with detrital material and the other filled with sparry calcite; × 25.

EXPLANATION OF PLATE 34

Figure		Page
1.	**Homotrypa obliqua** Ulrich	219

Thin-sections of zoarium (monticules distinct on zoarial surface); Loc. 6; UCM 40345.

1a. Longitudinal view of exozone; ×40.
1b. Longitudinal view of endozone showing an 'abandoned' growing tip of the zoarium with diaphragms sparsely developed distally; × 25.
1c. Longitudinal view showing the nature of zooecia in endozone; × 25.
1d. Transverse view of exozone and endozone; × 40.
1e. Tangential view of exozone, showing megazooecia in upper left; × 40.



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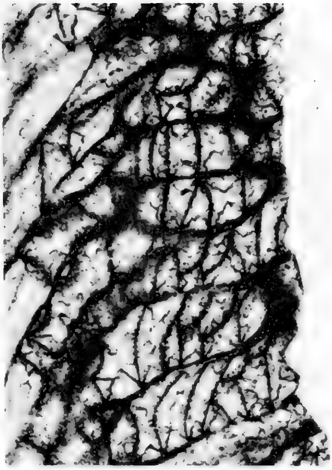

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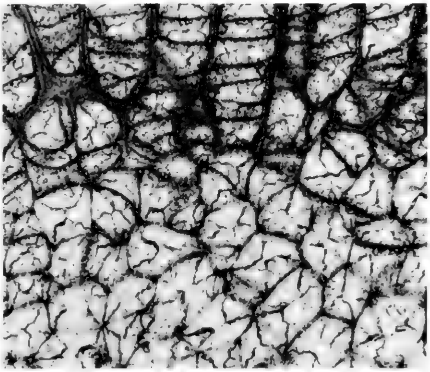

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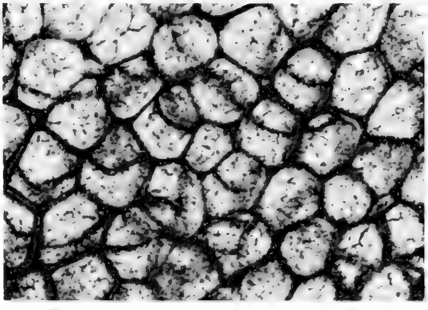

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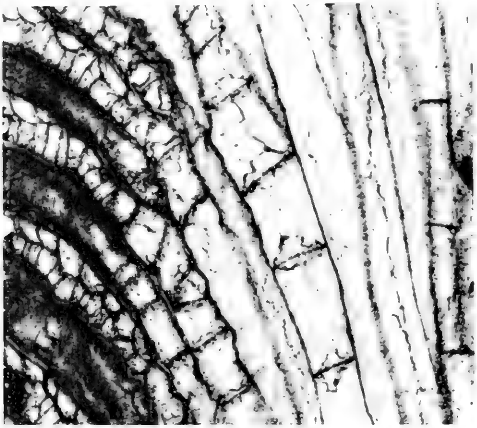

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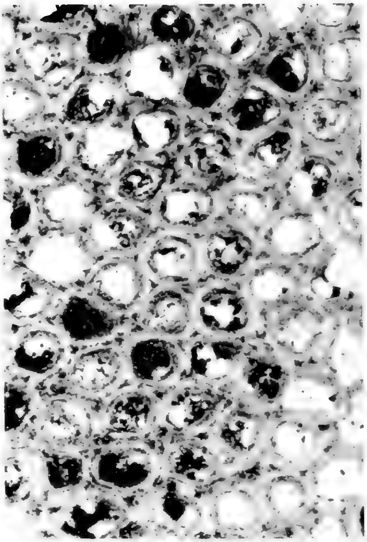

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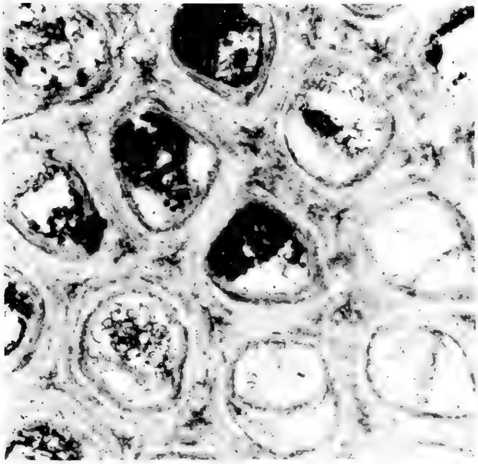

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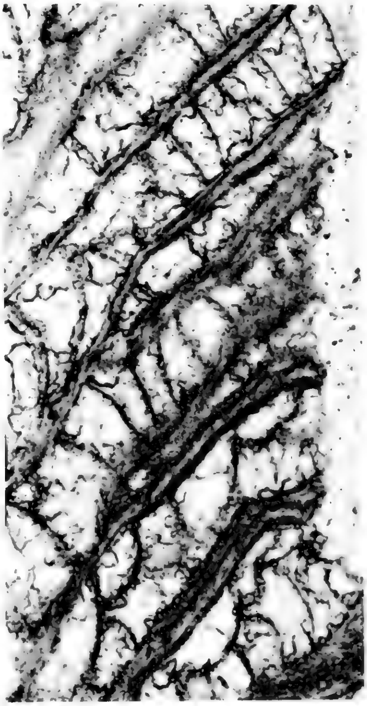

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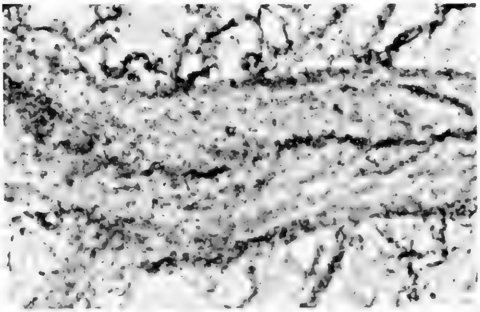

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EXPLANATION OF PLATE 35

Figure Page

1. **Homotrypa obliqua** Ulrich 219

Thin-sections of zoarium (monticules indistinct on zoarial surface); Loc. 2; UCM 40346.

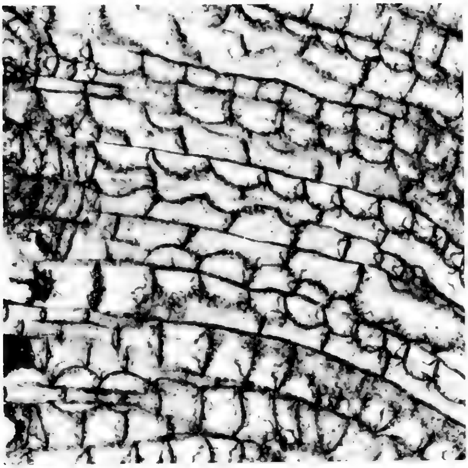
1a. Longitudinal view of exozone and endozone; zooecial surface angle is small; × 40.
1b. Tangential view showing uniform size of zooecial openings; × 40.
1c. Tangential view showing details of median layer and minute lumen in some acanthopores; × 100.
1d. Longitudinal view of exozone; × 100.
1e. Longitudinal view of median layer in exozone; laminae slightly offset along median layer; breaks in layer correspond to similar discontinuities seen in fig. 1c; × 400.

EXPLANATION OF PLATE 36

Figure		Page
1, 2.	**Monticulipora mammulata** d'Orbigny	222

Thin-sections of zoarium (monticules distinct on zoarial surface).

1. Loc. 1; UCM 40347.
    - 1a. Longitudinal view showing distal growing edge of a frondose zoarium; repair in central part resulted in change in direction of growth showing transverse view of zooecia; × 10.
    - 1b. Longitudinal view of exozone; × 40.
2. Loc. 2; UCM 40348.
    - 2a. Longitudinal view of exozone, showing conspecific incrustation on a monticule; abundant brown bodies present below basal layer (center of photograph); × 40.
    - 2b. Longitudinal view showing abundant dark, opaque, spherical granules outlining a funnel; × 100.
    - 2c. Tangential view showing monticule at lower right; × 40.



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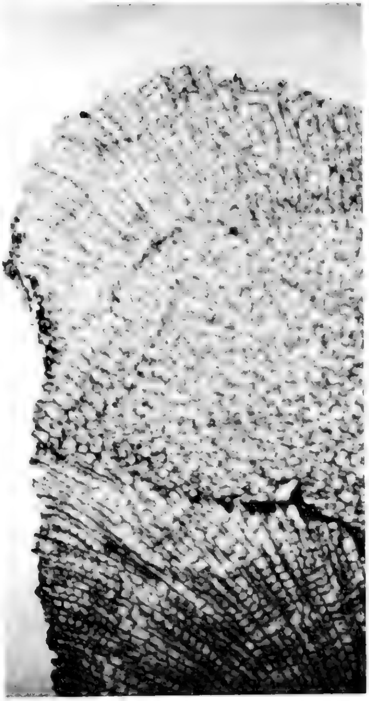

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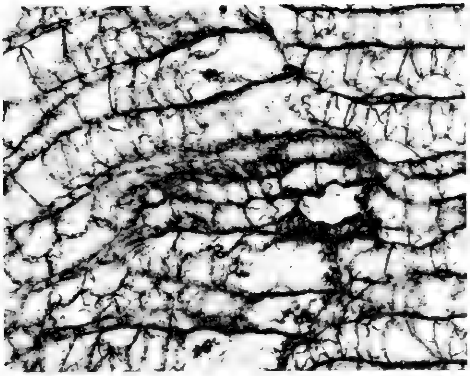

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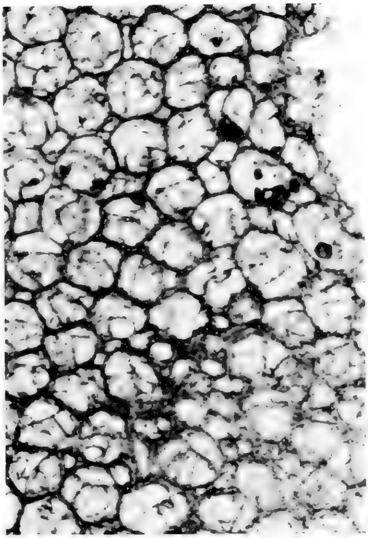

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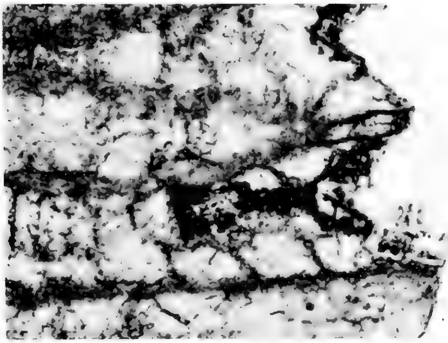

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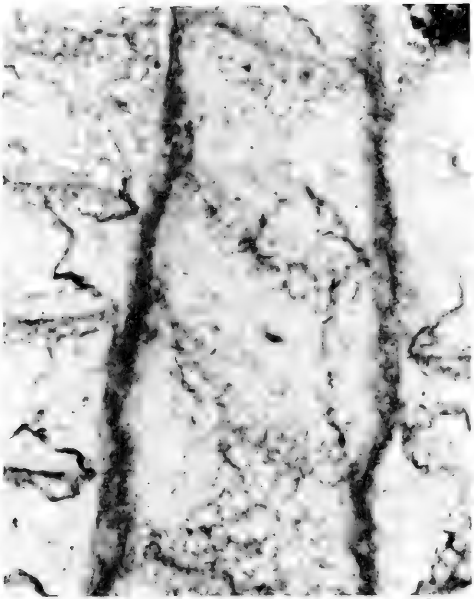

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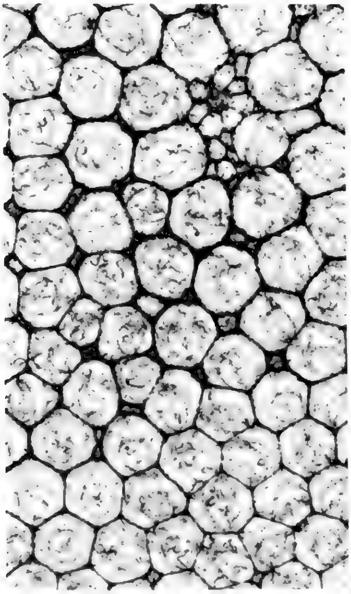

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EXPLANATION OF PLATE 37

Figure Page

1-3. **Monticulipora mammulata** d'Orbigny 222

Thin-section of zoarium (monticules distinct on zoarial surface).

1. Loc. 2; UCM 40348.
   Longitudinal view showing indistinct laminar nature of wall; note dark, granular material within wall; × 250.
2. Loc. 7; UCM 40349.
   Tangential view showing cluster of mesopores surrounded by megazooecia forming a monticule; × 40.
3. Loc. 2; UCM 40350.
   - 3a. Longitudinal view of ramose zoarium showing distal growing zone, exozone is indistinct; × 10.
   - 3b. Longitudinal view of ramose zoarium showing portions just proximal to that in fig. 3a; note abandoned growing zones and more distinct exozone; × 10.

Explanation of Plate 38

Figure Page

1. **Parvohallopora laevigata,** n. sp. 233

Thin-sections of zoarium (zoarial surface smooth); Loc. 3; UCM 40351 (holotype).

1a. Longitudinal view of smooth zoarium showing details of exozone and endozone; × 10.

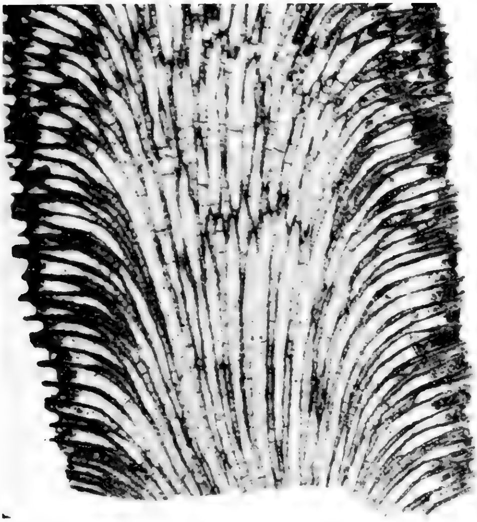
1b. Tangential view showing scattered megazooecia; one at upper right surrounded by mesopores; × 10.

1c. Longitudinal view of wall in exozone; note lack of diaphragms and thin walls; × 40.

1d. Longitudinal view of wall in exozone; note dark, opaque, spherical granules in mesopore; × 100.

1e. Tangential view showing small, round mesopores between zooecia; × 100.

1f. Longitudinal view of wall in exozone showing sharply convex laminae continuous across ZCL. Zoarial surface at left; × 250.



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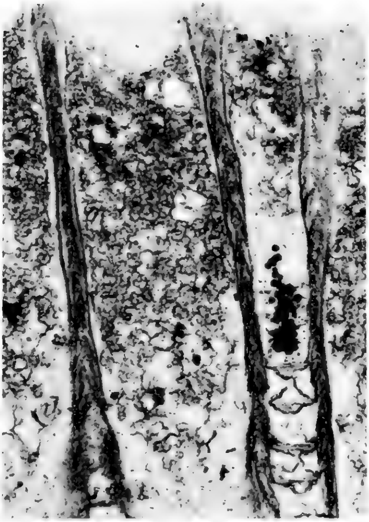

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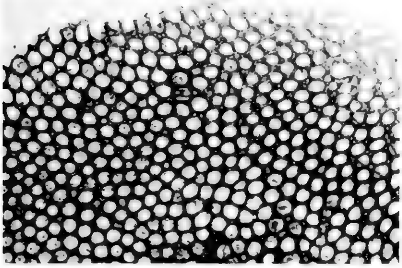

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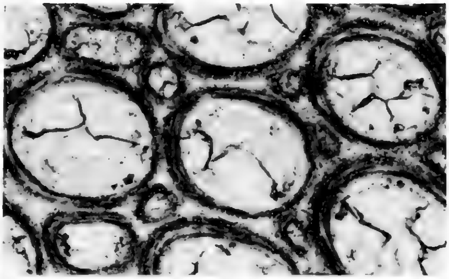

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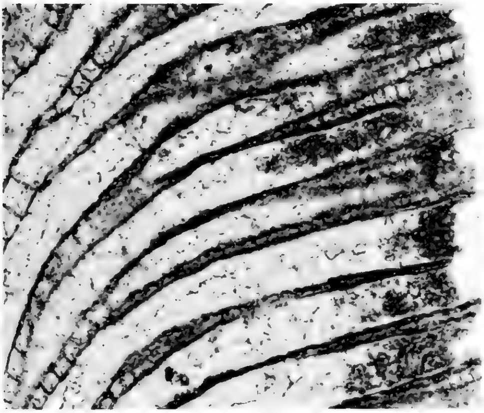

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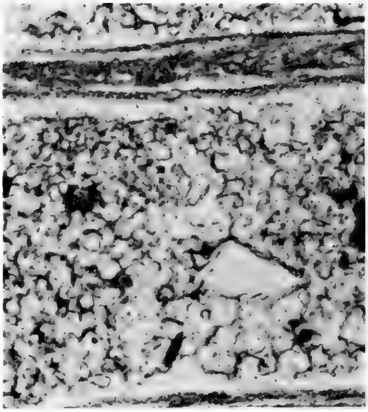

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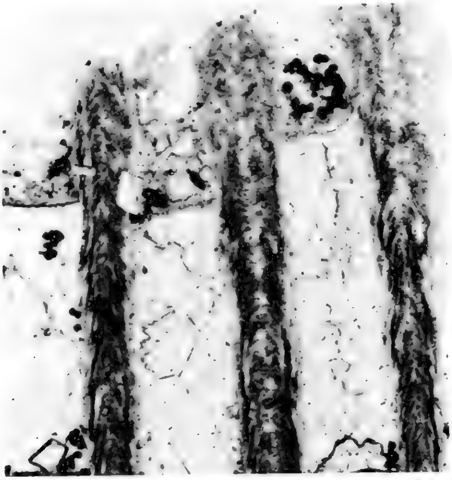

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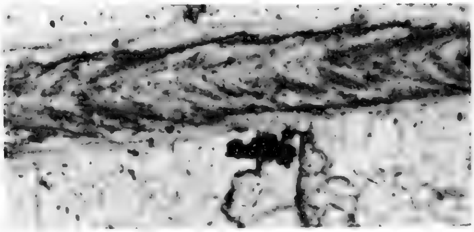

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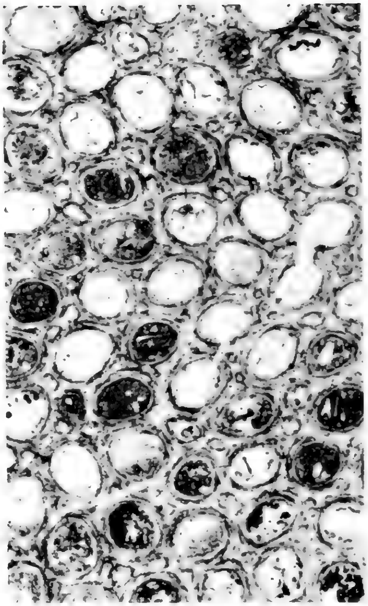

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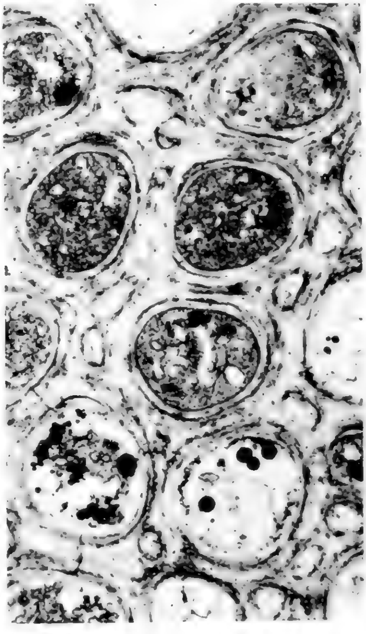

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EXPLANATION OF PLATE 39

Figure		Page
1.	**Parvohallopora laevigata,** n. sp.	233

Thin-sections of zoarium (zoarial surface smooth); Loc. 8; UCM 40352 (paratype).

1a. Longitudinal view showing details of exozone and endozone; × 10.
1b. Tangential view; note uniform size of zooecia; × 40.
1c. Tangential view showing disposition of mesopores between zooecia; × 100.
1d. Longitudinal view of wall in exozone; laminae are continuous across ZCL but are distinctly darker in their proximal ends leaving a narrow white zone, locally not seen; compare with tangential view in fig. 1c; × 100.
1e. Longitudinal view of wall in exozone. Note that the laminae are darker at their proximal ends (where these are least curved); × 250.

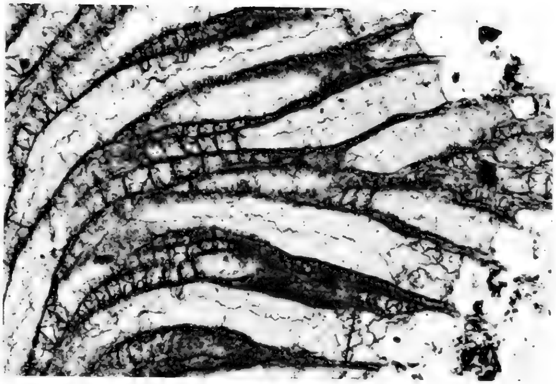
EXPLANATION OF PLATE 40

Figure Page

1, 2. **Parvohallopora laevigata,** n. sp. 233

Thin-sections of zoarium (distinct monticules on zoarial surface).

1. Loc. 4; UCM 40353 (paratype).
   - 1a. Longitudinal view of exozone beneath a monticule; note lack of diaphragms in zooecia; diaphragm-wall units well developed in mesopores; × 40.
   - 1b. Longitudinal view of endozone showing scarce or no diaphragms in distal portions of zooecia; × 40.
   - 1c. Tangential view through monticule; note irregular nature of laminae; × 100.
   - 1d. Tangential view of intermonticular zone; note similarity in size of zooecia with those in fig. 1c; laminae are regularly arranged; × 100.
2. Loc. 1; UCM 40354 (paratype).
   Transverse view showing arrangement of zooecia in endozone; occasional diaphragm in exozone; × 40.



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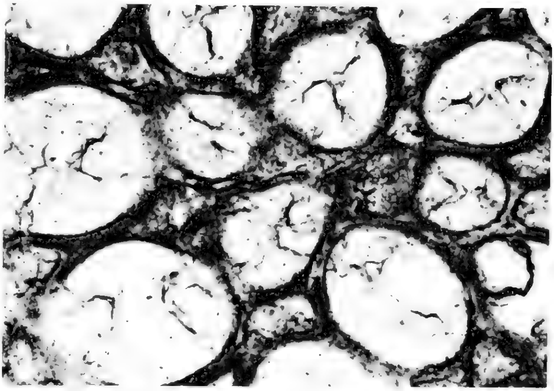

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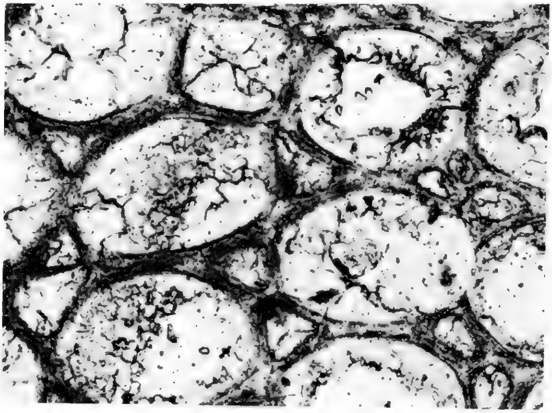

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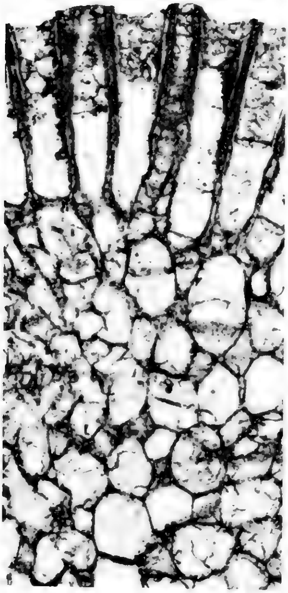

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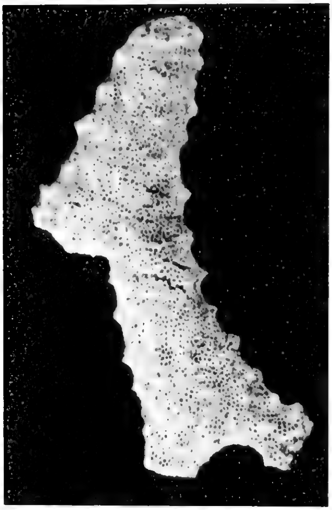
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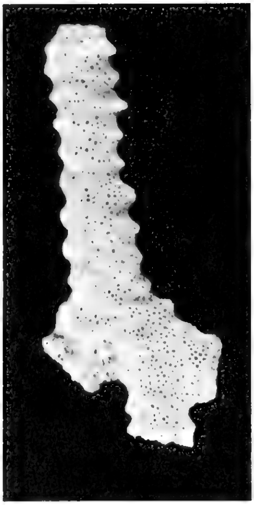
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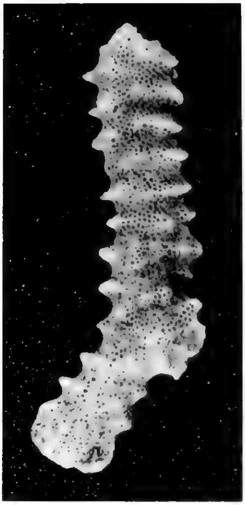
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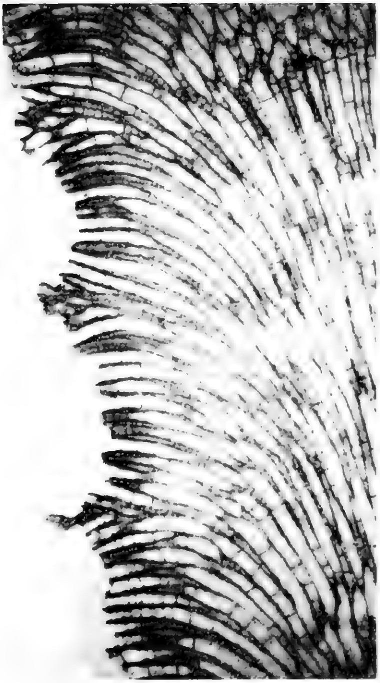
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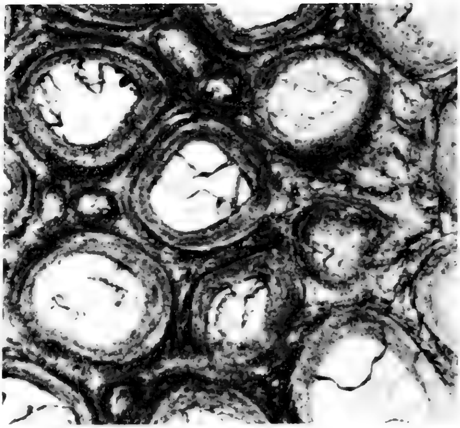
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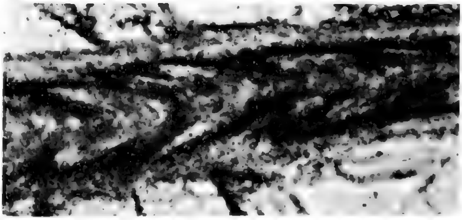
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EXPLANATION OF PLATE 41

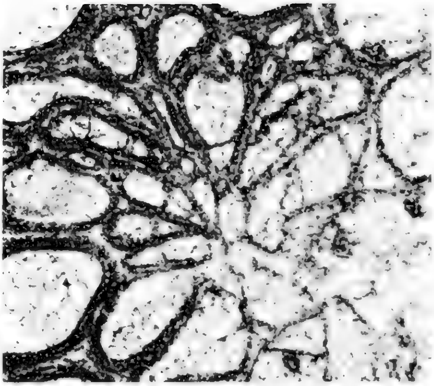
Figure | Page
1-4. **Parvohallopora ramosa** (d'Orbigny) 228

1. Loc. 1; UCM 40355.
   External view showing more or less isolated but sharply elongated and aligned monticules, and a few sharply conical ones that also lie in transverse alignments; × 3.5.
2. Loc. 1; UCM 40356.
   External view showing transversely elongated and a few sharply conical monticules. (Distal end of zoarium at lower side of the photograph); × 3.5.
3. Loc. 1; UCM 40357.
   External view showing transversely elongated monticules and incipient rugosity; × 3.5.
4. Thin-sections of zoarium; Loc. 6; UCM 40358.
   - 4a. Longitudinal view; note diaphragms in exozone and endozone; × 10.
   - 4b. Tangential view showing part of a monticule at right identified by irregular wall laminae. Zooecial boundary is between dark "rings"; × 100.
   - 4c. Longitudinal view of wall in exozone; laminae are distinctly dark in their proximal portions where they are not sharply bent; these portions produce the "rings" seen in fig. 4b; × 250.

EXPLANATION OF PLATE 42

Figure		Page
1-3.	**Parvohallopora ramosa** (d'Orbigny)	228

1. Acetate replica of zoarium; Loc. 7; UCM 40359.
   Tangential view of the only observed stellate pattern of zooecia and mesopores; photographed from acetate replica; × 100.
2. Acetate replica of zoarium; Loc. 9; UCM 40360.
   Longitudinal view of exozone showing rare cystiphragms; photographed from acetate replica; × 100.
3. Thin-sections of zoarium; Loc. 1; UCM 40361.
   - 3a. Longitudinal view of exozone with conspecific incrustation; × 10.
   - 3b. Transverse view showing endozone and part of exozone; × 40.
   - 3c. Longitudinal view of exozone showing convex laminae continuous across ZCL; laminae dark in their proximal ends; thick zooecial lining locally interfingered with wall; × 100.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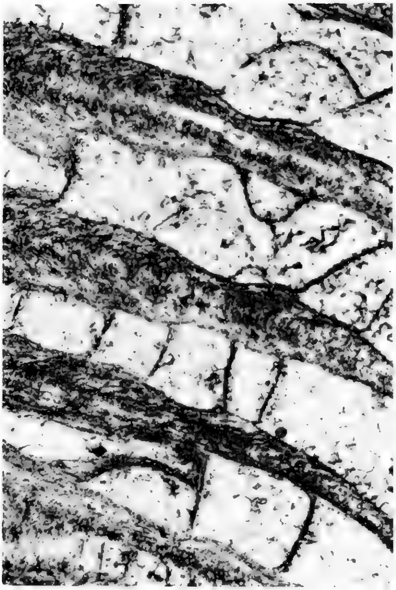
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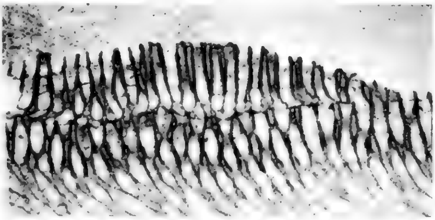
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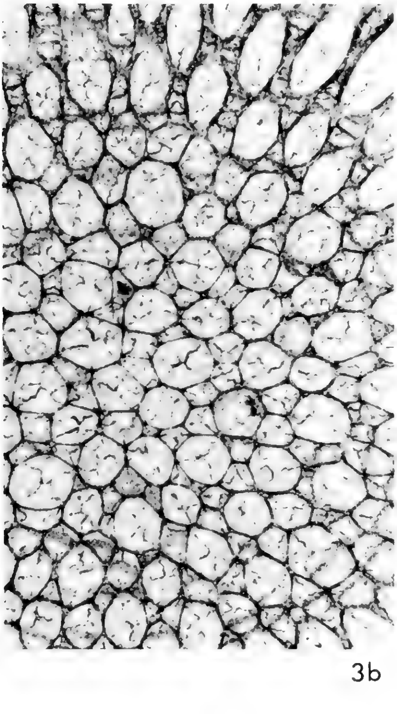
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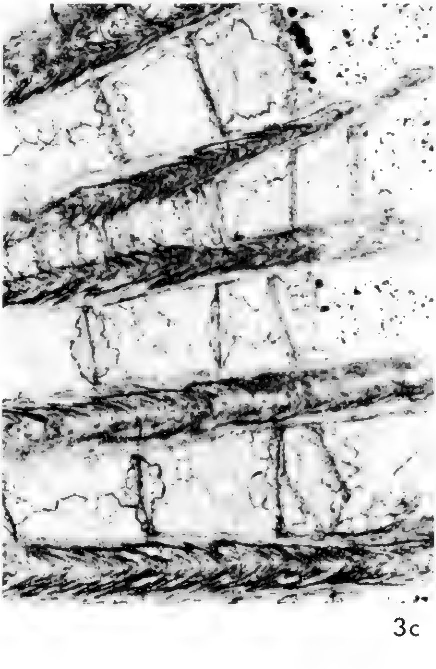
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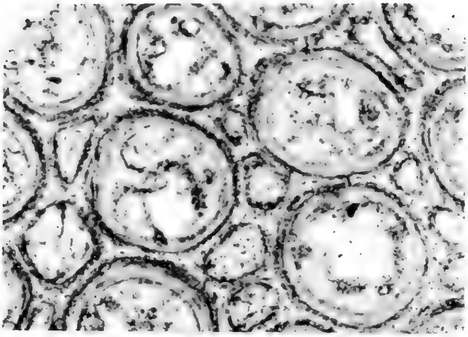

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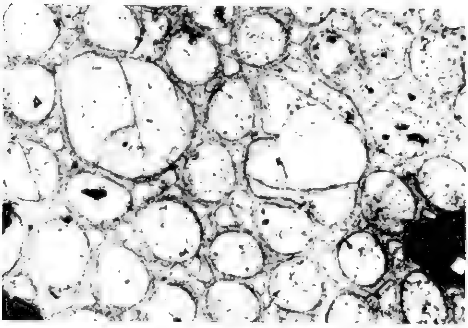

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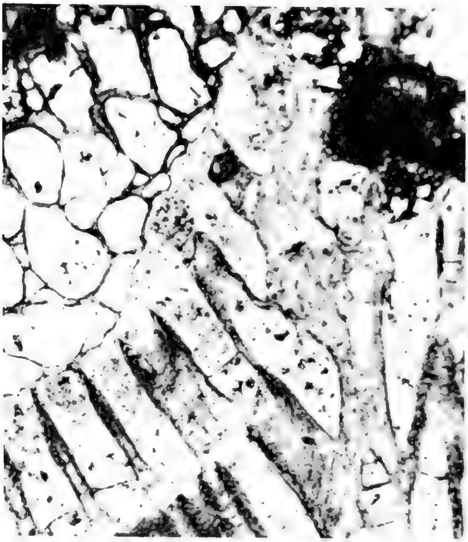

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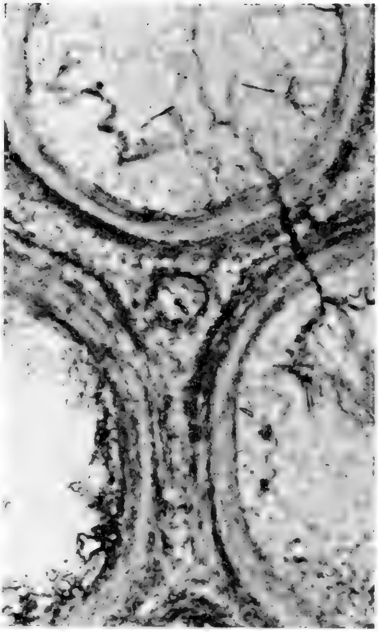

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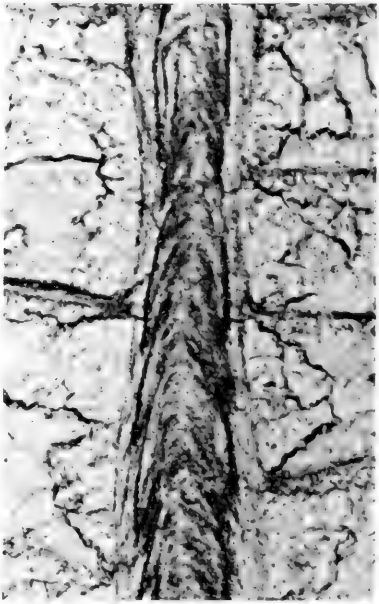

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EXPLANATION OF PLATE 43

Figure		Page
1-3.	**Parvohallopora ramosa** (d'Orbigny)	228

1. Thin-sections of zoarium; Loc. 1; UCM 40361.
    - 1a. Tangential view of intermonticular zooecia and mesopores with regular wall laminae; × 100.
    - 1b. Tangential view showing details of wall laminae; × 250.
    - 1c. Longitudinal view showing thick zooecial lining; light colored laminae in central part of ZCL; features correspond to tangential view seen in fig. 1b; × 250.
2. Acetate replica of zoarium; Loc. 5; UCM 40362.
   Tangential view showing the only observed, exceptionally large megazooecia which are not located within a monticule; note cystose diaphragm in megazooecium at left. Photographed from acetate replica; × 40.
3. Acetate replica of zoarium; Loc. 3; UCM 40363.
   Longitudinal view of exozone showing an exceptionally complete monticule preserved by overgrowth of *Dekayia;* note conspecific overgrowth at lower left; × 40.

EXPLANATION OF PLATE 44

Figure Page

1, 2. **Peronopora decipiens** Röminger 234

1. Thin-sections of zoarium (monticules low on zoarial surface); Loc. 6; UCM 40364.
    - 1a. Longitudinal view of exozone; brown bodies shown at center right; × 40.
    - 1b. Longitudinal view of median layer and endozone; tubules in median layer; × 100.
    - 1c. Tangential view showing conspicuous cystiphragms; × 40.
    - 1d. Tangential view showing lumen of acanthopores; × 100.
2. Acetate peel of zoarium; Loc. 4; UCM 40365.
   Transverse view of exozone and endozone; median tubules in median layer; note unequal width of exozone, unusually thick and well developed median layer; × 40.

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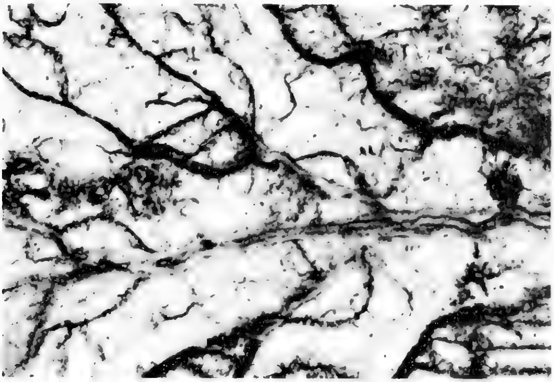

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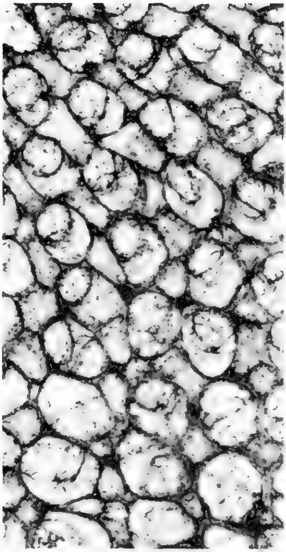

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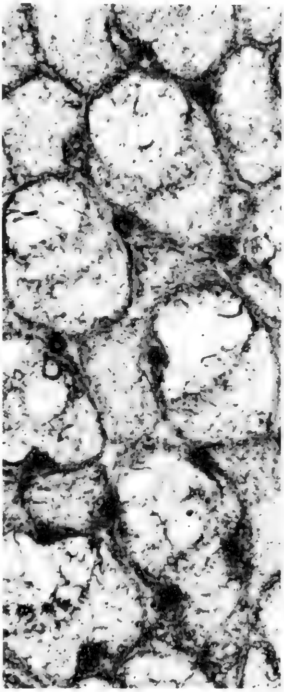

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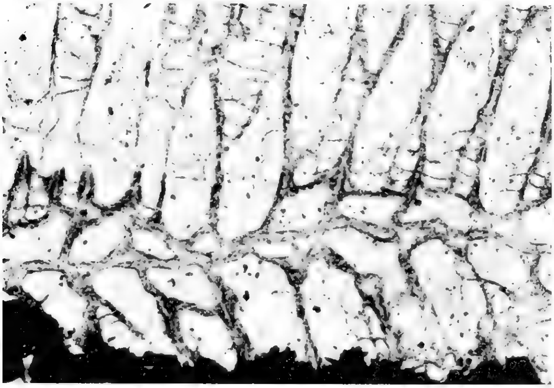

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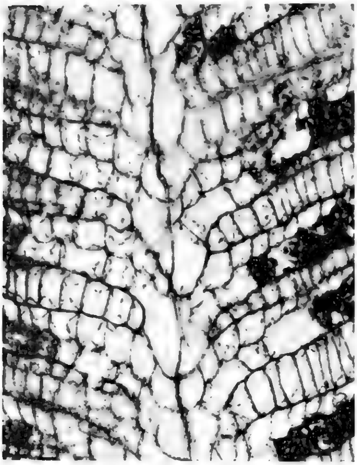

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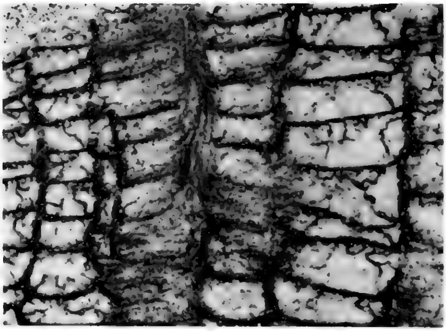

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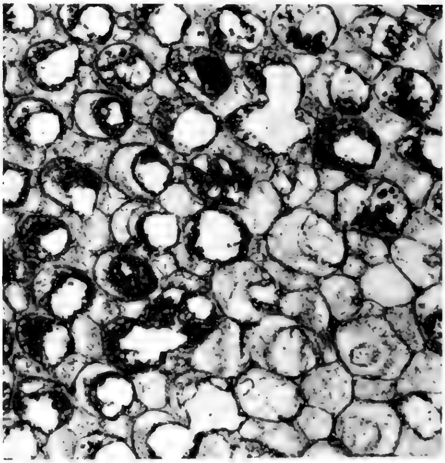

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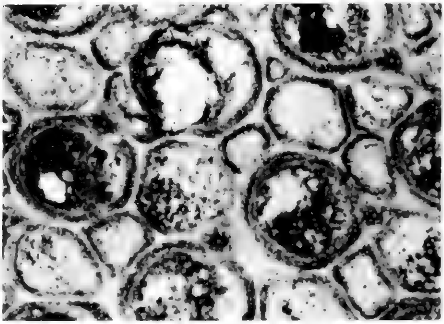

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EXPLANATION OF PLATE 45

Figure	Page
1. **Peronopora decipiens** Röminger	234

Thin-sections of zoarium (low monticules); Loc. 2; UCM 40366.

- 1a. Longitudinal view of exozone and endozone; × 40.
- 1b. Transverse view of exozone and endozone; median tubules in median layer; × 40.
- 1c. Longitudinal view of exozone showing many mesopores apparently pertaining to a monticule; acanthopore in central part is irregular longitudinally; × 100.
- 1d. Tangential view showing megazooecia and clusters of mesopores at lower right forming a monticule; × 40.
- 1e. Tangential view of intermonticular area; acanthopores have a minute lumen; × 100.

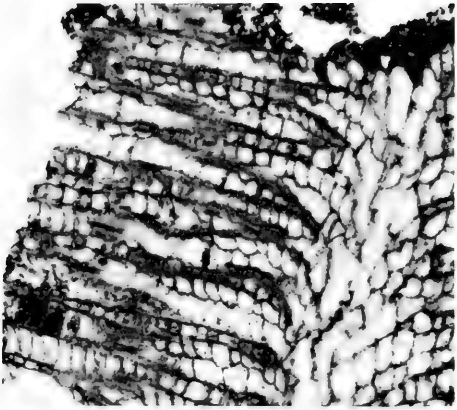
EXPLANATION OF PLATE 46

Figure Page

1, 2. **Peronopora dubia** (Cumings and Galloway) 238

Thin-sections of zoaria (zoarial surfaces smooth).

1. Loc. 1; UCM 40367.
    - 1a. Longitudinal view of exozone and endozone showing thin median layer, not developed distally; × 25.
    - 1b. Longitudinal view of wall in exozone showing a "hooked" acanthopore; × 100.
    - 1c. Tangential view showing irregular zooecial openings, due to invasion of zooecium by acanthopores; × 40.
    - 1d. Tangential view showing thick walls; distinct lumen of acanthopores; × 100.
    - 1e. Longitudinal view, part of cystiphragms at left; × 250.
2. Loc. 2; UCM 40330.
    - 2a. Tangential view showing regular sized zooecia; × 40.
    - 2b. Tangential view showing megazooecia; large opening is a boring of unknown nature; × 40.



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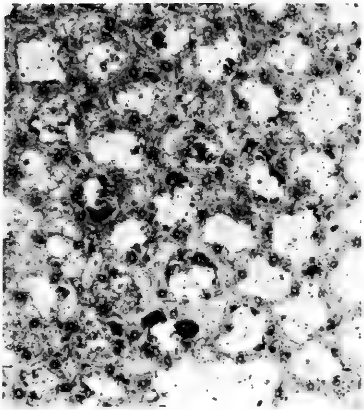

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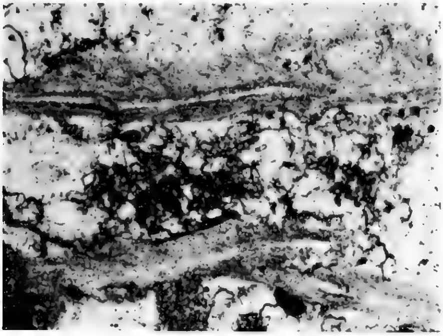

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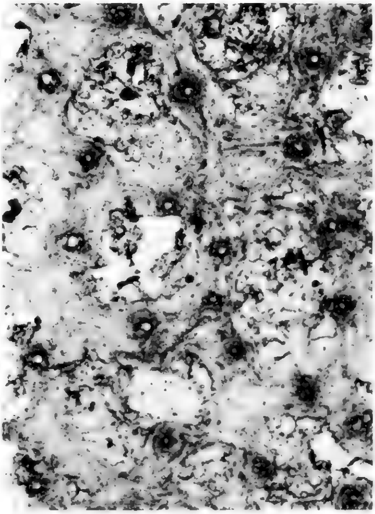

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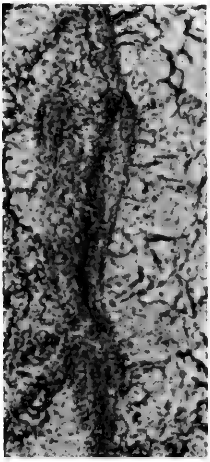

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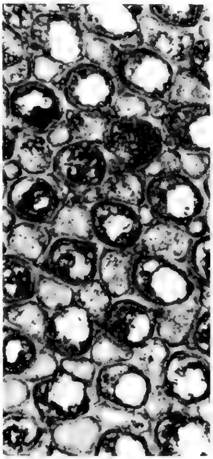

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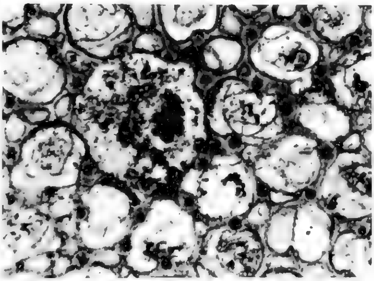

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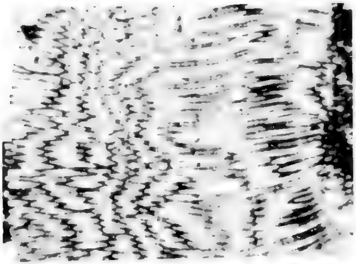
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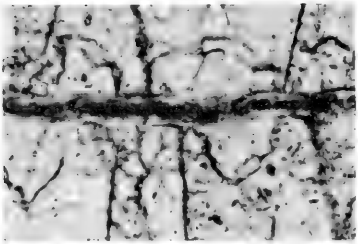
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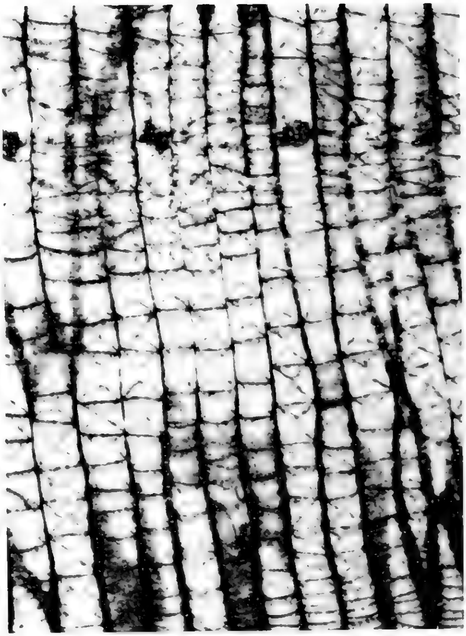
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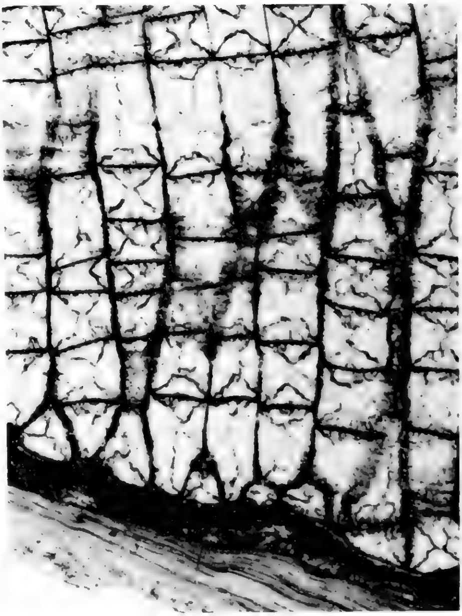
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EXPLANATION OF PLATE 47

Figure		Page
1, 2.	**Amplexopora (?) filiasa** (d'Orbigny)	240

1. Thin-sections of zoarium (zoarial surface smooth); Loc. 5; UCM 40368.
   - 1a. Longitudinal view showing many thick- (exozone) and thin-walled (endozone) zones in continuity without zooecial bends; × 2.5.
   - 1b. Longitudinal view showing details of exozone and endozone; aligned brown bodies in upper portion; spacing of diaphragms is distinctive for each zone; × 25.
   - 1c. Longitudinal view showing acanthopores (central portion) and clusters of brown bodies in upper portion; × 100.
   - 1d. Longitudinal view showing dark material within indistinctly laminate wall; × 250.
2. Thin-sections of zoarium (zoarial surface covered with monticules); Loc. 5; UCM 40369.
   Transverse view of proximal portion incrusting a brachiopod shell fragment. Note dark material, probably detrital, between shell surface and basal layer; × 40.

EXPLANATION OF PLATE 48

Figure Page

1. **Amplexopora (?) filiasa** (d'Orbigny) 240

Thin-sections of zoarium (zoarial surface covered with monticules); Loc. 5; UCM 40369.

1a. Longitudinal view showing funnel diaphragms and brown bodies; × 40.

1b. Tangential view of monticular (with megazooecia and irregularly laminate wall) and intermonticular regions; × 40.

1c. Tangential view of monticular and intermonticular wall; × 100.

1d. Longitudinal view of wall near zoarial surface showing many cystose diaphragms; × 100.

1e. Longitudinal view of wall showing distinctly laminate wall; laminae are sharply convex, continuous across ZCL; × 250.


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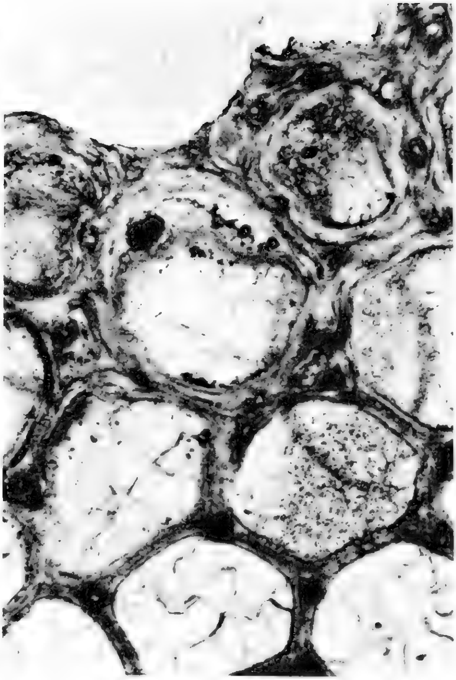
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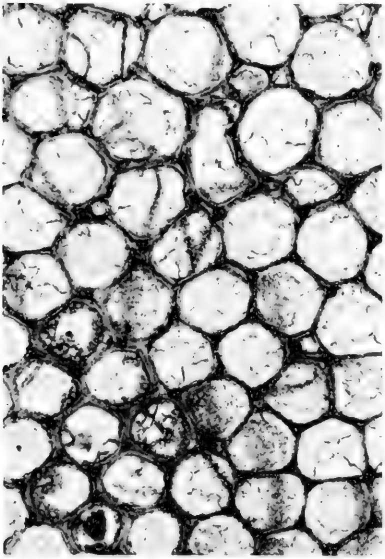
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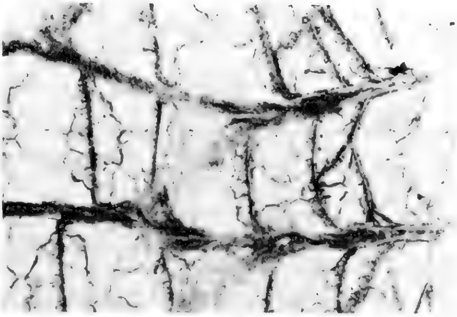
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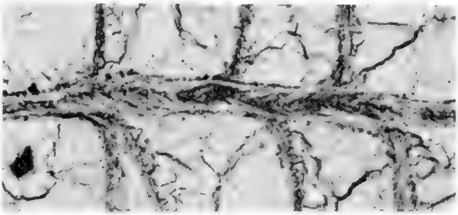
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INDEX

NUMBER 307

Note: Page numbers in light face; plate numbers in **bold face** type.

INDEX

INDEX

INDEX

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Collinson, J.
1962. *Size of lettering for text-figures.* Jour. Paleont., v. 36, p. 1402.


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UPPER SILURIAN (PRIDOLI) STROMATOPOROIDEA OF NEW YORK

By

CARL W. STOCK

1979

Paleontological Research Institution
Ithaca, New York 14850 U. S. A.

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CONTENTS

Stratigraphy

Systematic Paleontology

Descriptions

Family Clathrodictyidae Kühn, 1939

Family Actinostromatidae Nicholson, 1886b

Family Stromatoporidae Winchell, 1867

Family Densastromatidae Bogoyavlenskaya, 1974

LIST OF ILLUSTRATIONS

LIST OF TABLES

UPPER SILURIAN (PRIDOLI) STROMATOPOROIDEA OF NEW YORK

By

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Department of Geology and Geography
The University of Alabama
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ABSTRACT

Stromatoporoids are a major component of the faunas of the Upper Silurian (Pridoli) rocks in New York. They are found in the Wilbur, Glasco, and Cobleskill Members of the Rondout Formation.

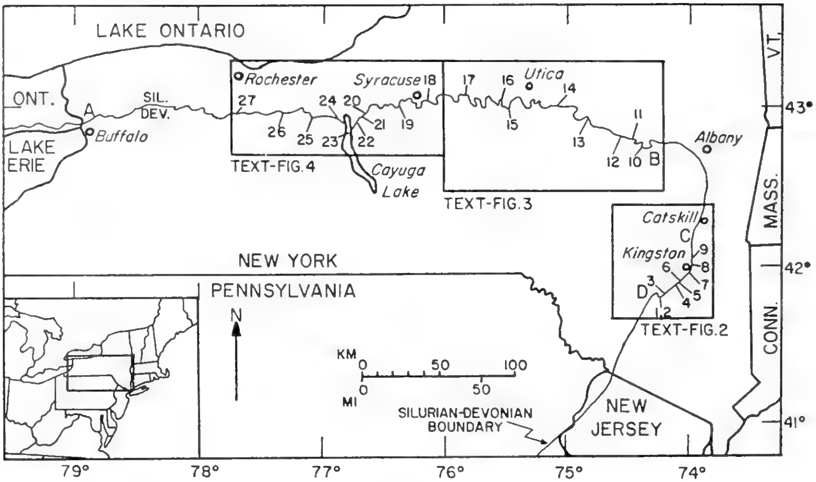
Eleven species are described. Three, *Stromatopora clarkei* Parks, *Parallelostroma constellatum* (Hall), and *Densastroma tenuissimum* (Parks) have previously been described from the Cobleskill Member. *Stictostroma pseudoconvictum,* n. sp., *Plectostroma micum* (Bogoyavlenskaya), *Stromatopora bekkeri* Nestor, *Stromatopora coconcentrica,* n. sp., *Parallelostroma typicum* (Rosen), *Parallelostroma kaugatomicum* (Riabinin), *Parallelostroma rondoutense,* n. sp. and *Densastroma pexisum* (Yavorsky) are reported here for the first time.

Stromatoporoid faunas from the Rondout Formation are typical of the Upper Silurian. Some of these species reflect relationships with taxa from earlier or later ages.

A study of the stratigraphy and paleoecology of the Rondout Formation stromatoporoids indicates that they lived in shallow water near the shore of the Appalachian Basin. Information from the lithofacies and stromatoporoid biofacies gives a more precise indication of the depositional environments. The presence of dolomite is indicative of intertidal or supratidal conditions, except where it was transported as a coastal silty dolomite facies. Silicified stromatoporoids represent an early stage of diagenesis in shallow or supratidal areas. Fossiliferous limestones indicate deeper water, farther from shore. Subspherical stromatoporoid-dominated biostromes resulted from carbonate bank development in the surf zone.

The Wilbur Member in eastern New York, consisting predominantly of fossiliferous limestone, resulted from deeper conditions than the correlative Cobleskill Member in central and western New York, which contains both limestone and dolomite. A biostrome in the Cobleskill Member in the Cayuga Lake area also resulted from shallower conditions. The same relationship exists between the younger Glasco Member (fossiliferous limestone) in the east, and the correlative Chrysler Member (barren dolomite) in the central and western part of the state. Within the Cobleskill Member, the increase in dolomite to the west, the biostrome in the Cayuga Lake area, and the silicified stromatoporoids to the west, all indicate shallower conditions in the western part of New York than in the central part.

Wilbur-Cobleskill deposition took place in deeper water than did Glasco-Chrysler deposition. Fossiliferous limestone and dolomite of the Cobleskill Member were succeeded by the barren dolomite of the Chrysler Member. Just as the biostrome in the Cobleskill Member indicates shallower conditions than in the Wilbur Member, biostromes in the Glasco Member are a result of shallower conditions than in the earlier Wilbur Member.



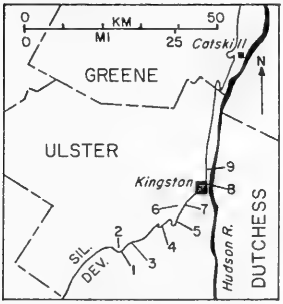
Text-figure 1. — Index map of New York showing the outcrop trace of the Silurian-Devonian boundary and collecting localities.

INTRODUCTION

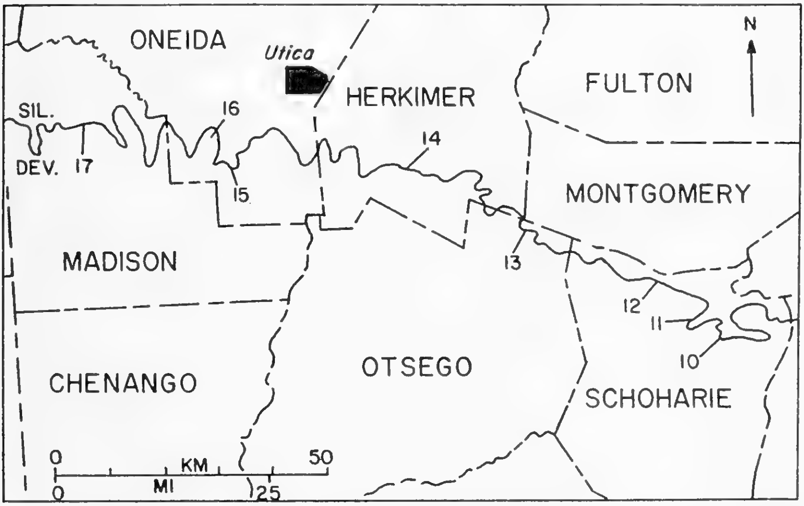
This study systematically describes stromatoporoids from the uppermost Silurian (Pridoli) Rondout Formation of New York. Analyses of the paleoecology and paleobiogeography of the described stromatoporoids supplement knowledge of the paleoecology and paleogeography of New York during deposition of the Rondout Formation.

Pridoli stromatoporoids are found in the Wilbur and Glasco Members of the Rondout Formation in eastern New York (Text-fig. 2), and the Cobleskill Member in central New York (Text-figs. 3, 4). Over 100 localities, 27 of which yielded stromatoporoids, were visited during the summers of 1974 and 1975. These 27 localities are shown on the sketch maps (Text-figs. 1-4), and are described in the following list.

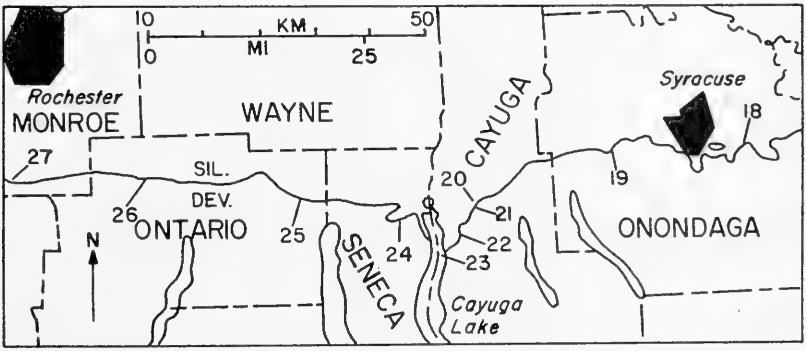
More than 325 stromatoporoids were collected, from which 534 thin-sections were prepared. This Pridoli stromatoporoid fauna contains eleven species (three new) belonging to five genera.



Text-figure 2. — Index map of collecting localities in eastern New York.



Text-figure 3. — Index map of collecting localities in east-central New York.



Text-figure 4. — Index map of collecting localities in west-central New York.

COLLECTING LOCALITIES

Names in brackets are U.S. Geol. Survey 7-1/2 minute topographic quadrangles.

1. South side of hill 1.3 km (0.8 mi.) south of bridge over Rondout Creek at Accord [Mohonk Lake].
2. Abandoned railroad cut 0.5 km (0.3 mi.) southwest of bridge over Rondout Creek at Accord [Mohonk Lake].
3. Roadcut on road along Rondout Creek, 1.6 km (1.0 mi.) west of Alligerville and 6.8 km (4.25 mi.) southwest of High Falls [Mohonk Lake].
4. Along Coxing Kill, 1.7 km (1.05 mi.) southwest of Lawrenceville, between NY Rt. 213 and Mossy Brook Road [Rosendale].
5. Abandoned cement mine and quarry east of NY Rt. 32, 0.9 km (0.6 mi.) south of junction of NY Rt. 32 and NY Rt. 213 [Rosendale].
6. Abandoned cement mine on southeast side of Fourth Binnewater Lake, 1.7 km (1.1 mi.) north of Binnewater Station, along the New York Central Railroad [Rosendale].
7. Roadcut on west side of NY Rt. 32, 3.9 km (2.4 mi.) northeast of the junction of NY Rt. 32 with NY Rt. 213 in Rosendale, and 0.5 km (0.3 mi.) west of Bloomington [Kingston West].
8. Abandoned quarries on east side of Vlightberg Hill in Hasbrouck Park, Rondout [Kingston East].
9. Roadcut on west side of NY Rt. 32, 0.4 km (0.3 mi.) south of entrance to the Kingston-Rhinecliff Bridge, NY Rt. 199 [Kingston East].
10. Along west side of Schoharie Creek, 0.3 km (0.2 mi.) south of the bridge west of Schoharie [Schoharie].
11. Roadcut 0.3 km (0.2 mi.) west of Howes Cave on road between Howes Cave and Braymanville [Cobleskill].
12. Low north-facing escarpment, north side of road, 1.4 km (0.9 mi.) northwest of Carlisle [Carlisle].
13. Roadcut along road north of Dugway Gorge, 1.6 km (1.0 mi.) southwest of Salt Springville [East Springfield].
14. Small quarry on hillside behind old barn west of road, 0.9 km (0.6 mi.) west of Getman Corners [Millers Mills].
15. At the bank of Big Creek, west of NY Rt. 315 about 0.3 km (0.2 mi.) south of Forge Hollow [Oriskany Falls].
16. Small roadcut on south side of Prospect Hill, just south of radio tower, 0.2 km (0.1 mi) east of Skyline Drive [Clinton].
17. Roadcut 1.1 km (0.7 mi.) south of Clockville [Oneida].
18. Small hill 0.2 km (0.1 mi.) south of the Jamesville-DeWitt High School, 0.4 km (0.2 mi.) northwest of the abandoned London-Heard Gypsum quarry [Syracuse East].
19. Roadcut on east side of NY Rt. 174, 0.2 km (0.1 mi.) south of the dam at Marcellus Falls [Camillus].
20. Outlier forming low hill south of US Rt. 20 and NY Rt. 5, 0.4 km (0.25 mi.) east of abandoned New York Central Railroad and 0.6 km (0.35 mi.) west of intersection with Stony Pitch Road [Cayuga].
21. Hillside and abandoned quarry south of NY Rt. 326, 0.9 km (0.55 mi.) southeast of Relius [Cayuga].
22. Low roadcut at Cross Roads on Connors Road, 0.2 km (0.1 mi.) east of the junction with Cross Road [Cayuga].
23. Frontenac Island in Cayuga Lake, west of Union Springs [Union Springs].
24. Abandoned McQuan's quarry at the end of dirt road, 0.8 km (0.5 mi.) southeast of the Kingdom Bridge over the Cayuga and Seneca Canal and 0.2 km (0.15 mi.) west of abandoned Lehigh Valley Railroad just southwest of the city limits of Seneca Falls [Seneca Falls].
25. Oaks Corners quarry, 0.3 km (0.2 mi.) northwest of Oaks Corners [Phelps].

26. Streambank of Mud Creek, 0.6 km (0.4 mi.) south of NY Rt. 96 at a point 1.15 km (0.7 mi.) west of its junction with NY-332 [Canandaigua].
27. North-facing hillside 0.8 km (0.5 mi.) east-northeast of Five Points [Rush].

ACKNOWLEDGMENTS

This study of the stromatoporoids of the Upper Silurian of New York was carried out under the direction of Dr. Joseph St. Jean, Jr., and was submitted in partial fulfillment of the requirements for the Ph.D. degree in Geology at the University of North Carolina at Chapel Hill.

I wish to thank Dr. St. Jean for his helpful advice during the course of this study, and for access to his personal library of stromatoporoid literature. Dr. John M. Dennison, Dr. Daniel A. Textoris, and Dr. Joseph G. Carter also made helpful suggestions. The author also appreciates help given in the field by Samuel J. Ciurca, Jr. and Steven R. Strait. Mr. Ciurca also contributed stromatoporoids from Localities 23 and 27. Thanks are due to the Department of Geology at the University of North Carolina at Chapel Hill for use of thin-section and photographic equipment, and to the Department of Geological Sciences of the State University of New York at Binghamton for use of thin-section equipment. Thanks are also due to the Gulf Oil Foundation, whose fellowship supported me during the 1975-1976 academic year, and to the Society of Sigma Xi for a grant to help defray costs of field work. The author is also grateful for a loan of the Parks (1909) type specimens by the New York State Museum. Thanks must also go to my wife, Marsha S. Stock, for her help in the field, her help with the manuscript and her patience and encouragement. The College of Arts and Sciences and the Department of Geology and Geography of The University of Alabama contributed equal amounts toward the cost of publication.

PREVIOUS WORK

Upper Silurian (Pridoli) stromatoporoids, especially those from North America, have received little attention. Only three valid species have been described previously from New York.

The earliest description of stromatoporoids from the Rondout Formation of New York was made by Hall (1852, p. 324). He described *Stromatopora concentrica* Goldfuss, 1826, and the new species *Stromatopora constellata* from the "Coralline limestone" (Cobleskill Member) of Schoharie County, but his taxonomy was based on external morphology alone.

Parks (1908, p. 44) used a topotype specimen to redescribe *S. constellata*. His was the first use of thin-sections for the description of the species. In 1909, Parks again described *S. constellata* (p. 46), and introduced two new species from the "Niagara limestone" (Cobleskill Member) of Schoharie County: *Actinostroma tenuissimum* (p. 42) and *Stromatopora clarkei* (p. 48).

The presence of stromatoporoids in the Rondout Formation of New York has been noted in the following reports on the geology of 15-minute quadrangles: Clarke and Luther (1904, pp. 10, 11), Grabau (1906, pp. 317, 318), Luther (1910, p. 11), Smith (1935, p. 14), Goldring (1935, p. 81), Chadwick (1944, p. 51), and Rickard and Zenger (1964, p. 37). In his extensive report on the Cobleskill Limestone, Hartnagel (1903, pp. 1117-1133) frequently mentioned stromatoporoids. Rickard (1962, pp. 27-36) mentioned the distribution of stromatoporoids within the Rondout Formation across New York, as did Hoar and Bowen (1967, p. 7) and Harper (1969, p. 266) from the eastern part of the state. Harper also devoted a section to stromatoporoid and halysitid coral paleoecology.

Other studies of North American stromatoporoids from uppermost Silurian (Pridoli) and lowermost Devonian (Gedinne) rocks have been published, but few of the stratigraphic units involved are equivalent in age to the Rondout Formation (Berry and Boucot, 1970, pl. 2). Girty (1895) named six new species of stromatoporoids from the "Lower Pentamerus limestone" (Coeymans Formation, Lower Devonian [Rickard, 1962, p. 65]) in Albany, Herkimer and Onondaga counties.

Parks (1907, 1908, 1909) studied Silurian stromatoporoids from the U.S.A. and Canada, including *Stromatopora constellata* Hall, *Stromatopora clarkei* Parks, and *Actinostroma tennuissimum* Parks. He also described 24 species of stromatoporoids from Baie des Chaleurs at Port Daniel, Quebec, that ranged in age from late Llandovery through middle Ludlow (Parks, 1933).

Three species were described by C. K. Swartz (1913, pp. 221-225) from the Pridoli/Gedinne correlatives of the Keyser Member (now Formation) of Maryland, West Virginia, and Pennsylvania: *Stromatopora constellata* Hall, 1852 [partly *Parallelostroma kaugatomicum* (Riabinin, 1951)], *Syringostroma barretti* Girty, 1895 [= *Stromatopora clarkei* Parks, 1909], and *Syringostroma centro-*

tum Girty, 1895 [prob. *P. kaugatomicum*]. A specimen attributed to *S. constellata* was reported by Swartz and Prouty (1923, p. 399) from the Pridoli age Tonoloway Formation of Maryland and West Virginia, but the published figure (pl. 10, figs. 8-9) is unrecognizable. Swartz and Prouty referred their specimens to the "type C" of *S. constellata* described by Swartz (1913, p. 223). F. M. Swartz (1929, pp. 33-34, 59, 61-68) noted stromatoporoids in the Keyser Limestone of Virginia and West Virginia.

Nine species of stromatoporoids were described by Stearn and Hubert (1966) from the Matapedia-Temiscouata area of Quebec. Most specimens were of Ludlow age, but some poorly preserved specimens came from the Lac Croche [Crooked Lake] Formation of Pridoli age, parts of which may be as young as the Rondout Formation (Berry and Boucot, 1970, p. 172).

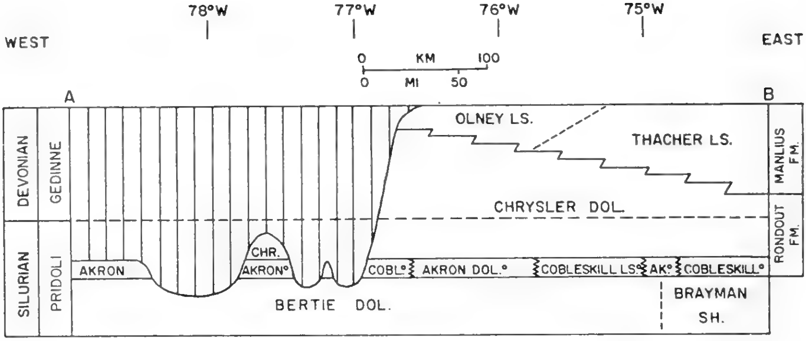
Most descriptions of Pridoli age stromatoporoids have come from Europe, including Estonia (Riabinin, 1951; Nestor, 1966), Gotland (Mori, 1970), mainland Sweden (Mori, 1969) and the U.S.S.R. (Yavorsky, 1929, 1955; Riabinin, 1953; Bogoyavlenskaya, 1969a, 1973; Bolshakova, 1969, 1973).

Although abundant in Pridoli age rocks of the Appalachian Basin from New York to Virginia, stromatoporoids have received little attention in the literature. Because the first described species of this age came from the Rondout Formation of New York, that area is appropriate for more detailed study. Parks' description (1908, p. 44) of *S. constellata* was based on a single specimen, as were those of *A. tenuissimum* and *S. clarkei* (Parks, 1909, pp. 42, 48). The material collected for this study provides a better understanding of intraspecific variation in these three species, and includes eight additional species.

STRATIGRAPHY

Regional stratigraphy. — The uppermost Silurian (late Pridoli) in New York is represented by the Rondout and Decker Formations. The New York exposures of the Rondout Formation, some of which were sampled for the present study, extend from the east bank of the Niagara River, north of Buffalo, east to the Albany area, and south to the New Jersey border (Text-fig. 1).

In the study area the Rondout Formation consists of seven members, some of which extend into the lowermost Devonian

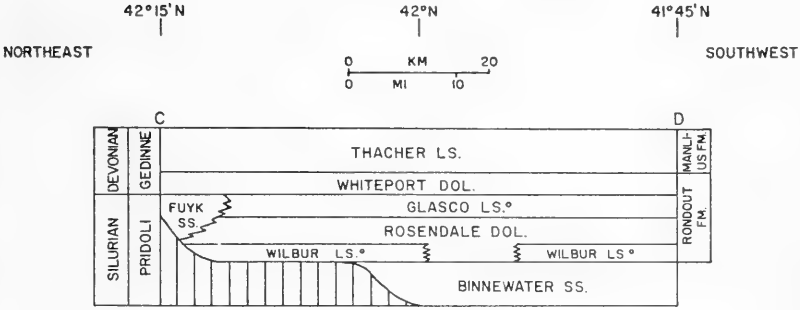


Text-figure 5. — Stratigraphy of the Rondout and adjacent Formations along the outcrop belt in central and western New York (between points A and B in Text-fig. 1). Vertical dimension is time, not thickness (after Rickard, 1975, pls. 2, 3). ° indicates units of the Rondout Formation containing stromatoporoids.

(Gedinne). They are the Wilbur, Rosendale, Glasco, Whiteport and Fuyk Members in eastern New York, and the Cobleskill and Chrysler Members in central and western New York. Rickard (1975, pls. 2, 3) has summarized the stratigraphy of the Rondout Formation and associated Silurian and Devonian strata (Text figs. 5, 6).

The Wilbur Member is the oldest member of the Rondout Formation in eastern New York. Hartnagel (1903, p. 1145) gave this name to exposures of the lowermost member of the Rondout Formation from 1.6 km south of Kingston north to Locality 9. Harper (1969, figs. 6, 7) extended the usage to rocks previously included in the Rosendale Member in an area to the south, between Localities 1 and 4. The Wilbur Member is a buff- to gray-weathering, brown-gray, argillaceous, mottled to nodular, very fossiliferous crinoid, brachiopod, calcarenite (Harper, 1969, p. 10), that also contains stromatoporoids and halysitid corals. The Wilbur Member varies from 1.2 m thick near Wilbur (1.6 km south of Kingston), to 3.7 m thick at Locality 9 (Hoar and Bowen, 1967, p. 4).

The Rosendale Member typically overlies the Wilbur Member, except in the area between Locality 4 and Wilbur, where the lower Rosendale Member is the lateral equivalent of the Wilbur Member (Text-fig. 6). Hartnagel (1905, p. 356) gave the name Rosendale Member to generally unfossiliferous, "buff-weathering, dark gray on fresh [surfaces], argillaceous" dolomite (Harper, 1969, p. 11).



Text-figure 6. — Stratigraphy of the Rondout and adjacent Formations along the outcrop belt in eastern New York (between points C and D in Text-fig. 1). Vertical dimension is time, not thickness (after Rickard, 1975, pls. 2, 3). ° indicates units of the Rondout Formation containing stromatoporoids.

The Rosendale Member is thickest (6.5 m) in a quarry 1.3 km west of Rosendale, 2.2 km northeast of Locality 4, and 2 km west of Locality 5 (Harper, 1969, fig. 6).

The Glasco Member overlies the Rosendale Member and is composed of very fossiliferous, thick-bedded, "dark-brown weathering, very dark-gray to black on fresh [surfaces]" limestone (Harper, 1969, p. 12). It was named by Chadwick (1944, p. 44) based on exposures near the town of Glasco, 8.1 km north of Locality 9. Stromatoporoids are the most abundant fossils, developing biostromes in the Glasco Member at Localities 1, 3, and 9 (Text-fig. 2). Tabulate and rugose corals are also abundant. The Glasco Member is found at every locality here reported in eastern New York, except Loc. 8, where the overlying Whiteport Member rests on the Rosendale Member. Where present, its thickness ranges from 3.1 to 4.6 m (Rickard, 1962, p. 35). The Glasco is the youngest member of the Rondout Formation and is assigned to the Silurian on the basis of the presence of the chain coral *Cystihalysites.* Sutton (1964, p. 452) noted that previous authors had been slow to accept *Cystihalysites,* and placed specimens in the older genus *Halysites.* Whichever genus is used, halysitid tabulate corals are index fossils for the Silurian (Berry and Boucot, 1970, pp. 33, 215; Harper, 1969, pp. 13, 161; Berdan, 1964, p. B16; 1972, p. 9).

The Whiteport Member, named by Rickard (1962, p. 36), is the highest unit in the Rondout Formation throughout eastern New

York. It is a buff-weathering, gray, argillaceous, silty dolomite, rarely containing fossils. Well-developed supratidal mudcrack polygons can be seen in bedding-plane exposures 3.2 km southwest of High Falls between Localities 3 and 4. Its thickness ranges from 1.2 m at Locality 9, increasing southward to 4.9 m at High Falls.

The Fuyk Member (Chadwick, 1944, p. 51) consists of calcareous, "medium-bedded, fine to medium-grained, brown and gray sandstones" (Rickard, 1962, p. 33) found near the town of Catskill (Text-fig. 2), and having a maximum thickness of 4.9 m (measured from Harper, 1969, p. 33, fig. 10, sect. 65-6). Rickard (1975, pl. 2) placed the Fuyk Member in a position equivalent to the Glasco and Rosendale Members (Text-fig. 6).

The Cobleskill Member was recently reduced from formation to member rank by Rickard (1975, p. 4), at the suggestion of Harper (1969, p. 160). The name was first applied by Clarke (1903, p. r42) and later by Hartnagel (1903, p. 1114) for what had previously been known as the "Coralline limestone" in the vicinity of Locality 10. The Cobleskill Member in the type area is 2.8 m thick, with a lower portion of 1.2 m of "two massive beds composed of blue-black limestone of medium grain" and an upper portion of 1.6 m of "fine-grained mottled limestone grading upwards into a dolomitic limestone with a slight conchoidal fracture" (Rickard, 1962, p. 25). Its thickness may reach 4.6 m near Syracuse. In some areas the lithology is partly or entirely dolomite (Text-fig. 5). Stromatoporoids, favositid tabulate corals, solitary rugose corals, brachiopods, ostracods, gastropods and pelecypods are common fossils. Stromatoporoid biotromes are developed in the Cayuga Lake area (Localities 21-23).

The Cobleskill Member outcrops from Gallupville in eastern Schoharie County westward to the Niagara River gorge and into Ontario, Canada. Limestone and barren, fine-grained gray dolomite alternate laterally as major Cobleskill lithologies across New York (Text-fig. 5); at Locality 17 limestone overlies dolomite. The portion of the Cobleskill Member west of Locality 24 has been referred by Rickard (1975, pl. 2) to the Akron Dolomite of Sherzer and Grabau (1909, p. 550). Some workers justified the two names by the lateral discontinuity of the two units (Rickard, 1962, p. 25), and by the supposed absence of fossils in the Akron Dolomite, and their presence in the "dolomitic Cobleskill Member." Ciurca (1973, p.

D6) traced Akron and Cobleskill outcrops and concluded that the Akron Dolomite was the lithologic equivalent of the Cobleskill Member. He found fossils in the unit at Localities 25 and 27 and at Honeoye Falls, 5.6 km east of Locality 27. Rickard (1975, pl. 2) however, retained the usage of the Akron Dolomite (now Member) for the rocks west of Locality 24, and extended it to the area between Locality 19 eastward to Chittenango Creek, 8.9 km west of Locality 17, and a segment north of Richfield Springs, represented by Locality 13. The repeated exchange of names across New York, corresponding to lateral lithologic change, is unnecessarily complicated. The term "Akron Facies" is used here for dolomitic rocks in the Cobleskill Member.

The Cobleskill Member is of the same age as the Wilbur Member in eastern New York (Rickard, 1975, pl. 2). The Rosendale, Glasco, and Whiteport Members, which overlie the Wilbur Member, are of the same age as the Chrysler Member of the Rondout Formation in central New York. Rickard (1962, p. 41) described the contact of the Cobleskill Member with the overlying Chrysler Member:

> Passage upward from the Cobleskill into the Rondout [Chrysler] is characterized by introduction of thinner bedding and more argillaceous strata, the development of conchoidal fracture and the apparently complete disappearance of fossils.

The name Chrysler was proposed by Chadwick (1930, p. 81) for beds previously called Rondout in central New York, as he did not believe they were of the same age as what was then called Rondout in eastern New York. Chadwick (Swartz, *et al.*, 1942, p. 534) abandoned the name Chrysler when he realized that the beds in central New York were the same age as those in the eastern part of the state. Rickard (1962, p. 39) restored the name Chrysler as a member. Lithologically, the Chrysler Member is an argillaceous thin-bedded dolomite with occasional massive beds, weathering to buff color and often breaking with a conchoidal fracture. Although Rickard (1962, p. 41) cited a complete lack of fossils, he did mention (p. 39) abundant ostracods and eurypterid fragments near Syracuse. Ciurca (1975) also found eurypterids in the Chrysler Member. The combination of dolomitic lithology, the presence of ostracods and eurypterids at some localities, and the total absence of fossils at others suggests a shallow, perhaps supratidal depositional environment for the Chrysler Member.

The Chrysler Member outcrops from Albany County, east of Locality 10, west to Locality 24. A small recurrence to the west in Monroe County 5.6 km east of Locality 27 was reported by Ciurca (1973, p. D7), who called it the Honeoye Falls Formation. However, Rickard (1975, pl. 2) included it in the Chrysler Member. Rickard (1962, p. 41) recorded representative thicknesses of up to 19.8 m at Chittenango Falls (9.7 km southwest of Locality 17 in Madison County) and as little as 6.1 m in Schoharie County.

The Decker Formation is found only in the extreme southeastern part of New York, but extends into New Jersey. It is equivalent in age to the Silurian parts of the Rondout Formation (Rickard, 1975, pl. 2). No stromatoporoids are known from the New York part of the Decker Formation.

Stromatoporoid biostratigraphy. — Eleven species of stromatoporoids belonging to five genera were collected from 27 localities. Their stratigraphic distribution is shown in Table 1. Most of the species identified have previously been recognized from Ludlow or Pridoli age strata.

Table 1. — Stratigraphic Distribution of New York Stromatoporoids.

Rondout Formation

- Glasco Member
  - *Stictostroma pseudoconvictum*, n. sp.
  - *Plectostroma micum* (Bogoyavlenskaya, 1969a)
  - *Stromatopora clarkei* Parks, 1909
  - *Stromatopora bekkeri* Nestor, 1966
  - *Parallelostroma constellatum* (Hall, 1852)
  - *Parallelostroma kaugatomicum* (Riabinin, 1951)
  - *Parallelostroma rondoutense*, n. sp.
  - *Densastroma tenuissimum* (Parks, 1909)
  - *Densastroma pexisum* (Yavorsky, 1929)
- Wilbur Member
  - *Stromatopora bekkeri* Nestor, 1966
  - *Parallelostroma constellatum* (Hall, 1852)
  - *Parallelostroma kaugatomicum* (Riabinin, 1951)
- Cobleskill Member
  - *Stictostroma pseudoconvictum*, n. sp.
  - *Stromatopora clarkei* Parks, 1909
  - *Stromatopora eoconcentrica*, n. sp.
  - *Parallelostroma constellatum* (Hall, 1852)
  - *Parallelostroma typicum* (Rosen, 1867)
  - *Parallelostroma kaugatomicum* (Riabinin, 1951)
  - *Parallelostroma rondoutense*, n. sp.
  - *Densastroma tenuissimum* (Parks, 1909)
  - *Densastroma pexisum* (Yavorsky, 1929)

Many stromatoporoids once thought to come from rocks of late Ludlow age are of Pridoli age, a term first applied to the uppermost Silurian by Bouček, *et al.* (1966, p. 55). This situation is true of the Skala Horizon of the U.S.S.R. (Boucot and Pankiwskyj, 1962, p. 7; Berry and Boucot, 1970, pp. 18, 19) and the Kaugatuma and Okhesaare Stages of Estonia (Nestor, 1975, written comm.). Mori (1970, p. 74) correlated the Eke, Burgsvik, Hamra and Sundre Beds of Gotland with the Kaugatuma Stage of Estonia.

The following species from the Rondout Formation have been reported from rocks of Pridoli age outside North America (Bolshakova, 1973, p. 8; Mori, 1970, p. 137; Riabinin, 1951, p. 43; 1953, p. 46):

Plectostroma micum (Bogoyavlenskaya) from Podolia (U.S.S.R.)
Parallelostroma constellatum (Hall) from Estonia
Parallelostroma typicum (Rosen) from Podolia (U.S.S.R.), Gotland and Estonia
Parallelostroma kaugatomicum (Riabinin) from Estonia
Parallelostroma rondoutense, n. sp., from Gotland [as *P. typicum* (Rosen) Mori (part)]

The Rondout Formation stromatoporoid assemblage has ties with older Silurian rocks. *Densastroma pexisum* (Yavorsky) is known from rocks of Wenlock age in Estonia (Nestor, 1966, p. 71) and Gotland (Mori, 1968, p. 75).

Just as some European stratigraphic units once considered as of Ludlow age are now assigned to the Pridoli, some Wenlock age units have been placed in the Ludlow. This is true of the Malinovetski Horizon of the U.S.S.R. (Boucot and Pankiwskyj, 1962, p. 6). The following species from the Rondout Formation have been reported from Ludlow rocks (Bogoyavlenskaya, 1969a, p. 165 [transl.]; Bolshakova, 1973, p. 8; Mori, 1970, pp. 123, 137; Nestor, 1962, pp. 18, 23; 1966, p. 72; Riabinin, 1951, p. 55; 1953, p. 60):

Plectostroma micum (Bogoyavlenskaya) from Podolia (U.S.S.R.)
Stromatopora bekkeri Nestor from Estonia and Gotland
Parallelostroma typicum (Rosen) from Podolia (U.S.S.R.), Estonia and Gotland
Parallelostroma kaugatomicum (Riabinin) from Estonia

None of the species from the Rondout Formation is definitely known from Lower Devonian deposits. *Stromatopora eoconcentrica*, n. sp., resembles specimens of *S. concentrica* which come from rocks no older than Middle Devonian, and *Parallelostroma rondoutense*,

n. sp., appears related to species of *Syringostroma* from the Lower and Middle Devonian. The relationships of these species are discussed in the Systematic Paleontology section.

The Rondout Formation stromatoporoid assemblage has stronger taxonomic ties with penecontemporaneous European (Gotland, Estonia, U.S.S.R.) assemblages than with those in North America. In North America only the species from the central Appalachian Basin described by Swartz (1913, pp. 221-225) and Swartz and Prouty (1923, p. 399) are in common with those of the New York Rondout Formation. This is understandable from the perspective of Silurian continental positions. A number of workers, (e.g., Oliver, 1976, text-fig. 3), have noted that Europe was relatively close to North America in Late Silurian time. The New York Appalachian Basin would then have been close to Europe, and a single faunal province might have included both areas.

The close affinity between the Rondout Formation stromatoporoid assemblage and European assemblages may be an artifact, because most Upper Silurian and Lower Devonian stromatoporoid faunas have been described from Europe. Most of North America outside the Appalachian Basin appears to have been unfavorable for stromatoporoid growth during the Late Silurian and Early Devonian. Only in the U.S.S.R. do Lower Devonian stromatoporoids occur in the diversity and abundance typical of Silurian and Middle and Upper Devonian deposits in other parts of the world. In the midwestern U.S.A. most Upper Silurian stromatoporoids have been altered by dolomitization. The fact remains that the Rondout stromatoporoid assemblage is more similar to the Ludlow assemblages from Europe than to late and middle Pridoli assemblages from Canada.

Of all benthonic marine invertebrate groups that lived during Late Silurian/Early Devonian time, the brachiopods are known best. Brachiopods were cosmopolitan between North America and Eurasia during the Llandovery and early Wenlock, but became increasingly provincial during the remainder of the Silurian and Early Devonian (Boucot and Johnson, 1973, figs. 1-3; Johnson, 1970, p. 2088; Johnson and Boucot, 1973, fig. 1). It appears that the Rondout Formation fauna lived in the restricted Appalachian Province, while Eurasian faunas were in the larger Old World Province.

North American Silurian stromatoporoid distributions are insufficiently well known to allow valid analogies with the brachiopod faunal provinces discussed by Boucot and Johnson. One can assume that because both brachiopods and stromatoporoids are benthonic marine organisms, they were affected by similar interprovincial barriers. If the Appalachian Province [containing the stromatoporoid faunas of both the Rondout Formation of New York and correlative units in Quebec (Stearn and Hubert, 1966)] was partly restricted during the Pridoli, an observation by Boucot (1975, p. 1105) could apply. He noted that geographically restricted Silurian and Devonian brachiopod genera have relatively short time ranges. Stromatoporoids which may have migrated into Quebec during Ludlow time could already have become extinct by Pridoli time. Some of the Rondout Formation stromatoporoids in New York might have migrated in during the Pridoli, just as others could have evolved from the Quebec fauna.

STROMATOPOROID EXTERNAL MORPHOLOGY

Lecompte (1956, pp. F108-F109) and Galloway (1957, pp. 374-375, 377-378) have thoroughly discussed general stromatoporoid external morphology. Consequently, only specific characteristics pertinent to the Rondout Formation stromatoporoids are treated here.

The surfaces of the many stromatoporoids from the Rondout Formation are featureless, lacking either mamelons or traces of astrorhizae. This absence of surface detail may be a result of post-mortem abrasion of the coenostea. The surfaces of many coenostea are obscured by surrounding sediment matrix.

The coenosteal shapes of the Rondout stromatoporoids are here defined as follows:

1. Subspherical — rounded forms.
2. Laminar — flat forms.
3. Hemispherical — forms having flat base and convex upper surface.
4. Irregular — coenostea with sedimentary inclusions and non-uniform growth.
5. Encrusting — specimens that grew on foreign objects and inherited their coenosteal shape from the encrusted form.

The distribution of coenosteal shapes within the Rondout Formation is outlined in Table 2.

Table 2. — Abundance of Coenosteal Forms by Collecting Locality. Fragmental coenostea that could not be identified with any of the above morphologies have been omitted from this table. No coenosteal forms could be identified from the Glasco Member at Locality 7 or the Wilbur Member at Locality 2.

Locality	*subspherical*	*laminar*	*hemispherical*	*irregular*	*encrusting*
		Glasco Member			
1	—	5	—	2	—
2	—	2	—	—	—
3	8	16	2	—	—
4	2	2	1	—	—
5	—	3	—	—	—
6	—	1	—	—	—
7	—	—	—	—	—
9	16	10	1	5	6
		Wilbur Member			
1	1	—	—	—	—
2	—	—	—	—	—
8	7	1	—	1	—
		Cobleskill Member			
10	6	1	—	—	2
11	5	—	—	—	3
12	3	—	—	—	—
13	17	2	2	1	6
14	2	5	—	1	2
15	6	—	—	—	—
16	3	—	—	1	1
17	7	—	—	—	1
18	9	—	1	11	—
19	2	—	—	1	—
20	6	—	—	5	5
21	13	1	—	—	3
22	10	—	1	—	5
23	10	—	—	—	4
24	1	—	—	—	—
25	2	—	—	—	—
26	—	1	—	—	—
27	8	1	1	—	1

STROMATOPOROID INTERNAL MACROSTRUCTURE

The internal macrostructure of stromatoporoids consists of skeletal features which can easily be seen in thin-sections at low magnifications, such as latilaminae, laminae, pillars, astrorhizae, and similar structures. See Lecompte (1956, pp. F109-F118) and Galloway (1957, pp. 364-374, 376-387) for illustrations and definitions of these macrostructural features.

Mamelons.— Although mamelons were not observed on the surface of any Rondout Formation coenostea, specimens of *Parallelo-*

stroma constellatum (Hall, 1852) may show upward arching of individual laminae into mamelons that are not superposed into mamelon columns.

Astrorhizae. — Astrorhizae are present in all species of *Stromatopora* and *Parallelostroma* from the Rondout Formation (Pls. 50-55). Astrorhizal columns were developed in specimens of *Parallelostroma kaugatomicum* (Riabinin, 1951) by the superposition of succeeding astrorhizae. Astrorhizae in species of *Densastroma* from the Rondout Formation are faintly visible or absent in tangential section (Pls. 55-56). Astrorhizae are not present in specimens of *Stictostroma pseudoconvictum,* n. sp., and *Plectostroma micum* (Bogoyavlenskaya, 1969a).

Mori (1970, pp. 62-68) summarized differing opinions regarding the origin and taxonomic value of astrorhizae. It was his opinion that astrorhizae are significant at the specific level because stromatoporoid species with similar skeletal structures contain similar astrorhizae. I agree. Mori disagreed with Bogoyavlenskaya's (1965, p. 105) opinion that astrorhizae are important for generic-level taxonomy, pointing out that only certain species of *Clathrodictyon* and *Densastroma* show astrorhizae.

Because astrorhizae may not be visible in some thin-sections of a specimen because they are sparsely distributed throughout the coenosteum, the conclusion that they are absent requires careful observation if their presence or absence is regarded as a taxonomic character.

Latilaminae. — Latilamination is characteristic of stromatoporoids, and latilaminae are variably developed in species collected from the Rondout Formation. Periodic variation in the physical environment of the stromatoporoids was apparently the factor determining latilamination. Monthly and semi-monthly tidal changes resulting in dryness, burial, and overlighting, seasonal changes in temperature, and sexual cycles have been suggested as controlling agents (Galloway, 1957, p. 386; Mori, 1970, p. 51; Termier and Termier, 1975, p. 99). It is also likely that changes in salinity in conjunction with precipitation seasonality could have affected latilamination.

The upward development of latilaminae is often accompanied by a decrease in gallery height. The succeeding latilamina begins with an increase in gallery height. This relationship is seen well in specimens of *Parallelostroma kaugatomicum* (Riabinin, 1951) [Pl. 53, fig. 1].

In some specimens, the separation of adjacent latilaminae is marked by a clear break in deposition of skeletal material that represents a hiatus in growth. This break was noted in a number of specimens in seven of the eleven species collected from the Rondout Formation, including *Plectostroma micum* (Bogoyavlenskaya, 1969a) [Pl. 49, fig. 4]. Nicholson (1886b, p. 40) noted these breaks in coenosteal growth in his original description of latilaminae.

Species of *Densastroma* exhibit latilaminae, the limits of which are difficult to delineate. In vertical section at magnifications from ×1 to ×10, the latilaminae appear as bands of variably dense skeletal material. At higher magnifications (×50) the density differences are less apparent, and the boundaries of the latilaminae cannot be determined (Pl. 56, figs. 1, 5).

Even though latilamination is pervasive in stromatoporoids, it is of little taxonomic significance. Differences in thickness between latilaminae occur within a coenosteum. Thickness within a single latilamina may also vary in different parts of a coenosteum, as in specimens of *Parallelostroma typicum* (Rosen, 1867) from the Rondout Formation.

Basic horizontal structures. — Stromatoporoids contain one of two basic horizontal skeletal elements: laminae and radial processes.

Species in the Clathrodictyidae contain sheet-like laminae. Horizontal structures in the Actinostromatidae are radial rods connecting adjacent pillars. Some are aligned horizontally and others are irregularly spaced.

In many species of the Stromatoporidae, the laminae are quite regular, but in some species from the Rondout Formation the skeletal elements are irregular, and differentiation of laminae and pillars is difficult. Bogoyavlenskaya (1968, p. 153 [transl.]) introduced the term "coenostroma" (pl. "coenostromata") for "very strongly thickened" structures resembling inflections in the laminae of species of *Stromatopora* similar to *S. concentrica* Goldfuss, 1826. I regard the term coenostroma as unnecessary and have not used it here. If an irregular skeletal element can be recognized as horizontal, the term "irregular lamina" is employed.

Cyst-plates, also known as dissepiments, are thin, often upward-arched layers of skeletal material within the coenostea of some stromatoporoids. In some genera, especially in the Labechiidae, cyst-plates are the major horizontal skeletal elements. By the Late Silurian, cyst-plates were predominantly of two types: poorly oriented plates within galleries in the Clathrodictyidae (e.g. *Stictostroma*); or horizontal elements crossing pseudozooidal tubes in the Stromatoporidae. In some specimens the cyst-plates in pseudozooidal tubes are aligned with laminae, and may represent an evolutionary reduction of laminae. In other specimens, there is no alignment of cyst-plates with other horizontal structures when they occur both in galleries and in pseudozooidal tubes.

Basic vertical structures.—The basic vertical elements in most stromatoporoids, including those from the Rondout Formation, are called pillars, and serve to separate and support adjacent laminae. In vertical thin-section the pillars lie between adjacent laminae, as in the Clathrodictyidae, or extend through a number of laminae or rows of radial processes, as in some genera of the Actinostromatidae, Labechiidae and Stromatoporidae.

Bogoyavlenskaya (1968, p. 153 [transl.]) introduced the term "coenostele" (pl. "coenosteles") for irregular vertical skeletal elements. She stated that coenosteles are, ". . . vertical elements so closely fused that the boundaries between them are imperceptible," and stated that coenosteles confined between two adjacent laminae are found in *Parallelostroma typicum* (Rosen, 1867). Pillars in *P. typicum* are better described as irregular, rather than "closely fused," and the term "irregular pillar" is used here for such features.

STROMATOPOROID MICROSTRUCTURE

The term microstructure is used to describe the nature of the skeletal material forming the laminae, pillars, and cyst-plates of stromatoporoids.

Most investigators concerned with stromatoporoid paleontology use the term "skeletal tissue" to indicate skeletal material. Skeletal tissue is not a legitimate name for the skeletal material in stromatoporoids. Coelenterate skeletal material is formed by the epidermis as exoskeleton (Barnes, 1963, pp. 68, 85). Sponge spicules are secreted by mesenchymal amoebocytes (Barnes, 1963, p. 51), but the calcareous skeleton of sclerosponges is secreted by a basal epidermal layer (Stearn, 1975a, p. 90). The term "skeletal material" was used by Barnes (1963, p. 50) in his description of the Porifera. Hartman and Goreau (1970, p. 228) commented that ". . . paleontologists have the unfortunate habit of referring to the finer structures of the skeleton of stromatoporoids as 'tissue'. The word is used here to denote living cellular material."

The microstructure of the skeletal material is important in the identification of stromatoporoids. Lecompte (1956, pp. F118-F119) divided skeletal material into three types: compact, cellular and fibrous. He considered that cellular material was predominant in the Paleozoic stromatoporoids, and that compact material was of secondary importance.

Galloway (1957, pp. 360-364) regarded skeletal materials as "primary" (e.g., the thin median layer of the laminae or cyst-plates) or "secondary" (e.g., the material below or above the primary material). He described three types of skeletal material: 1) compact, homogeneous and flocculent, 2) compact and vacuolate, with transversely fibrous or tubulate structure, and 3) maculate, with dark or light round spots. He separated stromatoporoids into families partially on the basis of microstructure, whereas Lecompte (1951, pp. 44-47) considered differences in microstructure to be largely of secondary importance.

Stearn (1966a) reviewed stromatoporoid microstructure, and attempted to resolve this disagreement by proposing twelve types of microstructure. With the exception of the recent literature, stromatoporoid photomicrographs have not been published at magnifications between ×50 and ×100, i.e., the magnifications optimal for illustrating skeletal microstructure. Stearn differentiated between primary microstructures, i.e., those secreted by the organism, and secondary microstructures, or those acquired during fossilization. He concluded that compact, cellular and microreticulate, vacuolate, ordinicellular, striated, tubulate, and peripherally vesicular microstructures are primary, while waterjet fibrous, flocculent, pseudotubular, and melanospheric microstructures are secondary. Several kinds were designated as both primary and secondary, i.e., fibrous, tripartite laminar, and transversely porous.

St. Jean (1967, p. 419) discussed maculate skeletal material, originally described by Galloway and St. Jean (1957, p. 42) and

Galloway (1957, p. 355). He indicated that the maculate microstructures represent a variety of distinct types that have been variably preserved. St. Jean (1967, p. 422) suggested that maculate or melanospheric material may have evolved from reticulate material, but he indicated the need for more information to verify this relationship.

James (1974), in his study of diagenetic changes in late Pleistocene corals in the subaerial vadose zone on northern Barbados Island, recognized two major solution-precipitation processes: 1) solution and accompanying precipitation on a fine scale, leading to preservation of microstructure, and 2) total leaching and destruction of microstructure followed by later precipitation of void-filling calcite spar. He inferred that diagenesis in corals and stromatoporoids may be similar, but warned that close analogy is premature.

Stearn (1975a, pp. 93-96) postulated two origins for stromatoporoid microstructure. Assuming that stromatoporoids were sponges, he suggested that an original trabecular aragonite skeleton would have been secreted by a basal layer of cells (the basal pinacoderm), producing skeletal materials having transversely fibrous, water-jet, tripartite, and compact microstructures. In contrast cellular, melanospheric, and maculate skeletal materials probably resulted from secretion of spherulitic aragonite by mesenchymal amoebocytes. The amoebocytes presumably did not surround themselves with skeletal material, as is the case in vertebrates, but rather secreted spheres which were initially suspended in soft tissue and later fused with adjacent spheres as they increased in diameter. Stearn did not state an origin for microreticulate skeletal material, but did rule it out as a precursor to cellular material. He believed that the varieties of preserved stromatoporoid microstructure depend on the diagenetic alteration of fibrous or spherulitic microstructures originally secreted.

Kazmierczak (1971, pp. 42-46) believed that microreticulate skeletal material originated in the Ordovician in genera like *Plumatalinia* Nestor, 1960 (p. 225) that had coenostea composed of a dense, uniform reticulum. Kazmierczak also agreed with St. Jean (1967, p. 422) that microreticulate skeletal material was the evolutionary precursor of the various forms of maculate skeletal material, having undergone a process of "condensation and homogenization of microreticulum."

Skeletal material is one aspect of classification, but problems of diagenesis are acknowledged. The classification of Upper Silurian stromatoporoids is largely independent of the microstructure of the skeletal material.

With few exceptions, Stromatoporidae and Densastromatidae from the Rondout Formation are constructed of microreticulate skeletal material. Stromatoporoids in the Densastromatidae consist of a mass of microreticulate skeletal material that is not interrupted by galleries. Astrorhizae and latilaminae are the only macrostructural elements present. In some specimens of *Stromatopora clarkei* Parks, 1909 the skeletal material is melanospheric, probably a result of diagenetic alteration of microreticulations. Specimens of *Parallelostroma kaugatomicum* (Riabinin, 1951) are also variably preserved. The microstructure of *Densastroma pexisum* (Yavorsky, 1929) is microreticulate, but not so clearly as in *Densastroma tenuissimum* (Parks, 1909).

The skeletal material in well-preserved specimens of *Stictostroma* is a combination of tubulate, transversely fibrous, and compact microstructures (St. Jean, 1962, p. 198). In specimens of *Stictostroma pseudoconvictum,* n. sp. the skeletal material is compact only, and may be the result of diagenetic alteration. Specimens of *Plectostroma micum* (Bogoyavlenskaya, 1969a) from the Rondout Formation also have compact skeletal material, which is typical of the Actinostromatidae.

PALEOECOLOGY OF THE STROMATOPOROIDS

> Stromatoporoids are sessile, benthonic, marine organisms, most often associated with corals, and occur frequently in limestones, rarely in calcareous shales. They probably lived in clear, shallow, moving water, of tropical to subtropical environment. (Galloway, 1957, p. 400)

I studied the paleoecology of the stromatoporoids of the Rondout Formation with two goals in mind: 1) to determine the effects of the physical environment (turbulence, turbidity, depth, depositional slope) on stromatoporoid gross morphology; and 2) to describe their paleobiogeographic setting within the Appalachian Basin of New York.

Because non-stromatoporoid fossils were not collected in this study, few conclusions are justified regarding community relationships. Hoar and Bowen (1967) described Rondout Formation brachiopods and noted other faunas in the Rondout Formation in the Rosendale 15′ quadrangle in eastern New York. The brachiopods and ostracods of the Cobleskill Member were described by Berdan (1972). William A. Oliver, Jr. (1975, pers. comm.) is studying the rugose corals of the Rondout Formation.

In the following discussion of the paleoecology of stromatoporoids, some terms are used that may be ambiguous. These are defined below:

reef — ". . . a skeletal deposit formed by organisms possessing the ecologic potential to erect a rigid topographic structure." (Nelson, *et al.,* 1962, p. 234)
bank — ". . . a skeletal deposit formed by organisms which do not have the ecologic potential to erect a rigid wave-resistant structure." (Nelson, *et al.,* 1962, p. 234)
bioherm — Massive, mound-shaped structure of organic origin which is in discordant relationship with the surrounding layered rocks of different lithology. (Cumings, 1932, p. 333)
biostrome — Coarsely layered strata, primarily of organic origin, which grade concordantly into the surrounding layered sediments. (Cumings, 1932, p. 334)

Klement (1967) stated that a reef is represented in the geologic record by a bioherm, and that banks could be preserved as bioherms or biostromes.

Only in the last 25 years has the paleoecology of stromatoporoids been explored in detail. Lecompte studied Frasnian stromatoporoid and coral reefs in the Ardennes and concluded (1954, pp. 4, 11, [transl.]) that: 1) stromatoporoids were adapted to shallow water exclusively; 2) corals were more tolerant of deeper and muddier water than were stromatoporoids; and 3) reefs of massive stromatoporoids were built up in the zone of agitation, while coral reefs formed in deeper water. He also inferred that reefs of mixed coral-stromatoporoid composition began with corals, which were then progressively replaced by stromatoporoids as the upper reef surface became shallower. A similar succession has been noted by others (e.g., Klovan, 1964, p. 37; Harper, 1969, pp. 215-217; Embry and Klovan, 1972, p. 680; Read, 1973, p. 378; Walker and Alberstadt, 1975, pp. 242-243). An important aspect of these successions is that carbonate cycles tend to be shoaling units (Read, 1973, p. 377) with tidal-supratidal indicators near the top of each cycle.

Broadhurst (1966) described growth forms of some Silurian stromatoporoids from Norway. Some coenostea included tongues of sediment, others exhibited sediment inclusions within the coenosteum, and others ("irregular coenostea" here) contained both. Broadhurst believed that irregular coenostea resulted from variations in stromatoporoid growth rate and rate of influx of sediment. He further suggested a killing off of part of the stromatoporoid, then regrowth over the sediment. Irregular coenostea are not unusual in specimens from the Rondout Formation of New York, particularly those in the Cobleskill Member at Locality 18.

Dolphin and Klovan (1970, pp. 322-327) considered that paleoecological differences between fossil reefs and banks may be reconciled by postulating different gradients on the seaward margins. Using a reef with steep gradient described by Klovan (1964) they determined that waves were little affected by the marginal slope. A zone of high turbulence developed where the waves broke. Massive stromatoporoids were best adapted to the turbulent zone, there constructing a rigid reef framework. Laminar, encrusting forms were found in the deeper, less turbulent water of the forereef.

Where shallower submarine slopes prevailed, as in the case described by Laporte (1967), an area of high turbulence was produced, and wave energy was reduced where the waves impinged on the ocean bottom. Massive forms were common in the most turbulent zone, but because this was not a breaker zone, reefs were not formed. The laminar, less resistant stromatoporoids inhabited the shallow, sheltered water of the bank interior.

A third situation was cited by Dolphin and Klovan where the original bottom slope was even shallower than in Laporte's example. Waves dissipated their energy slowly, creating minimum turbulence and massive forms did not develop.

The paleoecology of stromatoporoids in the Rondout Formation of eastern New York was studied by Harper (1969, pp. 215-223). He described a "patch reef facies" in the Glasco Member that grew upon the upper surface of the Rosendale Member. Four zones were named, in ascending order: 1) Basal Stromatoporoid Zone; 2) Halysitid Zone; 3) Stromatoporoid-Coenitid-Rugose Coral Zone; 4) Massive Stromatoporoid Zone.

Stromatoporoids in the Basal Stromatoporoid Zone grew upon Rosendale supratidal deposits that had subsequently been submerged below wave base. This zone was interpreted by Harper as muddy, providing few sites for stromatoporoid attachment [or larval settling]. Sediments were commonly included within the coenostea called "ragged" forms (= *irregular forms* herein).

Stromatoporoids in the Halysitid Zone were laminar in form, and commonly served as bases of attachment for halysitid tabulate corals. The sediment in this zone was less muddy, indicating shallowing and increased turbulence.

Coenosteal forms from the previous two zones were represented in the Stromatoporoid-Coenitid-Rugose Coral Zone. Halysitid corals disappeared, but coenitids became the abundant tabulates. In addition to the laminar and irregular coenostea, unusual digitate forms were present. This zone represented increased wave turbulence.

The upper Massive Stromatoporoid Zone contained large massive forms in black shale or argillaceous limestone. Harper interpreted the environment here to be shallow quiet water, and maintained that this allowed the stromatoporoids to reach massive proportions. He believed that the substrate was probably firm, and stated (p. 222),

> Salinities and water temperature were probably higher in this environment, as a result of restriction, and this led to the accumulation of black, organic (?) rich, shales.

This last interpretation counters the ideas of most other workers (e.g., Lecompte, 1956, p. F127; Fischbuch, 1962, p. 69; Dolphin and Klovan, 1970, p. 325) who believed that massive forms grew exclusively in turbulent conditions. Klovan (1964, pp. 35-36) suggested an alternative solution to a similar situation. He stated that it was possible that the fine argillaceous material may have settled between massive stromatoporoids which had served as baffles, or may have settled during short intervals of quiescence. Shallowing continued with deposit of supratidal sediments in the overlying Whiteport Member (see Text-fig. 6).

Walker and Alberstadt (1975, pp. 242-243) identified four stages of reef succession: stabilization, colonization, diversification, and domination. They noted an increase in diversity from stabilization through diversification. Domination stage faunas displayed low diversity, and in reefs where stromatoporoids were present, they were dominant.

The biostrome in the Cobleskill Member (Localities 20-24) and the biostromes in the Glasco Member (Localities 1-3, 9) represent different stages of development. Subspherical coenostea outnumber laminar forms 40 to 1 in the Cobleskill biostrome, where stromatoporoids dominated the fauna (Table 2). In the more northerly Glasco biostrome (Locality 9) subspherical forms were not so dominant (16 to 10 over laminar forms) while the southerly Glasco biostrome (Localities 1-3) shows the opposite relationship (laminar forms outnumber subspherical forms 23 to 8). There is a more diverse fauna in the Glasco biostromes than in the Cobleskill biostrome. In the Glasco biostromes stromatoporoids, favositid, halysitid, and coenitid tabulate corals, solitary rugose corals, bryozoans, brachiopods and calcareous algae are prominent fossils. Halysitid and coenitid tabulate corals, bryozoans and calcareous algae are absent from the Cobleskill biostrome. Applying the criteria associated with the four zones of Harper (1969, pp. 215-223) and Walker and Alberstadt (1975, p. 242), the Cobleskill, northern Glasco and southern Glasco biostromes form a gradient of either or both deepening water and earlier stages of development.

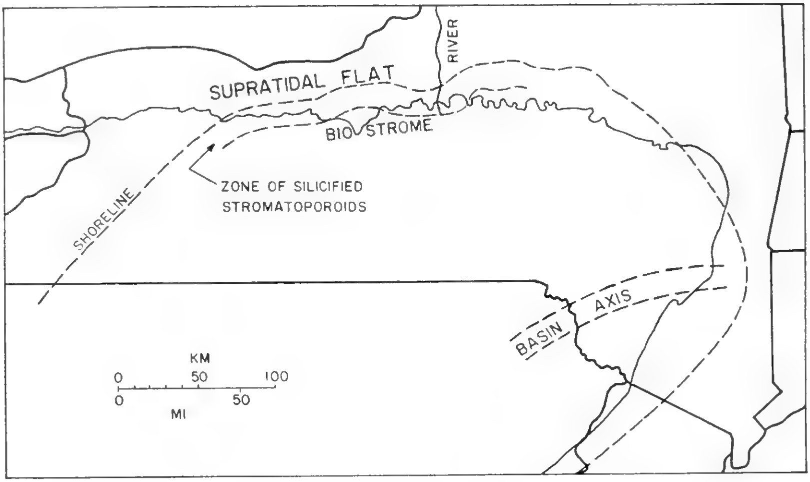
The distribution and relative abundance of the stromatoporoid species from the Rondout Formation are listed in Table 3. The total numbers of specimens collected from the individual localities are too small to allow a statistical evaluation of species diversity within the Rondout Formaton. Rare species may have been missed, and those present may not have been collected in proportions reflecting their occurrence. The criteria of Dennison and Hay (1967) were used to determine the reliability of different size samples as representative of species occurrence at a locality.

Stromatopora eoconcentrica, n. sp. and *Parallelostroma typicum* (Rosen) are only found in the Cobleskill Member. Because only thirteen specimens were collected from the synchronous Wilbur Member, their absence in eastern New York at that time is not conclusively proven. The absence of *S. eoconcentrica* and *P. typicum* from the Glasco Member, from which a larger sample (107 specimens) was taken is more reliable, and may be a result of extinction of these species in the New York area before Glasco time.

Plectostroma micum (Bogoyavlenskaya) is stratigraphically restricted to the Glasco Member and *Stromatopora bekkeri* Nestor is

Table 3. — Stratigraphic and Geographic Distribution of Rondout Formation Stromatoporoid Species (Localities 6 and 26 have been omitted because no specimens collected there could be identified to species).

	Glasco Mbr. Localities							Wilbur Mbr. Localities				Cobleskill Mbr. Localities																	Total	Relative Abundance (percent)
	1	2	3	4	5	7	9	1	2	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27		
S. pseudoconvictum	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	1	—	—	1	—	—	1	—	—	—	—	—	1	6	1.9
P. micum	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.6
S. clarkei	—	—	—	—	—	—	2	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—	1	—	1	—	—	—	9	2.9
S. bekkeri	—	—	1	—	—	—	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	2.3
S. eoconcentrica	—	—	—	—	—	—	—	—	—	—	—	—	2	—	3	1	—	1	3	—	—	—	—	—	—	—	—	—	10	3.2
P. constellatum	4	3	10	1	1	—	14	—	—	9	—	1	1	2	7	6	5	1	—	—	—	2	4	5	4	1	2	7	90	29.0
P. typicum	—	—	—	—	—	—	—	—	—	—	—	3	1	1	5	—	—	—	2	—	3	—	1	—	—	—	—	1	17	5.5
P. kaugatomicum	—	—	6	5	1	—	3	—	1	1	1	6	1	1	4	3	1	2	2	1	—	2	9	4	2	—	—	2	58	19.0
P. rondoutense	3	—	7	—	—	—	4	—	—	—	—	—	1	—	1	—	1	—	—	4	—	2	2	—	1	—	—	—	26	8.4
D. tenuissimum	—	—	—	1	—	1	3	—	—	—	—	—	1	—	2	2	—	—	—	1	—	—	—	—	—	—	—	—	11	3.6
D. pexisum	3	—	11	—	1	—	14	—	—	—	—	—	—	—	—	—	1	2	—	12	—	8	6	8	7	—	—	—	73	24.0
Total	10	3	35	7	3	1	48	1	1	10	1	10	7	4	28	13	8	6	8	18	3	15	23	17	15	1	2	11	309	



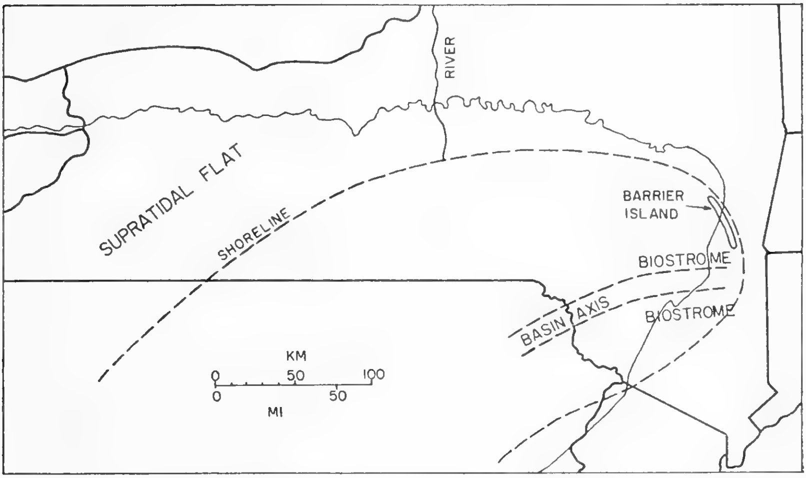
Text-figure 7. — Non-palinspastic map of Wilbur-Cobleskill depositional environments (modified after Harper, 1969, fig. 53).

geographically restricted to eastern New York. Both are rare species, and may have been missed in collections from the Cobleskill Member.

In the Cobleskill Member *Densastroma tenuissimum* (Parks) and *Densastroma pexisum* (Yavorsky) are mutually exclusive in occurrence, except at Locality 18 (Text-fig. 1). *D. tenuissimum* is concentrated in the eastern localities of the Cobleskill Member, while *D. pexisum* is found predominantly in the central localities.

The unique distributions of the species mentioned above may be a result of differences in water depth across New York. *S. eoconcentrica* and *P. typicum* are restricted to the fairly shallow environments represented by the Cobleskill Member (Text-fig. 7). Conversely, *P. micum* and *S. bekkeri* have only been collected from the deeper environments of eastern New York (Text-figs. 7, 8). *D. tenuissimum* is found in the eastern, deeper environments within the Cobleskill Member, and is replaced to the west by *D. pexisum* as the water shoaled.

Past workers rarely correlated stromatoporoid species with particular depositional environments. This is particularly true of Silurian stromatoporoids. Future studies of Silurian stromatoporoid faunas can be compared with my work on the Rondout Formation fauna to test the tentative conclusions I have reached.



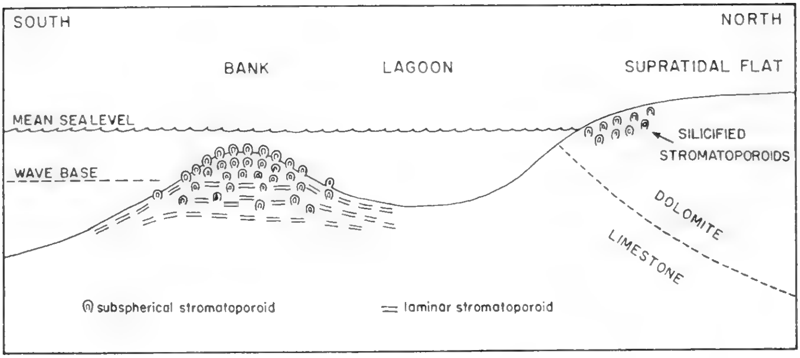
Text-figure 8. — Non-palinspastic map of Glasco-Chrysler depositional environments (modified after Harper, 1969, fig. 55).

PALEOGEOGRAPHY

Lithofacies and biofacies data from the Rondout Formation provide insight into the paleogeography of the northern Appalachian Basin. The paleogeographic setting of the Rondout Formation in eastern New York was summarized by Harper (1969, figs. 34-36) who also described the regional paleogeography of the Rondout Formation and equivalent units (Harper, 1969, figs. 53-58). Some of his ideas are incorporated in Text-figures 7 and 8.

Dolomites, deposited in supratidal and intertidal environments, are barren of fossils, and may contain desiccation features such as mud cracks. Limestone is the major lithology produced from sediments deposited in subtidal areas. Stromatoporoids lived in shallow water. The preponderance of subspherical over laminar coenostea is a result of extremely shallow conditions within the zone of wave agitation. Corals increasingly dominate deeper-water fossil assemblages. Inferred relationships between water depth and stromatoporoids are illustrated in Text-figure 9.

Outcrops of the Rondout Formation in eastern New York were deposited in deeper water than those in western and central New York, as indicated by differences in facies of the same age in the two parts of the state (Text-figs. 5 and 6). When stromatoporoid-



Text-figure 9. — Generalized cross-section of Cobleskill Member depositional environments.

bearing limestones of the Glasco Member were being deposited in the eastern part of the state, unfossiliferous silty dolomites of the Chrysler Member, at least partly supratidal, were deposited across the central and western areas. The relationship of the Wilbur Member to the Cobleskill Member is similar. The Wilbur Member is a stromatoporoid-bearing limestone, while the Cobleskill Member is at least 50 percent dolomite, and commonly is unfossiliferous or sparsely fossiliferous, especially west of the Cayuga Lake area.

The Cobleskill Member contains more limestone in the eastern part of its outcrop belt, Localities 10-17 (Text-fig. 3), probably because there it was deposited in deeper water, close to the limestone of the Wilbur Member. Shallower waters and dolomite deposition would be expected further west. An exception to the increase in dolomite to the west in the Cobleskill Member is the limestone in the Cayuga Lake area. Collecting localities there are south of adjacent outcrops of the Cobleskill Member, and the rocks present were more likely to have been deposited in deeper water in the Late Silurian. Apparently the ancient shoreline paralleled the general trend of the Cobleskill Member outcrop belt.

Halysitid tabulate corals apparently could not exist in water shallow enough to cause wave-generated turbulence (Harper, 1969, pp. 221-222). Harper (1969, p. 217) reported that they disappeared when this third, stromatoporoid-coenitid-rugose coral zone was reached. Halysitids, present in the eastern Wilbur Member, are only found abundantly to the northwest at Locality 13 in the Cobleskill Member (Text-fig. 1).

Rocks in the Rondout Formation that probably were deposited in the deepest water are exposed at Localities 4-8 (Text-fig. 2). Some coenostea were fragmental when buried and are not in growth position. These appear to have been transported. They may have rolled downslope after being dislodged and abraded by storm waves. Black calcareous shale, characteristic of deeper, quieter waters is most common at Localities 4-8. The deepest area was not to the north, because the Fuyk Sandstone Member, found to the north of Locality 9, represents a near-shore deposit (barrier island of Harper, 1969, p. 95). At Localities 5-7 the Wilbur Member grades into the lower part of the Rosendale Member which is a dolomitic siltstone at that horizon. Harper (1969, p. 50) called this a "coastal silt facies", deposited by longshore drift rather than in the shallower waters associated with most of the dolomites.

During Wilbur-Cobleskill time, relative sea level was apparently higher than during Glasco-Chrysler time. The Cobleskill Member is commonly a fossiliferous limestone at the same places that the Chrysler Member is a barren dolomite. It is difficult to show that the Glasco Member was deposited in shallower conditions than was the Wilbur Member. Development in the Glasco Member of biostromes containing massive subspherical and laminar stromatoporoids may have resulted from shallower conditions than those that produced the Wilbur Member. Certainly the biostrome in the Cobleskill Member in the Cayuga Lake area is not far from the dolomitic Akron Facies of the Cobleskill Member, which was deposited in shallow water or supratidal conditions.

Localities 18 and 27 in the Cobleskill Member have yielded seemingly anomalous results. At the westernmost locality (Loc. 27) there are abundant large subspherical stromatoporoids, all silicified. One would expect that west of Cayuga Lake, stromatoporoids would become increasingly rare and disappear. None has been reported from areas west of Locality 27, and they are very rare at Localities 25 and 26. All the stromatoporoids from localities 19, 25, and 26 are silicified, as are those at Chittenango Falls, between Localities 17 and 18, where no specimens could be collected because of the hard rock matrix. These occurrences seem to form a zone between the barren dolomite and calcareous fossil-bearing limestone within the Cobleskill Member.

Namy (1974) described the silicification of carbonate allochems (oncolites and oolites) in the Marble Falls Group (Pennsylvanian) of central Texas. He concluded that very early diagenetic silica in the form of pore-filling cement and replaced carbonate allochems formed during an Early Pennsylvanian episode of subaerial exposure. Such an episode of subaerial exposure probably took place in western New York, because the Cobleskill Member is typically overlain unconformably by the Onondaga Limestone (Middle Devonian). The unconformity probably resulted from nondeposition and/or erosion during a large part of the Early Devonian. Cotter (1966, p. 768) has reported early dissolution of organic opaline silica and its redeposition as replacement chert in fossils in Mississippian carbonates in Montana. Wilson (1966, p. 1044) noted that conditions favored silica replacement of allochems and/or micrite in Upper Jurassic limestones in England, and that there were early and late stages of silicification separated by a period of calcite cementation (Wilson, 1966, p. 1048). He stated that the abundant cherts may be related to the failure of calcite cementation to eliminate porosity at an early stage in diagenesis, allowing silica-rich waters to permeate the limestone.

The previous examples dealt with silicification in limestones. Silicification of allochems has also been reported from the Copper Ridge Dolomite (Upper Cambrian) of the Knox Group in southwestern Virginia. Dietrich, *et al.* (1963, pp. 648-649) proposed three steps in early diagenesis of the Copper Ridge Dolomite: 1) dolomitization of pelletal $CaCO_3$ sediment, 2) interruption of dolomitization by silicification of $CaCO_3$, but not dolomite (as is the case in the Cobleskill Member where $CaCO_3$ and silicified stromatoporoids can be found in a dolomite matrix), and 3) subaerial exposure. Broughton (1972, p. 874) noted that silicified algal stromatolites are present in the Copper Ridge Dolomite, and proposed two periods of silicification interrupting the dolomitization process, the first period occurring soon after the commencement of dolomitization, and involving the replacement of $CaCO_3$, not dolomite (Broughton, 1972, p. 880).

On the basis of the research outlined above, the presence of silicified stromatoporoids in the Cobleskill Member suggests subaerial or very shallow water conditions, as illustrated in the proposed model of northern Appalachian Basin paleogeography (Text-fig. 7). This environment was apparently conducive to dolomitization and early silicification.

A possible origin for the silica in the Cobleskill Member is suggested by an analogous situation described by Lowe (1975) for silica transportation and deposition in the Ouachita Basin. He postulated (p. 1123) that volcanism during the Taconic and Acadian Orogenies may have provided much of the primary silica through increase in the concentration of silica in sea water. Ocean currents carried the silica-rich water to the Ouachita Basin, where marine organisms (radiolarians and siliceous sponges) living on shallow marine shelves concentrated the silica in their skeletons. Solution of the skeletons provided a source for the silicification of the Ouachita carbonates.

During the Late Silurian in New York, the source of primary silica could have been volcanism associated with the Appalachian-Caledonian orogenic belt. Upper Silurian volcanics have been reported from Massachusetts, Maine, and New Brunswick (Gates, 1969, pp. 489, 490, 495), and there are igneous intrusions of the same age in North Carolina (Fullagar, 1971, table 1) and Ireland (Brindley, 1969, p. 351). Silica was subsequently transported to the New York area by ocean currents. No fossils of radiolarians or siliceous sponges have been reported from the Rondout Formation. However, Lowe (1975, p. 1126) warned that little evidence of the true origin of the silica might be revealed, because of the complex diagenesis involved.

At Locality 18, in the middle of the central Akron Facies dolomite belt, there are abundant calcitic stromatoporoids. Fifty-two percent of the coenostea from this locality are irregular, more than at any other location. The combination of an original irregular shoreline and the present irregular outcrop belt may preserve the record of an environment at Locality 18 that was slightly seaward of the zone of silicified stromatoporoids. Excess sediments, inducing irregular coenostal growth, would have been derived from wave erosion of the nearby shoreline, and transported by long-shore currents.

It is also possible that Locality 18 was near the mouth of a Late Silurian river draining southward off the craton. The presence of a river would account for the increased sediment influx and resultant irregular coenostea. The accompanying influx of fresh water at irregular intervals would have produced a severe and unpredictable environment which could have resulted in the unusually low species diversity of stromatoporoids at Locality 18 (near Syracuse). Unfortunately, too few specimens (18) were collected to accurately determine species diversity. The river may still have been active during deposition of the Chrysler Member, since the Syracuse area is the one place where the Chrysler Member is fossiliferous. Fresh water from the river would have diluted saline waters, and provided an estuarine environment inland from the regional shoreline. Harper (1969, p. 193) reported a clastic influx in the Syracuse area during deposition of the Wilbur Member (therefore Cobleskill Member), of a volume sufficiently large to influence offshore facies distributions.

SYSTEMATIC PALEONTOLOGY

SPECIMEN MEASUREMENT PROCEDURES

Coenosteal size was measured with a vernier caliper. Internal measurements were made by means of a light microscope equipped with a calibrated occular micrometer.

Most measurements were made from vertical sections, including laminae per mm, pillars per mm, laminar thickness, pillar width, gallery height, and latilaminar thickness. Pillar diameter, pseudozooidal tube diameter, distance between pillars, and astrorhizal canal width were measured from tangential sections.

Counts of laminae per mm were begun in the middle of a lamina. If four additional laminae were included within the interval of 1 mm, the count was recorded as 4.5 laminae per mm. If four additional laminae and part of a fifth laminae were included, the count was 5 laminae per mm. The same method was employed for counting pillars per mm.

Distance between pillars was taken from the centers of adjacent pillars to avoid the effect of pillar diameter. Laminar thickness and gallery height were measured at the same time to insure proper proportions between the two when compared.

At least 20 measurements or counts were taken for each character in most specimens. Occasionally the small size or poor preservation of a specimen prevented that many measurements.

When an average value for a particular character is given, the average of the averages obtained for each specimen is indicated.

This method insures equal weighting of each specimen, regardless of its size.

REPOSITORY AND SPECIMEN NUMBERS

All types and illustrated specimens collected for the present study are kept in the United States National Museum of Natural History (USNM). Type specimens of species first described by Hall (1852) and Parks (1909) are kept in the New York State Museum (NYSM).

Each stromatoporoid coenosteum is given a number preceded by the letters indicating its repository (*e.g.* USNM 248100). Each thin-section of a specimen is given a number (*e.g.* USNM 248100-1, USNM 248100-2, . . .).

KEY TO UPPER SILURIAN AND LOWER DEVONIAN STROMATOPOROID FAMILIES AND GENERA

Suprafamilial taxa are not considered in this paper because of uncertainties concerning the phylogenetic position of stromatoporoids. Many authors believe that stromatoporoids should be considered an order of the Class Hydrozoa, Phylum Coelenterata. But Hartman and Goreau (1970, p. 228) described stromatoporoids as a new class, the Sclerospongia, within the Phylum Porifera. Stearn (1972, p. 385) suggested that they comprise a subphylum of the Porifera.

Classification at the family level is also open to question. Lecompte (1951, 1952, 1956) based families primarily on basic skeletal morphology. Galloway and St. Jean (1957) placed genera in various families based on the nature of the skeletal material, as well as skeletal morphology. Mori's (1968, 1970) classification of genera within families was basically an updated version of Galloway and St. Jean's, but was limited to Silurian genera.

Other suprageneric classifications have been proposed. The following workers have raised former familial classifications to higher systematic levels. Khalfina and Yavorsky (1973) considered the Stromatoporoidea to be an order divided into seven superfamilies: Actinostromatacea, Clathrodictyacea, Tienodictyacea, Syringostromatacea, Hermastromatacea, Stromatoporacea, and Labechiacea. Nestor (1974) divided Order Stromatoporoidea into five superfamilies: Labechiacea, Lophiostromatacea, Clathrodictyacea, Actinostromacea, and Stromatoporacea. Bogoyavlenskaya (1974) raised the Stromatoporoidea to subclass level, containing six orders: Labechiida, Clathrodictyida, Actinostromatida, Gerronostromatida, Syringostromatida, and Stromatoporida.

The following key is modeled after those employed by Galloway and St. Jean (1957, pp. 90, 91, 148, 164) and Mori (1970, pp. 76, 77, 85, 108, 120). Some genera used by other authors for the Upper Silurian and Lower Devonian are not included in the key, mostly because sufficient information is not available, or because they are junior synonyms. The majority of new Upper Silurian and Lower Devonian genera named in the last ten years were authored by workers in the Soviet Union, who often publish brief descriptions of new genera, and compare them with only a few other genera (Bogoyavlenskaya, 1965, p. 110; 1969b, p. 461 [transl.]; 1972a, p. 168 [transl.]; Bolshakova, 1969, p. 473 [transl.]; Nestor, 1966, p. 27). Many articles from that country are difficult or impossible to obtain. Many of the deleted genera are discussed here under other genera.

KEY TO FAMILIES

1a. Coenosteum laminar, subspherical, hemispherical, not ramose.
  2a. Skeleton composed entirely of laminae; all vertical skeletal elements absent; galleries absent; microstructure delicately multilayered.
      LOPHIOSTROMATIDAE Nestor, 1966
  2b. Skeleton composed of laminae and pillars and/or microlaminae and micropillars.
    3a. Microstructure compact or fibrous; laminae and pillars clearly distinguishable from each other; galleries present.
      4a. Mostly horizontally aligned rows of cyst-plates.
          LABECHIIDAE Nicholson, 1879
      4b. Laminae not horizontal rows of cyst-plates.
        5a. Laminae more continuous than short pillars that are confined between two laminae.
            CLATHRODICTYIDAE Kühn, 1939
        5b. Pillars predominant and long; horizontal elements composed of laminae or rod-like radial processes.
            ACTINOSTROMATIDAE Nicholson, 1886b
    3b. Microstructure microreticulate or maculate; skeleton amalgamated, with no line of contact between laminae and pillars.
      4c. Galleries present, commonly occupying smaller space than skeletal parts.
          STROMATOPORIDAE Winchell, 1867
      4d. Galleries commonly absent, leaving a microreticulate mass of microlaminae and micropillars.
          DENSASTROMATIDAE Bogoyavlenskaya, 1974
1b. Coenosteum dendroid or ramose.
    IDIOSTROMATIDAE Nicholson, 1886b

KEY TO GENERA

Family **LOPHIOSTROMATIDAE**

one genus in U. Sil/L. Dev. **Lophiostroma** Nicholson, 1891a

Family **LABECHIIDAE**

1a. Vertical columns present; pillars exclusively in vertical columns.
  2 a. Distinct pillars divergently arranged in columns.
    Pseudolabechia Yabe and Sugiyama, 1930
  2b. Pillars in columns grouped together in fan-like masses.
    Vikingia Bogoyavlenskaya, 1969a
1b. Vertical columns absent; pillars evenly distributed.
  2c. Pillars well-developed.
    Labechia Milne-Edwards and Haime, 1851
  2d. Pillars sporadically developed.
    Actinodictyon Parks, 1909

Family **CLATHRODICTYIDAE**

1a. Laminae crumpled or persistent, but not forming chevron-like folds.
  2a. Pillars extending from downward inflection of laminae.
    Clathrodictyon Nicholson and Murie, 1878
  2b. Laminae not inflected downward above pillars.
    3a. Pillars rod-like or spool-shaped.
      Stictostroma Parks, 1936
    3b. Pillars conical, basally pointed, often **Y**- or **V**-shaped in vertical section.
      Anostylostroma Parks, 1936
1b. Laminae may be irregular or strongly crumpled, at times forming chevron-like folds.
  2c. Laminae always crumpled.
    Ecclimadictyon Nestor, 1964
  2d. Straight, continuous laminae alternating with irregular or strongly crumpled laminae.
    3c. Pillars intersecting between adjacent straight laminae to form a network of secondary laminae, with few single pillars reaching between straight laminae.
      Intexodictyon Yavorsky, 1963
    3d. Pillars and crumpled laminae forming a regular zigzag pattern, with pillars reaching between straight laminae.
      Plexodictyon Nestor, 1966

Family **ACTINOSTROMATIDAE**

1a. Rod-like radial processes present.
  2a. Radial processes regularly arranged at the same level.
    3a. Radial processes form a hexactinellid pattern in tangential section.
      Actinostroma Nicholson, 1886b
    3b. Radial processes giving a triangular appearance to the pillars in tangential section.
      Trigonostroma Bogoyavlenskaya, 1969b
  2b. Radial processes irregularly arranged at different levels.
    Plectostroma Nestor, 1964
1b. Rod-like radial processes absent.
  2c. Laminae continuous.
    Gerronostroma Yavorsky, 1931
  2d. Laminae commonly discontinuous.
    Gerronodictyon Bogoyavlenskaya, 1969b

Family **STROMATOPORIDAE**

1a. Galleries commonly irregular in arrangement.
  2a. Pseudozooidal tubes present.
    Stromatopora Goldfuss, 1826
  2b. Pseudozooidal tubes absent.
    Ferestromatopora Yavorsky, 1955
1b. Galleries commonly regularly arranged.
  2c. Laminae more continuous than pillars; galleries horizontally arranged.
    Parallelostroma Nestor, 1966
  2d. Pillars more continuous than weak laminae.
    3a. Pillars not circular in tangential section.
      4a. Rod-like radial processes present.
        Actinostromella Boehnke, 1915
      4b. Rod-like radial processes absent.
        Parallelopora Bargatzky, 1881
    3b. Pillars circular in tangential section.
      Syringostroma Nicholson, 1875

Family **DENSASTROMATIDAE**

1a. Micropillars short, commonly confined between two microlaminae.
  Pycnodictyon Mori, 1970
1b. Micropillars long.
  Densastroma Flügel, 1959

Family **IDIOSTROMATIDAE**

The existence of this family as a separate entity is in doubt. Some genera in this family could be placed in other genera, were it not for the dendroid or ramose coenostea. For this reason, and because no ramose forms were collected from the Rondout Formation, a breakdown into genera is not undertaken.

DESCRIPTIONS

Family **CLATHRODICTYIDAE** Kühn, 1939
Genus **STICTOSTROMA** Parks, 1936

Stictostroma Parks, 1936, p. 77; Fritz and Waines, 1956, p. 111; Galloway and St. Jean, 1957, p. 124; Galloway, 1957, p. 435; Galloway and Ehlers, 1960, p. 84; St. Jean, 1962, p. 186; Stearn, 1966a, p. 96; 1966b, p. 43; Birkhead, 1967, p. 46; Flügel and Flügel-Kahler, 1968, p. 566; Stearn and Mehrotra, 1970, p. 9; Kaźmierczak, 1971, p. 82; Zukalová, 1971, p. 51; Khalfina and Yavorsky, 1973, p. 148 (transl.).

Type species. — *Stictostroma mamilliferum* Galloway and St. Jean; *Stromatopora mammillata* Nicholson (not Schmidt, 1858), (Nicholson, 1873, p. 94, pl. 4, fig. 4), Middle Devonian, Port Colborne, Ontario.

Other species. — Flügel and Flügel-Kahler (1968, p. 566) listed 11 species unquestionably assigned to *Stictostroma.* Additional species are *S. cavosite* Stearn and Mehrotra (1970, p. 9, pl. 2, figs. 3-4), Middle Devonian Ogilvie Formation, Yukon Territory, Canada; *S. jasperense* Stearn (1975b, p. 1650, pl. 1, figs. 4-6), Upper Devonian Cairn Formation, Alberta, Canada.

Diagnosis. — Coenosteum composed of continuous laminae and pillars confined to an interlaminar space. Laminae may show a medial light line of one or several rows of cellules. Pillars short and spool-shaped; rarely superposed. Galleries usually higher than the thickness of the laminae. Pillar skeletal material compact; pillars round in tangential section.

Discussion. — *Stictostroma* can be distinguished from *Stromatoporella* Nicholson, 1886 by its lack of ring-pillars. Some specimens with the gross structure of *Stictostroma* have laminae showing no distinctive microstructure, but are a single layer of skeletal material, usually due to alteration. *Stictostroma* can be differentiated from *Anostylostroma* by the upward dividing of pillars in the latter. In *Clathrocoilona,* laminae are usually thicker than the height of galleries (Stearn, 1966a, p. 98).

The genus *Simplexodictyon* Bogoyavlenskaya, 1965 (p. 110), is very similar to both *Stictostroma* and *Anostylostroma,* and probably contains species from both of the latter genera. The fact that *Simplexodictyon* lacked the median-porous or tubular laminae and pillars of *Stictostroma* was considered by Nestor (1966, p. 24) to support only a conditional separation of the two genera. He pointed out that such conditions of skeletal material could be lost with poor preservation. Mori (1968, p. 57; 1970, p. 87) included in *Clathrodictyon* two species previously assigned to *Simplexodictyon*: *C. simplex* (Nestor, 1966), and *C. convictum* Yavorsky, 1929.

In addition, the genus *Diplostroma* Nestor, 1966 (pp. 27, 81), may include species of *Stictostroma.* Nestor (1966, p. 82) stated that, "*Diplostroma* differs from *Simplexodictyon* by the presence of clearly bipartite laminae with a split of unstable height in the middle." Mori (1968, p. 71) noted in specimens from Gotland that the laminar splits contained no skeletal structure, and were partially occupied by fine sediments or other organisms. Mori concluded that the splits were a growth phenomenon, induced by the environment, but continued to use the genus (Mori, 1968, p. 70; 1970, p. 100). Kazmierczak (1971, p. 31) also agreed that *Diplostroma* was probably a junior synonym of *Simplexodictyon,* but did not include the latter in *Stictostroma.* Examination of figures of the holotype of the type species of *Diplostroma, Clathrodictyon pseudobilaminatum* Khalfina (Khalfina, 1960, p. 47, pl. S-2, figs. 4a-b; pl. S-3, fig. 2), shows that the splits in the middle of the laminae resulted from bifurcations of the laminae as the coenosteum grew upward, a situation seen in many unrelated stromatoporoids in the Family Clathrodictyidae. Since the distinguishing characteristic of *Diplostroma,* bipartite laminae of greatly varying thickness, is not what it originally appeared to be, the genus is held to be invalid.

Stictostroma pseudoconvictum, n. sp. Pl. 49, figs. 1-3

Derivation of name. — The specific name was derived from the similarity in scale of macrostructure of this species to *Anostylostroma convictum* (Yavorsky) Yavorsky, 1929, pp. 91, 105, pl. 6, fig. 10; pl. 9, figs. 5-7).

Diagnosis. — Short spool- or rod-shaped pillars connect continuous laminae which, with the exception of a few minor inflections, are straight. Pillars round in cross1section. Cyst-plates rare or absent from galleries; astrorhizae absent. Five laminae, 0.04 to 0.06 mm thick, occur in 1 mm; 3 to 4 pillars, 0.06 to 0.07 mm in diameter, occur in 1 mm.

Description. — Most specimens of *Stictostroma pseudoconvictum* n. sp., have encrusted other stromatoporoids. The largest coenosteum, an encrusting form, (the holotype, USNM 248089) is 11.7 mm in maximum thickness, and 33.0 mm in maximum width.

Vertical sections show continuous and fairly thin laminae, from 0.02 to 0.13 mm, commonly 0.04 to 0.06 mm thick; a mean of five laminae occur in 1 mm, as do three to four pillars. The mean height of rectangular galleries is 0.15 mm. Pillars are confined to one interlaminar space and are circular in tangential section, with mean diameters of 0.06 to 0.07 mm. They are 0.18 to 0.19 mm apart, measured from pillar centers.

Rarely a light line can be seen within laminae, but no cellules have been observed. Inflections occur in some laminae at intersections with pillars, and some pillars are Y-shaped, but these are definitely less common than spool-shaped and rod-shaped pillars. Astrorhizae are absent. Skeletal material is compact.

Discussion. — *Stictostroma pseudoconvictum* contains the basic characteristics of *Stictostroma*: continuous laminae which are thinner than galleries are high, and spool-shaped pillars confined between two laminae and round in cross-section. Light lines or cellules in the laminae are typically missing in *S. pseudoconvictum,* but this may be a preservational feature.

Specimens of *Anostylostroma convictum* (Yavorsky) (Yavorsky, 1929, pp. 91, 105, pl. 6, fig. 10; pl. 9, figs. 5-7) contain macrostructural elements spaced similarly to *S. pseudoconvictum.* The holotype of *A. convictum* has 3 to 6 laminae per mm and 3 to 4 pillars per mm. Consideration was given to placing the Rondout Formation specimens in synonymy with *A. convictum,* which had been included in *Simplexodictyon* by Nestor (1966, p. 26) and Bogoyavlenskaya (1973, p. 50). However, some Y-shaped pillars are evident in the figures of vertical sections of the holotype (Yavorsky, 1929, pl. 9, figs. 5-6). Yavorsky (1967, p. 9) reexamined the species and assigned it to *Anostylostroma.*

Among other similar species, *Clathrodictyon regulare* (Rosen) (Rosen, 1867, p. 74, pl. 9, figs. 1-4) and *Simplexodictyon simplex* Nestor (Nestor, 1966, p. 25, pl. 8, figs. 1-6) have macrostructure of a finer scale, and the latter species also has more pillars per mm. The laminae in specimens of *Simplexodictyon podolicum* (Yavorsky) (Yavorsky, 1929, pp. 83, 103, pl. 6, figs. 5-6) are thicker (Riabinin, 1951, p. 11, pl. 3, figs. 7-8; Yavorsky, 1955, p. 43, pl. 15, figs. 1-2; Bogoyavlenskaya, 1973, p. 50, pl. 22, figs. 2a-b; Bolshakova, 1973, p. 66, pl. 4, fig. 2). The macrostructure is coarser in *Clathrodictyon planum* Yavorsky (Yavorsky, 1961, p. 21, pl. 8, figs. 1-2; pl. 29, fig. 8).

?*Anostylostroma jewetti* (Girty, 1895) (p. 298, pl. 6, figs. 5-6) from the Lower Devonian Coeymans Formation of central New York contains Y-shaped pillars which are more closely spaced than in *S. pseudoconvictum.*

All species previously assigned unquestionably to *Stictostroma* are from the Middle and Upper Devonian, although many species of *Stictostroma* that have been assigned to *Simplexodictyon* occur in the Silurian. One species from the Silurian, ?*Stictostroma conodigitatum* (Riabinin) (Riabinin, 1951, p. 10, pl. 3, figs. 3-4), was questionably assigned to *Stictostroma* by Nestor (1964, pp. 76, 109). ?*S. conodigitatum* is from strata of Llandovery and Wenlock age of Estonia (Riabinin, 1951, p. 55; Nestor, 1964, p. 84), and has laminae and pillars which are thicker, more widely spaced, and less regular than those in *S. pseudoconvictum.*

Stratigraphic and geographic distribution. — Six specimens were collected, one from the Glasco Member at Locality 9, and five from the Cobleskill Member, one each from Localities 13, 14, 17, 20, and 27. The specimen from Locality 27 was poorly preserved and identification is provisional. The illustrated specimen (USNM 248089) is from the Cobleskill Member at Locality 13.

Type material. — The holotype (USNM 248089) is from the Cobleskill Member at Locality 13. Paratypes are USNM 248090 from the Glasco Member at Locality 9, and part of specimen USNM 248091, also containing *Densastroma pexisum* (Yavorsky), from the Cobleskill Member at Locality 20.

Family **ACTINOSTROMATIDAE** Nicholson, 1886b
Genus **PLECTOSTROMA** Nestor, 1964

Plectostroma Nestor, 1964, p. 78; Flügel and Flügel-Kahler, 1968, p. 559; Mori, 1968, p. 78; Bolshakova, 1973, p. 67.

Type species. — *Actinostroma intertextum* Nicholson (Nicholson, 1886a, p. 233, pl. 7, figs. 3-4, *not* figs. 5-6), Upper Silurian, Wenlock Limestone, England.

Other species. — Flügel and Flügel-Kahler (1968, pp. 559, 672) list 12 species unquestionably assigned to *Plectostroma.* Additional species are too numerous to list here, but have been described by Mori (1968, p. 78; 1969, p. 48; 1970, p. 111), Lesovaya (1970, p. 79; 1971, p. 115; 1972, p. 59), and Bolshakova (1969, p. 476 [transl.]).

Diagnosis. — Coenosteum consists of long, continuous pillars connected by rod-like radial processes distributed at different levels, not forming regular, continuous laminae. Skeletal material compact.

Discussion. — *Plectostroma* is intermediate in its characteristics between *Actinostroma* Nicholson, 1886b (p. 75) and *Densastroma* Flügel, 1959 (p. 196). The macrostructure of *Actinostroma* is typically of a coarser scale than that in *Plectostroma.* Radial processes in *Actinostroma* emanate from pillars in whorls at the same level, giving the impression of continuous laminae. *Densastroma* has a finer macrostructure than *Plectostroma,* and although the micropillars are more continuous than microlaminae, they are of about the same thickness. Pillars in *Plectostroma* are typically thicker than the radial processes.

In species of *Plectostroma,* where the radial processes are irregular, vertical sections give the impression of *Actinodictyon* Parks, 1936 (p. 112). However, the horizontal skeletal elements in *Actinodictyon* are flat or irregular plates, rather than radial processes, as seen in tangential section. Also, the macrostructure of species of *Actinodictyon* consists of laminae and pillars more widely spaced than in *Plectostroma.*

Plectostroma micum (Bogoyavlenskaya, 1969a) Pl. 49, figs. 4-6; Pl. 50, fig. 1

Actinodictyon mica Bogoyavlenskaya, 1969a, p. 165 (transl.), pl. 4, figs. 2a-b; Bolshakova, 1973, p. 78, pl. 10, figs. 1-2.

Diagnosis. — Characterized by long, thick (0.07 mm), round pillars connected by thin, irregular radial processes, these in both vertical and tangential sections forming a tangled network between pillars that is unique to this species of *Plectostroma.*

Description. — Pillars of *Plectostroma micum* are up to 2.35 mm long and average about 1.0 mm long in vertical section. The pillars are not perfectly straight, passing in and out of the plane of thin-sections. In tangential section, mean pillar diameter is 0.07 mm (range: 0.05 to 0.12 mm). The mean distance between pillar centers is 0.19 mm. Pillars are spaced 3 to 6 per mm; commonly 4 to 5 per mm, in vertical sections.

Pillars are connected by irregular horizontal radial processes that are circular in cross-section. The radial processes extend from the pillars at irregular intervals, not forming continuous laminae in vertical sections. Spacing of radial processes in vertical section ranges from 12 to 19 per mm (mean: 16.4 per mm) in specimen USNM 248092 to 15 to 22 per mm (mean: 17.6 per mm) in USNM 248093. Thickness of the radial processes is 0.01 mm. The radial processes may be inflected to form short pillars, 0.03 mm in diameter, extending between adjacent processes. Galleries are 0.02 to 0.06 mm high, and are irregular in shape as a consequence of the irregular radial processes. The radial processes form a sub-hexactinellid pattern in tangential section because they connect adjacent pillars. Skeletal material of both pillars and radial processes is compact. The coenosteum of USNM 248092 is subspherical with a maximum diameter of 23.0 mm. USNM 248093 has an irregular growth form, higher than wide, 33.0 mm at the highest, and 16.4 mm at the widest. No mamelons are developed, nor are astrorhizae. Latilaminae, averaging 2.37 mm thick, developed in both specimens, are represented in part by sediment inclusions, especially in marginal parts of the coenostea.

Discussion. — The specimens from New York are much like the holotype from Podolia. Both share the irregular radial processes and the noticeably thicker pillars. The holotype has four pillars per mm with a mean diameter of 0.05 mm. There were generally fewer laminae (12 to 13 per mm) in the holotype but this does not exclude the New York specimens from *P. micum.* The radial processes are 0.01 mm thick in both the holotype and the New York specimens.

Bogoyavlenskaya (1969a, p. 165 [transl.]) placed this species in *Actinodictyon* based, it would seem, on the appearance in vertical section of long thick pillars and irregular connecting processes. However, tangential sections show radial rods between pillars, not the horizontal plates of *Actinodictyon.* Horizontal plates are the dominant horizontal structure in the Labechiidae, and are rare in the Actinostromatidae. In *Plectostroma* the radial processes are arranged at irregular levels, as are those in specimens of *P. micum.* No other species mentioned in the literature comes close to *P. micum.*

Stratigraphic and geographic distribution. — Two specimens were collected from the Glasco Member at Locality 9. The illustrated hypotype specimen is USNM 248092.

Family **STROMATOPORIDAE** Winchell, 1867
Genus **STROMATOPORA** Goldfuss, 1826

Stromatopora Goldfuss, 1826, p. 21; Winchell, 1867, p. 99; Nicholson, 1875, p. 245; 1886b, p. 91; Nicholson and Murie, 1878, p. 217; Spencer, 1884, p. 44; Riabinin, 1941, p. 95; Lecompte, 1952, p. 263; 1956, p. F133; Yavorsky, 1955, p. 81; Fritz and Waines, 1956, p. 98; Galloway and St. Jean, 1957, p. 164; Galloway, 1957, p. 447; 1960, p. 627; Galloway and Ehlers, 1960, p. 50; Stearn, 1963, p. 664; 1966a, p. 110; 1966b, p. 54; Nestor, 1966, p. 43; Stearn and Hubert, 1966, p. 40; Birkhead, 1967, p. 68; Petryk, 1967, p. 26; St. Jean, 1967, pp. 422, 425; Flügel and Flügel-Kahler, 1968, pp. 568, 674; Mori, 1968, p. 82; 1970, p. 120; Fischbuch, 1969, p. 172; Stearn and Mehrotra, 1970, p. 21; Kaźmierczak, 1971, p. 88; Zukalová, 1971, p. 60; Bolshakova, 1973, p. 98.
Coenostroma Winchell, 1867, p. 99.

Type species. — *Stromatopora concentrica* Goldfuss (Goldfuss, 1826, p. 22, pl. 8, figs. 5a-c), Middle Devonian, Übergangskalk, Gerolstein, Germany; by original designation.

Other species. — Flügel and Flügel-Kahler (1968, pp. 568, 674) listed 138 species unquestionably assigned to *Stromatopora.* Some species attributed to *Stromatopora* by subsequent workers are placed better in other genera like *Parallelostroma* Nestor, 1966 (pp. 52, 85) (*e.g.,* Petryk, 1967, p. 26). Two additional species are *S. baillargensis* Petryk (1967, p. 31, pl. 4, figs. 5-6), Lower Silurian, Brodeur Peninsula, Baffin Island, District of Franklin, Canada and *S. porosa* Lesovaya (1970, p. 87, pl. 6, figs. 2a-b), Lower Devonian, Zeravshan Range, U.S.S.R.

Diagnosis. — Coenosteum composed of amalgamated network in which neither pillars nor laminae dominate. Irregular pseudozooidal tubes present. Tangential sections show an irregular, continuous network of skeletal structure. Skeletal material cellular, melanospheric or microreticulate.

Discussion. — *Stromatopora* lacks the long, continuous pillars of *Syringostroma* Nicholson, 1875 (p. 251), *Syringostromella* Nestor, 1966 (pp. 47, 83), *Amnestostroma* Bogoyavlenskaya, 1969b (p. 467 [transl.]), *Actinostromella* Boehnke, 1915 (p. 162), and *Parallelopora* Bargatzky, 1881 (p. 291), and the continuous laminae of *Parallelostroma* Nestor, 1966 (pp. 52, 85). *Ferestromatopora* Yavorsky, 1955 (p. 109) also has an irregular amalgamated skeletal network, but lacks pseudozooidal tubes. When Mori (1970, p. 121) viewed the holotype of the type species, *Stromatopora concentrica* Goldfuss, 1826, he saw no vertical pseudozooidal tubes. For this reason he believed that all specimens formerly placed in *Ferestromatopora* belonged in *Stromatopora. Ferestromatopora,* however, lacks any pseudozooidal tubes, and the holotype of *S. concentrica* does contain pseudozooidal tubes (St. Jean, 1976, written comm.).

Stromatopora clarkei Parks, 1909 Pl. 50, figs. 2-4

Stromatopora clarkei Parks, 1909, p. 48, pl. 17, fig. 12; pl. 18, fig. 1.
Syringostroma barretti Girty, Swartz, 1913, p. 224, pl. 28, figs. 3-4.
Syringostromella clarkei (Parks), Nestor, 1966, p. 48.

Diagnosis. — Thick laminae (0.18 mm) and pillars (0.16 mm); both widely-spaced; 1.5 to 4.5 laminae per mm and 2 to 4 pillars per mm. Neither more continuous than the other; both commonly irregular. Astrorhizae and irregular pseudozooidal tubes also present.

Description. — In terms of laminar and pillar thickness and spacing, *Stromatopora clarkei* Parks has the coarsest macrostructure of any stromatoporoid collected from the Rondout Formation. In vertical section, there are 2 to 4 pillars and 1.5 to 4.5 laminae per mm; laminar thickness ranges from 0.07 to 0.31 mm, commonly 0.16 to 0.24 mm (mean: 0.18 mm). In tangential section, pillar width is comonly 0.14 to 0.19 mm (mean: 0.16 mm), in a range of 0.08 to 0.26 mm, and the pseudozooidal tube mean diameter is 0.13 mm (range: 0.09 to 0.19 mm).

Pillars are vermicular in tangential section, and their orientation defines the well-developed dichotomously branching astrorhizae, which average 0.13 mm in width (range: 0.09 to 0.20 mm). The astrorhizae apparently form along laminar planes, as they are not evident in vertical section.

The skeletal material is microreticulate in well-preserved specimens, grading to melanospheric in altered specimens. Thin, flat, horizontal cyst-plates commonly cross pseudozooidal tubes, but are typically absent from astrorhizal canals.

Coenostea are typically subspherical. The largest, a partial coenosteum, is 88 × 73 mm wide × 68 mm high. One specimen had encrusted a large gastropod.

Discussion. — The specimens collected compare well with the holotype (NYSM 6820), but are slightly coarser in the scale of the macrostructure. Significant measurements from the holotype, a Glasco specimen and two Cobleskill specimens are given in Table 4.

Table 4. — Comparison of the Skeletal Dimensions of Four Specimens of ***Stromatopora clarkei.***

	Cobleskill Mbr.			Glasco Mbr.
	NYSM 6820 (Holotype)	USNM 248095	USNM 248096	USNM 248094
laminae per mm in vertical section	2.9	2.7	2.5	3.0
pillars per mm in vertical section	3.6	3.3	2.9	3.5
pillar width (mm) in tangential section	—	0.14	0.19	0.15
pillar width (mm) in vertical section	0.12	0.13	0.17	0.14
laminar thickness (mm) in vertical section	0.13	0.16	0.24	0.17
pseudozooidal tube width (mm) in vertical section	0.14	0.13	0.13	0.12

The specimens collected from the Rondout Formation also compare well with *Stromatopora carteri* Nicholson (Nicholson, 1891a, p. 174, pl. 1, figs. 6-7; pl. 23, figs. 1-3), which also has a coarse macrostructure, but lacks astrorhizae.

Nestor (1966, p. 48) placed *S. clarkei* in his new genus *Syringostromella. S. clarkei* lacks the long, continuous pillars of *Syringostromella,* and has laminae which, although not strong, are better developed than in any species placed in *Syringostromella.* One other species assigned to *Syringostromella* that seems closely related to *S. clarkei* is *?Syringostromella borealis* (Nicholson) (Nicholson, 1891b, p. 315, pl. 9, figs. 7-8).

Swartz (1913, p. 224) referred specimens collected from the Keyser Formation in Maryland to *Syringostroma barretti* Girty (Girty, 1895, p. 286, pl. 7, figs. 5-6), although he stated (p. 225), "Such specimens seem to agree so closely with Parks' *Stromatopora clarkei* as to lead the writer to believe that the latter species may be identical with this." His illustration agrees with *S. clarkei,* and little resembles Girty's illustration of *S. barretti.*

Stratigraphic and geographic distribution. — The figured holotype (NYSM 6820) is from the Cobleskill Member in Schoharie County. The figured hypotype specimen (USNM 248096) was collected from the Cobleskill Member at Locality 13. Two specimens were collected from the Glasco Member at Locality 9, and seven from the Cobleskill Member at Localities 13, 21, and 23.

Stromatopora bekkeri Nestor, 1966 Pl. 50, figs. 5-6; Pl. 51, fig. 1

Stromatopora bekkeri Nestor, 1966, pp. 46, 83, pl. 17, figs. 1-2; Mori, 1970, p. 123, pl. 12, figs. 3-4.

Diagnosis. — Laminae appear more continuous than pillars, but are cut by pseudozooidal tubes, with resultant equal continuity of laminae and pillars. Laminae 0.09 to 0.10 mm thick, 3 to 6 per mm; 5 pillars per mm, 0.13 mm wide in tangential section. Microreticulate microstructure contains large cellules. Pillars vermicular in tangential section, where astrorhizae also well-developed.

Description. — Coenostea of *S. bekkeri* may be subspherical, hemispherical, or laminar. The largest subspherical specimen, a fragment, has a maximum diameter of 40 mm. The one hemispherical specimen has a maximum basal diameter of 78 mm, with a height of

44 mm at the center. The largest laminar specimen is also a fragment, with a maximum thickness of 73 mm.

Pillars connect from two to nine laminae with which they are amalgamated. Cellules in the microreticulate pillars commonly are not aligned, although there is some impression of divergence within pillars as they expand upward between laminae. There is a mean of 5 pillars per mm (range: 3.5 to 6 per mm). In vertical section mean pillar width is 0.11 mm; in tangential section, 0.13 mm. Pillars commonly form a vermicular network in tangential section. The diameter of pseudozooidal tubes in tangential section ranges from 0.05 mm to 0.10 mm, commonly 0.07 to 0.08 mm. Astrorhizae are also evident in vertical and tangential sections, especially the latter where dichotomously branching astrorhizal canals are 0.09 mm wide (range: 0.05 to 0.15 mm). They are crossed in a few places by flat to slightly upward-arching cyst-plates.

The laminae are about as thick as the pillars, usually 0.09 to 0.10 mm wide, and are spaced about the same as the pillars, with 3 to 6 occurring in 1 mm, with a mean between four and five. The laminae give the impression of continuity, but are cut frequently by pseudozooidal tubes which, along with longer pillars, are developed in horizontal zones. The pseudozooidal tubes are crossed by thin, flat cyst-plates at the level of laminae. Mean gallery height is 0.10 mm. The microstructure of the laminae is also microreticulate.

Discussion.—*Stromatopora bekkeri* appears similar to some species of *Parallelostroma* in that the laminae appear continuous, although they are not. The laminae and pillars are the most regular of any species of *Stromatopora* seen in the Rondout Formation. Although Mori (1970, p. 123) stated that the laminae were indistinct, laminar trends can be seen in his illustration (Mori, 1970, pl. 12, fig. 3).

In *Parallelopora ornata* Mori, laminae are more weakly developed, and cellules are aligned in the pillars (Mori, 1969, p. 50, pl. 2, figs. 3-6; pl. 3, figs. 5-6). *Parallelostroma typicum* (Rosen) (Rosen, 1867, p. 58, pl. 1, figs. 1-3; pl. 2, fig. 1) has more continuous laminae separated by irregular pillars and irregular laminae. *Parallelostroma constellatum* (Hall) (Hall, 1852, p. 324, pl. 72, figs. 2a-b) has laminae that are thicker and more continuous, and pillars that are more commonly irregularly round than vermicular in tangential section. Obvious rods are developed in the microstructure of the pillars of *Stromatopora pseudotypica* Riabinin (Riabinin, 1953, p. 47, pl. 18, figs. 3-4). Of all the species in the Rondout Formation, only *Stromatopora clarkei* Parks (Parks, 1909, p. 48, pl. 17, fig. 12; pl. 18, fig. 1) has as well-developed cellules in the microstructure as does *S. bekkeri.*

Stratigraphic and geographic distribution. — Seven specimens were collected, one from the Wilbur Member at Locality 1, one from the Glasco Member at Locality 3, and five from the Glasco Member at Locality 9. The illustrated hypotype specimen (USNM 248097) is from the Glasco Member at Locality 9.

Stromatopora eoconcentrica, n. sp. Pl. 51, figs. 2-3

Derivation of name. — The specific name was derived from the similar irregular arrangement of the macrostructure in this species and *Stromatopora concentrica* Goldfuss (Goldfuss, 1826, p. 22, pl. 8, figs. 5a-c), and from the earlier occurrence (Late Silurian) of the new species compared to *S. concentrica* (Middle Devonian).

Diagnosis. — Amalgamated laminae and pillars extremely irregular; neither show continuous development. Skeletal material microreticulate or cellular. Pseudozooidal tubes short, irregular. Pillars vermicular in tangential section. Laminae and pillars 0.13 mm thick.

Description. — Coenostea are most commonly subspherical in form. The largest specimen, a weathered fragment, has a maximum diameter of 98 mm and a maximum height of 54 mm.

The laminae and pillars are irregularly arranged in vertical sections, so that it is difficult to tell them apart. They are both 0.13 mm thick, with extremes of 0.02 to 0.21 mm. There are 3.5 to 5.5 laminae and pillars in 1 mm. The cellules in the skeletal material are not clearly defined. In tangential section, pillars are vermicular, and dichotomously branching astrorhizae are developed. Astrorhizal canals average 0.10 mm wide (range: 0.05 to 0.20 mm), and commonly lack cyst-plates.

Vertically, the coenosteum is divided into zones which are probably latilaminae 0.81 to 3.59 mm thick. The zones are bounded by a single straight lamina or microlamina. These give rise to pillars that remain perpendicular to the lamina through one gallery. Above this the typical irregular network of macrostructure predominates.

Discussion.—*Stromatopora eoconcentrica,* n. sp., most resembles *Stromatopora concentrica,* with its irregular, amalgamated macrostructure, regular laminae and pillars at the margins of latilaminae, and irregular, short pseudozooidal tubes.

Specimens of *S. eoconcentrica* were not assigned to *S. concentrica* because the skeletal elements of *S. concentrica* are thicker, with pillars 0.17 to 0.25 mm thick, as measured from the holotype (Lecompte, 1952, p. 272), yet are commonly spaced more closely than in *S. eoconcentrica* (4.7 to 5.2 per mm). All verified specimens of *S. concentrica* are from the Middle and Upper Devonian. Specimens previously described from Silurian rocks were identified by external morphology only. The difference in pillar thickness combined with the stratigraphic separation preclude assignment to *S. concentrica.*

Parallelostroma constellatum (Hall) (Hall, 1852, p. 324, pl. 72, figs. 2a-b), and ?*Stromatopora prima* Parks (Parks, 1933, p. 28, pl. 5, figs. 6-8) both contain laminae which are more continuous than in *S. eoconcentrica. Stromatopora venukovi* Yavorsky (Yavorsky, 1929, pp. 99, 109, pl. 11, figs. 8-9) has laminae that are more regular and pseudozooidal tubes that are wider. *Stromatopora tuvensis* Yavorsky (Yavorsky, 1961, p. 37, pl. 21, figs. 1-8, pl. 23, fig. 8) has wider, longer pseudozooidal tubes. Laminae and pillars are more regular in *Stromatopora lamellosa* Yavorsky (Yavorsky, 1929, pp. 97, 108, pl. 21, figs. 3-4), and pillars and pseudozooidal tubes are straighter and longer in *Stromatopora carteri* Nicholson (Nicholson, 1891a, p. 174, pl. 23, figs. 1-3), and *Stromatopora amii* Parks (Parks, 1909, p. 36, pl. 19, figs. 7-8).

Stratigraphic and geographic distribution.—Ten specimens were collected from the Cobleskill Member at Localities 11, 13, 14, 16, and 17. The figured specimen (USNM 248098) is from the Cobleskill Member at Locality 13.

Type material.—The holotype specimen (USNM 248098) is from the Cobleskill Member at Locality 13. A paratype (USNM 248099) shares this provenance.

Genus **PARALLELOSTROMA** Nestor, 1966

Parallelostroma Nestor, 1966, pp. 52, 85; Flügel and Flügel-Kahler, 1968, p. 671; Mori, 1970, p. 132; Bolshakova, 1973, p. 86.

Type species.—*Stromatopora typica* Rosen (Rosen, 1867, p.

58, pl. 1, figs. 1-3; pl. 2, fig. 1), Upper Silurian, Ludlow, Paadla Horizon, Estonia.

Other species. — Flügel and Flügel-Kahler (1968, p. 671) listed 18 species assigned to *Parallelostroma.* Additional species are too numerous to list here, but have been described by Mori (1970, pp. 134, 135), Bogoyavlenskaya (1972b, pp. 61-63; 1973, p. 55), and Bolshakova (1973, pp. 88, 89, 92, 95).

Diagnosis. — Coenosteum consisting of continuous laminae connected by pillars that may be superposed. Pseudozooidal tubes may be present. Microstructure microreticulate. In tangential section, pillars seen either as vermicular structures or as irregular circles.

Discussion. — Nestor (1966, pp. 52, 85) created *Parallelostroma* to include species formerly included in *Stromatopora* Goldfuss, 1826 which had, according to Nestor (1966, p. 85), ". . . a perfect laminar structure, regular reticulate microstructure of the skeletal tissue and clearly differentiated autotubes [pseudozooidal tubes]." Actually the long, continuous laminae distinguish *Parallelostroma* from *Stromatopora.* The pillars in *Parallelostroma* are commonly more regular than in *Stromatopora,* but are never as continuous as the laminae.

Nestor (1966, p. 85) interpreted the laminae to be ". . . very thick, of reticulate microstructure, composed of extremely thin reticular microlaminae which are intersected by the vertical rows [pillars]." He also stated, "Laminae divided from each other by astrorhizae which are distributed layerwise and have strongly forked anastomosing canals." Nestor apparently regarded the galleries not as simple open spaces between skeletal elements, but as ramifications of astrorhizae which cut the very thick laminae, leaving vertical microreticulate structures, which Bogoyavlenskaya (1968, p. 153 [transl.]) has called coenosteles. Mori (1970, p. 132), however, referred to regular galleries horizontally arranged parallel to the laminae.

Parallelostroma constellatum (Hall, 1852) Pl. 51, figs. 4-6; Pl. 52, figs. 1-4

Stromatopora constellata Hall, 1852, p. 324, pl. 72, figs. 2a-b; Parks, 1908, p. 44, pl. 13, figs. 7-8, 10; 1909, pp. 41, 46, pl. 17, figs. 10-11 (lectotype), pl. 18, fig. 8; 1933, p. 16, pl. 3, figs. 6-7; Swartz, 1913 (part), p. 221, pl. 27, figs. 1-4 (not figs. 5-6, pl. 28, figs. 1-2); Yavorsky, 1955, p. 87, pl. 46, figs. 1-2.
Parallelostroma constellatum (Hall), Nestor, 1966, p. 53.

Diagnosis. — Laminae and pillars regularly placed perpendicular to each other. Laminae (0.12 mm thick) more continuous than pillars (0.12 mm in diameter). Pillars often traversing up to seven laminae, but still less continuous than laminae. Pillars irregularly round in tangential section. Laminae 4.2 to 5.5 per mm; pillars 4.7 to 5.5 per mm.

Description. — Coenostea can be subspherical, laminar, or encrusting. The majority of the specimens from the Glasco Member are laminar, while only about 6 percent of those from the Cobleskill Member are laminar. The largest subspherical specimen, encased in sediment, has a maximum diameter of 68 mm. The specimen is in turn encrusted by at least 30 mm of *Densastroma pexisum* (Yavorsky, 1929). The largest laminar specimen, a fragment of a massive coenosteum, is up to 77 mm thick with a maximum lateral expanse of approximately 155 mm. Encrusting specimens are found to have grown on favositid tabulate corals or on other stromatoporoids.

The skeletal material of the amalgamated laminae and pillars is microreticulate. The laminae are continuous throughout the specimen, a characteristic of all species of *Parallelostroma.* Cellules are not aligned vertically in the pillars, although they may be arranged horizontally in the laminae. Pillars traverse as many as seven laminae.

Averages of 4.2 to 5.5 laminae per mm and 4.7 to 5.5 pillars per mm were obtained for specimens measured. Mean pillar width from vertical sections is 0.10 mm, and diameter from tangential sections is 0.12 mm. Mean laminar thickness is also 0.12 mm, and mean gallery height is 0.07 mm. Mean pseudozooidal tube diameter is also 0.07 mm.

The pseudozooidal tubes, crossed by flat or slightly upward arching cyst-plates are developed only locally within specimens. Dichotomously branching astrorhizae can be seen in both vertical and tangential views. Astrorhizal canals average 0.09 mm wide when measured in tangential section, with a range of 0.03 to 0.15 mm. Only rarely do flat cyst-plates cross astrorhizae.

Discussion. — A holotype specimen was not designated for *Parallelostroma constellatum.* Hall (1852, p. 324, pl. 72, figs. 2a-b) based his original description of the species on external morphology of a specimen from Schoharie, N.Y. Parks (1907, pl. 4, figs. 6, 8) illustrated a specimen from the Cobleskill Member loaned to him by J. M. Clarke, which he attributed to *P. constellatum.* He (Parks, 1908, p. 44, pl. 13, figs. 7-8, 10) described and again illustrated *P. constellatum.* His figures included a drawing (fig. 7), a slightly intensified photograph (fig. 8), and a slightly retouched photograph (fig. 10), and did not give a true representation of his specimen from Cobbleskill [*sic.*], N.Y. Parks (1909, p. 46, pl. 17, figs. 10-11; pl. 18, fig. 8), again discussed *P. constellatum* and illustrated either thin-sections 851 and 853 (p. 48) or thin-sections 851 and 852 (pp. 50-51). All that remains in the New York State Museum are thin-sections 851 and 852, mirror images of each other apparently made from either side of a cut through a single specimen, now missing. Thin-section 851 was used for both vertical and tangential illustrations (Pl. 51, figs. 4-5), as it is thinner than 852. The specimen from which these two thin-sections were made (NYSM 6821) was from Schoharie County, N.Y., and may be the undeclared holotype. The writing on the thin-sections was done by two different people. One writer was probably Parks, as it is the same writing as on holotype thin-sections of *Densastroma tenuissimum* (Parks, 1909) and *Stromatopora clarkei* Parks, 1909. The other, earlier writer, may have been James Hall, the author of *P. constellatum,* since the writing is in the same style as notes on slides of stromatoporoids collected for Hall from the Devonian of Iowa. The identity and location of specimens used by Parks in earlier studies (1907, 1908) are unknown. Therefore, specimen NYSM 6821, represented by thin-sections 851 and 852, is chosen as the lectotype. It is from the same stratigraphic unit (Cobleskill Member) and the same general locality (Schoharie County) as Hall's original specimen.

Measurements of the macrostructure of the lectotype fall within the ranges of the specimens collected from the Rondout Formation (Table 5). The only internal measurements previously published for *P. constellatum* were by Parks (1908, p. 45), but it is not known if they are from the lectotype. He stated that there were an average of 7 laminae and pillars per mm, high for specimens from the Rondout Formation. Perhaps Parks also measured some Canadian specimens which he had included in synonymy with *P. constellatum.*

Parks (1908, p. 46) also discussed possible affinities between *P. constellatum* and *P. typicum* (Rosen) (Rosen, 1867, p. 58, pl. 1, figs. 1-3; pl. 2, fig. 1). In *P. typicum* an amalgamated network of irregular pillars and laminae are found between continuous microlaminae. The laminae and pillars in *P. constellatum* are more regular, and the pillars extend through more laminae (up to 7) than is typical of *P. typicum*. Nestor (1966, p. 55) also discussed the possibility of synonymy between these two species, but saw the need for a reexamination of the holotype of *P. constellatum* before any conclusions could be drawn.

The presence of small mamelons, hardly noticeable in vertical sections, on Yavorsky's (1955, p. 87) specimens of *P. constellatum* is not critical to their inclusion in the species. At least 14 specimens of *P. constellatum* from the Glasco and Cobleskill Members contain slight inflections in the laminae in vertical section that appear in tangential section as concentric rings of obliquely-cut laminae.

Specimens attributed by Birkhead (1976, p. 115, pl. 7, figs. 5-6) to *P. typicum*, but which look more like *P. constellatum*, have laminae and pillars that are too thick and galleries that are too low for inclusion in *P. constellatum*.

Three of the 90 specimens of *P. constellatum* collected vary somewhat from the rest. The most atypical specimen (USNM 248104) (Pl. 52, figs. 2-4) from the Cobleskill Member, has an extremely regular arrangement of laminae and pillars. The pillars may traverse as many as 11 laminae. The laminae appear thinner than in other specimens, but are thicker toward the margins of the coenosteum where some alteration has taken place. Serious consideration was given to assigning this specimen to *P. maestermyrense* Mori (Mori, 1970, p. 134, pl. 16, figs. 1-4; pl. 24, figs. 5-6) which shares the basic appearance of USNM 248104, but has a coarser macrostructure. Two specimens (USNM 248105 and USNM 248106) from the Cobleskill Member are intermediate between USNM 248104 and the remainder of the specimens of *P. constellatum* collected. Such variation should not be regarded as unusual among 90 specimens of the same species.

Stratigraphic and geographic distribution.—*Parallelostroma constellatum* is the most abundant species collected from the Rondout Formation, with a total of 90 specimens, representing 29 percent of all stromatoporoids collected. Nine specimens were found in the Wilbur Member at Localities 2 and 8, 33 in the Glasco Member from Localities 1-5, and 9, and 48 specimens from the Cobleskill

Table 5.—Comparison of the Skeletal Dimensions of Four Specimens of *Parallelostroma constellatum* with the Lectotype [Ranges are followed by arithmetic means in parentheses].

	Cobleskill Mbr.			Glasco Mbr.	Wilbur Mbr.
	NYSM 6821 (Lectotype)	USNM 248100	USNM 248101	USNM 248102	USNM 248103
Laminae per mm in vertical section	3.0-6.0 (4.3)	3.0-6.0 (4.2)	4.0-6.0 (4.9)	4.0-7.0 (5.0)	4.0-6.5 (5.4)
Pillars per mm in vertical section	4.0-7.0 (5.7)	4.0-6.5 (5.1)	3.0-6.0 (4.7)	3.5-7.0 (5.2)	3.5-6.0 (5.0)
Pillar width (mm) in vertical section	0.04-0.21 (0.11)	0.04-0.20 (0.11)	0.04-0.23 (0.11)	0.05-0.16 (0.09)	0.05-0.23 (0.10)
Pillar diameter (mm) in tangential section	0.06-0.14 (0.10)	0.08-0.13 (0.11)	0.10-0.16 (0.13)	0.07-0.13 (0.10)	0.08-0.17 (0.12)
Laminar thickness (mm) in vertical section	0.06-0.26 (0.16)	0.05-0.27 (0.14)	0.05-0.17 (0.12)	0.07-0.24 (0.12)	0.06-0.19 (0.12)
Gallery height (mm) in vertical section	0.06-0.27 (0.10)	0.04-0.13 (0.09)	0.04-0.11 (0.07)	0.05-0.12 (0.07)	0.04-0.11 (0.07)
Pseudozooidal tube diameter (mm) in tangential section	0.05-0.10 (0.07)	0.05-0.13 (0.08)	0.05-0.12 (0.07)	0.04-0.10 (0.07)	0.06-0.11 (0.09)

Member at Localities 10-16, 18, 20-25, and 27. The figured lectotype (NYSM 6821) is from the Cobleskill Member in Schoharie County, New York. The hypotype specimens illustrated here are from the Glasco Member at Locality 3 (USNM 248102) and from the Cobleskill Member at Locality 15 (USNM 248104).

Parallelostroma typicum (Rosen, 1867) Pl. 53, figs. 4-6

Stromatopora typica Rosen, 1867, p. 58, pl. 1, figs. 1-3, pl. 2, fig. 1; Yavorsky, 1929 (part), pp. 95, 107, pl. 10, figs. 2-5, (not figs. 6-7); 1947, pp. 10, 30, pl. 4, figs. 4-8; Nestor, 1962, pp. 18, 23, pl. 6, figs. 1-4 (holotype), pl. 8, figs. 3, 5 (holotype).

Stromatopora typica Rosen var. *kudrinzyensis* Riabinin, 1953, p. 46, pl. 17, figs. 4-5, pl. 18, figs. 1-2.

Parallelostroma typicum (Rosen), Nestor, 1966, p. 54, pl. 19, figs. 1-4 (holotype); pl. 20, figs. 1 (holotype), 2-3; Mori, 1970, p. 136 (part), pl. 17, figs. 1-2, (not figs. 3-6; pl. 18, figs. 1-4; pl. 24, fig. 3).

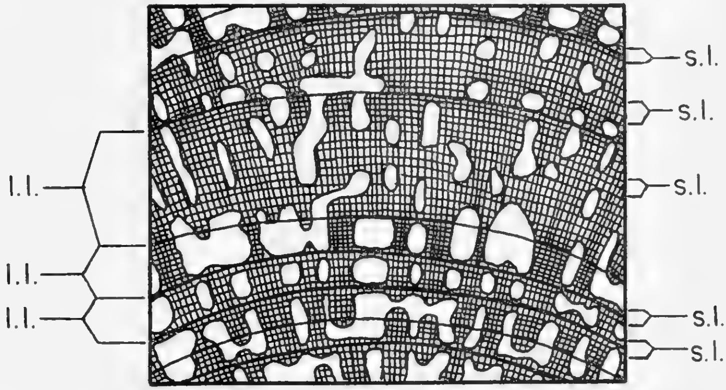
Diagnosis. — Continuous microlaminae; spanning coenosteum below these is amalgamated network of irregular laminae (0.13 mm thick) and pillars (0.08 mm wide) of microreticulate microstructure. Pseudozooidal tubes may cut single microlaminae. Pillars vermicular in tangential view, anastomosing around pseudozooidal tubes.

Description. — Nearly all the coenostea collected are subspherical. One encrusted a favositid tabulate coral, and another a solitary rugose coral. The largest complete subspherical coenosteum measures 102 mm × 71 mm × 54 mm. A second subspherical fragment has a maximum diameter of 113 mm.

Nestor (1962, p. 23) redescribed the holotype of Rosen (1867), stating in part:

> A charactertistic feature of the species is a laminar structure. Laminae thick — 0.15 - 0.50 mm. Galleries placed on one level, on the uppermost surfaces of the laminae. Pseudozooidal tubes, short, going through one lamina only. There are 4 - 6 laminae (in vertical direction) and up to 8 pseudozooidal tubes (in horizontal direction) situated in 2 mm. Astrorhizae joined into vertical systems with central canals. Microstructure of skeleton regularly net-shaped.

Specimens collected from the Rondout Formation are in essential agreement with Nestor's (1962, pp. 18, 23) description. The continuous laminae are obvious. But Nestor considered the microlaminae and amalgamated network of irregular laminae and pillars below each microlamina all to be part of one large lamina. Variations in the amalgamated network resulted in variations (0.15 to 0.50 mm) in the thickness of the large laminae. He saw no pillars, but rather "vertical rows" defined by the limits of adjacent galleries (Text-fig. 10).



Text-figure 10. — Macrostructure of a vertical section of ***Parallelostroma typicum*** (Rosen, 1867). Note the variations in thickness and regularity of the laminae. l.l. = large lamina, s.l. = small lamina.
(approximately ×20)

Rondout Formation specimens were measured with both concepts of laminae in mind. Large laminae, which may be latilaminae, range in thickness from 0.07 to 1.98 mm with means from four specimens of 0.33 to 0.55 mm. About three large laminae are found in 1 mm in vertical section. A mean of 4.5 small laminae were counted in 1 mm, with thickness ranging from 0.05 to 0.30 mm (mean: 0.13 mm). Mean gallery height is 0.09 mm (range: 0.05 to 0.16 mm). Pseudozooidal tube mean spacing is 4.7 per mm in vertical section. The pseudozooidal tubes, 0.08 mm in mean diameter, are crossed by thin, flat, or slightly upward-arching cyst-plates or dissepiments which show no regular relationship with the small laminae. Pillars are spaced at 4.7 per mm and are 0.04 to 0.30 mm wide.

Skeletal material is microreticulate. Dichotomously branching astrorhizae are developed along laminar planes and are seen in both vertical and tangential views. Astrorhizal canals in tangential section are 0.03 to 0.18 mm wide (mean: 0.075 mm).

Discussion. — Considerable variation occurs within the coenostea of *P. typicum.* Some laminar zones contain amalgamated networks of irregular laminae and pillars. In other zones, a microreticulate mass of material below the top microlamina extends downward into pillars which in turn join the next lowest microlamina. The latter situation is representative of specimens of *Parallelostroma kaugatomicum* (Riabinin) (Riabinin, 1951, p. 43, pl. 36, figs. 4, 6). Some authors (Nestor, 1962, p. 18; 1966, p. 54; Mori, 1970, p. 136) have included *P. kaugatomicum* in *P. typicum,* perhaps due to the similarity of pillar construction, or because some of the original specimens of *P. kaugatomicum* (Riabinin, 1951, pl. 36, fig. 5; pl. 37, fig. 5) are synonymous with *P. typicum. P. kaugatomicum* is retained as a separate species here because of its consistent differences from specimens of *P. typicum,* which are noted in the discussion of *P. kaugatomicum. Stromatopora typica kudrinzyensis* Riabinin (Riabinin, 1953, p. 46, pl. 17, figs. 4-5; pl. 18, figs. 1-2) looks much like the Rondout Formation specimens. Measurements from figures of vertical sections (Riabinin, 1953, pl. 17, fig. 4; pl. 18, fig. 1) show 4.0 to 4.5 small laminae per mm and 3.5 to 5.5 pillars per mm, well within ranges of Rondout specimens. Pillar width similarly measured is 0.05 to 0.18 mm, also close to *P. typicum,* as are pseudozooidal tube diameters of 0.05 to 0.10 mm, as measured by Riabinin (1953, p. 46). The presence of mamelons in *S. typica kudrinzyensis* does not exclude it from *P. typicum.* As indicated earlier not all specimens of *Parallelostroma constellatum* (Hall) have mamelons. The subspherical shape of nearly all specimens of *P. typicum* from the Rondout Formation did not allow sufficiently large tangential sections of individual laminar planes to make adequate comparisons of astrorhizae between that species and *S. typica kudrinzyensis.* Mori (1970, p. 137) questionably included Riabinin's subspecies in the synonymy of *P. typicum.* Riabinin's subspecies is not different enough to set it apart as a new species. Establishment of separate biological entities below the species level for fossils is of doubtful validity. This is especially true for extinct groups like stromatoporoids.

The specimens attributed to *P. typicum* by Birkhead (1976, p. 115, pl. 7, figs. 5-6) are not included in synonymy. His figures do not show the large laminae in vertical section, and pseudozooidal tubes are rarely present. Birkhead's specimens have a more regular arrangement of laminae and pillars, as in *P. constellatum,* but are not included therein.

The pillars in *Stromatopora bekkeri* Nestor (Nestor, 1966, pp. 46, 83, pl. 17, figs. 1-2) are longer than in *P. typicum,* and the laminae are less well developed. The macrostructure of *Parallelostroma constellatum* (Hall) (Hall, 1852, p. 324, pl. 72, figs. 2a-b) is more regular than in *P. typicum,* and the pillars are commonly circular in tangential section, rather than vermicular.

Stratigraphic and geographic distribution. — Seventeen specimens were collected, all from the Cobleskill Member at Localities 10-13, 17, 19, 21, and 27. The figured hypotype specimen (USNM 248107) is from the Cobleskill Member at Locality 13.

Parallelostroma kaugatomicum (Riabinin, 1951) Pl. 52, figs. 5-6; Pl. 53, figs. 1-3

Stromatopora constellata Hall, Swartz, 1913 (part), "Type C," p. 223, pl. 27, figs. 5-6, (not figs. 1-4), pl. 28, figs. 1-2; Swartz and Prouty, 1923, p. 399, pl. 10, figs. 8-9.

Stromatopora kaugatomica Riabinin, 1951 (part), p. 43, pl. 36, figs. 4, 6 (lectotype), (not figs. 1-3, 5, 7; pl. 37, figs. 1-5; pl. 38, fig. 1; pl. 39, fig. 1).

Diagnosis. — Continuous laminae (0.13 mm thick) connected by short pillars (0.11 mm in diameter) typically traversing only one gallery, and irregularly round in tangential view. Laminae and pillars 4.4 per mm. Skeletal material microreticulate. Some laminae composed of multiple microlaminae. Pseudozooidal tubes absent.

Description. — Coenostea are subspherical, laminar, or encrusting. One specimen is digitate. Subspherical and laminar forms are equally common in the Glasco Member, while most of those in the Cobleskill Member are subspherical. All encrusting specimens are from the Cobleskill Member, and grew on halysitid and favositid tabulate corals, solitary rugose corals, or on other stromatoporoids, commonly species of *Densastroma.* The largest subspherical coenosteum measures 145 mm × 125 mm × 122 mm. The largest laminar specimen is a fragment 54 mm at the thickest and 98 mm at the widest. Some of the prominences on the digitate specimen extend 27 mm above the remainder of the coenosteum.

The laminae in *Parallelostroma kaugatomicum* continue through the coenosteum. They often appear as a layer of microreticulate skeletal material extending downward from a microlamina. Separate pillars extend downward from the microreticulate layer to the next lamina. In the seven specimens from which measurements were taken, the following ranges were obtained: 2.5 to 6.5 laminae per mm (mean: 4.4), 2.0 to 7.5 pillars per mm (mean: 4.4), laminar thickness 0.03 to 0.32 mm (mean: 0.13 mm), gallery height 0.02 to 0.20 mm (mean: 0.10 mm), pillar width 0.02 to 0.29 mm (mean: 0.11 mm) in vertical section, and pillar diameter 0.05 to 0.17 mm (mean: 0.11 mm) in tangential section. Some specimens have multilayered laminae with up to five microlaminae in a lamina. These noticeably increase the thickness of the laminae.

Dichotomously branching astrorhizae are developed in both vertical and tangential sections. Astrorhizal canals, measured in six specimens, average 0.09 mm wide (range: 0.03 to 0.25 mm). Vertical sections show astrorhizal canals developed along the tops of laminae and merged in widely spaced, slightly inflected astrorhizal columns, commonly 1.50 mm wide. The longest vertical expression of an astrorhizal column is 5.98 mm.

Cyst-plates are developed to varying degrees in specimens of *P. kaugatomicum.* Many astrorhizae contain no cyst-plates, while others have some thin, flat or slightly upward-arching plates. Pseudozooidal tubes are absent, but some galleries are divided horizontally by one or two cyst-plates like those in the astrorhizal canals. Cyst-plates in galleries are rare to common, but never abundant in specimens of *P. kaugatomicum.*

Discussion. — Riabinin (1951, p. 43) failed to designate a holotype for *P. kaugatomicum,* but did illustrate thin-sections of five specimens: 25b, 27b, 31, M-V, and M-VI. St. Jean (1976, written comm.) examined four of the five illustrated specimens, as there were no sections of M-V available, and stated that specimen 31 is different from the others. St. Jean saw similarities between 25b and 27b, and thought that M-VI was also different from the other three.

Only Riabinin's specimen 31 (Riabinin, 1951, pl. 36, figs. 4, 6), the vertical section of which (Riabinin, 1951, fig. 4) is inverted, resembles specimens collected from the Rondout Formation, having short pillars restricted between continuous laminae. Specimen 27b (Riabinin, 1951, pl. 36, fig. 5; pl. 37, fig. 5) looks more like *Parallelostroma typicum* (Rosen, 1867) with amalgamated layers of irregular laminae and pillars.

Only two specimens of *P. kaugatomicum* were illustrated in both vertical and tangential section (specimens 27b and 31, the first of which is probably synonymous with *P. typicum*). Because at least three different species were included in the original description of

P. kaugatomicum, specimen 31 is chosen as the lectotype. *P. kaugatomicum* was included in synonymy with *P. typicum* by Nestor (1962, p. 18; 1966, p. 54) and Mori (1970, p. 136), possibly because of the multiplicity of species used in the original description, or because they chose those specimens which resemble *P. typicum* (*e.g.*, No. 27b) to represent *P. kaugatomicum.* Some of the laminae in *P. typicum* resemble those in *P. kaugatomicum* in that they consist of microlaminae from which descends a layer of microreticulate material. Pillars extend from the bottom of the microreticulate layer.

The pillars in *P. kaugatomicum* are always short and restricted between laminae, while the pillars in *P. typicum* may be long or short, and may traverse several laminae. Tangential sections of New York specimens of *P. typicum* are dominated by vermicular pillars, with a few free-standing round pillars (Pl. 53, fig. 6). Round pillars are prevalent in tangential sections of *P. kaugatomicum* (Pl. 52, fig. 6). One tangential section of the holotype of *P. typicum* (Nestor, 1966, pl. 19, fig. 2) shows both irregular round pillars and vermicular pillars, the latter too well-developed for *P. kaugatomicum.*

Riabinin (1951) did not give measurements of laminar and pillar spacing or thickness, but did indicate (p. 44) pseudozooidal tube diameters of 0.05 to 0.10 mm. Since pseudozooidal tubes are absent in the lectotype, the measurements do not apply to the redefined *P. kaugatomicum.* Measurements from the figure of the vertical section of the lectotype (Riabinin, 1951, pl. 36, fig. 4) show 5.4 laminae per mm from a range of 4.5 to 6.0, indicating a finer macrostructure in the lectotype than in most Rondout Formation specimens. One must remember that these measurements are from one small area of a larger coenosteum, and do fall within the overall range for Rondout specimens of 2.5 to 6.5 laminae per mm and 2.5 to 7.5 pillars per mm.

Parallelostroma malinovzyense (Riabinin) (Riabinin, 1953, p. 39, pl. 14, figs. 1-2) develops amalgamate networks between some laminae, and might be synonymous with *P. kaugatomicum.* Measurements from a vertical section (Riabinin, 1953, pl. 14, fig. 1) show 3.0 to 7.0 laminae per mm and 3.0 to 6.5 pillars per mm, similar to *P. kaugatomicum.* Mori (1970, p. 138) included *P. malinovzyense* in *P. typicum,* since the number of laminae per unit and the diameter of pseudozooidal tubes in the former fell within the range of the latter. Nestor (1966, p. 55) stated that *P. malinovzyense* was close to *P.*

typicum, but had thinner laminae and small astrorhizae compared to *P. typicum.*

The major difference between *Parallelostroma tuberculatum* (Yavorsky) (Yavorsky, 1929, pp. 98, 108, pl. 11, figs. 5-7) and *P. kaugatomicum* is in the spacing of laminae. Measurements from Yavorsky's illustrations of *P. tuberculatum* (Yavorsky, 1929, pl. 11, figs. 5, 7) show 6.6 laminae per mm, an average slightly higher than the maximum number measured for any Rondout Formation specimen or for the lectotype specimen of *P. kaugatomicum* (6.5 laminae per mm). Further study of the holotype of *P. tuberculatum* could reveal that it is a synonym of *P. kaugatomicum.*

Parallelostroma constellatum (Hall, 1852) also has round pillars in tangential section, but the pillars can traverse more than one lamina. The laminae in *Parallelostroma dnestriense* (Riabinin) (Riabinin, 1953, p. 40, pl. 14, figs. 3-4; pl. 15, figs. 1-2) and *Parallelostroma grinchukense* Bolshakova (Bolshakova, 1973, p. 89, pl. 13, figs. 1-2) are less straight than in *P. kaugatomicum. P. grinchukense* also has 3.5 to 4.0 laminae per mm, less than in *P. kaugatomicum. Parallelostroma multilaminatum* Bolshakova (Bolshakova, 1973, p. 92, pl. 15, figs. 1-2; pl. 16, figs. 1-2; pl. 17, fig. 1) has multilayered laminae, but they are thicker (0.20 to 0.30 mm) and the pillars are more widely separated (3.9 per mm).

The microstructure of the five specimens collected from Locality 4 is unusually distinct, and as a result, they may look like members of a different species than other New York specimens. Astrorhizal canals are developed along the tops of laminae. Pillars descend from a microreticulate layer which lies below a microlamina. Pillars are not superposed, and are round in tangential section. Cyst-plates are found in galleries. For these reasons, and because skeletal dimensions compare favorably with other Rondout Formation specimens, the five specimens from Locality 4 are retained in *P. kaugatomicum.*

Stratigraphic and geographic distribution. — Fifty-eight specimens were collected from all three stromatoporoid bearing members, making *Parallelostroma kaugatomicum* the third most abundant species in the Rondout Formation. Three specimens were collected from the Wilbur Member at Localities 2 and 8. Fifteen specimens were collected from the Glasco Member at Localities 3 - 5, and 9. The Cobleskill Member yielded forty specimens from Localities

10 - 18, 20 - 23, and 27. The figured hypotype specimens are USNM 248108 from the Cobleskill Member at Locality 13 and USNM 248109 from the Glasco Member at Locality 4.

Parallelostroma rondoutense, n. sp. Pl. 54, figs. 1-5; Pl. 55, fig. 1

Parallelostroma typicum (Rosen), Mori, 1970 (part), p. 136, pl. 17, figs. 3-4, (not figs. 1-2, 5-6; pl. 18, figs. 1-4; pl. 24, fig. 3).

Derivation of name. — This species is named after the Rondout Formation of New York in which it occurs over an extensive area.

Diagnosis. — Distinguished by thick, microreticulate pillars (0.14 mm diameter) and laminae (0.14 mm thick). Laminae more continuous than pillars. Cellules in pillars aligned vertically. Pillars superposed, and seen as large and round or as meanders in tangential section. Astrorhizae present, but weakly developed. Pseudozooidal tubes also present.

Description. — Coenostea are subspherical, laminar, hemispherical, irregular or encrusting. Laminar forms dominate in the Glasco Member, and subspherical forms are the major morphology in the Cobleskill Member. One specimen had encrusted a favositid tabulate coral, and a second encrusted a specimen of *Parallelostroma kaugatomicum* and a favositid coral which had also encrusted the *P. kaugatomicum.* A third specimen had encrusted the stromatoporoid *Densastroma pexisum* which itself had encrusted a solitary rugose coral. The largest subspherical coenosteum is a fragment with a maximum diameter of 68 mm. The largest laminar specimen is also a fragment, with a maximum width of 136 mm and a maximum thickness of 30 mm. One-third of the specimens from the Cobleskill Member developed irregular growth forms in response to an unstable sedimentary environment.

Important skeletal measurements are given in Table 6 for three specimens: USNM 248110 and USNM 248111 from the Glasco Member, and USNM 248112 from the Cobleskill Member. The average measurements for all three specimens of *P. rondoutense* obtained from vertical section are 4.6 laminae per mm, 4.8 pillars per mm, laminar thickness and pillar width of 0.14 mm, and gallery height of 0.09 mm. Tangential section measurements are a pillar diameter of 0.14 mm and pseudozooidal tube diameter of 0.07 mm.

The microstructure is microreticulate, with cellules showing a vertical alignment in pillars and a horizontal alignment in laminae.

The pillars and laminae are thick, resulting in relatively small galleries. Pillars are superposed, traversing as many as 10 laminae, but are not as continuous as the laminae. Pseudozooidal tubes are present in some specimens, and are not crossed by arching cyst-plates, but rather by microlaminae that are laterally aligned with the normally thick laminae. Dichotomously branching astrorhizae may be developed in vertical section along laminar planes, and are well-developed in tangential section. Astrorhizal canal mean width is 0.08 mm in tangential section (range: 0.04 to 0.19 mm).

In tangential section the pillars are large and (or) vermicular. In areas where vermicular meanders grade to separate round pillars, due to a slightly oblique cut of the laminae, it appears that the pillars are connected by pale radial processes, which are remnants of the meanders; these are not cyst-plates. Within the pillars the cut ends of micropillars are seen as melanospheres.

In one specimen from the Cobleskill Member (USNM 248112) there are laminar zones within which galleries are absent, these having been filled by microreticulate material. These zones were first thought to be a product of alteration, but a tangential section through such a zone shows a small astrorhizal system developed within (Pl. 54, fig. 5; Pl. 55, fig. 1). The small astrorhizal canals are dichotomously branching, and are 0.01 to 0.03 mm wide (mean: 0.02 mm).

Discussion.—*Parallelostroma rondoutense,* n. sp., is transitional between *Parallelostroma* and *Syringostroma.* The type species of *Syringostroma, S. densum* Nicholson (Nicholson, 1875, p. 251, pl. 24, figs. 2-2b) from the Middle Devonian, has large continuous pillars, and short pillars confined between two laminae. The large pillars of *S. densum* are much like the pillars of *P. rondoutense,* in that they are thick and round in tangential section, and display vertically aligned cellules in vertical section. In *P. rondoutense* the laminae are not upwardly inflected into the pillars, as in most species of *Syringostroma. Syringostroma ristigouchense* (Spencer) (Spencer, 1884, p. 49, pl. 6, figs. 12-12a) from the Lower Devonian, first illustrated in thin-section by Nicholson (1886b, pl. 11, figs. 11-12), has thick and round pillars that are connected by the "radial processes" mentioned above. Similar structures are displayed in a tangential section of *Parallelopora pulchra* Galloway

Table 6. — Comparison of the Skeletal Dimensions of Three Specimens of *Parallelostroma rondoutense.*

	Glasco Mbr.				Cobleskill Mbr.	
	USNM 248110 (holotype)		USNM 248111		USNM 248112	
	range	mean	range	mean	range	mean
laminae per mm in vertical section	3-6	4.4	3-6	4.5	3-7	5.0
pillars per mm in vertical section	3.5-6.5	4.8	4.0-6.5	5.1	3.5-7.0	4.6
laminar thickness (mm) in vertical section	0.07-0.30	0.16	0.07-0.26	0.15	0.04-0.23	0.11
gallery height (mm) in vertical section	0.05-0.12	0.08	0.07-0.22	0.10	0.03-0.13	0.08
pillar width (mm) in vertical section	0.06-0.31	0.14	0.05-0.23	0.13	0.07-0.30	0.14
pillar diameter (mm) in tangential section	0.10-0.19	0.14	0.10-0.17	0.13	0.10-0.21	0.15
pseudozooidal tube diameter (mm) in tangential section	0.05-0.11	0.07	0.05-0.08	0.06	0.02-0.07	0.05

and St. Jean (Galloway and St. Jean, 1957, p. 211, pl. 20, figs. 1a-b) where the pillars were said to be amoeboid in shape (Galloway and St. Jean, 1957, p. 212). Both species of *Syringostroma* have pillars which are more continuous than laminae, excluding them from synonymy with *P. rondoutense.*

Species of *Parallelopora* have a microreticulate microstructure in the pillars in which the cellules are vertically aligned, as in *Parallelostroma rondoutense. Parallelopora* has pillars that are more continuous than laminae, and that are vermicular in tangential section. The cellules in the pillars of many species of *Parallelopora* tend to be vertically elongate.

If the pillars, and to some degree the laminae, of *P. rondoutense* were thinner, it would have been included in *P. constellatum* (Hall, 1852). The latter has pillars which traverse about the same number of laminae and which are round in tangential section. The laminae also show the same degree of continuity. *P. rondoutense* has thinner pillars and more laminae per mm than *Parallelostroma tuberculatum* (Yavorsky) (Yavorsky, 1929, pp. 98, 108, pl. 11, figs. 5-7), which is similar in other respects. The laminae and pillars of *P. rondoutense* are more regularly arranged than in *P. typicum* (Rosen) (Rosen, 1867, p. 58, pl. 1, figs. 1-3; pl. 2, fig. 1). One specimen referred to *P. typicum* by Mori (1970, pl. 17, figs. 3-4) looks very similar to *P. rondoutense* from New York, and has been included in synonymy.

The absence of galleries in some laminar zones described earlier for specimen USNM 248112 (Pl. 54, fig. 5; Pl. 55, fig. 1) highlights possible relationships between massively microreticulate genera like *Densastroma,* and those with microreticulate skeletal material in laminae and pillars like *Parallelostroma.* This relationship was recognized by Parks (1909, p. 43) who compared *Densastroma tenuissimum* (Parks, 1909) to *Parallelostroma constellatum* (Hall, 1852). The astrorhizal system within the galleryless zone is on a scale typical of *Densastroma,* and finer than astrorhizae in other parts of the coenosteum. The zones are not the result of alternating encrustations, as changes between zones with galleries and those without are gradational.

Stratigraphic and geographic distribution. — Of the twenty-six specimens collected, fourteen are from the Glasco Member at

Localities 1, 3, and 9, and twelve specimens are from the Cobleskill Member at Localities 11, 13, 15, 18, 20, 21, and 23. The figured specimens are USNM 248110 from the Glasco Member at Locality 3, and USNM 248112 from the Cobleskill Member at Locality 18.

Type material. — The holotype (USNM 248110) is from the Glasco Member at Locality 3. Paratypes are USNM 248111 from the Glasco Member at Locality 1, and USNM 248112 from the Cobleskill Member at Locality 18.

Family **DENSASTROMATIDAE** Bogoyavlenskaya, 1974
Genus **DENSASTROMA** Flügel, 1959

Actinostroma (Densastroma) Flügel, 1959, p. 196.

Densastroma Flügel, Nestor, 1966, p. 35; Stearn and Hubert, 1966, p. 38; Flügel and Flügel-Kahler, 1968, pp. 541, 668; Mori, 1968, p. 72; Bolshakova, 1973, p. 73.

?*Pichiostroma* Bogoyavlenskaya, 1972a, p. 168 (transl.).

Type species. — *Stromatopora astroites* Rosen (Rosen, 1867, p. 62, pl. 2, figs. 6-7), Upper Silurian, Pridoli, Kaugatuma Horizon, Estonia.

Other species. — Flügel and Flügel-Kahler (1968, p. 542) listed 12 species unquestionably assigned to *Densastroma.*

Diagnosis. — Coenosteum composed of a mass of microreticulate skeletal material lacking galleries. Astrorhizae may be present, but are rare in vertical section. Micropillars more continuous than microlaminae, radial processes joining adjacent micropillars.

Discussion. — The skeletal elements, especially micropillars, in *Densastroma* are finer than those in *Plectostroma* Nestor, 1964 (p. 78). The microlaminae in *Pycnodictyon* Mori, 1970 (p. 103) are more continuous than the micropillars. The pillars (or micropillars) of *Desmostroma* Bolshakova, 1969 (p. 473 [transl.]) are grouped in columns. *Pichiostroma* Bogoyavlenskaya, 1972 (p. 168 [transl.]) features a coenosteum composed of a mass of skeletal material cut vertically by "slitlike cavities of indeterminate outlines" (Bogoyavlenskaya, 1972a, p. 168 [transl.]).

Densastroma may be ancestral to genera in other families. Coarsening of the microlaminae and micropillars and associated cellules would produce *Plectostroma,* and with alignment of radial processes, *Actinostroma* Nicholson, 1886b (p. 75). Cutting of the mass of microreticulate skeletal material of *Densastroma* by well-developed astrorhizae would result in species of the Stromatoporidae like *Parallelostroma* Nestor, 1966 (pp. 52, 85). Progressive clumping and enlarging of micropillars are found in *Desmostroma, Pseudolabechia* Yabe and Sugiyama, 1930 (p. 59) and *Vikingia* Bogoyavlenskaya, 1969a (p. 165 [transl.]), Kazmierczak (1971, p. 58) first suggested these relationships of *Densastroma* to *Desmostroma, Pseudolabechia,* and *Vikingia.*

Nestor (1974, p. 35) took a somewhat different point of view. He saw *Plectostroma* as an ancestor to both *Actinostroma* and *Densastroma.* He did agree that *Densastroma* led to some of the Stromatoporidae like *Parallelostroma* and *Actinostromella* Boehnke, 1915 (p. 162) which in turn gave rise to *Parallelopora* Bargatzky, 1881 (p. 291). He suggested that *Plectostroma* and the group including *Pseudolabechia* arose separately from the Labechiidae.

Pichiostroma Bogoyavlenskaya, 1972a is apparently a preservational variation of *Densastroma* with small-scale microreticulations. The poor illustration of the type species (Bogoyavlenskaya, 1972a, pl. 5, figs. 1a-b) prevents conclusive evaluation. This relationship is discussed further under *Densastroma pexisum* (Yavorsky, 1929).

Densastroma tenuissimum (Parks, 1909) Pl. 55, figs. 2-6

Actinostroma tenuissimum Parks, 1909, p. 42, pl. 18, figs. 2-3, 9, 12.
Densastroma tenuissimum (Parks), Nestor, 1966, p. 37.

Diagnosis. — Coenosteum a microreticulate mass lacking any gallery space. Micropillars more continuous and straighter than microlaminae. Microlaminae 16 to 25 per mm; micropillars 15 to 23 per mm. Astrorhizae absent or questionably present.

Description. — Coenostea are subspherical, laminar, or encrusting. The largest laminar specimen is 102 mm at the widest and 21 mm at the thickest. The largest subspherical specimen, a fragment, has a maximum diameter of 38 mm. Encrusting forms were found on species of *Parallelostroma* and on a solitary rugose coral.

Internally, the coenosteum consists of a microreticulate mass in which the micropillars are straighter and more continuous than microlaminae. Microlaminae are generally 0.01 to 0.02 mm thick and are spaced 16 to 25 per mm. Micropillars are as thick as microlaminae and occur 15 to 23 per mm.

Tangential sections show that micropillars are connected by radial processes that form the microlaminae. A so-called "hexactinellid" pattern is formed, although the number of radial processes per pillar is commonly closer to four than six.

Astrorhizae are absent from most specimens of *D. tenuissimum,* and are only doubtfully present in other specimens. A tangential section of USNM 248113 from the Cobleskill Member at Locality 14 contains a faint, star-shaped pattern resulting from the absence of radial processes connecting micropillars, apparently an astrorhiza. The astrorhizal canals are apparently shallower than the thickness of the thin-section, as some skeletal material does cross between both sides of the canals. It is less likely that skeletal material later filled what were once larger, open astrorhizal canals.

Discussion. — All measurements compare very well with those of the holotype (NYSM 6812).

No other species of *Densastroma* is like *D. tenuissimum. D. astroites* (Rosen) (Rosen, 1867, p. 62, pl. 2, figs. 6-7), and *D. podolicum* (Yavorsky) (Yavorsky, 1929, pp. 80, 101, pl. 5, figs. 3-6) have comparable numbers of laminae per mm, but have fewer pillars per mm. Both also contain obvious astrorhizae.

Stratigraphic and geographic distribution. — Eleven specimens were collected, five from the Glasco Member at Localities 7 and 9, and six specimens from the Cobleskill Member at Localities 11, 13, 14, and 18. The figured hypotype specimen (USNM 248114) is from the Cobleskill Member at Locality 14. The figured holotype (NYSM 6812) is from the Cobleskill Member in Schoharie County.

Densastroma pexisum (Yavorsky, 1929) Pl. 56, figs. 1-6

Actinostroma pexisum Yavorsky, 1929, pp. 82, 102, pl. 6, figs. 1-2.
Actinostroma cf. *pexisum* Yavorsky, Riabinin, 1953, p. 13, pl. 1, figs. 1-2.
Densastroma pexisum (Yavorsky), Nestor, 1966, p. 37, pl. 13, fig. 1; pl. 14, figs. 1-2; Mori, 1968, p. 72, pl. 11, figs. 1-7; pl. 12, figs. 1-2; pl. 13, figs. 1-2.

Diagnosis. — Coenosteum a very fine microreticulate mass lacking gallery spaces, except in some thin laminar zones. Microlaminae and micropillars both irregular. Microlaminae 25 to 39 per mm; micropillars 24 to 34 per mm. Faint astrorhizae developed in tangential section.

Description. — Coenostea are subspherical, laminar, irregular, or encrusting. All laminar forms are from the Glasco Member. The largest subspherical specimen is a fragment 70 mm × 62 mm × 116 mm high. The largest laminar specimen, also a fragment, is 20 mm thick with a maximum width of 60 mm. Another laminar fragment attained a thickness of 24 mm. About 25 percent of the coenostea collected were encrusting. About 33 percent of those encrusted solitary rugose corals, and the rest encrusted stromatoporoids, mostly species of *Parallelostroma*. About 20 percent of all the specimens are irregular, the highest number for any Rondout Formation species.

The entire coenosteum is a microreticulate mass of irregular microlaminae and micropillars. In some specimens zones of small galleries are developed that may correspond to the astrorhizae that are developed along laminar planes. The microlaminae and micropillars are approximately 0.01 mm thick. The spacing of microlaminae and micropillars varies between specimens (Table 7).

Table 7. — Comparison of Skeletal Counts from Three Specimens of *Densastroma pexisum*. Both parameters measured in vertical section.

	microlaminae per mm	micropillars per mm
USNM 248116 (Glasco Mbr.)	26-32	25-28
USNM 248117 (Cobleskill Mbr.)	30-34	—
USNM 248118 (Cobleskill Mbr.)	31-39	26-34

In tangential sections there is some hint of micropillars connected by the radial processes which form the microlaminae, but the thinness and irregularity of the skeletal parts makes description difficult. One might as easily get the impression of a melanospheric mass.

Astrorhizae are never present in vertical section and are not always present in tangential section, but when present are represented by faint, narrow dichotomously branching astrorhizal canals. The canals are faint because they are extremely narrow and do not take up the entire thickness of a thin-sction, as is also the case in *D. tenuissimum* (Parks, 1909). Canal width in two specimens is 0.014 mm in USNM 248118 from the Cobleskill Member at Locality 18, and 0.019 mm in USNM 248115 from the Glasco Member at Locality 3.

Coenostea are clearly latilaminate, represented in thin-sections at low magnification by laminar zones composed of skeletal material of variable density (Pl. 56, figs. 1, 5). Unfortunately, the margins of the latilaminae are often gradational, making precise measurements difficult to impossible. With this problem considered, latilaminae average about 1.60 mm thick.

Discussion. — Specimens collected from the Rondout Formation compare best with *D. pexisum*. The skeletal counts in the holotype (Yavorsky, 1929, p. 82) are slightly coarser with 20 to 25 micropillars per mm and up to 30 microlaminae per mm. Specimens collected by Mori (1968, p. 72) had 20 to 29 micropillars per mm and 28 to 42 microlaminae per mm.

Flügel (1959, p. 121) questioned Yavorsky's (1929, pp. 82, 102) naming of *D. pexisum* as a separate species, because it might have been a poorly preserved example of *Densastroma astroites* (Rosen) (Rosen, 1867, p. 62, pl. 2, figs. 6-7). Yavorsky (1963, p. 11) reaffirmed his original identification, refuting Flügel's remarks.

In many of the Rondout Formation specimens the vertical sections consist of a melanospheric mass cut by vertical slits. The slits are apparently the product of the alignment of micropillars enclosing a light zone of vertically superposed cellules or "microgalleries." They may also be related to the astrorhizae. This feature was used by Bogoyavlenskaya (1972a, p. 168 [transl.] to distinguish *Pichiostroma* Bogoyavlenskaya. In part her generic description reads,

> . . . vertical elements closely fused together and boundaries between them are practically absent. Vertically, coenosteum permeated by slitlike cavities of indeterminate outlines.

Plates of the type species *Pichiostroma pichiense* Bogoyavlenskaya (Bogoyavlenskaya, 1972a, p. 168 [transl.], pl. 15, figs. 1a-b) look much like Rondout Formation specimens of *D. pexisum*. Unfortunately, Bogoyavlenskaya gave no measurements of microlaminae and micropillars, and the quality of published figures are such that the number of microlaminae and micropillars cannot be determined. *Pichiostroma* is here considered a variation of *Densastroma*, and therefore invalid.

D. pexisum also occurs in rocks of Wenlock age (Nestor, 1966, p. 71; Mori, 1968, p. 72). Other species of *Densastroma* have long ranges. *D. astroites* is known from rocks of Llandovery through Ludlow age. *Densastroma pichiense* came from Ludlow age rocks of Tuva, U.S.S.R., and further study of that species may indicate synonymy with *D. pexisum*. The specimens which Birkhead (1976, p. 110, pl. 6, figs. 1-2) attributed to *D. pexisum* contain 20 microlaminae per mm, too few for inclusion in the species.

The presence of small galleries in laminar zones calls attention to the evolutionary position of *Densastroma*. Perhaps species like

Parallelostroma rondoutense, n. sp., are newly separated from *Densastroma,* since they may have zones lacking galleries. Species like *Parallelostroma typicum* (Rosen, 1867) may represent further development of astrorhizae, resulting in greater gallery development. Conversely, it could be argued that *D. pexisum* and *P. rondoutense* are really the same species, and astrorhizae and gallery development are affected by the same mechanism which caused variations in gallery development in specimen USNM 248112 of *P. rondoutense.* However, the second argument is not supported by measurements of the microstructure of specimens of *P. rondoutense* (USNM 248110, 248111) of an average of 12.6 microlaminae per mm and 15.9 micropillars per mm, much lower than similar measurements from specimens of *D. pexisum* of 30.8 microlaminae per mm and 27.4 micropillars per mm. The poor preservation of USNM 248112 made accurate counts impossible. Evolutionary changes provide a more satisfactory explanation, but possible effects of variation in environmental parameters should not be ignored.

Stratigraphic and geographic distribution. — *Densastroma pexisum* is the second most abundant species collected from the Rondout Formation. Seventy-three specimens were collected, representing 24 percent of the total number of stromatoporoids. Twenty-nine specimens were collected from the Glasco Member at Localities 1, 3, 5, and 9, and forty-four specimens from the Cobleskill Member at Localities 15, 16, 18 and 20-23. *D. pexisum* (Yavorsky) and *D. tenuissimum* (Parks) occur together only at Localities 9 and 18. The figured hypotype specimens are USNM 248115 from the Glasco Member at Locality 3, and USNM 248117 from the Cobleskill Member at Locality 18.

CONCLUSIONS

Identification of stromatoporoids from the Rondout Formation of New York has yielded a more diverse fauna than previously was known. In addition to the three species previously noted from the Rondout Formation, eight more species are now known, three of them new. The stromatoporoid assemblage described in this paper is more typically Silurian in nature than Devonian, as none of the species are known with any certainty from Devonian rocks. However, two species show relationships to Devonian forms: *Stroma-*

topora eoconcentrica, n. sp. is similar to *S. concentrica* from the Middle Devonian, and *Parallelostroma rondoutense,* n. sp. resembles species of *Syringostroma* from the Devonian. There are no species in common with either the overlying Manlius Formation (Laporte, 1967) or the next highest Coeymans Formation (Girty, 1895). With the exception of other strata of similar age in the Appalachian Basin, the Rondout Formation stromatoporoid assemblage is more like Upper Silurian assemblages from Europe than those thus far described from North America.

The lithofacies of the Rondout Formation give some idea of the paleogeography of New York during the latest Silurian. The presence of dolomite is accepted as an indicator of intertidal or supratidal conditions, except where it was transported as a coastal silty dolomite facies. Limestone generally indicates deeper water or greater distance from shore. Silicified stromatoporoids record an early stage of diagenesis that took place in supratidal or very shallow conditions. Subspherical stromatoporoids lived in shallower, more turbulent conditions than did laminar forms. Biostromes resulted from carbonate bank development in the surf zone. The combined evidence reveals that the deepest conditions existed at or near Kingston, with decreasing depth to the north and west across New York. Comparatively deep conditions existed during deposition of the limestones in the Wilbur and Cobleskill Members, followed by shallowing and the dolomite deposition of the Rosendale and Chrysler Members. Sea level rose, but not so high as before, and the Glasco Member limestone and the shallower water Whiteport Member dolomite were deposited while deposition of dolomite in the Chrysler Member continued in central and western New York.

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PLATES

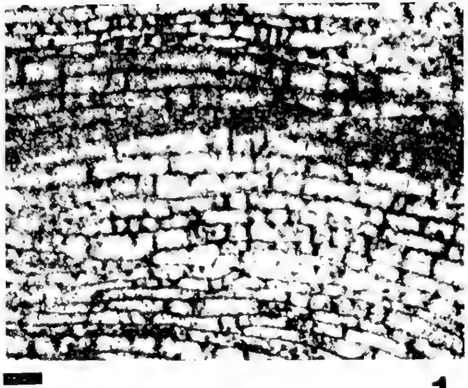
EXPLANATION OF PLATE 49

(All scales 0.5 mm)

Figure — Page

1-3. **Stictostroma pseudoconvictum** n. sp. 332
Holotype: 1. vertical section showing continuous laminae and short, rod-like pillars between adjacent laminae, USNM 248089-3, ×10; 2. tangential section showing discrete, round pillars, USNM 248089-3, ×10; 3. vertical section showing compact skeletal material and pillars; note the clear median zone in the upper lamina, USNM 248089-3, ×50 (figs. 1-3, Cobleskill Member, Locality 13).

4-6. **Plectostroma micum** (Bogoyavlenskaya, 1969a) 335
Hypotype: 4. vertical section showing long pillars and irregular radial processes, USNM 248092-3, ×10; 5. tangential section showing round pillars and processes, USNM 248092-1, ×10; 6. vertical section showing greater detail, USNM 248092-3, ×50 (Figs. 4-6, Glasco Member, Locality 9).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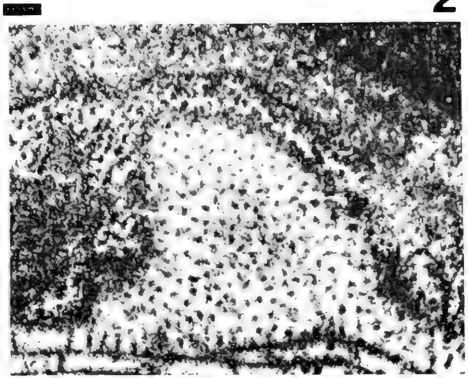
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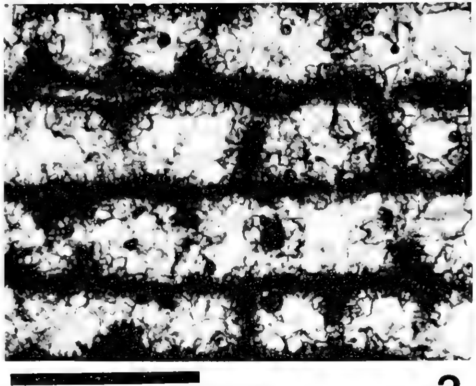
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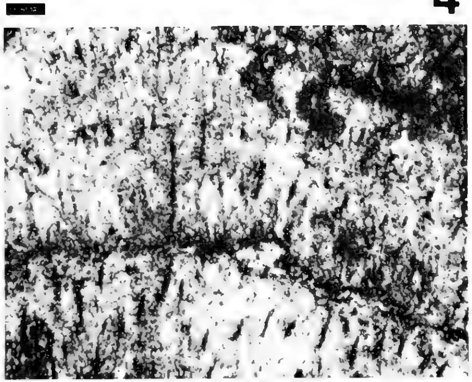
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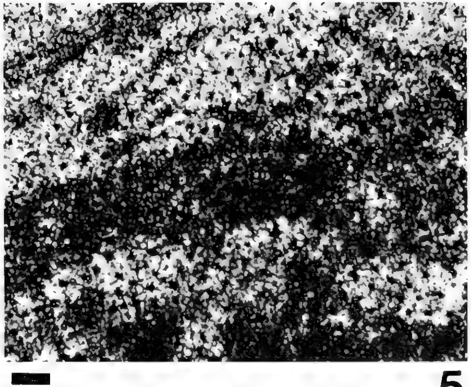
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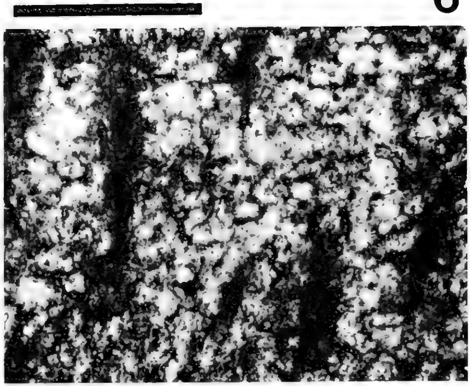
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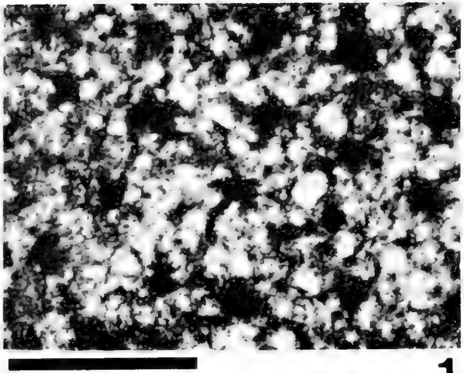

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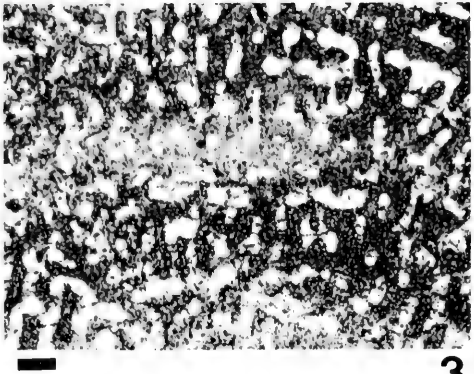

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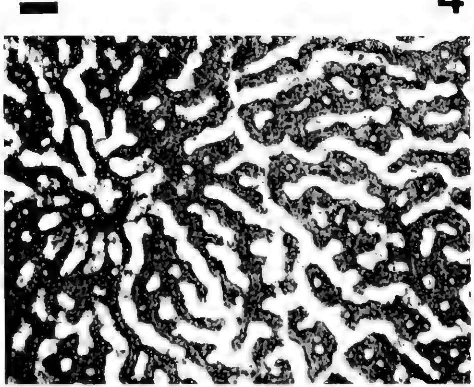

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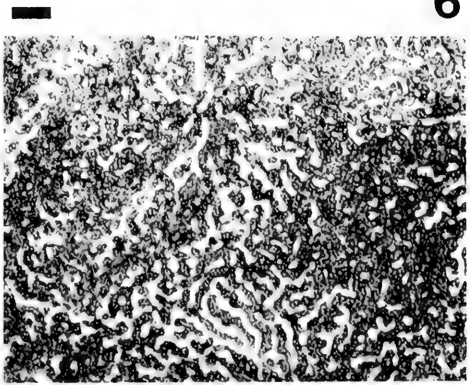


6

Explanation of Plate 50

(All scales 0.5 mm)

Figure — Page

1. **Plectostroma micum** (Bogoyavlenskaya, 1969a) 335
   Hypotype: 1. tangential section showing greater detail, USNM 248092-1, ×50 (Fig. 1, Glasco Member, Locality 9).

2-4. **Stromatopora clarkei** Parks, 1909 337
   Holotype: 2. vertical section, NYSM 6820, ×10 (Fig. 2, Cobleskill Member, Schoharie County).
   Hypotype: 3. vertical section showing thick, widely-spaced irregular macrostructure, USNM 248096-3, ×10; 4. tangential section showing thick, widely-spaced vermicular pillars and an astrorhiza, USNM 248096-2, ×10 (Figs. 3-4, Cobleskill Member, Locality 13).

5-6. **Stromatopora bekkeri** Nestor, 1966 339
   Hypotype: 5. vertical section showing irregular macrostructure, USNM 248097-1, ×10; 6. tangential section showing vermicular pillars and dichotomously branching astrorhizae, USNM 248097-2, ×10 (Figs. 5-6, Glasco Member, Locality 9).

EXPLANATION OF PLATE 51

(All scales 0.5 mm)

Figure Page

1. **Stromatopora bekkeri** Nestor, 1966 339

Hypotype: 1. tangential section showing microreticulate skeletal material, pseudozooidal tubes, astrorhizal canals, and a few cyst-plates, USNM 248097-2, ×50 (Fig. 1, Glasco Member, Locality 9).

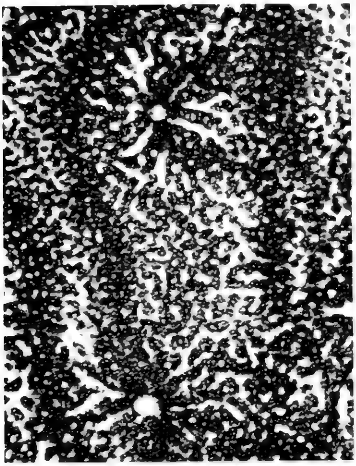
2-3. **Stromatopora eoconcentrica** n. sp. 341

Holotype: 2. vertical section showing irregular laminae, pillars and pseudozooidal tubes, USNM 248098-1; ×10; 3. tangential section showing an astrorhiza, USNM 248098-2, ×10 (Figs. 2-3, Cobleskill Member, Locality 13).

4-6. **Parallelostroma constellatum** (Hall, 1852) 343

Lectotype: 4. vertical section, NYSM 6821, slide 851, ×10; 5. tangential section, NYSM 6821, slide 851, ×10 (Figs. 4-5, Cobleskill Member, Schoharie County).

Hypotype: 6. vertical section showing continuous laminae, and a few pillars transcending as many as seven laminae; dark specks are due to inclusion of replacement minerals within the coenosteum, USNM 248102-1, ×10 (Fig. 6, Glasco Member, Locality 3).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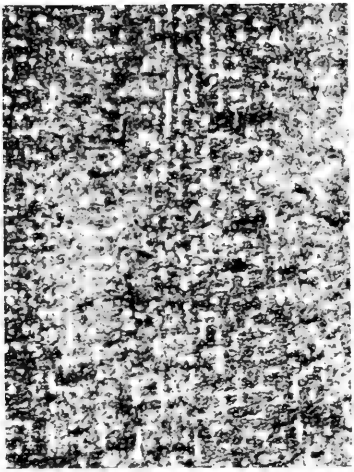
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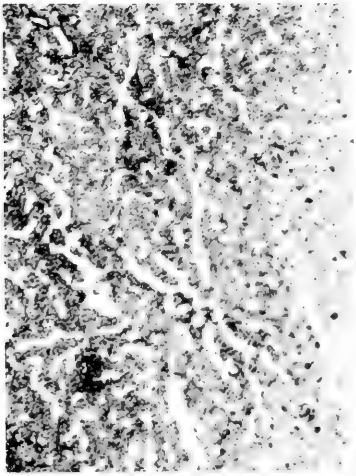
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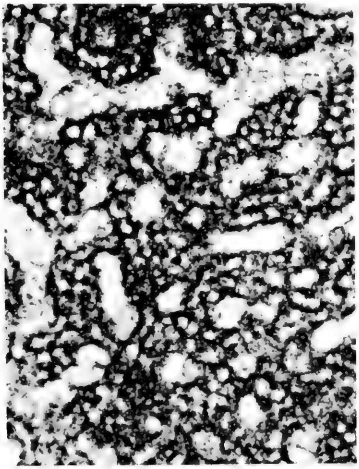
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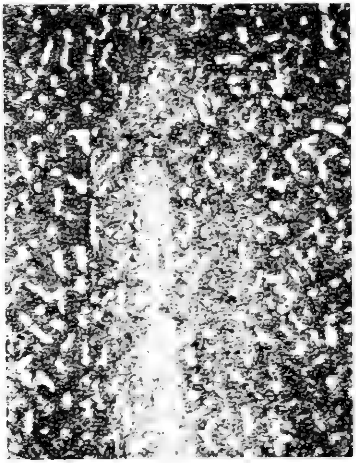
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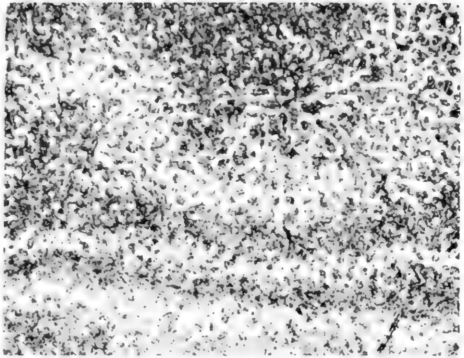
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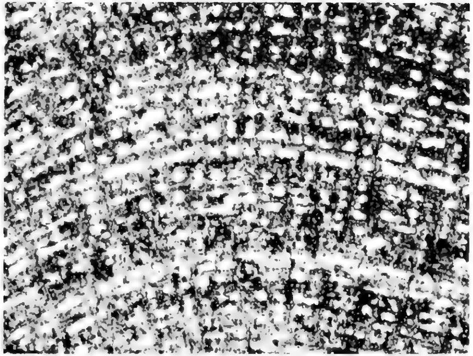
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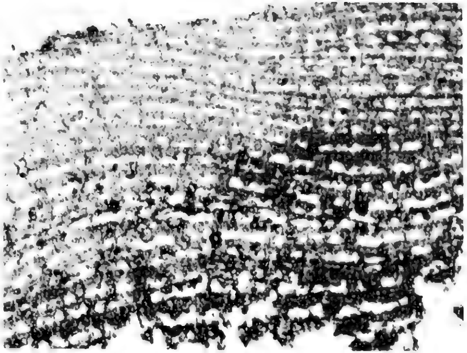
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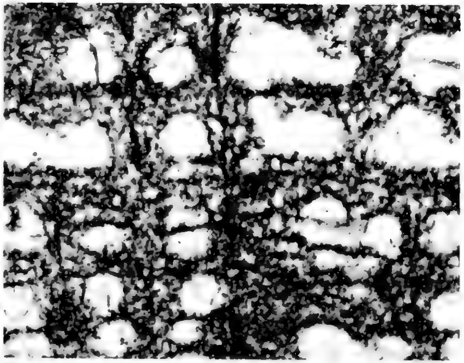
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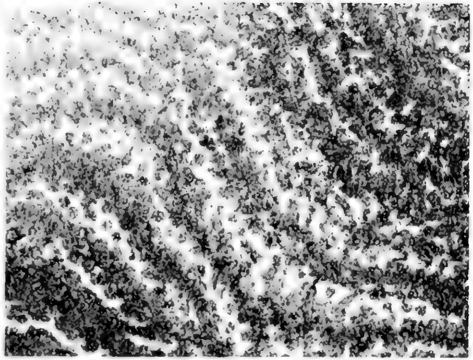
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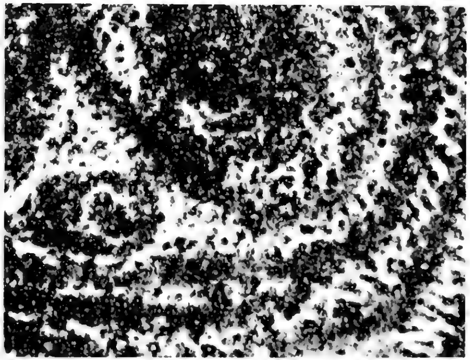

EXPLANATION OF PLATE 52

(All scales 0.5 mm)

Figure | Page

1-4. **Parallelostroma constellatum** (Hall, 1852) 343
Hypotypes: 1. tangential section showing irregularly round pillars and laminar sheets perforated by pores, USNM 248102-2, ×10 (Fig. 1, Glasco Member, Locality 3); 2. vertical section showing microreticulate microstructure; note abundant cyst-plates, USNM 248104-1, ×50; 3. vertical section showing pillars superposed through as many as twelve laminae, USNM 248104-1, ×10; 4. tangential section showing irregularly round pillars and undulating sheet-like laminae, USNM 248104-2, ×10 (Figs. 2-4, Cobleskill Member, Locality 15).

5-6. **Parallelostroma kaugatomicum** (Riabinin, 1951) 351
Hypotype: 5. vertical section showing continuous laminae and non-superposed pillars, USNM 248108-1, ×10; 6. tangential section showing irregularly round pillars and sheet-like laminae containing pores, USNM 248108-2, ×10 (Figs. 5-6, Cobleskill Member, Locality 13).

EXPLANATION OF PLATE 53

(All scales 0.5 mm)

Figure | Page

1-3. **Parallelostroma kaugatomicum** (Riabinin, 1951) 351
Hypotype: 1. vertical section showing continuous laminae and astrorhizae developed on laminar planes and superposed into an astrorhizal column, USNM 248109-1, ×10; 2. tangential section showing irregularly round pillars and sheet-like laminae with pores, USNM 248109-2, ×10; 3. vertical section showing microreticulate microstructure, USNM 248109-1, ×50 (Figs. 1-3, Glasco Member, Locality 4).

4-6. **Parallelostroma typicum** (Rosen, 1867) 348
Hypotype: 4. vertical section showing amalgamated irregular pillars and laminae developed between continuous microlaminae, USNM 248107-1, ×50; 5. vertical section showing continuous, regular microlaminae, USNM 248107-1, ×10; 6. tangential section showing vermicular pillars and an astrorhiza, USNM 248107-3, ×10 (Figs. 4-6, Cobleskill Member, Locality 13).


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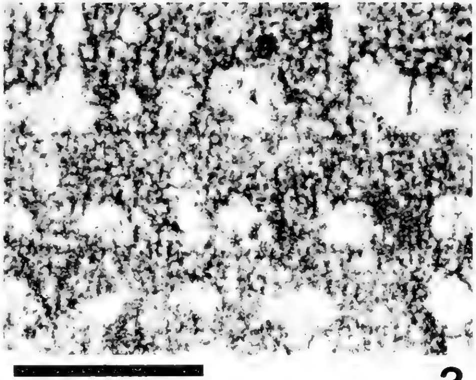
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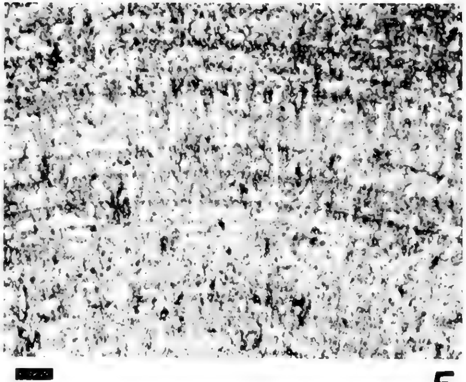
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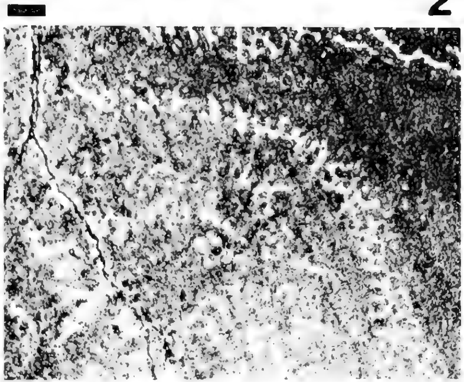
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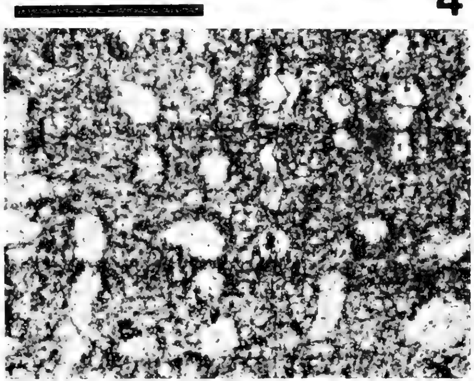
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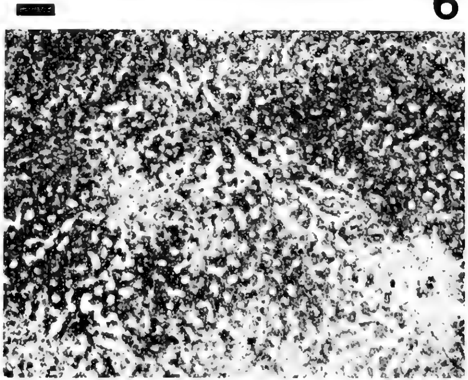
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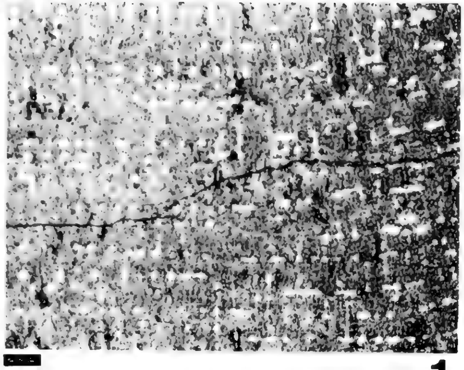
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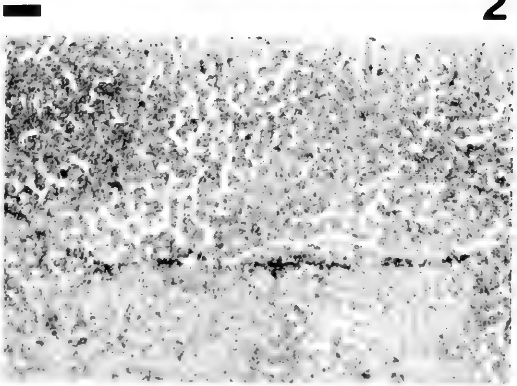
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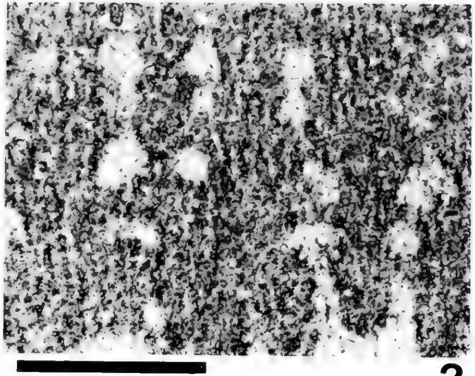
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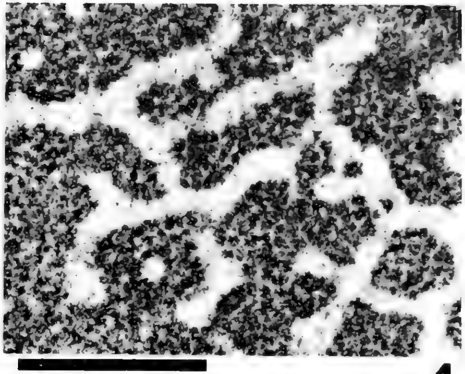
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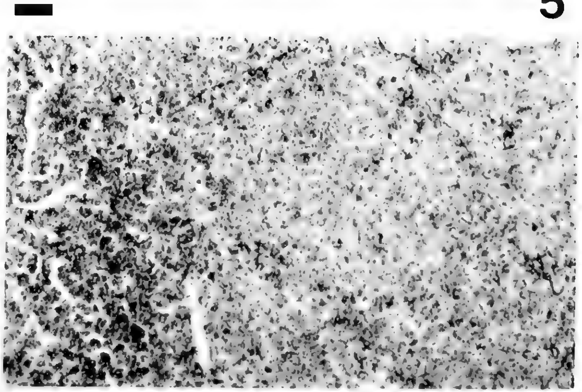
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EXPLANATION OF PLATE 54

(All scales 0.5 mm)

Figure		Page
1-5.	**Parallelostroma rondoutense** n. sp.	355

Holotype: 1. vertical section showing thick continuous laminae and superposed pillars, USNM 248110-1, ×10; 2. tangential section showing thick round and vermicular pillars, USNM 248110-2, ×10; 3. vertical section showing microreticulate microstructure, USNM 248110-1, ×50; 4. tangential section showing microreticulate microstructure and "radial-processes" between pillars, USNM 248110-2, ×50 (Figs. 1-4, Glasco Member, Locality 3).

Hypotype: 5. tangential section showing irregularly round pillars and astrorhizal canals on the left, grading into a laminar sheet containing finer astrorhizae, USNM 248112-2, ×10 (Fig. 5, Cobleskill Member, Locality 18).

EXPLANATION OF PLATE 55

(All scales 0.5 mm)

Figure | Page

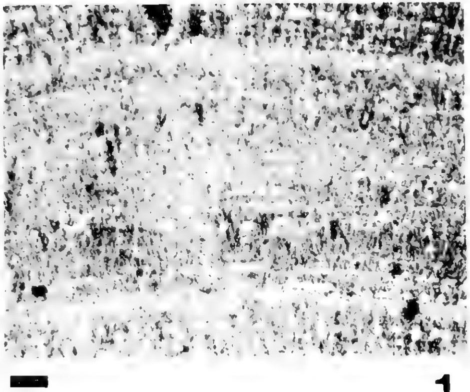
1. **Parallelostroma rondoutense** n. sp. 355

Hypotype: 1. vertical section showing varying development of galleries in laminar zones, USNM 248112-1, ×10 (Fig. 1, Cobleskill Member, Locality 18).

2-6. **Densastroma tenuissimum** (Parks, 1909) 360

Holotype: 2. vertical section, NYSM 6812, ×10 (Fig. 2, Cobleskill Member, Schoharie County).

Hypotype: 3. vertical section showing mass of microreticulate skeletal material, USNM 248114-1, ×10; 4. tangential section showing mass of microreticulate skeletal material; dark star-like pattern in lower right is not an astrorhiza, USNM 248114-2, ×10; 5. vertical section showing microlaminae, non-aligned radial processes and micropillars, USNM 248114-1, ×50; 6. tangential section showing micropillars and radial processes, USNM 248114-2, ×50 (Figs. 3-6, Cobleskill Member, Locality 14).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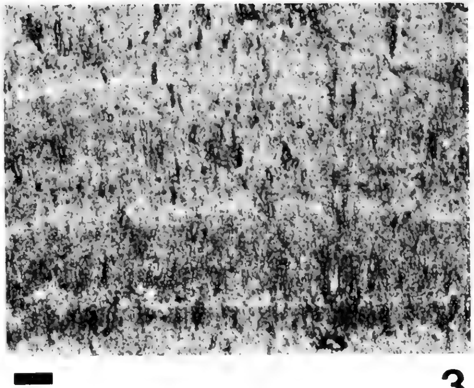
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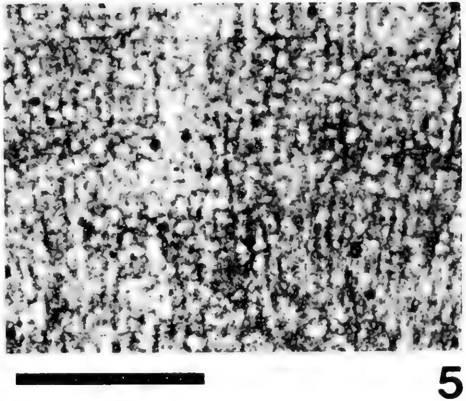
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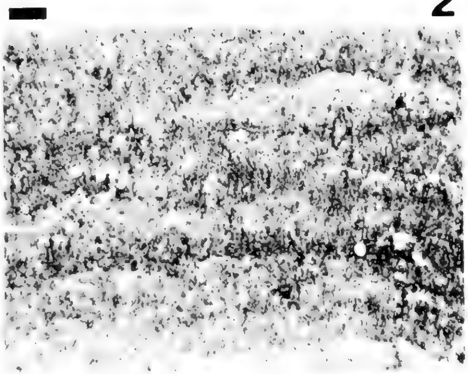
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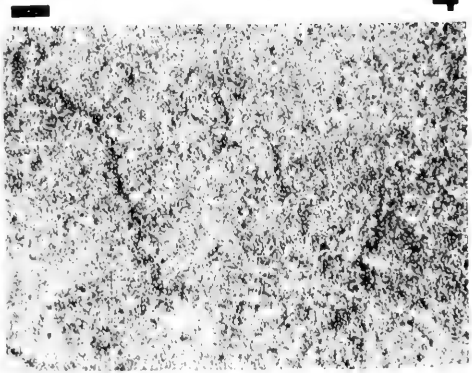
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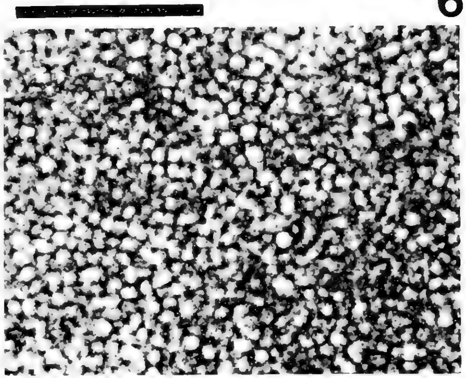
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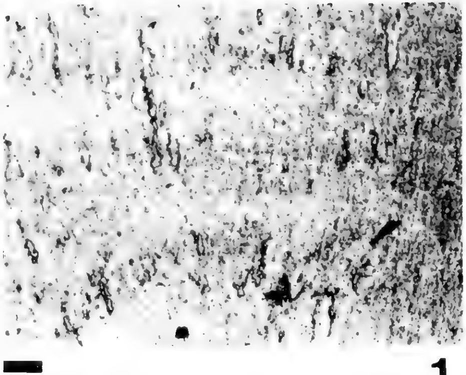
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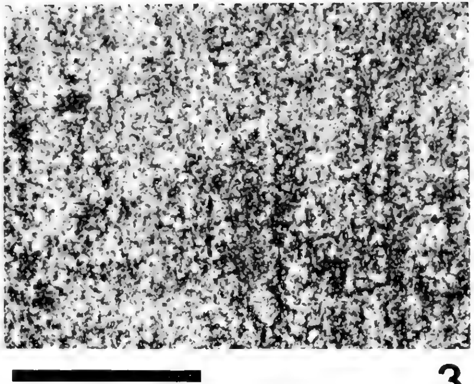
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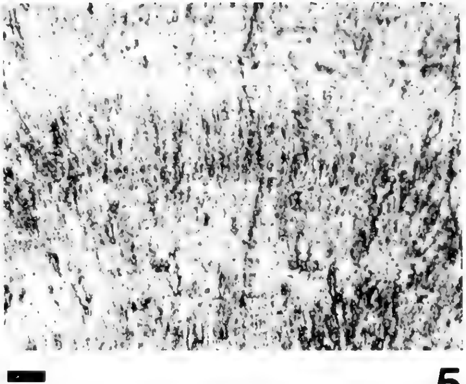
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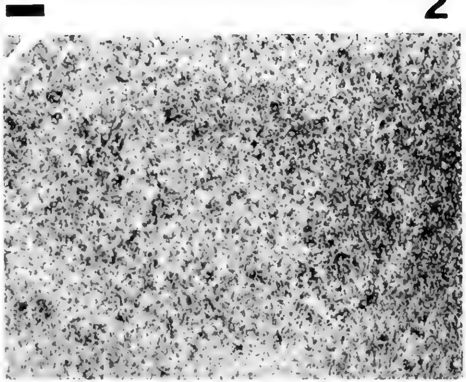
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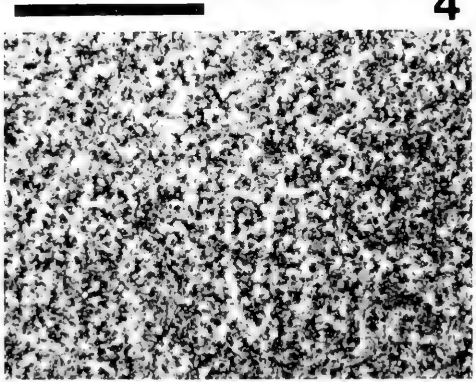
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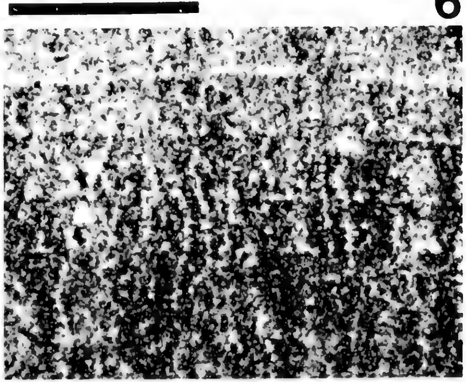
6

EXPLANATION OF PLATE 56

(All scales 0.5 mm)

Figure Page

1-6. **Densastroma pexisum** (Yavorsky, 1929) 361
Hypotypes: 1. vertical section showing mass of microreticulate skeletal material, USNM 248115-1, ×10; 2. tangential section showing mass of microreticulate skeletal material; light ring is coincident with a laminar zone of development of faint astrorhizae, USNM 248115-2, ×10; 3. vertical section showing irregular microlaminae and micropillars, USNM 248115-1, ×50; 4. tangential section showing micropillars and radial processes, USNM 248115-2, ×50 (Figs. 1-4, Glasco Member, Locality 3); 5. vertical section showing laminar zones of small galleries, USNM 248117-1, ×10; 6. vertical section showing small galleries and vertical "slits," USNM 248117-1, ×50 (Figs. 5-6, Cobleskill Member, Locality 18).

INDEX

NUMBER 308

Note: Page numbers in light face; plate numbers in **bold face** type.

INDEX

INDEX

INDEX

PREPARATION OF MANUSCRIPTS

Bulletins of American Paleontology currently comprises from four to six separate monographs in two volumes each year. The *Bulletins* are a publication outlet for significant longer paleontological, paleoecological and biostratigraphic monographs for which high quality photographic illustrations are a requisite.

Manuscripts submitted for publication in *Bulletins of American Paleontology* must be typewritten, and double-spaced *throughout* (including direct quotations and references). All manuscripts should contain a table of contents, lists of text-figures and/or tables, and a short, informative abstract that includes names of all new taxa. Format should follow that of recent numbers in the series. All measurements must be stated in the metric system, alone or in addition to the English system equivalent. The maximum dimensions for photographic plates are 114 x 178 mm (4½" x 7": plate area is outlined on this page). Single-page text-figures are limited to 108 x 178 mm (4¼" x 7"), but arrangements can be made to publish text-figures that must be larger. Any lettering in illustrations should follow the recommendations of Collinson (1962).

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All dated text-citations must be referenced, except those that appear only within long-form synonymies. Additional references may be listed separately if their importance can be demonstrated by a short general comment, or individual annotations. Citations of illustrations within the monograph bear initial capitals (e.g., Plate, Text-figure), but citations of illustrations in other articles appear in lower-case letters (e.g., plate, text-figure).

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Authors are requested to enclose $10 with each manuscript submitted, to cover costs of postage during the review process.

Collinson, J.
1962. *Size of lettering for text-figures.* Jour. Paleont., v. 36, p. 1402.


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