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ABSTRACT

The Hermitage Formation of East-Central Tennessee is stratigraphically situated between the Carters Limestone below and the Cannon Limestone above. It contains a diverse and abundant fauna dominated by trepostome bryozoans. Four continuous stratigraphic sections have been examined—two within the Sequatchie Valley of the Appalachian Plateau (Howard Cemetery and Wilson Branch) and two within the Valley and Ridge Province (Norris Lake IV and Chamberlain Branch). The Hermitage varies between 45 and 130 feet (13.7 and 39.6 m) (thickens to the east), and is composed of clean to argillaceous wackestones and packstones deposited in an open marine platform carbonate setting. The present study systematically describes the trepostome bryozoan fauna and takes note of their changing relative abundances and biostratigraphy within each section. This is the first study of this type south of the plateau deposits in Kentucky for Middle Ordovician sediments younger than Blackriveran in age. The lower boundary of the Hermitage Formation is close to the underlying T-3 Bentonite providing an ideal starting point for such a biostratigraphic/taxonomic study since this bentonite is an isochronous surface upon which lateral and temporal distributions of these bryozoans can be based.

Within the Hermitage Formation, 36 species-group taxa have been recognized. These include 17 genera and 33 species which include five varieties. A new genus, *Acantholaminatus,* consists of new species *A. typicus* and *A. multistylus.* Other new species include *Parvohallopora granda, Anaphragma hermitagensis, Peronopora weirae, Heterotrypa magnopora, H. subtrentonensis, H. exovaria, H. rugosa, Stigmatella distinctaspinosa,* and *Homotrypa tabulata.* New varieties include *Batostomella subgracilis* var. *robusta,* and *Parvohallopora granda* var. *inflata.* Species previously described and found within the present study area include *Bythopora dendrina, Batostomella subgracilis, Prasopora falesi, Eridotrypa mutabilis, Mesotrypa angularis, Parvohallopora pulchella, Homotrypa minnesotensis, H. flabellaris* var. *spinifera, H. subramosa, H. callosa, H. similis, H. tuberculata, ?Heterotrypa subramosa, Heterotrypa praenuntia* var. *simplex, H. praenuntia* var. *echinata, Cyphotrypa acervulosa, Peronopora mundula, Tarphophragma ampla, T. multitabulata,* and *Hemiphragma ottawaensis.* Three species were not assigned a trivial name and are identified herein as *Monticulipora* sp. A, *Homotrypa* sp. A, and *Mesotrypa* sp. A.

The new varieties assigned to various species (*Parvohallopora granda* var. *inflata* and *Batostomella subgracilis* var. *robusta*) are of particular interest from a taxonomic standpoint since they differ from the non-varietal forms primarily in the development of the exozone (e.g., length of the exozone and wall thickness) and pose questions as to the possible effect of environment on the trepostome phenotype. Criteria used to delimit boundaries between some co-occurring species in the present study area (e.g. *Tarphophragma ampla* → *Tarphophragma multitabulata*; *Bythopora dendrina* → *Batostomella subgracilis*; *Parvohallopora pulchella* → *Parvohallopora granda*) are rather subtle since the range in morphologies found within these species-couplets is often expressed as a largely continuous gradient in zoarial form between taxa.

Groups of numerically dominant trepostome species were observed to occur in time and space and have been referred to herein as Bryozoan Assemblages (One, Two, and Three). Assemblages are generally correlated with subtle changes in lithotype (= lithofacies) ranging from muddy and argillaceous wackestones to clean packstones.

When compared with other Middle Ordovician bryozoan faunas, taxa from the Hermitage appear to be most similar in species composition to part of Karklins' (1984) *Tarphophragma multitabulata* Assemblage Zone of Kirkfieldian to lower Shermanian age.

Three loosely defined local biostratigraphic zones (five zones within the eastern sections) are present within the Hermitage of the study area and have boundaries which are possibly influenced by variations of local lithofacies.

INTRODUCTION

John Rodgers (1953, p. 64) stated that "probably more controversy has raged over the stratigraphy of the Chickamauga limestone and equivalent rocks in the southern Appalachians than over that of any other major unit here discussed except the Ocowee Series, and this despite the generally good outcrops, the ready accessibility of the outcrop area, the well characterized and differentiated lithologic units, the several usable key beds, and the abundant fossils. The controversy has concerned both subdivisions and correlation." Over thirty years later, much of what he said is still true. Time-equivalence of strata when attempted is based mainly on presumed lateral lithofacies relationships with a minimum of biostratigraphic control (Walker *et al.,* 1983; Ruppel and Walker, 1977; Walker, 1974; Walker and Alberstadt, 1976; Wilson, 1949). The problem of correlation is further complicated by the fact that exposures occur along strike belts that are sometimes widely separated because of folding and thrusting. It is apparent that in order to reconstruct geologic and evolutionary events that took place in the southern Appalachians during the early Paleozoic, a detailed, workable biostratigraphic zonation is needed.

The research presented herein is principally a biostratigraphic study carried out within the Hermitage Formation as exposed in the Valley and Ridge Province and Appalachian Plateau of East-Central Tennessee. Efforts have been specifically directed toward the systematic paleontology of the trepostomatous bryozoans. Bryozoans have biostratigraphic potential and are numerically dominant, geographically widespread, and taxonomically diverse, but are virtually ignored within strata of the Southern Appalachian Basin. Indeed, Walker and Ferrigno (1973, p. 301) in a study of Middle Ordovician reefs in East Tennessee stated their opinion "that the abundance, wide occurrence, and rapid evolution of the ectoprocts of the Middle Ordovician require their careful testing as biostratigraphic indicators." The bryozoans, then, would seem to be a potential tool in the understanding of facies changes and other lateral relationships at this place and time. An initial advantage in carrying out this particular study has been the presence of a distinctive lithologic unit traceable throughout the study area, namely, the T-3 Bentonite which occurs at the base of the Upper Carters Limestone (see Kolata *et al.*, 1987, and Samson *et al.*, 1987, for chemical correlations of the T-3 Bentonite with K-bentonites of the Upper Mississippi Valley). Since bentonites are generally believed to be deposited isochronously, the study of fossiliferous strata above the T-3 horizon allows us to gain an increased perspective of the spatial and temporal variations of a faunal group within approximately time-equivalent strata.

At the time that McKinney (1971a) completed his work on the Middle Ordovician trepostomatous Bryozoa from Alabama, he remarked that only one study of Middle Ordovician bryozoans south of Kentucky had been published (although he notes a number of "incidental reports" found in several stratigraphic works), that of Coryell (1921) on the ectoprocts of the Stones River Group of Central Tennessee. (Presently, the Stones River Group is thought to encompass that part of the Chickamauga limestone up to and including the Carters Limestone.) McKinney limited his work to the lower Chickamauga Group up to the T-3 Bentonite in northeast Alabama. Within Central Tennessee, the only contributions to the paleontology of the Hermitage Formation are those of Bassler (1932) and Wilson (1949) who merely list species of Bryozoa from the Central Basin. Techniques accessible and knowledge available at the time of their publications concerning the bryozoans were rather poor (compare, for example, the 1953 Treatise volume with the latest (1983) edition published by Boardman *et al.*); furthermore, many species in the past were defined typologically, largely ignoring the effects of genetic and ecophenotypic variability among population members.

The present report, then, is the first major paleontological study of bryozoans from Ordovician strata above the T-3 Bentonite within the Appalachians south of Kentucky. Only a few other studies provide detailed information on the presence and distribution of Ordovician trepostome species from areas in relatively close geographic proximity to the Hermitage of Tennessee. McKinney (1971a,b) studied the trepostomes (24 species) within environmentally undifferentiated biomicrudites, micrites, and calcareous shales from the Lower Chickamauga Group of northeastern Alabama. The upper stratigraphic limit of his study is marked by the T-3 Bentonite. His lowermost strata are equivalent to beds not older than the Ridley Formation. Within the present study area the T-3 Bentonite is separated from the Hermitage by the Upper Carters Formation, approximately 35 feet (10.7 m) of fossil-poor strata. Karklins' (1984) detailed work describing 22 species of trepostomes from predominantly platform carbonates of the Middle Ordovician Lexington Limestone and Upper Ordovician Clays Ferry Formation in northern Kentucky and Brown's (1965) work in the lower Lexington Limestone of central Kentucky are, in part, laterally equivalent to the Hermitage (environments of the various Lexington Limestone Members are described in Cressman, 1973). Singh (1979) identified 16 trepostome species mainly within "organoclastic" limestones of the Upper Ordovician Bellevue Limestone of Kentucky, Indiana, and Ohio which is separated from the Clays Ferry by the Fairview Formation.

Though the integration of bryozoan species distributions from varied published geographic and stratigraphic works is beyond the scope of the present report, the trepostome systematics and distributional data presented herein should permit a better understanding of trepostome bryozoan evolution as well as the larger-scale biostratigraphic and paleogeographic relationships within and among various southern Appalachian Middle Ordovician environments. Any attempt to unravel such phylogenetic and paleoecological distributions must begin with a detailed and thorough examination of the component fauna. The study and included data base presented herein, then, is a first step and major building block in the understanding of these relationships within a heretofore largely unstudied, yet fossil-rich, geographic area.

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MATERIALS AND STUDY TECHNIQUES

COLLECTING LOCALITIES

1. NORRIS LAKE IV SECTION. 36° 14′ 51″ N, 83° 58′ 10″ W, Big Ridge Park Quadrangle, Union County, Tennessee.

This section is found on the northeast side of the fourth peninsula east of the Andersonville dock. Carters, Hermitage and Cannon Formations present. Outcrop locality from R. C. Milici (pers. comm.).

2. CHAMBERLAIN BRANCH SECTION. 35° 49′ 13″ N, 84° 31′ 06″ W, Bacan Gap Quadrangle, Roane County, Tennessee.

This section outcrops on the southwest side of the Tennessee River, directly southwest of the southeastern end of Long Island. The Chamberlain Branch flows northeastward into a small embayment of the Tennessee River found south of the outcrop. Carters, Hermitage, and Cannon Formations present. Outcrop locality from R. C. Milici (pers. comm.).

3. HOWARD CEMETERY SECTION, 35° 29′ 08″ N, 85° 15′ 45″ W, Mount Airy Quadrangle, Bledsoe County, Tennessee.

This section is found in Sequatchie Valley, east of East Valley Road, approximately 700 feet (213.4 m) northeast of Howard Cemetery. Outcrop was measured northeast of the branch flowing into the Sequatchie River. Entire section is exposed up the hillside. See also description found in Milici (1970). Carters, Hermitage, Cannon, and Catheys Formations present.

4. WILSON BRANCH SECTION. 35° 46′ 23″ N, 85° 00′ 45″ W, Vandever Quadrangle, Cumberland County, Tennessee.

This section is found in Sequatchie Valley three miles northeast of the intersection of East Valley Road and the road to Lowe Gap (on Melvine Quadrangle). Outcrop is on the east side and at the very end of East Valley Road near the intersection of the road leading west to the Alvin C. York highway. (Wilson Branch was not found approximately 500 feet [152.4 m] south of the road leading to the Alvin C. York highway as indicated on the 1956 Vandever, Tennessee Quadrangle, but was found directly north of it). Hermitage and lower Cannon Formations are present. Outcrop locality from R. C. Milici (pers. comm.).

SAMPLE PREPARATION AND STUDY METHODS

At each locality, hand-sized samples were collected from each fossiliferous horizon. Where fossils were apparently absent or sparse, or where the unit was exceedingly fossiliferous, samples were collected at approximately 0.5 meter intervals. At each horizon, specimens of all the macroinvertebrate fauna were taken from different areas along individual bedding planes. At the same time, detailed field notes were taken of lithological variation, sedimentary structures, and bedding features.

Sections were measured beginning at the chert bed found directly beneath the T-3 (or T-4) Bentonite.

Samples were returned to the lab and cut into 2 cm thick slabs using a standard diamond blade. Slabs were then ground flat on a glass plate using 220, 600, and 800 silicon carbide grit in that order. Frequent crumbling of friable slabs during both the cutting and grinding procedure was dealt with by impregnating the sample with epoxy, Duco cement, or a clear acrylic lacquer and then placing a thick rubber band around the periphery. After the final grit, slabs were highly polished on an 8-inch diameter lap using 0.3 micron aluminum oxide powder on a Buehler felt polishing cloth. Each slab was then etched for 3 to 4 seconds in a solution of 1:60 formic acid. Acetate peel replicas were prepared using 0.005 or 1.5 mm thick cellulose acetate sheeting. The peels were examined for lithologic content, and the positions of nearly 5,500 trepostome bryozoan specimens were noted on drawings of each polished side. About 1,500 specimens spanning all possible species and from varying lithofacies were selected for further examination involving three-dimensional analysis. By matching peel to rock surface, these specimens were located on the actual hand samples and were cut out. Each zoarium was matched to the portion of its colony found on the non-polished side of the succeeding contiguous slab. This latter slab was sliced in half parallel to the other cuts so as to not destroy the polished face when cutting out the zooecial counterparts.

Both pieces of individual zoaria were examined under a binocular microscope and oriented in such a manner that the best longitudinal, tangential, and transverse sections could be prepared from either or both of the zoarial samples. Where necessary, specimens were embedded in epoxy cubes for ease of handling and/or the preservation of morphological features found at the colony surface. These specimens were cut using a Raytech Blue Blazer ultrathin blade and subsequently ground, polished, and etched as noted above for the large hand samples. Tangential sections were frequently attained by making a cut near the colony periphery and grinding down to the surface using a diamond studded lap. Oriented sections of each zoarium were then placed on individual slides of 1.5 mm thick acetate for further study.

Over 12,000 measurements were used in the quantitative characterizations of taxa. On average, 11 colonies per taxon, 6 characters per colony, and 5 replicates per character were measured.

Characters measured included cavity diameters of autozooecia and mesozooecia, autozooecial wall thickness, number of autozooecia per square millimeter, diameters of acanthostyle laminar sheath and lumen, and colony diameter. Where appropriate, measurements were made in the exozone and endozone as well as within macular and non-macular regions.

Repository of Specimens

Holotypes, paratypes, hypotypes and colony remnants are deposited in the U.S. National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C.

Stratigraphic Collection Levels and Specimen Identification Labels

Norris Lake IV Section

At the Norris Lake IV Section, the Carters/Hermitage contact appears 52 ft (15.8 m) above the top of the T-3 Chert. The lowermost exposed bed of the underlying Carters Formation occurs 35 ft (10.7 m) above the T-3 Chert. This Carters bed is the horizon above which the specimen data were collected. The T-4 Chert occurs 19 ft (5.8 m) above the T-3 Chert.

Typical label: NL IV 108(143)A-1-D(M) [USNM 432401]

NL IV = Norris Lake IV section.
108 = The number of feet above the base of the exposed Carters Formation from which the specimen was collected.
(143) = The corresponding number of feet above the top of the T-3 Chert.
A = Hand sample indicator (A = first hand sample from this horizon, B = second, etc.).
1 = Slab number from hand sample. Trepostome colony was noted from right side of slab unless otherwise indicated with an "L" (from left side). If slab was cut into two pieces, each was denoted (*e.g.*, as "a" or "b").
D = Trepostome colony indicator (A = first colony noted from slab, B = second colony, . . . AA = 27th colony, etc.).
(M) = Various measurements were made on this colony and they appear in the statistical tables.
(F) = Indicates material which was particularly fragmentary.
[USNM 432401] = the specimen catalog number at the United States National Museum

Chamberlain Branch Section

At the Chamberlain Branch Section, the base of the exposed Hermitage appears 45 ft (13.7 m) above the top of the T-3 Chert. This chert is the horizon above which the specimen data were collected. The T-4 Chert occurs 34 ft (10.4 m) above the T-3 Chert.

Typical label: CB 145B-4-A (F)

CB = Chamberlain Branch section.
145 = The number of feet above the top of the T-3 Chert from which the specimen was collected.
Other symbols are as for the Norris Lake IV Section above.

Wilson Branch Section

At the Wilson Branch Section, the base of the exposed Hermitage Formation appears 12 ft (3.7 m) above the top of the T-4 Chert. This base is the horizon above which the specimen was collected. The T-3 Chert is not visible but is estimated to occur at about 21 ft (6.4 m) below the level of the T-4.

Typical label: WB 44(56)A-5-D (M)

WB = Wilson Branch section.
44 = The number of feet above the base of the exposed Hermitage Formation from which the specimen was collected.
(56) = The corresponding number of feet above the top of the T-4 Chert.
Other symbols are as for the Norris Lake IV Section above.

Howard Cemetery Section

At the Howard Cemetery Section, the base of the exposed Hermitage Formation appears 39 ft (11.9 m) above the top of the T-3 Chert. This base is the horizon above which the specimen data were collected. The T-4 Chert occurs 30 ft (9.1 m) above the T-3 Chert.

Typical label: HCM 43(82)B-3-A (M)

HCM = Howard Cemetery section.
43 = The number of feet above the base of the exposed Hermitage Formation from which the specimen was collected.
(82) = The corresponding number of feet above the top of the T-3 Chert.
Other symbols are as for the Norris Lake IV Section above.

THE HERMITAGE FORMATION

General Distribution and Subdivisions

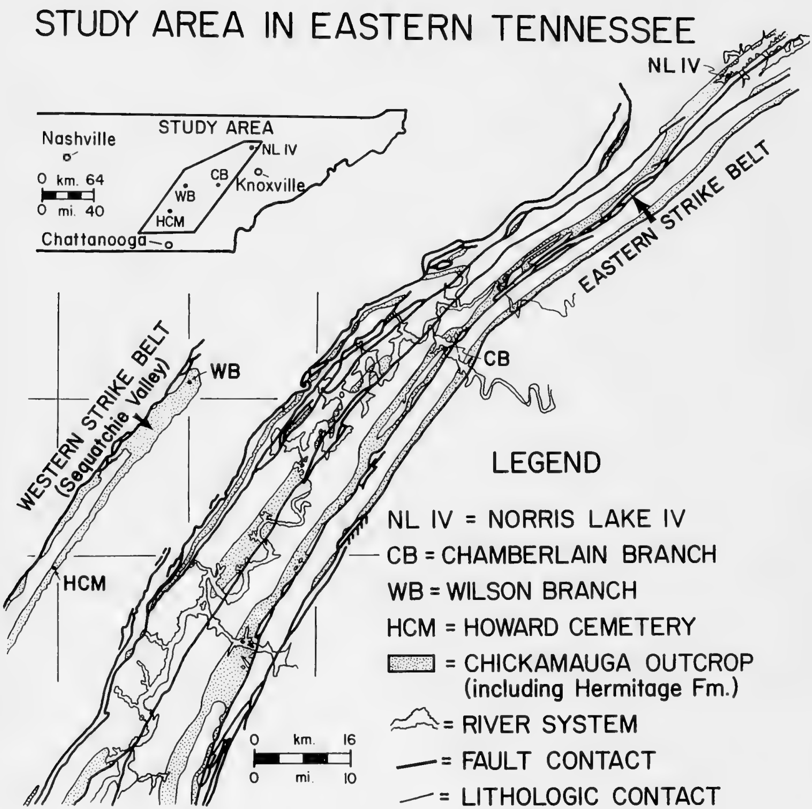
The Hermitage is one of the more widespread formations of the Central Basin of Tennessee and contiguous regions (Bassler, 1932, p. 74). It can be found east of the Tennessee River, throughout the Central Basin, and into Sequatchie Valley. The eastern boundary noted by Bassler (1932, p. 75), is "the western part of the Appalachian Valley from southwest Virginia to Alabama." To the north, the Hermitage is not found north of north-central Kentucky (Bassler, 1932, p. 75). To the south, strata of the Hermitage dip southward under sediments of the Gulf Coastal Plain.

Safford (1869) originally referred to the beds of the present-day Hermitage Formation in central Tennessee as the "*Orthis* bed," named for the preponderance of the brachiopod *Orthis testudinaria,* now designated *Dalmanella fertilis.* Specific designation as the Hermitage Formation, and therefore of the type locality, was by Hayes and Ulrich (1903), who alluded to an outcrop located near Hermitage station, Davidson County, in central Tennessee, "near the old home of President Jackson on the Tennessee Central Railroad, . . . " Bassler (1932) specifically located and described this section (work completed with Ulrich in 1899 according to Bassler) as being composed of 67 feet (20.4 m) of thin-bedded, impure limestone with interbedded shales.

In addition, Bassler recognized the Hermitage to be lithologically variable from county to county within the Central Basin of Tennessee but did not attempt to correlate the strata. He did, however, divide the Hermitage into a minimum of eight faunal zones believed by him to be chronologically ordered but not persistently distributed throughout the region.

Wilson (1949) studied several exposures of the Hermitage near its type locality and presented a complete composite of the formation with a total thickness approaching 70 feet (21.3 m). He proposed that the Hermitage could be divided into seven lithologic and faunal units, or members, and attempted to correlate the sections suggesting at the same time that Bassler's faunal zones were not strictly temporally sequential. Wilson's basal unit was called the Curdsville Member, a name used to designate the lower Hermitage in Kentucky. Succeeding the Curdsville and thickening to the west is the Laminated Argillaceous Member above which a Silty Nodular Limestone Member thickens to the east. The latter two members form the bulk of the Hermitage in Central Tennessee. Sandwiched in between the Laminated Argillaceous and Silty Nodular Limestone Members from west to east and generally increasing in age are four lenticular sedimentary bodies, the *Dalmanella* Coquina Member, Granular Phosphatic Member, *Ctenodonta* Member and Blue-Clay Shale Member. This type of stratigraphic framework would permit the Hermitage to exist as several members (or facies) at any one time (see Wilson, 1949, fig. 15, p. 84). Templeton and Willman (1963, p. 206), on the other hand, suggest that Wilson's post-Curdsville Hermitage units are more stratigraphically successive than contemporaneous in their distribution.

The overall thickness of the Hermitage in Central Tennessee varies from 50 to 70 feet (15.2 to 21.3 m) to the east and central with a rapid thickening to the west (Laminated Argillaceous Limestone Member) where it attains a maximum thickness of 180 feet (54.9 m) (Wilson, 1949). In northwestern Georgia, the Hermitage is 35 feet thick (10.7 m) (Milici and Smith, 1969) and in southwest Virginia it is 150 feet thick (45.7 m) (Bassler, 1932). East of Grundy, Van Buren,



Text-figure 1.—Partial geologic map of the Tennessee Study Area indicating the locations of the four measured sections.

and White counties of east-central Tennessee (nearly 90 miles (144.9 km) southeast of the type section), the Silty Nodular Limestone Member is the sole constituent of the Hermitage Formation (forming about 60 to 70 feet (18.3 to 21.3 m) of section in Sequatchie Valley; Milici, 1970).

Variation in the above lithotypes was largely controlled by tectonic movements of the Cincinnati Arch or Nashville Dome (Wilson, 1962). The lesser amount of clastic (*i.e.*, detrital) silt within the Silty Nodular Limestone member as compared to other members suggests a western to southwestern source area (Wilson, 1949, p. 102).

Hermitage of the Study Area

Within the study area at Sequatchie Valley (Text-figure 1), the Hermitage Formation is composed of 45 to 60 feet (13.7 to 18.3 m) of predominantly irregularly bedded, argillaceous, skeletal wackestones (sparse to packed biomicrites). Further to the east, at Norris Lake and Chamberlain Branch, the Hermitage is more variable in lithology and of greater thickness (between 100 and 130 feet; 30.5 and 39.6 m). Interspersed with lithologies similar to the Sequatchie Valley sections are irregularly bedded, clean to slightly argillaceous to argillaceous, fine-grained to coarse-grained packstones (packed biomicrites to poorly washed biosparites), and clean to slightly argillaceous wackestones (packed biomicrites). The Hermitage Formation found in Sequatchie Valley would represent the Silty Nodular Limestone Member of Wilson (1949). The other sections are not so lithologically distinct as to merit a separate designation and are therefore included in this member. Several beds within these eastern sections, however, may be considered similar to Wilson's *Dalmanella* Coquina Member of the Central Basin, in that scattered horizons contain concentrations of *Dalmanella fertilis* in such abundance that they form the greater part of the rock.

STRATIGRAPHIC POSITION

The Hermitage Formation is the lowermost of three units forming the Nashville Group. The Cannon Limestone overlies the Hermitage while the Carters Limestone, the uppermost unit of the Stones River Group, underlies the Hermitage. Both Groups form the Chickamauga Supergroup (Milici and Smith, 1969; Milici, 1970) embracing the Black River and Trenton Stages of the Middle Ordovician. Twenhofel et al. (1954) placed the Hermitage of the Central Basin of Tennessee within the middle of the Trentonian Stage (time-correlative with the "representative" Kirkfield and lower Sherman Falls Formations) of the Champlainian Series. In addition, Twenhofel *et al.* (1954) correlated the Hermitage with the lower half of the Lexington Limestone in Central Kentucky, and with the Ion Member of the Decorah Formation and Prosser Formation in the Upper Mississippi Valley. Cooper (1956) placed the Hermitage of the Central Basin in his lowermost Trenton Stage (Cooper's Trenton is not the time-stratigraphic equivalent of the Trentonian Stage defined by Twenhofel *et al.,* 1954) with the Carters Limestone being placed in his uppermost Wilderness Stage.

According to Ross *et al.* (1982) (also see Sweet and Bergstrom, 1976), the Hermitage of the Central Basin of Tennessee (early Shermanian in age) is separated from the uppermost Carters Limestone (mid-Kirkfieldian) by an erosional unconformity (truncation of the upper Carters; see Wilson, 1949). In Sequatchie Valley, the Hermitage (in apparent conformity with the Carters Limestone) spans the greater part of both the Rocklandian and Kirkfieldian Stages (and possibly the lowermost Shermanian). The present author finds these correlations of Ross *et al.* to be suspect in part. The position of the T-3 Bentonite in the upper Carters Limestone (found close to the overlying Hermitage) was personally observed to occur in the Central Basin, Sequatchie Valley, and western Valley and Ridge, offering rather strong evidence of the time-equivalence of the upper Carters and hence the lower Hermitage boundary across this area. Kolata *et al.* (1987) noted that the T-3 and T-4 Bentonites of the upper Carters Limestone appear to correlate on geophysical logs with the Deicke and Millbrig Bentonites (early Rocklandian Age) in the lower Decorah Formation of the Upper Mississippi Valley. Samson *et al.* (1987) used chemical correlation methods to corroborate this lateral relationship. This is more in line with the chronostratigraphic correlations for the Hermitage suggested above for Sequatchie Valley. Votaw in Fetzer (1973) found the lowest representatives of the conodont *Phragmodus undatus* in the lowermost Hermitage of Central Tennessee suggesting a Rocklandian age (lower Midcontinent Conodont Zone 8) for these basal beds, again, not inconsistent with the correlations suggested directly above.

GENERAL DEPOSITIONAL SETTINGS OF THE HERMITAGE FORMATION AND STRATIGRAPHICALLY CONTIGUOUS STRATA

Within the study area, the Carters Limestone underlies the Hermitage Formation. Wilson (1949) divided the Carters into two formal members, an Upper and Lower, separated by the T-3 bentonite bed. At sections east of Sequatchie Valley, the exposed Upper Carters is largely pinkish to maroon and olive grey mudstone with 2 to 8 inch (5.1 to 20.3 cm) regular and even beds. Laminations and mudcracks are scattered throughout. At Davis Crossroads, Georgia, beds of the Upper Carters vary in thickness from 1 to 8 inches (2.5 to 20.3 cm), are even and regular, commonly calcilutitic, and contain varying amounts of birdseye and dessication structures, intraclasts, ostracods, and vertical burrows. In addition, Milici and Smith (1969) noted the presence of mudcracks and fine crossbeds. In Sequatchie Valley, Milici (1970) noted the presence of mudcracks, laminations, and intraclasts in fine-grained (calcilutite to calcisiltite) limestones, in beds generally 1 to 6 inches (2.5 to 15.2 cm) thick, even and irregularly bedded.

The presence of mudcracks, birdseye features, laminations and vertical burrows, depauperate fauna, fine-scale cross-stratification and intraclasts would certainly suggest intertidal to supratidal conditions (see Walker and Laporte, 1970; Laporte, 1971, for summaries of environmental criteria for carbonate regimes) existing throughout the Upper Carters Limestone and across a huge expanse of carbonate platform prior to deposition of the Hermitage Formation.

The onset of Hermitage deposition is marked by the presence of more argillaceous and irregular beds with an abundant and diverse invertebrate fauna. Positions of the lower Hermitage boundary with respect to Wilson's T-4 Bentonite strongly suggest the rapid relative subsidence of the carbonate platform, perhaps related to a general worldwide rise in sea level (see Vail *et al.*, 1977) and consequent invasion of a normal marine biota into newly developing habitats.

Within the Hermitage of the study area, the striking lithological difference among outcrops is the almost total restriction of an argillaceous wackestone (sparse, or sparse to packed biomicrite) lithofacies to strata of Sequatchie Valley. The only exceptions to this are sparitic limestone beds containing relatively large amounts of detrital silt and sand in the lowermost beds of each section. Typical "Sequatchie-looking" strata (fairly argillaceous and rubbly weathering) in the two eastern sections are relatively few, being limited to approximately the upper fifth of the Hermitage Formation at Norris Lake, and perhaps small portions in the middle and uppermost levels of the Chamberlain Branch Hermitage. Other rocks of the Hermitage Formation in these eastern sections are predominantly packstones (packed biomicrites) with varying amounts of argillaceous sediment or wackestones (packed biomicrites) with some argillaceous input that are nearly packstones.

The tendency for grain support within the eastern sections suggests that they were deposited in more agitated waters than those at Sequatchie Valley (a fact further supported by the presence of some crossbeds at both eastern sections). The subtle differences in lithofacies are strikingly amplified in the distribution of several prominent macroinvertebrate species. The two major brachiopod taxa abundantly distributed within Norris Lake and Chamberlain Branch sections include *Sowerbyella* sp. and *Dalmanella fertilis,* neither of which is found in the Hermitage of Sequatchie Valley. While the distribution of the bryozoan fauna will be elaborated elsewhere in this text, the strikingly obvious hemispherical-shaped colonies of *Prasopora* and *Mesotrypa,* common to certain strata of the eastern sections are totally absent in Sequatchie Valley save for two colonies of *Mesotrypa.* These massive encrusting growth forms further suggest an adaptation of taxa able to withstand a more physically rigorous wave-swept environment. Indeed, even within individual sections to the east, the presence or absence of these two co-occurring genera is reflected by the associated fauna and lithofacies. *Rhynchotrema increbescens,* on the other hand, the common brachiopod of the Sequatchie Valley Hermitage, is found scattered in small numbers within beds of eastern sections having wackestones with relatively high amounts of argillaceous detritus. The point is that several different lithological subfacies exist within the Hermitage reflecting variations and combinations of water depth, wave or current energy, amounts of terrigenous detritus, and type and amount of carbonate materials produced within the basin. The sediments to the east were, in general, subjected to a higher degree of reworking due to higher energy conditions allowing for the development of a packstone fabric.

The Cannon Limestone overlying the Hermitage is generally a clean wackestone (sparse to packed biomicrite) in the eastern sections. In Sequatchie Valley as well as northwest Georgia, lithologies contain more carbonate mudstone (fossiliferous micrites). The Cannon, for the most part, supports a normal marine fauna. Sections examined south of Howard Cemetery include some beds containing leperditid ostracods and birdseye structures, suggestive of at least intertidal conditions. The general increase in carbonate mud within the Cannon compared to the Hermitage would indicate more quiet waters prevalent during deposition of these sediments. The intermingling of features indicative of intertidal or supratidal environments with the more fully marine strata is suggestive of generally shallower-water conditions than for the Hermitage, at least for several localities in Sequatchie Valley and northwestern Georgia. In addition, the general association of the tabulate coral *Tetradium,* leperditid ostracods, archaeogastropods (*Hormotoma*), the spiriferid brachiopod *Zygospira,* and some cryptostome bryozoans found especially in certain Cannon beds south of Howard Cemetery is a recurrent one in marine facies interpreted to be shoreward of Ordovician carbonates level-bottom faunas (Walker, 1972; Longman and Sprinkle, 1976; Cameron and Kamal, 1977). Rocks having this general faunal association are here considered to represent the shallowest-water environments of the study area capable of supporting invertebrate life. Elsewhere within the Cannon, the increased prominence of a molluscan fauna is supportive of a shallower water (nearshore) interpretation (see Bretsky, 1969; Berry, 1974). This is no doubt due in part to ecological constraints resulting from the shoreward accumulation of lime muds commonly associated with epicontinental sedimentation (see Irwin, 1965; Heckel, 1972) and/or an increased suitability for more eurytypic molluscan species.

TREPOSTOME BRYOZOAN FAUNAL ANALYSIS

TREPOSTOME BRYOZOAN ASSEMBLAGES FROM THE HERMITAGE FORMATION OF THE EASTERN TENNESSEE STUDY AREA

Three groups of trepostome bryozoan species populations were observed to regularly occur in time (within specific stratigraphic intervals) and space (over several geographic localities) and are referred to herein as Bryozoan Assemblages One, Two, and Three. Each is presumed to largely reflect similar species responses to particular environmental demands.

Bryozoan Assemblage One

This assemblage is numerically dominated by *Bythopora dendrina* (39%), *Eridotrypa mutabilis* (11%), and *Parvohallopora pulchella* (10%), with lesser *Heterotrypa subtrentonensis* (4%), *Stigmatella distinctaspinosa* (4%), *Tarphophragma multitabulata* (3%), *Homotrypa flabellaris* var. *spinifera* (3%), *Mesotrypa angularis* (3%), and *Parvohallopora granda* (3%) (comprising 80% of the total trepostome fauna) (Table 5). It occurs at all four study localities (Text-fig. 6) within the following sampling intervals—Norris Lake IV 19–40 ft (5.8–12.2 m), 61–73 ft (18.6–22.2 m), 85–87 ft (25.9–26.5 m) (Table 1; Text-fig. 2), Chamberlain Branch 41–46 ft (12.5–14.0 m), 67–79 ft (20.4–24.1 m), 114–132 ft (34.8–40.2 m), 149–161 ft (45.4–49.1 m) (Table 2; Text-fig. 3), Wilson Branch 2–32 ft (0.6–9.8 m) (Table 3; Text-fig. 4), and Howard Cemetery 3–11 ft (0.9–3.4 m) (Table 4; Text-fig. 5). Of particular note is the relative paucity of *Eridotrypa mutabilis* at the two western sections (Howard Cemetery and Wilson Branch), of *Heterotrypa subtrentonensis* at Norris Lake IV, and of *Parvohallopora pulchella* at Chamberlain Branch and Howard Cemetery.

Other benthic invertebrates generally preserved with Assemblage One at Norris Lake and Chamberlain Branch are large numbers of *Dalmanella fertilis* and lesser numbers of *Rafinesquina hermitagensis, Sowerbyella* sp., various strophomenoids, pelmatozoan columnals, and occasional *Rhynchotrema increbescens* (where especially argillaceous). Within Sequatchie Valley to the west (at Howard Cemetery and Wilson Branch) non-bryozoan elements commonly associated with Assemblage One are *R. increbescens,* pelmatozoan columnals, and *Zygospira recurvirostra.*

Associated lithologies within the western sections of Sequatchie Valley are predominantly wackestone (sparse/packed biomicrite) to wackestone (packed biomicrite). Within the eastern sections at Norris Lake IV and Chamberlain Branch lithologies are primarily packstone (nearly wackestone; packed biomicrite) with lesser amounts of cleaner packstone and, then, wackestone (nearly packstone; packed biomicrite). Rocks associated with Assemblage One generally are fairly clean throughout the study area though some strata, especially in the western sections, are somewhat argillaceous.

Environmental Interpretation—The packstones (packed biomicrite), generally large allochems (mainly brachiopods), and occasional coquinite beds at Norris Lake IV suggest a relatively high energy environment, perhaps a moderately agitated open shelf. At the western outcrops, predominantly wackestones with minor interbeds of packstone (poorly washed biosparite) and fine-grained wackestones with terrigenous silt suggests intermittent mild turbulence in an overall moderately quiet water environment.

Bryozoan Assemblage Two

This assemblage is composed primarily of *Bythopora dendrina* (31%), *Eridotrypa mutabilis* (17%), *Anaphragma hermitagensis* (16%), *Mesotrypa angularis* (9%), *Prasopora falesi* (6%), *Tarphophragma ampla* (3%) and *Heterotrypa subtrentonensis* (3%) (cumulatively 85%) (Table 6). It occurs over three sampling intervals (Text-figure 6) only within the eastern sections—Norris Lake IV 43–51 ft (13.1–15.5 m) (Table 1; Text-fig. 2), and Chamberlain Branch 50–62 ft (15.2–18.9 m), 138–145 ft (42.1–44.2 m) (Table 2; Text-fig. 3). *Dalmanella fertilis, Rafinesquina hermitagensis, Sowerbyella* sp., and *Dinorthis pectinella* are common faunal associates.

Lithologies associated with this fossil material consist primarily of packstone (packed biomicrite) with lesser amounts of packstone (nearly a wackestone; packed biomicrite). Argillaceous input is variable but in general is higher than for Assemblage One.

Environmental Interpretation—The density of shell material, the massive zoaria of many trepostomes (including the only two common hemispherical-shaped species in the study area, *Prasopora falesi* and *Mesotrypa angularis*), size-sorted beds of *Dalmanella fertilis* (diameter approximately 10 mm), and presence of cross-bedding leave no doubt of a current-swept, relatively high energy (highest of the three assemblages), open marine, shallow shelf environment.

Bryozoan Assemblage Three

Abundant and commonly associated trepostomes of this assemblage include *Batostomella subgracilis* (30%), *Bythopora dendrina* (16%), *Homotrypa flabellaris* var. *spinifera* (12%), *Parvohallopora granda* var. *inflata* (7%), *P. granda* (7%), and *Homotrypa subramosa* (3%), and *Parvohallopora pulchella* (3%) (cumulatively 78%) (Table 7).

This association of species occurs within a single

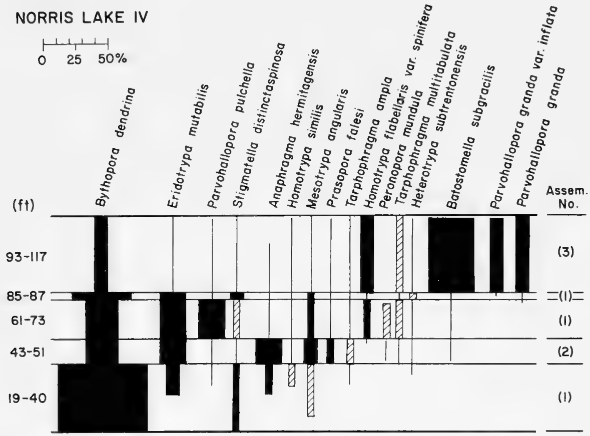
Table 1.—Relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages found at Norris Lake IV section arranged in stratigraphic order. Inter. = stratigraphic interval in feet above the base of measured section from which data were gathered; Assem. = Bryozoan Assemblage Number; Species present = a listing of trepostome species occurring in abundances ≥ 3%; Specimens = number of individuals of each species as counted from acetate peels; % = percentage abundance of each trepostome species; Cum. % = cumulative percentage.

Inter.	Assem.	Species present		Specimens	%	Cum. %
19–40 ft	1	*Bythopora dendrina*		65	67.7	67.7
(5.8–12.2 m)		*Eridotrypa mutabilis*		8	8.3	76.0
		Anaphragma hermitagensis		6	6.2	82.2
		Stigmatella distinctaspinosa		5	5.2	87.4
		Homotrypa similis		4	4.2	91.6
		Mesotrypa angularis		3	3.1	94.7
		Other species (each < 3.0%)		5	5.2	99.9
		[Total: 9 genera/11 species]	Total	96	99.9	
43–51 ft	2	*Bythopora dendrina*		194	27.3	27.3
(13.1–15.5 m)		*Eridotrypa mutabilis*		148	20.8	48.1
		Anaphragma hermitagensis		136	19.2	67.3
		Mesotrypa angularis		71	10.0	77.3
		Prasopora falesi		42	5.9	83.2
		Tarphophragma ampla		28	3.9	87.1
		Other species (each < 3.0%)		91	12.8	99.9
		[Total: 14 genera/20 species]	Total	710	99.9	
61–73 ft	1	*Bythopora dendrina*		169	26.8	26.8
(18.6–22.2 m)		*Eridotrypa mutabilis*		132	21.0	47.8
		Parvohallopora pulchella		115	18.2	66.0
		Homotrypa flabellaris var. *spinifera*		40	6.3	72.3
		Mesotrypa angularis		35	5.6	77.9
		Peronopora mundula		30	4.8	82.7
		Tarphophragma multitabulata		23	3.6	86.3
		Stigmatella distinctaspinosa		23	3.6	89.9
		Other species (each < 3.0%)		63	10.0	99.9
		[Total: 14 genera/22 species]	Total	630	99.9	
85–87 ft	1	*Bythopora dendrina*		52	46.8	46.8
(25.9–26.5 m)		*Eridotrypa mutabilis*		22	19.8	66.6
		Stigmatella distinctaspinosa		9	8.1	74.7
		Mesotrypa angularis		6	5.4	80.1
		Heterotrypa subtrentonensis		4	3.6	83.7
		Other species (each < 3.0%)		18	16.2	99.9
		[Total: 10 genera/15 species]	Total	111	99.9	
93–117 ft	3	*Batostomella subgracilis*		506	37.2	37.2
(28.4–35.7 m)		*Parvohallopora granda* var. *inflata*		144	10.6	47.8
		Bythopora dendrina		140	10.3	58.1
		Homotrypa flabellaris var. *spinifera*		126	9.3	67.4
		Parvohallopora granda		116	8.5	75.9
		Tarphophragma multitabulata		40	2.9	78.8
		Other species (each < 3.0%)		288	21.2	100.0
		[Total: 14 genera/27 species]	Total	1360	100.0	

interval at each stratigraphic section of the study area (Text-fig. 6)—Norris Lake IV 93–117 ft (28.4–35.7 m) (Table 1; Text-fig. 2) and Chamberlain Branch 81–85 ft (24.7–25.9 m) (Table 2; Text-fig. 3) to the east, and Wilson Branch 38–44 ft (11.6–13.4 m) (Table 3; Text-fig. 4) and Howard Cemetery 18 ft (5.5 m), 38–43 ft (11.6–13.1 m) (Table 4; Text-fig. 5) to the west.

Associated non-trepostome faunal elements commonly include *Rhynchotrema increbescens* and pelmatozoan columnals (these commonly co-occur with argillaceous carbonates). Some *Dalmanella fertilis* and/or *Sowerbyella* sp. are noticeable in the eastern sections at Norris Lake IV and Chamberlain Branch.

Lithologies at the western outcrops are wackestone (sparse biomicrite to sparse/packed biomicrite). Within the eastern outcrops, lithologies are mainly packstone (nearly wackestone; packed biomicrite) with somewhat lesser amounts of wackestone (nearly packstone;



Text-figure 2.—Graphic display illustrating the relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages found at the Norris Lake IV section. Percent occurrences are rounded off to the nearest 5%. The bar graph is solid if the actual occurrence of a species is ≥ 5%. The graph is cross-hatched if ≥ 3% and < 5%. A single vertical line indicates an occurrence < 3%. Endpoints of vertical species distributions delimit the actual biostratigraphic ranges within the section. Numbers to the left indicate the stratigraphic intervals (in feet above the base of measured section) containing the various Bryozoan Assemblages. See section on Stratigraphic Collection Levels (p. 8) as well as section on Trepostome Bryozoan Assemblages (p. 13) for more precise stratigraphic information and metric equivalents.

packed biomicrite) and, then, cleaner packstone. Across the entire study area, argillaceous input is relatively higher for this assemblage than for either of the other two.

Environmental Interpretation—The relatively large amount of wackestone in this assemblage suggests generally low energy conditions (lowest of the three assemblages). Packstone fabrics in the eastern outcrops indicate periodic moderate agitation. Pulses of argillaceous sediment are common. Concentrations of clastic material are enhanced due to relatively quiet water reducing the winnowing of fine-grained sediment (see Table 8 for a summary of Bryozoan Assemblages and their relation to associated lithotypes, macrofossils, and environments of deposition).

COMPARISON WITH SOME OTHER MIDDLE ORDOVICIAN BRYOZOAN ASSEMBLAGES

Only a handful of studies in recent years have described in any detail assemblages of trepostome bryozoans present within well-defined intervals of time and space. In one of the most recent reports of this type, Karklins (1984) described both the trepostome and cystoporate bryozoans from the Lexington Limestone and the Clays Ferry Formation (Middle and Upper Ordovician, respectively) of northern Kentucky. This study noted the precise stratigraphic distributions of the trepostomes and cystoporates, and attempted to quantify their relative abundances.

Karklins (1984, p. 18) defined two bryozoan assemblage zones, each based on the "restricted vertical ranges and geographic occurrences of individual taxa." The *Tarphophragma multitabulata* assemblage zone includes upper parts of the Curdsville, as well as the Logana and Grier Members of the Lexington Limestone and a few feet of the overlying rock units (stratigraphically equivalent to the lowermost part of the Brannon Member). This assemblage zone includes nine characteristic species. The base of the interval is placed at the lowermost known occurrence of *T. multitabulata.* The top is defined by the first appearances of species characteristic of the succeeding *Constellaria teres* assemblage zone. Not all species of the *T. multitabulata* zone are restricted to it, some disappear slightly above the top of the interval.

According to correlations in Ross *et al.* (1982) and Karklins (1984), that portion of the Lexington Limestone represented by the *Tarphophragma multitabu-*

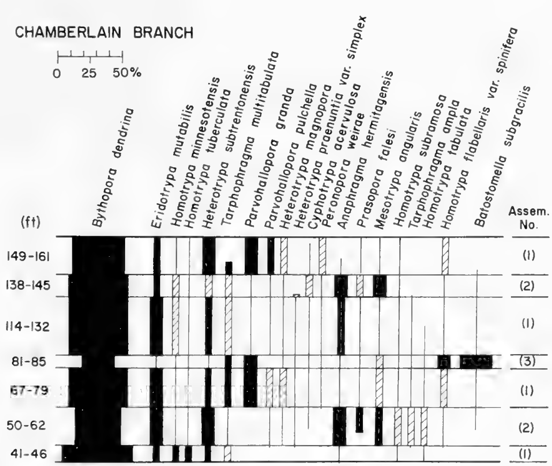
Table 2.—Relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages at Chamberlain Branch section arranged in stratigraphic order. See Table 1 for explanation of column headings and abbreviations used.

Inter.	Assem.	Species present		Specimens	%	Cum. %
41–46 ft (12.5–14.0 m)	1	*Bythopora dendrina*		74	56.9	56.9
		Eridotrypa mutabilis		8	6.2	63.1
		Homotrypa minnesotensis		7	5.4	68.5
		Homotrypa tuberculata		7	5.4	73.9
		Heterotrypa subtrentonensis		7	5.4	79.3
		Tarphophragma multitabulata		4	3.1	82.4
		Other species (each < 3.0%)		23	17.7	100.1
		[Total: 9 genera/16 species]	Total	130	100.1	
50–62 ft (15.2–18.9 m)	2	*Bythopora dendrina*		67	34.2	34.2
		Eridotrypa mutabilis		20	10.2	44.2
		Anaphragma hermitagensis		19	9.7	54.1
		Heterotrypa subtrentonensis		17	8.7	62.8
		Prasopora falesi		13	6.6	69.4
		Mesotrypa angularis		13	6.6	76.0
		Homotrypa subramosa		7	3.6	79.6
		Tarphophragma ampla		6	31	82.7
		Homotrypa tabulata		6	3.1	85.8
		Other species (each < 3.0%)		28	14.3	100.1
		[Total: 14 genera/22 species]	Total	196	100.1	
67–79 ft (20.4–24.1 m)	1	*Bythopora dendrina*		127	43.5	43.5
		Eridotrypa mutabilis		25	8.6	52.1
		Parvohallopora granda		23	7.9	60.0
		Tarphophragma multitabulata		16	5.5	65.5
		Heterotrypa subtrentonensis		16	5.5	71.0
		Parvohallopora pulchella		13	4.4	75.4
		Mesotrypa angularis		13	4.4	79.8
		Heterotrypa magnopora		12	4.1	83.9
		Homotrypa flabellaris var. *spinifera*		10	3.4	87.3
		Other species (each < 3.0%)		37	12.7	100.0
		[Total: 13 genera/23 species]	Total	292	100.0	
81–85 ft (24.7–25.9 m)	3	*Batostomella subgracilis*		47	26.2	26.2
		Bythopora dendrina		44	24.6	50.8
		Homotrypa flabellaris var. *spinifera*		21	11.7	62.5
		Parvohallopora granda		14	7.8	70.3
		Tarphophragma multitabulata		11	6.1	76.4
		Mesotrypa angularis		7	3.9	80.3
		Other species (each < 3.0%)		35	19.6	99.9
		[Total: 11 genera/17 species]	Total	179	99.9	
114–132 ft (34.8–40.2 m)	1	*Bythopora dendrina*		145	47.4	47.4
		Eridotrypa mutabilis		26	8.5	55.9
		Heterotrypa subtrentonensis		16	5.2	61.1
		Anaphragma hermitagensis		16	5.2	66.3
		Tarphophragma multitabulata		12	3.9	70.2
		Homotrypa minnesotensis		11	3.6	73.8
		Other species (each < 3.0%)		80	26.1	99.9
		[Total: 14 genera/27 species]	Total	306	99.9	
138–145 ft (42.1–44.2 m)	2	*Bythopora dendrina*		60	44.8	44.8
		Anaphragma hermitagensis		12	9.0	53.8
		Mesotrypa angularis		10	7.5	61.3
		Eridotrypa mutabilis		9	6.7	68.0
		Heterotrypa subtrentonensis		6	4.5	72.5
		Homotrypa minnesotensis		5	3.7	76.2
		Prasopora falesi		5	3.7	79.9
		Tarphophragma multitabulata		4	3.0	82.9
		Heterotrypa praenuntia var. *simplex*		4	3.0	85.9
		Cyphotrypa acervulosa		4	3.0	88.9
		Other species (each < 3.0%)		15	11.2	100.1
		[Total: 14 genera/21 species]	Total	134	100.1	

Table 2.—Continued.

Inter.	Assem.	Species present		Specimens	%	Cum. %
149–161 ft (45.4–49.1 m)	1	*Bythopora dendrina*		92	41.2	41.2
		Heterotrypa subtrentonensis		21	9.4	50.6
		Parvohallopora granda		20	9.0	59.6
		Eridotrypa mutabilis		14	6.3	65.9
		Tarphophragma multitabulata		14	6.3	72.2
		Parvohallopora pulchella		13	5.8	78.0
		Heterotrypa magnopora		10	4.5	82.5
		Homotrypa flabellaris var. *spinifera*		7	3.1	85.6
		Peronopora weirae		7	3.1	88.7
		Other species (each < 3.0%)		25	11.2	99.9
		[Total: 13 genera/21 species]	Total	223	99.9	

lata zone (Kirkfieldian to mid-Shermanian; Curdsville through Grier Members) is largely coincident with the Hermitage and Cannon Formations of Sequatchie Valley (and the Hermitage and upper Carters of the Central Basin). Nine (to possibly 11) trepostome species are described by Karklins (1984) to occur in the interval approximately time-equivalent to the Hermitage of the study area. Six of these are considered by Karklins to be characteristic of the *Tarphophragma multitabulata* zone. Four of the nine (or five of the 11) are found within the eastern sections (Norris Lake IV and Chamberlain Branch) and all four (or four of the five), namely *Tarphophragma multitabulata, Mesotrypa angularis, Prasopora falesi,* and *Cyphotrypa acervulosa,* are within Karklins' group of six characteristic species. *Tarphophragma multitabulata,* and *M. angularis* are rare in the western sections at Wilson Branch and Howard Cemetery (Sequatchie Valley) while *P. falesi* and *C. acervulosa* do not occur there at all. Since the similar stratigraphic positions of the Sequatchie Valley and eastern sections above the T-3 Bentonite (a presumably time-equivalent horizon) strongly suggest a temporal correspondence among outcrops of the study area, the varying faunal occurrences and abundances could be the result of one or more factors. These include differential sampling (especially where portions

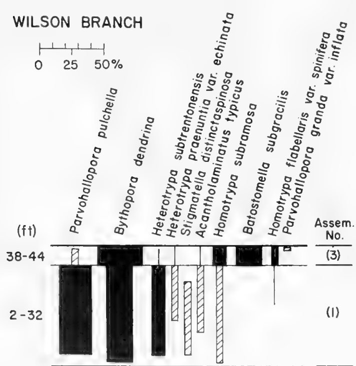


Text-figure 3.—Graphic display illustrating the relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages found at the Chamberlain Branch section. See Text-figure 2 for explanation of symbols used.

Table 3.—Relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages at Wilson Branch section arranged in stratigraphic order. See Table 1 for explanation of column headings and abbreviations used.

Inter.	Assem.	Species present		Specimens	%	Cum. %
2–32 ft	1	*Parvohallopora pulchella*		61	27.4	27.4
(0.6–9.8 m)		*Bythopora dendrina*		44	19.7	47.1
		Heterotrypa subtrentonensis		25	11.2	58.3
		Homotrypa subramosa		11	4.9	63.2
		Heterotrypa praenuntia var. *echinata*		9	4.0	67.2
		Stigmatella distinctaspinosa		9	4.0	71.2
		Acantholaminatus typicus		8	3.6	74.8
		Other species (< 3.0%)		56	25.1	99.9
		[Total: 11 genera/17 species]	Total	223	99.9	
38–44 ft	3	*Bythopora dendrina*		97	36.0	36.0
(11.6–13.4 m)		*Batostomella subgracilis*		51	19.0	55.0
		Homotrypa subramosa		32	11.9	66.9
		Homotrypa flabellaris var. *spinifera*		16	5.9	72.8
		Parvohallopora granda var. *inflata*		11	4.1	76.9
		Parvohallopora pulchella		9	3.3	80.2
		Other species (each < 3.0%)		53	19.7	99.9
		[Total: 11 genera/17 species]	Total	269	99.9	

of sections are covered), paleoecological control, or faunal provincialism (explanations also invoked by Karklins, 1984, to explain the lack of similarity among the bryozoan faunas of the eastern United States Ordovician carbonate platform). It is noteworthy that three of the above four species (*Prasopora falesi, Mesotrypa angularis,* and *Cyphotrypa acervulosa*) are most common to Bryozoan Assemblage Two. This assemblage is the only one found exclusively in the eastern sections and is associated with relatively high energy environments absent in the Hermitage of Sequatchie Valley.



Text-figure 4.—Graphic display illustrating the relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages found at the Wilson Branch section. See Text-figure 2 for an explanation of symbols used.

The remaining three (of nine) species considered by Karklins (1984) to be characteristic of the Kentucky *Tarphophragma multitabulata* zone (*Cyphotrypa switzeriensis, Balticopora arcuatilis,* and *Stigmatella* sp.) are the three stratigraphically highest taxonomic occurrences in that area, restricted to the upper few feet of this assemblage zone. Since they are absent in the present study area, this would suggest a correspondence between the Hermitage Formation of East-Central Tennessee and an interval within the greater portion of the *Tarphophragma multitabulata* zone.

The similarity between the *Tarphophragma multitabulata* zone of Karklins (1984) and the trepostome bryozoans of the Norris Lake IV and Chamberlain Branch sections is not intended to define a strict time-equivalence between the Kentucky and Tennessee sections (though such a relationship is supported by Ross et al. (1982). It is merely meant to point out a faunal resemblance suggestive of either a temporal correspondence or a general similarity in ecological control of faunal distribution. This is the case for all comparisons drawn below. Where possible, time-equivalence based on the correlations of Ross et al. (1982) is noted.

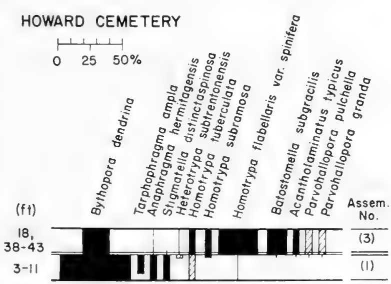
Brown (1965) reviewed the trepostomatous fauna from the "Logana and Jessamine Limestones" (= Logana and Grier Members of current usage according to Karklins, 1984) of the Lexington Limestone of Central Kentucky. He described 20 species and one subspecies, including 13 genera. Five of these 20 species are found in the present study area. These include *Tarphophragma multitabulata* (as *Hallopora multitabu-*

Table 4.—Relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages at Howard Cemetery section arranged in stratigraphic order. See Table 1 for explanation of the column headings and abbreviations used.

Inter.	Assem.	Species present		Specimens	%	Cum. %
3–11 ft (0.9–3.4 m)	1	*Bythopora dendrina*		68	53.5	53.5
		Tarphophragma ampla		9	7.1	60.6
		Homotrypa subramosa		9	7.1	67.7
		Anaphragma hermitagensis		7	5.5	73.2
		Stigmatella distinctaspinosa		7	5.5	78.7
		Heterotrypa subtrentonensis		6	4.7	83.4
		Homotrypa tuberculata		5	3.9	87.3
		Other species (each < 3.0%)		16	12.6	99.9
		[Total: 10 genera/15 species]	Total	127	99.9	
18, 38–43 ft (5.5, 11.6–13.1 m)	3	*Homotrypa flabellaris* var. *spinifera*		108	28.2	28.2
		Bythopora dendrina		78	20.4	48.6
		Batostomella subgracilis		51	13.3	61.9
		Homotrypa subramosa		22	5.7	67.6
		Homotrypa tuberculata		21	5.5	73.1
		Acantholaminatus typicus		21	5.5	78.6
		Parvohallopora pulchella		18	4.7	83.3
		Parvohallopora granda		12	3.1	86.4
		Other species (each < 3.0%)		52	13.6	100.0
		[Total: 12 genera/18 species]	Total	383	100.0	

lata), *Prasopora falesi, Eridotrypa mutabilis* (as *Eridotrypa aedilis*), *Cyphotrypa acervulosa,* and *Peronopora mundula* (as *Homotrypella mundula*). These are taxonomically similar to Karklins' (1984) *Tarphophragma multitabulata* zone. In fact, Brown noted *Tarphophragma multitabulata, Prasopora falesi,* and *Eridotrypa mutabilis,* three of the more common faunal elements described in the present report, to be some of the most abundant and well-characterized faunal components of his study area.

Bork and Perry (1967, 1968a,b) studied the trepostome fauna of the Ion and Guttenberg Formations



Text-figure 5.—Graphic display illustrating the relative abundances of common trepostome species (≥ 3%) within Bryozoan Assemblages found at the Howard Cemetery section. See Text-figure 2 for explanation of symbols used.

(lower Trentonian of Twenhofel *et al.,* 1954; mainly lower Kirkfieldian of Ross *et al.,* 1982) from northwestern Illinois and adjacent Wisconsin and Iowa where it lies stratigraphically above the Spechts Ferry Formation and is the time-equivalent to part of the Hermitage Formation in Sequatchie Valley (Ross *et al.,* 1982). Thirty species (34 taxa including varieties and subspecies), and 14 genera are present of which four species-group taxa are common within East-Central Tennessee—*Heterotrypa praenuntia* vars. *simplex* and *echinata, Homotrypa similis,* and *Homotrypa subramosa.* Bork and Perry (1968b) also describe the occurrence of *Prasopora simulatrix* in the same strata. Their specimens, however, are lacking acanthostyles and thereby are not synonymized with *P. falesi* described herein.

Perry (1962) examined the bryozoan fauna from the Spechts Ferry Formation (lowermost Trentonian of Twenhofel *et al.,* 1954; predominantly mid to upper Rocklandian according to Ross *et al.,* 1982) of northwestern Illinois, southwestern Wisconsin, and southeastern Iowa. He described 10 species, one variety, and seven genera of trepostomes. Only two of his described species are found in Tennessee, namely, *Prasopora falesi* (as *Prasopora simulatrix* var. *orientalis*) and *Heterotrypa praenuntia* var. *echinata* (as *Dekayella praenuntia* var. *echinata*). Neither is particularly common in the Spechts Ferry. This formation is roughly time-equivalent to the very lowermost Hermitage Formation in Sequatchie Valley (Ross *et al.,* 1982).

Ross (1967a,b, 1969, 1970) described 22 trepostome

Table 5.—Relative abundances of common trepostome species found within representative samples of Bryozoan Assemblage One. Column headings indicate the stratigraphic intervals (ft and m) within which the particular Bryozoan Assemblage occurs. NL IV = Norris Lake IV Section; CB = Chamberlain Branch Section; WB = Wilson Branch Section; HCM = Howard Cemetery Section. Numbers in parentheses indicate the percent abundances of each species occurring within the specified stratigraphic interval. Numbers not within parentheses are the totals of individual specimens per species counted within the interval in question. Dashes instead of a numerical value indicates that the species was absent to less than 1.0% in abundance within selected representative samples from which relative percentages were calculated. Column totals account for all specimens, including those with abundances less than 1%. A = species totally absent from all samples collected within the stratigraphic interval, including those not used in the above calculations.

Species present	Total (ft) (m)	NL IV 19–40 (5.8–12.2)	NL IV 61–73 (18.6–22.2)	NL IV 85–87 (25.9–26.5)	NL IV Total
Bythopora dendrina	836 (39.1)	65 (67.7)	169 (26.8)	52 (46.8)	286 (34.2)
Eridotrypa mutabilis	237 (11.1)	8 (8.3)	132 (21.0)	22 (19.8)	162 (19.4)
Parvohallopora pulchella	212 (9.9)	2 (2.1)	115 (18.2)	—	118 (14.1)
Heterotrypa subtrentonensis	95 (4.4)	—	—	4 (3.6)	—
Stigmatella distinctaspinosa	75 (3.5)	5 (5.2)	23 (3.6)	9 (8.1)	37 (4.4)
Tarphophragma multitabulata	70 (3.3)	A	23 (3.6)	—	24 (2.9)
H. flabellaris var. *spinifera*	69 (3.2)	A	40 (6.3)	—	41 (4.9)
Mesotrypa angularis	63 (2.9)	3 (3.1)	35 (5.5)	6 (5.4)	44 (5.2)
Parvohallopora granda	53 (2.5)	A	—	2 (1.8)	—
Anaphragma hermitagensis	52 (2.4)	6 (6.2)	6 (1.0)	A	12 (1.4)
Heterotrypa magnopora	38 (1.8)	A	—	3 (2.7)	8 (1.0)
Peronopora mundula	38 (1.8)	A	30 (4.8)	A	30 (3.6)
Homotrypa tuberculata	37 (1.7)	A	—	3 (2.7)	—
Tarphophragma ampla	35 (1.6)	1 (1.0)	16 (2.5)	—	18 (2.2)
Homotrypa subramosa	31 (1.5)	1 (1.0)	A	—	—
Peronopora weirae	25 (1.2)	A	11 (1.7)	A	11 (1.3)
Homotrypa minnesotensis	21 (1.0)	1 (1.0)	—	A	—
Acantholaminatus typicus	—	A	—	A	—
H. praenuntia var. *echinata*	—	A	—	A	—
Homotrypa similis	—	4 (4.2)	—	A	—
Other species	118 (5.5)	—	16 (2.5)	5 (4.5)	21 (2.5)
Column Totals	2138	96	630	111	837

Species present (ft) (m)	CB 41–46 (12.5–14.0)	CB 67–79 (20.4–24.1)	CB 114–132 (34.8–40.2)	CB 149–161 (45.4–49.1)	CB Total
Bythopora dendrina	74 (56.9)	127 (43.5)	145 (47.4)	92 (41.2)	438 (46.0)
Eridotrypa mutabilis	8 (6.2)	25 (8.6)	26 (8.5)	14 (6.3)	73 (7.7)
Parvohallopora pulchella	3 (2.3)	13 (4.4)	—	13 (5.8)	30 (3.2)
Heterotrypa subtrentonensis	7 (5.4)	16 (5.5)	16 (5.2)	21 (9.4)	60 (6.3)
Stigmatella distinctaspinosa	3 (2.3)	6 (2.0)	9 (2.9)	4 (1.8)	22 (2.3)
Tarphophragma multitabulata	4 (3.1)	16 (5.5)	12 (3.9)	14 (6.3)	50 (5.2)
H. flabellaris var. *spinifera*	—	10 (3.4)	7 (2.3)	7 (3.1)	25 (2.6)
Mesotrypa angularis	A	13 (4.4)	3 (1.0)	3 (1.3)	19 (2.0)
Parvohallopora granda	A	23 (7.9)	—	20 (9.0)	44 (4.6)
Anaphragma hermitagensis	2 (1.5)	5 (1.7)	16 (5.2)	—	23 (2.4)
Heterotrypa magnopora	A	12 (4.1)	3 (1.0)	10 (4.5)	25 (2.6)
Peronopora mundula	A	—	—	—	—
Homotrypa tuberculata	7 (5.4)	6 (2.0)	5 (1.6)	7 (3.1)	25 (2.6)
Tarphophragma ampla	3 (2.3)	—	5 (1.6)	A	—
Homotrypa subramosa	3 (2.3)	—	5 (1.6)	—	—
Peronopora weirae	A	—	—	7 (3.1)	—
Homotrypa minnesotensis	7 (5.4)	—	11 (3.6)	—	19 (2.0)
Acantholaminatus typicus	—	—	—	A	—
H. praenuntia var. *echinata*	—	—	—	—	—
Homotrypa similis	—	A	—	—	—
Other species	7 (5.4)	15 (5.1)	37 (12.1)	10 (4.5)	69 (7.2)
Column Totals	130	292	306	223	951

Table 5.—Continued.

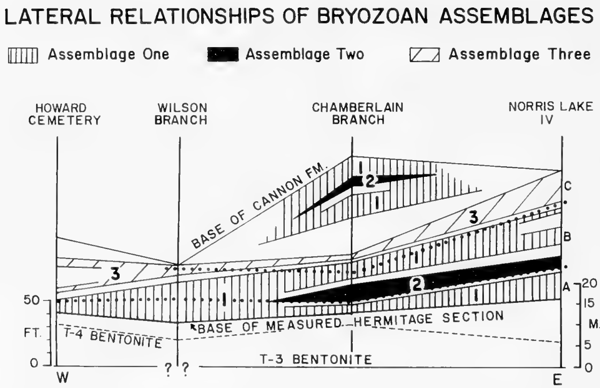
Species present (ft) (m)	WB 2–32 (0.6–9.8)	HCM 3–11 (0.9–3.4)
Bythopora dendrina	44 (19.7)	68 (53.5)
Eridotrypa mutabilis	—	A
Parvohallopora pulchella	61 (27.3)	3 (2.4)
Heterotrypa subtrentonensis	25 (11.2)	6 (4.7)
Stigmatella distinctaspinosa	9 (4.0)	7 (5.5)
Tarphophragma multitabulata	A	A
H. flabellaris var. *spinifera*	—	—
Mesotrypa angularis	—	A
Parvohallopora granda	3 (1.3)	—
Anaphragma hermitagensis	10 (4.5)	7 (5.5)
Heterotrypa magnopora	5 (2.2)	A
Peronopora mundula	6 (2.7)	A
Homotrypa tuberculata	A	5 (3.9)
Tarphophragma ampla	—	9 (7.1)
Homotrypa subramosa	11 (4.9)	9 (7.1)
Peronopora weirae	4 (1.8)	—
Homotrypa minnesotensis	A	A
Acantholaminatus typicus	8 (3.6)	2 (1.6)
H. praenuntia var. *echinata*	9 (4.0)	2 (1.6)
Homotrypa similis	A	A
Other species	22 (9.9)	6 (4.7)
Column Totals	223	127

species (13 genera) (not including *Constellaria* considered here to be a cystoporate) from the Blackriveran and Trentonian strata of New York State. Within the Rockland to Shoreham Formations (approximately the lower half of the Trentonian Stage of Twenhofel *et al.*, 1954), there are 11 species and 10 genera of trepostomes of which only three species are common to the Hermitage of the present study area, namely *Prasopora falesi* (as *P. simulatrix*), *Eridotrypa mutabilis,* and *Bythopora dendrina.* Twenhofel (1954) considered the Kirkfield to Shoreham Formations to be roughly time-equivalent to the Hermitage of the Central Basin of Tennessee.

Fritz (1957) studied the trepostome fauna from the Ottawa Formation of eastern Canada (Pamelia to Cobourg Formations: Black River through Trentonian of Twenhofel *et al.*, 1954; the Cobourg is now considered to be Cincinnatian in age by Sweet and Bergstrom,

Table 6.—Relative abundances of common trepostome species found within Bryozoan Assemblage Two. See Table 5 for explanation of column headings and abbreviations used.

Species present	Total (ft) (m)	NL IV 43–51 (13.1–15.5)	CB 50–62 (15.2–18.9)	CB 138–145 (42.1–44.2)	CB Total
Bythopora dendrina	321 (30.9)	194 (27.3)	67 (34.2)	60 (44.8)	127 (38.5)
Eridotrypa mutabilis	177 (17.0)	148 (20.8)	20 (10.2)	9 (6.7)	29 (8.8)
Anaphragma hermitagensis	167 (16.1)	136 (19.2)	19 (9.7)	12 (9.0)	31 (9.4)
Mesotrypa angularis	94 (9.0)	71 (10.0)	13 (6.6)	10 (7.5)	23 (7.0)
Prasopora falesi	60 (5.8)	42 (5.9)	13 (6.6)	5 (3.7)	18 (5.4)
Tarphophragma ampla	35 (3.4)	28 (3.9)	6 (3.1)	—	7 (2.1)
Heterotrypa subtrentonensis	29 (2.8)	—	17 (8.7)	6 (4.5)	23 (7.0)
Tarphophragma multitabulata	14 (1.3)	—	5 (2.6)	4 (3.0)	9 (2.7)
Homotrypa minnesotensis	14 (1.3)	9 (2.7)	A	5 (3.7)	5 (1.5)
H. praenuntia var. *simplex*	10 (1.0)	—	—	4 (3.0)	4 (1.2)
Cyphotrypa acervulosa	10 (1.0)	—	—	4 (3.0)	4 (1.2)
Homotrypa subramosa	—	—	7 (3.6)	2 (1.5)	9 (2.7)
Homotrypa tabulata	—	A	6 (3.1)	A	6 (1.8)
Other species	94 (9.0)	59 (8.3)	23 (11.7)	12 (9.0)	35 (10.6)
Column Totals	1040	710	196	134	330



Text-figure 6.—Lateral relationships of Bryozoan Assemblages 1, 2, and 3 across the East-Central Tennessee study area. Positioning of the four measured sections approximately reflects their relative distances of geographic separation. Dotted lines separating Biostratigraphic Zones A, B, and C are suggested to represent time-equivalent horizons (see section on Biostratigraphic Utility of Bryozoan Distributions, p. 24).

1971, among others). Of the 48 species described (51 taxa including varieties), 20 occur within the Rockland and/or Hull Formations (lower half of the Trentonian Stage of Twenhofel *et al.*, 1954) with four species in common with the Hermitage of the present study area. These include *Tarphophragma multitabulata* (as *Hallopora multitabulata*), *Prasopora falesi* (as *Prasopora simulatrix* var. *orientalis*), *Hemiphragma ottawaensis*, and cf. *Homotrypa similis*. Thirty species are found within the interval spanned by the Rockland, Hull, and Sherman Falls Formations (lower three-fourths of Twenhofel *et al.*'s, 1954, Trentonian Stage) with five species common to the Hermitage of Tennessee (the four species directly above in addition to *Heterotrypa praenuntia* var. *echinata* as *Dekayella praenuntia* var. *echinata*). Of these five species, *Prasopora falesi* and *Tarphophragma multitabulata* also occur in the *Tarphophragma multitabulata* zone of Karklins (1984).

Ulrich (1893) noted the occurrences of many trepostome bryozoan species from the Trenton Shales (=

Table 7.—Relative abundances of common trepostome species found within Bryozoan Assemblage Three. See Table 5 for explanation of column headings and abbreviations used.

Species present	Total (ft) (m)	NL IV 93–117 (28.4–35.7)	CB 81–85 (24.7–25.9)	WB 38–44 (11.6–13.4)	HCM 18, 38–43 (5.5, 11.6–13.1)
Batostomella subgracilis	655 (29.9)	506 (37.2)	47 (26.2)	51 (36.0)	51 (13.3)
Bythopora dendrina	359 (16.4)	140 (10.3)	44 (24.6)	97 (19.0)	78 (20.4)
H. flabellaris var. *spinifera*	271 (12.4)	126 (9.3)	21 (11.7)	16 (5.9)	108 (28.1)
P. granda var. *inflata*	159 (7.3)	144 (10.6)	4 (2.2)	11 (4.1)	—
Parvohallopora granda	148 (6.7)	116 (8.5)	14 (7.8)	6 (2.2)	12 (3.1)
Homotrypa subramosa	64 (2.9)	—	5 (2.8)	32 (11.9)	22 (5.7)
Parvohallopora pulchella	59 (2.7)	30 (2.2)	2 (1.1)	9 (3.3)	18 (4.7)
Tarphophragma multitabulata	52 (2.4)	40 (2.9)	11 (6.1)	—	A
H. praenuntia var. *echinata*	33 (1.5)	20 (1.5)	5 (2.8)	8 (3.0)	A
Acantholaminatus typicus	33 (1.5)	—	A	7 (2.6)	21 (5.5)
Heterotrypa magnopora	31 (1.4)	17 (1.2)	3 (1.7)	—	10 (2.6)
Homotrypa tuberculata	26 (1.2)	—	2 (1.1)	A	21 (5.5)
Mesotrypa angularis	21 (1.0)	—	7 (3.9)	—	—
Other species	280 (12.8)	197 (14.5)	14 (7.8)	29 (10.8)	40 (10.4)
Column Totals	2191	1360	179	269	383

Table 8 Summary of relationships of Bryozoan Assemblages to lithotype, associated macrofossils, and environments of deposition. (E) Eastern Strike Belt (Norris Lake IV and Chamberlain Branch). (W) = Western Strike Belt (Wilson Branch and Howard Cemetery).

Bryozoan assembl	Dominant trepostome species		Dominant lithotype	Commonly associated macrofossils	Environment
I	*Bythopora dendrina*	30%	(E) Packstone (nearly Wackestone) with lesser cleaner Packstone	(E) *Dalmanella fertilis*	Intermediate Energy
	Eridotrypa mutabilis	11		Lesser:	
	Parvohallopora pulchella	10		*Rafinesquina hermitagensis*	(E) Moderately agitated open shelf
	Heterotrypa subtrentonensis	4		*Sowerbyella* sp.	
	Stigmatella distinctaspinosa	4		strophomenoids	
	Tarphophragma multitabulata	3	(W) Wackestone	pelmatozoan columnals	(W) Moderately quiet water
	Homotrypa flabellaris var. *spinifera*	3	No to little Argillaceous input	(W) *Rhynchotrema increbescens*	
	Mesotrypa angularis	3		pelmatozoan columnals	
	Parvohallopora granda	3		*Zygospira recurvirostra*	
II	*Bythopora dendrina*	31%	(E) Packstone	(E) *Dalmanella fertilis*	Hi-energy
	Eridotrypa mutabilis	17		*Rafinesquina hermitagensis*	
	Anaphragma hermitagensis	16	Argillaceous input variable (greater than Assemblage I; less than Assemblage III)	*Sowerbyella* sp.	–Current swept
	Mesotrypa angularis	9		*Dinorthis pectinella*	–Open marine
	Prasopora falesi	6			–Shallow shelf
	Tarphophragma ampla	3			
	Heterotrypa subtrentonensis	3			
III	*Batostomella subgracilis*	30%	(E) Packstone (nearly Wackestone) with lesser Wackestone (nearly Packstone)	(E) some *Dalmanella fertilis*	Low Energy
	Bythopora dendrina	16			
	Homotrypa flabellaris var. *spinifera*	12		(W) *Rhynchotrema increbescens* and pelmatozoan columnals (especially where argillaceous)	(E) Quiet water shelf with periodic moderate agitation
	Parvohallopora granda var. *inflata*	7			
	Parvohallopora granda	7	(W) Wackestone		
	Homotrypa subramosa	3	Moderate to High		
	Parvohallopora pulchella	3	Argillaceous Input		

the Decorah Shales of other authors), Galena Shales and Limestones (Trenton) of Minnesota and their presence in some time-equivalent strata from Kentucky, Tennessee, Iowa, Wisconsin, and Canada. These include *Prasopora falesi* (as *P. simulatrix* and *P. simulatrix* var. *orientalis*), *Peronopora mundula* (as *Homotrypella mundula*), *Homotrypa similis, Homotrypa tuberculata, Homotrypa subramosa, Homotrypa callosa, Homotrypa minnesotensis, Batostomella subgracilis,* (as *Homotrypella* (?) *subgracilis*), *Eridotrypa mutabilis, Cyphotrypa acervulosa* (as *Leptotrypa acervulosa*), *Heterotrypa praenuntia* var. *simplex* (as *Dekayella praenuntia* var. *simplex*), *Heterotrypa praenuntia* var. *echinata* (as *Dekayella praenuntia* var. *echinata*), *Hemiphragma ottawaensis,* (as *Hemiphragma ottawense*), *Parvohallopora pulchella* (as *Callopora pulchella*), *Tarphophragma ampla* (as *Callopora ampla*), and *Tarphophragma multitabulata* (as *Callopora multitabulata*). Though less restricted in scope compared with other authors, Ulrich's work is included here due to the presence of so many common species.

Five species found in the present study area are thought to have possibly originated in Blackriveran time. These include *Tarphophragma multitabulata* (= *Hallopora multitabulata*) of Fritz (1957) (Pamelia Beds of the Ottawa Formation of Canada), *Hemiphragma ottawaense* of Fritz (1957) (Pamelia Beds) and Foord (1883) (= *Batostoma ottawaense* from the Black River Formation of Canada), *Prasopora falesi* (= *P. simulatrix* var. *orientalis*) of Fritz (Pamelia Beds), *cf. Homotrypa similis* of Fritz, 1957 (Pamelia Beds), and possibly *Heterotrypa praenuntia* var. *echinata* (= *Dekayella praenuntia* var. *echinata*) of Loeblich (1942) (Bromide Formation of Oklahoma).

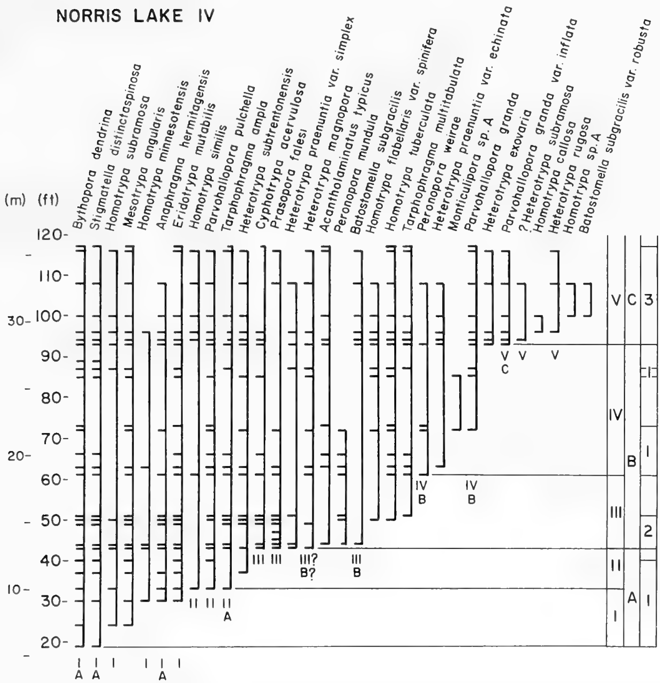
The 11 newly designated species and two new varieties described herein are suggested to be endemic to the study area. Nearly all of the remaining species are noted by Ulrich (1893) and other authors to first occur for the most part within the Trenton Shales (= Decorah Fm.), Galena Shales, lower Lexington Limestone, Rockland Formation, and Shales of the Trenton Group. Two of these species were formerly restricted to the Upper Ordovician (?*Heterotrypa subramosa* of Utgaard and Perry, 1964 and Ulrich, 1879, from the Richmondian of Indiana and Ohio; and *Homotrypa flabellaris* var. *spinifera* of Bassler, 1903 and Cumings, 1908, from the Cincinnatian). The lack of information as to the precise stratigraphic horizon of collection for previously described species as well as the absence of detailed conodont distributions for the Tennessee study area preclude any inferences as to the first temporal occurrences and hence speciation sites.

BIOSTRATIGRAPHIC UTILITY OF BRYOZOAN DISTRIBUTIONS FROM TENNESSEE STUDY AREA

The stratigraphic distribution of taxa between the two eastern sections, Norris Lake IV and Chamberlain Branch, is not dissimilar in relative order of appearance. Of 27 taxa in common to both sections, 20 have a similar order of stratigraphic appearance (the correlation coefficient for a bivariate plot comparing the first stratigraphic occurrences of these taxa is $r = 0.85$). If *Heterotrypa rugosa* is not taken into account (this species occurs at a single disproportionately high stratigraphic level at Chamberlain Branch compared to Norris Lake IV) the remaining 19 taxa have a correlation coefficient of $r = 0.96$ (see Sweet, 1984, for more information on the correlation method used herein). Some generalizations can be made concerning the overall stratigraphic sequence within these eastern sections. Each section (Norris Lake IV and Chamberlain Branch) is divided into five units (labelled I through V) whose boundaries are arbitrarily defined by the present author to be the most useful in correlation between the sections (Text-figs. 7–10).

Each unit (interval, zone) is composed of several diagnostic taxa (called "characteristic members") which make their initial stratigraphic appearances somewhere within the interval. Its lower boundary is defined as the lowermost appearance of any one taxon making up the unit, while the upper boundary is delineated by the lower boundary of the succeeding interval. Unit I, for example, is marked by the presence (at *each* of the two sections) of *Bythopora dendrina, Stigmatella distinctaspinosa, Homotrypa subramosa, Eridotrypa mutabilis, Anaphragma hermitagensis* and *Homotrypa minnesotensis.* This unit is followed by one (Unit II) defined by the first appearances of *Homotrypa similis, Parvohallopora pulchella,* and *Tarphophragma ampla.* Unit III follows with *Prasopora falesi, Batostomella subgracilis, Cyphotrypa acervulosa,* and possibly *Heterotrypa magnopora* (this latter species actually occurs in uppermost Unit II at Chamberlain Branch but occupies a position at the Unit II–III boundary at the other three study localities). Unit IV contains the first appearances of *Peronopora weirae* and *Parvohallopora granda.* Unit V is denoted by the occurrences of *Parvohallopora granda* var. *inflata,* ?*Heterotrypa subramosa,* and *Heterotrypa rugosa.*

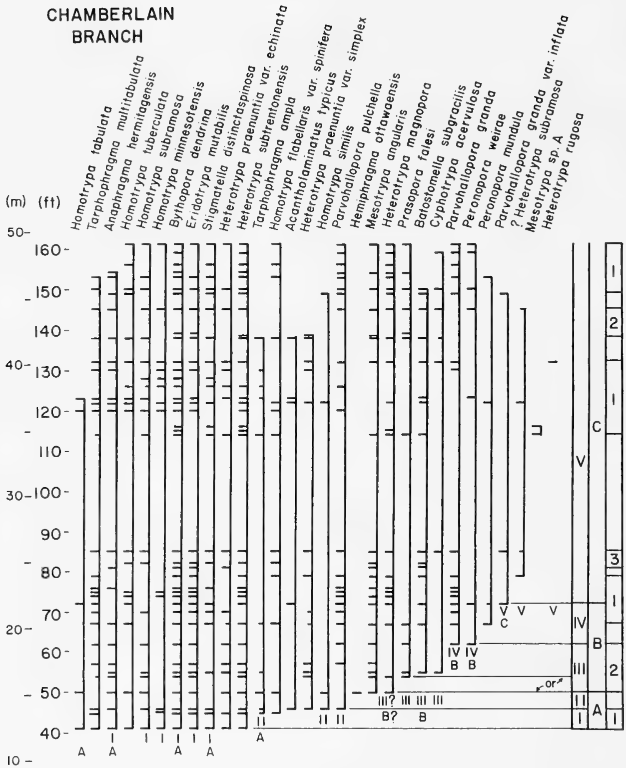
Since in most cases, ranges of individual taxa span over half the section and commonly terminate near the top of the section (see especially Norris Lake IV, Text-fig. 7), the development of range zones or concurrent range zones to create a refined biostratigraphy is prohibited. Units I through IV are, in a sense, assemblage zones with the appearances of new taxa in each zone



Text-figure 7.—Range chart of trepostome bryozoan species occurring at the Norris Lake IV Section and the relationship of this distribution to boundaries of Bryozoan Assemblages 1, 2 and 3 and Biostratigraphic Units I–V and A–C. Distributions of individual species are arranged according to their stratigraphic first appearances. The numbers along the y-axis indicate the number of feet (and meters) above the base of the measured section from which the specimens were collected. See section on Stratigraphic Collection Levels (p. 8) as well as section on Trepostome Bryozoan Assemblages (p. 13) for more precise stratigraphic information. A large slash to the left of the vertical range line indicates species presence. A shorter slash to the left represents an uncertain species presence. Roman numerals I–V indicate five correlatable biostratigraphic intervals within the two Eastern sections. Letters A–C are units correlatable among the Eastern and Western strike belt sections. A Roman numeral and/or capital letter found directly below an individual species range indicates its presence as a characteristic member of that particular biostratigraphic unit.

being added to a cooccurring faunal group which persists stratigraphically from the unit directly below.

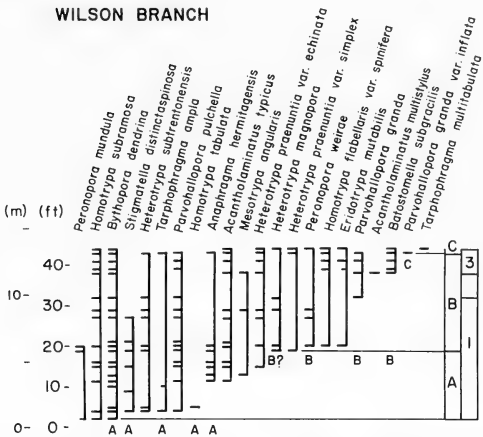
Within Sequatchie Valley to the west (Howard Cemetery and Wilson Branch sections), the delineation of intervals or zones is not nearly as apparent as they are to the east at Norris Lake IV and Chamberlain Branch due largely to the more inconsistent display of initial appearances between sections for any one taxon. The recognition of two and possibly three units (labelled A, B, and C) are designated at Howard Cemetery and Wilson Branch which are consistent with zonations assigned within eastern sections (where A = Unit I and II, B = Units III and IV, and C = Unit V). Within the *entire* study area, then, Unit A is recognized by the initial appearance and cooccurrence of the characteristic members *Bythopora dendrina, Stigmatella distinctaspinosa, Anaphragma hermitagensis, Homotrypa tabulata* (all four within Unit I to the east, the latter



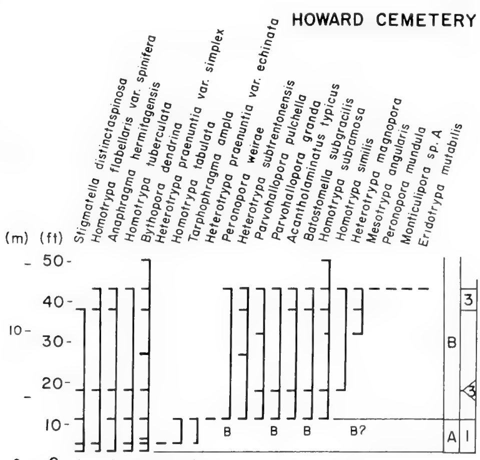
Text-figure 8. –Range chart of trepostome bryozoan species occurring at the Chamberlain Branch and the relationship of this distribution to boundaries of Bryozoan Assemblages 1, 2 and 3 and Biostratigraphic Units I–V and A–C. See Text-figure 7 for further explanation of symbols used.

species only occurring at Chamberlain Branch), and *Tarphophragma ampla* (within Unit II to the east) exclusive of species appearing for the first time higher in the section (defining Units B and C). Unit B is marked by the initial appearances of *Batostomella subgracilis, Parvohallopora granda, Peronopora weirae,* and possibly *Heterotrypa magnopora* (occurs in uppermost Unit A at Chamberlain Branch, but in Unit B at all other sections). *Parvohallopora granda* var. *inflata* is found in the uppermost strata at Wilson Branch and is the only representative of Unit V to occur to the west and hence is assigned to Unit C in order to point out this position high in each section. These species defining Units A–C are the basis for forming what is believed to be the best defined and consistently developed correlatable units presently available among *all* sections of the study area.

Inconsistencies in the relative distributions of taxa among the study localities are possibly due in part to the vagaries of sampling (*e.g.,* differences in sample



Text-figure 9.—Range chart of trepostome bryozoan species occurring at the Wilson Branch and the relationship of this distribution to boundaries of Bryozoan Assemblages 1, 2, and 3 and Biostratigraphic Units I–V and A–C. See Text-figure 7 for further explanation of symbols used.



Text-figure 10.—Range chart of trepostome bryozoan species occurring at the Howard Cemetery and the relationship of this distribution to boundaries of Bryozoan Assemblages 1, 2, and 3 and Biostratigraphic Units I–V and A–C. See Text-figure 7 for further explanation of symbols used.

size, or sampling only limited portions of the ancient sea bottom), the local absence of species both geographically and stratigraphically, and the effects of local facies on species presence and/or abundance (*i.e.*, appearances which are ecologically controlled). Consequently, the relative stratigraphic distributions for taxa found in outcrops of limited thicknesses, such as those examined in this report, are not unexpectedly somewhat variable. Therefore the subdivisions of the stratigraphic display into more numerous correlatable subunits than presented herein is prohibited.

It is notable, particularly at Norris Lake IV (Text-fig. 7), that the boundaries of several biostratigraphic units are correlatable with the appearances of particular bryozoan assemblages (which themselves are possibly tied in to local facies; see sections on Environmental Interpretations of Bryozoan Assemblages, pp. 13–15). Units I and II are largely coincident with Bryozoan Assemblage One. The lower boundary of Bryozoan Assemblage Two coincides with the appearance of Unit III, and Bryozoan Assemblage Three is stratigraphically equivalent to Unit V. In general, for all sections in the study area, species defining the lower boundaries of biostratigraphic zones are very minor constituents (<2%) of their associated assemblages. For example, the base of Unit IV is coincident with the reappearance of Bryozoan Assemblage One. Defining the base of Unit IV in the eastern sections are the initial stratigraphic appearances of *Peronopora weirae* and *Parvohallopora granda*. Each occurs in abundances of less than two percent reflecting only minor taxa added to the more common taxonomic components of Bryozoan Assemblage One found lower in the section. Elsewhere, due in large part to the compact distribution of Units A and B (Units I through IV) over a much thinner stratigraphic sequence, the relationship of biostratigraphic borders to bryozoan assemblage boundaries is less clear.

McKinney (1971a, p. 195), studying the distribution of trepostome bryozoans within about a 200 ft (61 m) interval of the lower Chickamauga Group in Alabama, concluded that "although occurrences and relative abundances of trepostomes have a recognizable vertical zonation, the zonation may be due as much or more to facies control as to sequential evolutionary development." The majority of his trepostome species, however, appear in two or more of his three major lithologic units, with abundance changes in individual taxa being a notable characteristic across lithic unit boundaries. It is noteworthy that in the present study area, in almost all instances, once a species appears in a section, it persists stratigraphically through the overlying bryozoan assemblages and the associated array of heterogeneous carbonate lithologies (though its relative abundance may vary). This is an important point when considering the control of lithofacies on the biostratigraphic display for it suggests a certain robustness of bryozoan taxa for purposes of correlation.

CONCLUSIONS

(1) The trepostome bryozoan fauna forms a numerically dominant fossil group in the Hermitage Formation of East-Central Tennessee. Here it is composed of 36 species-group taxa (encompassing 17 genera and 33 species (including 5 varieties).

(2) One new genus, 11 new species, and two new varieties are designated. The new genus, *Acantholaminatus,* consists of two species—*A. typicus* and *A. multistylus.* Other new species include *Parvohallopora granda, Anaphragma hermitagensis, Peronopora weirae, Heterotrypa magnopora, H. subtrentonensis, H. exovaria, H. rugosa, Stigmatella distinctaspinosa,* and *Homotrypa tabulata.* New varieties include *Batostomella subgracilis* var. *robusta* and *Parvohallopora granda* var. *inflata.*

Taxa previously described and found within the present study area include *Bythopora dendrina, Batostomella subgracilis, Prasopora falesi, Eridotrypa mutabilis, Mesotrypa angularis, Parvohallopora pulchella, Homotrypa minnesotensis, H. flabellaris* var. *spinifera, H. subramosa, H. callosa, H. similis, H. tuberculata,* ?*Heterotrypa subramosa, Heterotrypa praenuntia* var. *simplex, H. praenuntia* var. *echinata, Cyphotrypa acervulosa, Peronopora mundula, Tarphophragma ampla, T. multitabulata,* and *Hemiphragma ottawaensis.*

Three species were not assigned a trivial name and are identified herein as *Monticulipora* sp. A, *Homotrypa* sp. A, and *Mesotrypa* sp. A.

(3) Of the bryozoan taxa previously described, three or possibly four are known to have originated in the Blackriveran Stage. Other species first appeared in the lowermost Trenton but determination as to their precise stratigraphic first occurrences (as compared to the Hermitage and each other) are not yet determinable based on the detail of current biostratigraphic relationships and/or published locality information. For two species, the present study documents their lowest occurrence in the stratigraphic record, having previously been restricted to the Upper Ordovician.

(4) The Hermitage Formation has several trepostome taxa whose morphological limits are most difficult to discern due to the presence of nearly continuous gradations in character states. For example, the varieties *Parvohallopora granda* var. *inflata* and *Batostomella subgracilis* var. *robusta* differ from the non-varietal forms primarily in the development of the exozone (*e.g.*, length of the exozone, and wall thickness)

and raise questions as to possible environmental effects on the phenotype. Criteria employed to delimit morphological boundaries between taxa of some species-couplets (*e.g.*, *Tarphophragma ampla* → *Tarphophragma multitabulata*; *Bythopora dendrina* → *Batostomella subgracilis*; *Parvohallopora pulchella* → *Parvohallopora granda*) are often subtle because the range in morphologies between taxa of each couplet is largely a continuous gradient in zoarial form.

Other questions concerning phenotypic variability are illustrated by such species as *Homotrypa flabellaris* var. *spinifera* whose specimens in the present study area express only a limited portion of the morphologic variability exhibited elsewhere for this taxon.

(5) Groups of numerically dominant trepostome species were observed to occur in time and space and have been referred to herein as Bryozoan Assemblages One, Two, and Three. For sections throughout the study area as a whole, Assemblage One is characterized by *Bythopora dendrina* (39% of the trepostome colonies present in the assemblage), *Eridotrypa mutabilis* (11%), *Parvohallopora pulchella* (10%), *Heterotrypa subtrentonensis* (4%), *Stigmatella distinctaspinosa* (4%), *Tarphophragma multitabulata* (3%), and *Homotrypa flabellaris* var. *spinifera* (3%). Assemblage Two is composed of *Bythopora dendrina* (31%), *Eridotrypa mutabilis* (17%), *Anaphragma hermitagensis* (16%), *Mesotrypa angularis* (9%), *Prasopora falesi* (6%), and *Tarphophragma ampla* (3%). Assemblage Three is made up of *Batostomella subgracilis* (30%), *Bythopora dendrina* (16%), *Homotrypa flabellaris* var. *spinifera* (12%), *Parvohallopora granda* var. *inflata* (7%), and *Parvohallopora granda* (7%). Other species occur as less than 3%.

(6) Assemblage One is associated with a moderately agitated shelf environment to the east at the Norris Lake and Chamberlain Branch sections as suggested by the presence of packstones, large allochems, and scattered coquinite beds. To the west, wackestones with minor packstone interbeds indicate a somewhat quieter setting with intermittent turbulence. Assemblage Two is found only within the two eastern sections. It represents the highest energy environment (also open marine shallow shelf) found in the study area, being predominantly composed of packstones with some cross-bedding, size-sorted shelly beds and the most massive trepostome zoaria. Assemblage Three, present in all four sections, contains large amounts of relatively argillaceous muddy wackestones and is considered herein to have occupied the lowest energy environment of the study area. Pulses of moderate agitation in the eastern sections are suggested by the periodic appearance of a packstone fabric.

(7) A biostratigraphic comparison of the species contained in the Hermitage Formation with other Middle Ordovician assemblages from Kentucky, New York, and the Upper Mississippi Valley shows a relatively close similarity in species composition to Karklins' (1984) trepostome fauna of the lower 150 feet (45.7 m) of the Lexington Limestone (especially in the two eastern sections at Norris Lake and Chamberlain Branch) suggesting an equivalence of the Hermitage Formation to part of his *Tarphophragma multitabulata* Zone of Kirkfieldian to early Shermanian age.

(8) Biostratigraphic subdivisions within the Hermitage of the present study area are based on the first appearances of selected diagnostic species and their co-occurrences within a stratigraphic interval exclusive of species characteristic of the succeeding overlying zones. This allows the Hermitage to be divided into three loosely defined biostratigraphic zones (five zones within the eastern sections), the boundaries of which are possibly influenced by subtle variations of local lithofacies.

INTRODUCTION TO SYSTEMATIC PALEONTOLOGY

TAXONOMIC CONSIDERATIONS

A trepostome bryozoan colony consists primarily of a number of physically connected, asexually budded zooids and extrazooidal and multizooidal parts (the latter two are parts of colonies grown outside of zooidal boundaries). Only the initially formed zooid (or zooids) of the colony are sexually produced. The genotype within any one colony, then, is principally the same for each zooid. Any morphologic variation within the colony can be ascribed to four components of morphologic variability (Boardman *et al.*, 1970). These are (1) Astogeny, or changes associated with the development in the sequence of asexual generations of zooids and extrazooecial parts (parts such as acanthostyles, grown outside of zooecial boundaries), (2) Ontogeny, or changes associated with the development of individual zooecia, (3) Polymorphism, or distinct and discontinuous morphologic variations among zooids of any one colony at equivalent growth stages, and (4) Microenvironmental effects, or phenotypic variability within portions of a colony.

Assuming, then, that the above sources of morphologic variability can be identified within each colony, the remaining variability among colonies of any population should presumably reflect true genotypic differences among species members, and possibly any colony-wide phenotypic effects which can often be difficult to detect. Theoretically, the presence of such colony-wide effects may be inferred if the same type of morphologic variation is found elsewhere, in other colonies, as microenvironmental (portion of colony) differences, or if the variation in character state closely covaries with presumed environmental changes (gradients) (though they may be genetic; see, for example, Schopf and Dutton, 1976, who associated the clinal variation in avicularium size in a modern cheilostome bryozoan species with true genetic differences and not a covarying temperature gradient).

Within the systematic descriptions of trepostome bryozoans and tables of quantitative data herein, attempts have been made to include in the identification of each species those independent characters (character states not partly determined by states of other characters) that presumably reflect genetic and not environmental control (see Boardman *et al.*, 1983, for a more comprehensive review of genetic and environmental control as well as approaches to taxonomic characters in bryozoans). These particularly include features grown within the inner epidermis and protected by the body cavity from their immediate surroundings as compared to colony parts secreted by the external body wall such as the colony base (free-walled or double-walled stenolaemate Bryozoa of Borg, 1926). These will not only serve to truly characterize the species under examination, but also serve to increase the evolutionary faithfulness of any biologic classification.

Independent characters used in the present study from which data have been tabulated include such measurements as autozooecial cavity diameter within non-macular and macular (= polymorphic) areas, acanthostyle diameter, and mesozooecial cavity diameter (see section on Key to Abbreviations Used (p. 33) for additional characters). Another common quantitative measurement generally accepted by workers and also used in the present study is the number of zooecia per square mm. In and of itself, this character is a non-independent one since it reflects the variation of two independent characters, namely autozooecial size as well as wall thickness. If it is taken to indicate the relative spacing of zooecia, however, it might then be considered to reflect an independent taxonomic character (Boardman, 1983). Qualitative descriptions include a host of characters (see the section on Description Format; p. 32) such as shape of autozooecial aperture, wall microstructure, type of intrazooecial partition (*e.g.*, cystiphragm, diaphragm), and presence of polymorphs and extrazooecial parts (*e.g.*, mesozooecia and acanthostyles, respectively). A taxonomic character involving more than one zooecium would be the geometric configuration of endozone zooecia. This budding pattern appears to be quite regular within many individual species, suggesting a relatively high degree of genetic control (McKinney, 1977; Boardman, 1983). All of the above characters have been commonly used or are increasingly being used as standard taxonomic characters having evolutionary significance by bryozoan workers in the delineation of their individual species.

Certain characters used in descriptions of trepostome species are commonly considered by workers to be relatively variable within colonies (*i.e.*, generally more susceptible to short-time environmental effects). These include such features as diaphragm spacing, wall thickness, and diaphragm thickness since they are particularly sensitive to variations in colony growth rate (either microenvironmmentally or colony-wide). These, however, are valid taxonomic characters, since the limits within which the states of a character can express direct environmental modification are assumed to be genetically controlled (Boardman, 1983).

GLOSSARY OF TERMS USED IN MORPHOLOGIC DESCRIPTIONS

ACANTHOPORE—Synonym of acanthostyle.

ACANTHOSTYLE—Calcitic structure usually found between and parallel to zooecia and consisting of a clear non-laminated rod with surrounding concentric laminar sheaths that deflect zooecially inwards forming a cone-in-cone structure.

AMALGAMATE WALL STRUCTURE—See comments under Zooecial Boundary.

ASTOGENETIC CHANGES—Changes in morphology of a colony associated with asexual budding of new zooecia (rather than variation associated with the development of a single zooid).

AUTOZOOECIUM—The most common type of zooecium found in trepostomes, considered to be the skeletal part of normal feeding zooid.

AXIAL REGION—Zone encompassed within endozone.

AXIAL DIAPHRAGMS—Diaphragms present within endozone.

CRENULATE WALLS—Walls that are extremely irregular along their length.

CYSTIPHRAGM—Distinctly cystose skeletal partition formed by convex-outwards extension from zooecial wall into adjacent zooecial cavity with reattachment of recurved surface zooecially inwards to a subjacent diaphragm, another cystiphragm, or same zooecial wall. Cystiphragm will partly or entirely wrap around the periphery of zooecial chamber.

CYSTOSE (CYSTOIDAL) DIAPHRAGM—A diaphragm curved slightly convex outwards, extending only part way across zooecial tube and in contact with a lower diaphragm.

DIAPHRAGM—Skeletal partition extending across a zooecial (autozooecial or mesozooecial) cavity. It can be flat, curved convex zooecially inwards or outwards, or wavy. In addition, it can be perpendicular (transverse) to zooecial walls, or inclined (oblique).

DIAPHRAGM-WALL UNIT—A distinct skeletal unit consisting of a diaphragm and continuous part of the wall laminae, the latter which merges into the main portion of the zooecial wall after a short distance.

DISTAL DIRECTION—Principal growth direction of a colony away from founding zooid(s).

ENCRUSTING COLONY—Colony whereby all or most zooecia are attached to a foreign object by their basal walls forming a continuous encrusting skeleton adhering to the substrate.

ENDACANTHOPORE—Synonym of endacanthostyle.

ENDACANTHOSTYLE—An acanthostyle found in the endozone.

ENDOSTYLE—Synonym of acanthostyle.

ENDOZONE—Aggregation of inner zooecial tubes found parallel or nearly so to zoarial axis (or distal growth direction) in branches of ramose forms and are zooecially proximal (basal) in encrusting forms. Walls are characteristically thin, diaphragms, cystiphragms and other associated skeletal parts are usually absent or rare.

ENDOZONAL/EXOZONAL TRANSITION—The area along a zooecial tube whereby endozonal skeletal parts begin to attain those features most closely associated with the exozone. These generally include thickening of zooecial walls, an accelerated bending of tubes from an orientation more closely parallel to colony growth direction to one more closely perpendicular to colony surface and colony growth direction, and the acquisition of increased intrazooecial hard parts.

EVEN-SIDED WALLS—Zooecial walls whose sides are straight (planar), and parallel.

EXOZONE—Outer parts of zooecia that extend from the colony surface to the endozonal/exozonal transition. Intersection with colony surface (surface angle) is commonly at or nearly at 90° but sometimes is less. Walls are thicker than for endozone, and intrazooecial skeletal parts, primarily diaphragms, are nearly always present. Most mesozooecia and acanthostyles are similarly associated with the exozone.

GRANULAR WALL STRUCTURE—Wall structure that is not defined by laminae, but instead is apparently structureless and amorphous (but still appears translucent rather than transparent or clear).

GROWTH SURFACE—That part of the outermost (i.e. external) zoarial surface presumed to be undergoing growth (due to secretion of skeletal material by soft parts) at any particular instant in the astogenetic development of the colony.

HEMIPHRAGM—Shelflike projection extending perpendicularly from zooecial wall into chamber.

IMMATURE REGION—Synonym for endozone.

INCLINED DIAPHRAGM—Diaphragm not perpendicular to zooecial axis.

INCOMPLETE DIAPHRAGM—An inclined, relatively flat, diaphragm extending only part way across zooecial tube and in contact with a lower diaphragm.

INFLECTING ACANTHOSTYLE—Acanthostyle whose laminar sheath inflects into surounding zooecial cavity (i.e., reverses the convexity of the zooecial cavity outline). Some inflecting styles are offset.

INTEGRATE WALL STRUCTURE—See comments under Zooecial Boundary.

IRREGULAR WALLS—Zooecial walls that are not straight, but are wavy along their length.

LAMINAR SHEATH—Part of acanthostyle consisting of concentric laminae in a cone-in-cone structure pointed towards colony surface and surrounding a centrally located non-laminated clear calcite core (=lumen).

LONGITUDINAL SECTION—Section cut through colony which is parallel to zooecial axes, that is, parallel to the growth direction of individual zooecia.

LUMEN—Clear, non-laminated calcitic rod of an acanthostyle.

MACULAE—Clusters on zoarial surface consisting of varying combinations of zooecial polymorphs (megazooecia, mesozooecia), autozooecia, extrazooidal skeletal material (including acanthostyles), and thickened zooecial walls. Maculae commonly form protuberances raised above colony surface (monticules of some authors), sometimes flush with surface, or depressed.

MASSIVE COLONY—Colony of irregular shape. As for encrusting colonies, some zooecia bud from basal walls, as for ramose colonies, some zooecia bud from vertical walls of surrounding zooids.

MATURE REGION—Synonym for exozone.

MEDIAN LAYER—In some bryozoans, a distinctive colony wall parallel to zoarial growth direction from which zooids bud on either side forming a bifoliate pattern. Common in some species of *Peronopora.*

MEGAZOOECIA—Zooecia distinctively larger than surrounding autozooecia. Found commonly in maculae and within the inner endozone of some species.

MESOPORES—Synonym of Mesozooecia.

MESOZOOECIA—Polymorphic zooecial parts nearly always found in the exozone, parallel to and of generally smaller diameter than surrounding autozooecia, closely tabulated throughout, and with diaphragms commonly thicker than for autozooecia (= mesopores of some authors).

MONILIFORM—Zooecial walls found in the endozone that periodically split and rejoin to form one or more hollow beads along their lengths.

MONTICULES—See definition of Maculae.

MURAL LACUNAE—Small equidimensional irregularities or spaces in skeletal laminae. They often appear as faint "acanthostyle-like" markings seen especially well in tangential sections.

OFFSET ACANTHOSTYLE—Acanthostyle whose position between adjacent zooecia is non-symmetrical. Some offset acanthostyles will inflect.

ONTOGENETIC CHANGES—Changes associated with the development of individual zooids (and extrazooidal parts such as styles). Ontogenetic variation within a colony, then, is the sum total variation associated with developmental states of multitudinous individual zooids.

OVERLAPPING DIAPHRAGM—Synonym of Incomplete Diaphragm.

PETALOID ARRANGEMENT—A term commonly used in describing the petal-like arrangement of autozooecia around a centrally located acanthostyle.

POLYMORPHISM—Distinctive variation in morphology among zooecia of a single colony at the same developmental stage (e.g. mesozooecia and megazooecia).

PROXIMAL DIRECTION—Opposite to distal, direction towards founding zooid(s) of a colony.

RAMOSE COLONY—Colony with distinct branches, usually circular (in trepostomes) in transverse section, with nearly all zooecia formed by budding from vertical walls of other zooids.

STYLE—Synonym of acanthostyle.

SURFACE ANGLE—The angle at which zooecia intersect the colony surface.

TANGENTIAL SECTION—Section cut parallel to and just below the colony surface. In this type of section, autozooecia, mesozooecia, and acanthostyles will usually be cut transversely or nearly so (if they are inclined) to their axes (or growth directions).

TRANSVERSE SECTION—Section cut transverse to growth direction of zoarium (entire colony). In a section of this type, endozonal zooecia will be cut normal to their axes (growth direction).

U-SHAPED WALL LAMINAE—As viewed in longitudinal section, concentrically overlapping smoothly curving laminae oriented convex outwards in the direction of the colony surface and composed of the adjoining ends of contiguous zooecial walls (see also, Zooecial Boundary).

V-SHAPED WALL LAMINAE—As viewed in longitudinal section, concentrically overlapping cone-shaped laminae oriented with apices pointed outwards in the direction of the colony surface. Apices mark the contact of zooecial walls from contiguous zooecia (see also, Zooecial Boundary).

ZOARIUM—Skeleton of bryozoan colony.

ZOOECIAL BEND—A distinctive bend in a zooecium toward the colony surface and found generally at the endozonal/exozonal transition or in the lower exozone.

ZOOECIAL BOUNDARY—Vertical partition between adjacent zooecia marking the abutment of the respective contiguous zooecial walls. In some cases, laminae from each zooecium join to form smooth, evenly curved, seemingly continuous laminae (U-shaped) convex in the direction of zooecial growth ("amalgamate wall" of some authors). In other cases, abutment is readily observable as an apparent distinctive bend (V-shaped), which often then appears as a dark central line dividing the middle of the interzooecial wall ("integrate wall" structure of some authors).

ZOOECIAL CAVITY (CHAMBER, TUBE)—Void associated with zooecial skeleton occupied, or once occupied, by zooid.

ZOOECIALLY INWARDS—Within a zooecium, the direction away from colony surface and towards point of initial budding.

ZOOECIALLY OUTWARDS—Within a zooecium, the direction towards colony surface.

ZOOECIAL WALL—Skeletal wall of zooid.

ZOOECIUM—The skeletal part of a zoarium that houses a zooid (and previous generations of each zooid beginning with its inception through asexual reproduction).

ZOOIDS—Basic soft-part morphologic units of a colony. Each is asexually budded, regenerative, physically connected, and responsible for secretion of a skeletal zooecium. Zooids are very rarely preserved in the fossil record.

DESCRIPTION FORMAT

I. COLONY
   A. Zoarial Growth Habit (*e.g.,* Ramose, Encrusting, Frondose, Massive, Bilaminate, etc.)
   B. Budding Origin (*e.g.,* New zooecia initiated in outer endozone; secondarily in zone of zooecial bend)

II. ZOOECIA
   A. Zooecial shape in transverse section (of zooecial cavity outline and zooecial boundary in exozone and endozone)

B. Zooecial curvature from endozone to exozone (including zooecial bend)
C. Surface angle
D. Zooecial wall thickness—endozone and exozone (*e.g.*, abrupt thickening in early exozone; maximum thickness in outer exozone); zooecial boundary (wall) microstructure in endozone and exozone
E. Endozonal wall orientation (even; irregular; crenulate; parallel-sided); arrangement (*e.g.*, megazooecia in center of endozone)
F. Diaphragms
  (i) Orientation (*e.g.*, planar, inclined, convex, concave, cystose, incomplete)
  (ii) Thickness variation
  (iii) Spatial variation (*e.g.*, inequidistantly spaced, uniformly placed, etc.)
G. Cystiphragms
  (i) Orientation (e.g., proximal or distal side of zooecia)
  (ii) Relationship to other cystiphragms and diaphragms

III. MESOZOOECIA
A. Point of origin and termination
B. Cavity outline in tangential section
C. Longitudinal section shape (*e.g.*, moniliform)
D. Diaphragms (orientation, thickness, spatial distribution)
E. Relative arrangement
F. Turn into autozooecia (or vice-versa)?

IV. ACANTHOSTYLES
A. Point of origin and termination
B. Size variation (of lumen and laminar sheaths)
C. Configuration with respect to autozooecia and mesozooecia

V. MACULAE
A. Spacing
B. Arrangement of zooecia, megazooecia, mesozooecia, acanthostyles, cystiphragms, etc.)
C. Presence as a surficial feature (raised, flat, depressed)
D. Other variations distinctive to maculae (encompassing variables noted above)—zooecial shapes, wall thicknesses, variations in diaphragms and cystiphragms, etc.

KEY TO ABBREVIATIONS USED IN TABLES OF QUANTITATIVE DATA

ZCD .... Zooecial cavity diameter (autozooecium)
MxZCD .... Maximum zoocial cavity diameter (autozooecium)
MnZCD .... Minimum zoocial cavity diameter (autozooecium)
(mac) ...... Within macular region of a colony
(non-mac) .. Within non-macular region of a colony
ZWT .... Zooecial wall thickness (autozooecium)
Z/mm^2 ..... Zooecia per square millimeter (zooecium counted if more than half its area is within the square millimeter)
MCD ...... Mesozooecial cavity diameter
MxMCD ... Maximum mesozooecial cavity diameter
MnMCD ... Minimum mesozooecial cavity diameter
ht .... For mesozooecia whose shape approximates an equilateral triangle, "ht" is the height of the triangle
wth .... For mesozooecia whose shape approximates an equilateral triangle, "wth" is the length of the line connecting the midpoint of any two sides
AD .... Acanthostyle diameter
ED .... Endacanthostyle diameter
lam .... Laminar portion of acanthostyle
lum .... Core or lumen of acanthostyle
(mat) .... Within the mature region of a colony
(non-mat) ... Within the non-mature region of a colony
CD .... Colony diameter (branch diameter)
endo .... (measured) within the endozone
exo .... (measured) within the exozone
long .... (measured) within the longitudinal section
SD .... Standard deviation of a particular measurement
No.Meas. ... Number of measurements made within a particular colony
No.Spec. ... Number of specimens (colonies) of any one species

All measurements are in millimeters.

In some lists of material examined, the following abbreviations are used: e = encrusting habit; r = ramose habit.

SYSTEMATIC PALEONTOLOGY

Phylum **BRYOZOA** Ehrenberg, 1831

Class **STENOLAEMATA** Borg, 1926

Order **TREPOSTOMATA** Ulrich, 1882

Family **MONTICULIPORIDAE** Nicholson, 1881

Genus **PRASOPORA** Nicholson and Etheridge, 1877

Type species.—Prasopora grayae Nicholson and Etheridge, 1877, p. 44–48.

Prasopora falesi (James, 1884)
Plate 1, Figures 1–2

Monticulipora falesi James, 1884, p. 138, pl. 7, figs. 2–2d.
Prasopora simulatrix Ulrich, 1886, p. 85; Ulrich, 1893, p. 245–248, pl. 16, figs. 1–10; Ross, 1967a, p. 412–414, pl. 46, figs. 1, 2, 3, pl. 47, figs. 1, 3–5, pl. 49, figs. 5, 7, 9, pl. 50, figs. 1, 2.
Prasopora simulatrix var. *orientalis* Ulrich, 1893, p. 246, pl. 16, figs. 1, 2, 6, 7; Fritz, 1957, p. 34–35, pl. 28, figs. 2, 3; Perry, 1962, p. 17–18, pl. 3, figs. 7, 8.
Prasopora falesi (James). Bassler, 1906, p. 48, pl. 1, figs. 1–4; McFarlan, 1931, p. 95, pl. 2, figs. 11–12; Brown, 1965, p. 985–986, pl. 112, figs. 3, 5–7; Marintsch, 1981, p. 957, pls. 1, 2; Karklins, 1984, p. 142-145, pls. 13, 14.

Description.—Zoarial form varies from low discoidal to hemispherical. Zooecial cavity outlines rounded to subrounded. Each zooecium generally surrounded by and usually in contact with six others. Zooecia intersect colony surface at right angles. Walls thin and granular, even sided and parallel. In outermost portions of colony, or within colony along certain irregularly spaced colony-wide growth surfaces, walls thicken slightly and become laminar (cyclic rejuvenation). Diaphragms present throughout zoarium and thin, fairly evenly spaced at one-half to one zooecial cavity diameter apart, subparallel and normal to zooecial walls, but some inclined and/or overlapping in places. Individual diaphragms commonly in contact with adjacent cystiphragms and zooecial wall; however, some attached to wall alone where cystiphragm lacking. Cystiphragms thin and continuously overlapping throughout most of zooecial lengths. Cystiphragms generally project halfway to slightly greater into the zooecial cavity in section though some extend considerably further. Cystiphragm shape is semi-circular to semi-elliptical in longitudinal section. Newly formed cystiphragms usually overlap one-third to one-half of the one previously formed as measured parallel to the zooidal axis. Overlapping cystiphragms locally found without associated diaphragms over short segments of some zooecia. In tangential section, cystiphragms wrap around two-thirds to three-fourths of the zooecial perimeter. Mesozooecia common throughout colony. Polygonal to subrounded cavity outlines. Diaphragms within mesozooecia evenly spaced, closely tabulated and slightly thicker than in autozooecia. Walls between diaphragms sometimes slightly convex outwards. Generally, each of the six interzooecial voids surrounding any single zooecium is filled with at least one mesozooecium. Along its length, a mesozooecium occasionally develops into an autozooecium and vice-versa. Acanthostyles scattered throughout colony in those portions where thin, granular walls periodically thicken and become laminar. Maculae present with megazooecia. Zooecia not necessarily contiguous, the space between them being filled by mesozooecia which are generally more common than in non-macular areas. On occasion, entire zooecium completely isolated by mesozooecia. Maculae generally spaced about 4.0 to 4.5 mm from each other (measured between macular peripheries).

Measurements.—Measurements are summarized in Table 9.

Remarks.—*Prasopora falesi* is characterized by rounded to subrounded cavity outlines of zooecia which are generally surrounded by six contiguous zooecia, the interzooecial voids of which are usually filled with closely tabulated mesozooecia, more common mesozooecia and not necessarily contiguous autozooecia in macular areas, continuously overlapping cystiphragms which in longitudinal section are observed to be semi-circular to semi-elliptical, generally project halfway to slightly greater into zooecial tube, overlap one-third to one half of previously formed cystiphragms and in tangential section wrap around two-thirds to three-fourths of a zooecial perimeter, diaphragms spaced at one-half to one zooecial cavity diameter apart and commonly in contact with adjacent cystiphragms, and acanthostyles that are scattered throughout colony where wall laminae thickened.

Ulrich (1893) considered *Prasopora simulatrix* to have no acanthostyles. Specimens with morphologies comparable to *P. simulatrix* but possessing acanthostyles were assigned to *P. falesi* by several authors. Marintsch (1981) reexamined type material of *P. simulatrix* and found acanthostyles. Accordingly, this species is considered here to be a junior subjective synonym of *P. falesi.*

Bork and Perry (1967) describe *Prasopora simulatrix* from the Champlainian of Illinois, Iowa, and Wisconsin. Their specimens were noted to contain no acanthostyles. Consequently, they are not considered to represent *P. falesi.* Sparling (1964), in describing an occurrence of *Prasopora simulatrix* from Michigan, noted a similar lack of acanthostyles.

Distribution.—Localities NL IV, CB.

Studied material.—Hypotypes NL IV 45(80)A (M) [USNM 431717], NL IV 45(80)B (M) [USNM 431718], NL IV 47(82)D (M) [USNM 431719], NL IV 49(84)A-3L-Z (M) [USNM 431720], NL IV 49(84)A-7R-D (M) [USNM 431721], NL IV 49(84)A-7R-I [USNM 431722], NL IV 49(84)A-5R-B [USNM 431723], NL IV 51(86)A-11L-B [USNM 431724], NL IV 61(96)A-8-G [USNM 431725], NL IV 63(98)B-4LB-FF [USNM 431726], NL IV 72(107)B-3-I [USNM 431727], NL IV 108(153)A-7-I [USNM 431728], CB 54A-7-B (M) [USNM 431729], CB 55B-2-C (M) [USNM 431730], CB 138B-9-C (M) [USNM 431731], CB 145B-5-A (M) [USNM 431732], CB 145C-4-B (M) [USNM 431733], CB 55B-2-B [USNM

Table 9.—Quantitative data, *Prasopora falesi* (James). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. meas.	No. spec.
ZCD	NL IV	.24–.32	.28	.28	.017	50	5
	CB 54–55	.25–.32	.27	.26, .27	.017	20	2
	CB 138–145	.22–.29	.26	.26	.019	30	3
	CB Total	.22–.31	.26	.26	.020	50	5
	TOTAL	.22–.32	.27	.28	.020	100	10
ZCD (mac)	NL IV	.34–.50	.40	.40	.032	50	5
	CB 54–55	.38–.46	.42	.44	.029	15	2
	CB 138–145	.36–.50	.42	.38	.044	25	3
	CB Total	.36–.50	.42	.44	.039	40	5
	TOTAL	.34–.50	.41	.38, .40	.036	90	10
ZWT	NL IV	≤.01	—	—	—	—	5
	CB 54–55	≤.01	—	—	—	—	2
	CB 138–145	≤.01	—	—	—	—	2
		.02–.04	.03	.03	.007	10	1
	CB Total	≤.01	—	—	—	—	4
		.02–.04	.03	.03	.007	10	1
	TOTAL	≤.01	—	—	—	—	9
		.02–.04	.03	.03	.007	10	1
Z/mm^2	NL IV	12–18	16	16, 17	1.9	11	5
	CB 54–55	14–17	16	—	2.1	2	2
	CB 138–145	17–21	18	17	1.7	5	3
	CB Total	14–21	17	17	2.1	7	5
	TOTAL	12–21	16	17	2.1	18	10
MxMCD	NL IV	.03–.17	.08	.09	.03	25	5
	CB 54–55	.04–.10	.07	.07	.02	10	2
	CB 138–145	.03–.09	.07	.09	.02	15	3
	CB Total	.03–.10	.07	.08	.02	25	5
	TOTAL	.03–.17	.08	.09	.03	50	10
MnMCD	NL IV	.02–.12	.06	.07	.02	25	5
	CB 54–55	.02–.10	.05	.04, .06	.02	10	2
	CB 138–145	.02–.08	.05	.05	.02	15	3
	CB Total	.02–.10	.05	.04, .05	.02	25	5
	TOTAL	.02–.12	.05	.04	.02	50	10
MxMCD (mac)	NL IV	.05–.23	.09	.08, .09	.04	25	5
	CB 54–55	.05–.14	.09	.07	03	10	2
	CB 138–145	.04–.17	.08	.08, .09	.03	15	3
	CB Total	.04–.17	.09	.07	.03	25	5
	TOTAL	.04–.23	.09	.08	.03	50	10
MnMCD (mac)	NL IV	.03–.09	.06	.07	.02	25	5
	CB 54–55	.04–.12	.06	.05	.02	10	2
	CB 138–145	.02–.08	.05	.05	.02	15	3
	CB Total	.02–.12	.06	.05	.02	25	5
	TOTAL	.03–.12	.06	.05	.02	50	10

431734], CB 67B-8-C [USNM 431735], CB 67B-7-A [USNM 431736], CB 54A-6-A (F) [USNM 431737], CB 54A-5-A (F) [USNM 431738], CB 55A-3-A (F) [USNM 431739], CB 55B-1-A (F) [USNM 431740], CB 114A-1-A (F) [USNM 431741], CB 150B-4-C (F) [USNM 431742], CB 150B-6-B (F) [USNM 431743].

Genus **MESOTRYPA** Ulrich, 1886

Type species.—*Diplotrypa infida* Ulrich, 1886, p. 88.

Mesotrypa angularis Ulrich and Bassler, 1904
Plate 1, Figures 3–4

Mesotrypa angularis Ulrich and Bassler, 1904, p. 23, pl. 7, figs. 7–9; Karklins, 1984, p. 134–136, pl. 9, pl. 10, fig. 4.

Description.—Zoarium hemispherical, discoidal, conical, encrusting. Zooecial cavity outlines in early part of colony subrounded, near-surface cavities polygonal with larger diameter (as mesozooecia are absent). Walls thin, thicken slightly and composed of fine

Table 10.—Quantitative data, *Mesotrypa angularis* Ulrich and Bassler. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD (mat)	NL IV 24–61 (59–96)	.23–.36	.28	.27	.029	35	7
	NL IV 85–116 (120–151)	.24–.31	.27	.26	.015	29	6
	NL IV Total	.23–.36	.28	.27	.024	64	13
	CB 55–85	.24–.29	.27	.26	.014	10	2
	CB 114–145	.23–.32	.27	.28	.024	10	2
	CB Total	.23–.32	.27	.26, .28	.020	20	4
	HCM	.24–.28	.26	—	.016	5	1
	WB	—	—	—	—	—	—
	WEST Total	.24–.28	.26	—	.016	5	1
	TOTAL	.23–.36	.27	.26	.020	89	18
ZCD (mac/mat)	NL IV 24–61 (59–96)	.28–.50	.39	.36	.053	35	7
	NL IV 85–116 (120–151)	.38–.48	.41	.40	.026	15	3
	NL IV Total	.28–.50	.39	.40	.047	50	10
	CB 55–85	.36–.46	.41	.40	.029	10	2
	CB 114–145	.36–.44	.40	.38	.033	10	2
	CB Total	.36–.46	.40	.40	.030	20	4
	HCM	.38–.46	.41	.38	.034	5	1
	WB		—	—	—	—	—
	WEST Total	.38–.46	.41	.38	.034	5	1
	TOTAL	.28–.50	.40	.40	.042	75	15
ZCD (non-mat)	NL IV 24–61 (59–96)	.22–.30	.26	.26, .27	.022	35	7
	NL IV 85–116 (120–151)	.18–.29	.24	.25	.020	40	8
	NL IV Total	.18–.30	.25	.25	.022	75	15
	CB 55–85	.23–.28	.25	.24	.017	15	3
	CB 114–145	.23–.32	.26	.25, .27	.022	20	4
	CB Total	.23–.32	.26	.27	.020	35	7
	HCM	—	—	—	—	—	—
	WB	.23–.32	.26	—	.035	5	1
	WEST Total	.23–.32	.26	—	.035	5	1
	TOTAL	.18–.32	.25	.25	.022	115	23
ZCD (mac/non-mat)	NL IV 24–61 (59–96)	.36–.54	.42	.40	.042	25	5
	NL IV 85–116 (120–151)	.36–.46	.39	.40	.026	35	7
	NL IV Total	.36–.54	.40	.40	.036	60	12
	CB 55–85	.34–.42	.37	.36	.023	10	2
	CB 114–145	.38–.48	.43	.44	.031	15	3
	CB Total	.34–.48	.41	.38, .44	.040	25	5
	HCM	—	—	—	—	—	—
	WB	.40–.46	.42	.40	.028	5	1
	WEST Total	.40–.46	.42	.40	.028	5	1
	TOTAL	.34–.54	.41	.40	.036	90	18
ZWT	NL IV 24–61 (59–96)	.01–.04	.02	.02	.007	35	7
	NL IV 85–116 (120–151)	.01–.03	.02	.02	.006	30	6
	NL IV Total	.01–.04	.02	.02	.007	65	13
	CB 55–85	.01–.02	.02	.02	.005	10	2
	CB 114–145	.01–.04	.02	.02	.010	9	2
	CB Total	.01–.04	.02	.02	.008	19	4
	HCM	.01–.02	.01	.01	.002	5	1
	WB	—	—	—	—	—	—
	WEST Total	.01–.02	.01	.01	.004	5	1
	TOTAL	.01–.04	.02	.02	.007	89	18
Z/mm^2 (mat)	NL IV 24–61 (59–96)	16–19	17	16	1.0	17	6
	NL IV 85–116 (120–151)	17–20	19	19	1.1	5	4
	NL IV Total	16–20	17	16	1.2	22	10
	CB 55–85	19–21	20	—	1.4	2	2
	CB 114–145	15–17	16	—	1.4	2	1
	CB Total	15–21	18	—	2.6	4	3
	HCM	19–20	20	—	0.7	2	1
	WB	—	—	—	—	—	—
	WEST Total	19–20	20	—	0.7	2	1
	TOTAL	15–21	18	16	1.5	28	14

Table 10.—Continued.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
Z/mm² (non-mat)	NL IV 24–61 (59–96)	16–21	19	18	1.3	14	7
	NL IV 85–116 (120–151)	17–22	20	22	1.7	9	8
	NL IV Total	16–22	19	18, 19	1.7	23	15
	CB 55–85	17–22	20	20	2.1	4	3
	CB 114–145	16–21	18	18	1.7	7	5
	CB Total	16–22	18	20	1.9	11	7
	HCM	—	—	—	—	—	—
	WB	18–21	20	—	2.1	2	1
	WEST Total	18–21	20	—	2.1	2	1
	TOTAL	16–22	19	18	1.8	36	23
MxMCD (non-mat)	NL IV 24–61 (59–96)	.04–.26	.10	.08	.038	40	8
	NL IV 85–116 (120–151)	.06–.16	.10	.09	.025	40	8
	NL IV Total	.04–.26	.10	.09	.032	80	16
	CB 55–85	.06–.14	.09	.10	.023	15	3
	CB 114–145	.05–.15	.09	.10	.024	20	4
	CB Total	.05–.15	.09	.10	.023	35	7
	HCM	—	—	—	—	—	—
	WB	.10–.15	.13	—	.019	5	1
	WEST Total	.10–.15	.13	—	.019	5	1
	TOTAL	.04–.26	.10	.08	.032	120	24
MnMCD (non-mat)	NL IV 24–61 (59–96)	.03–.10	.06	.07			
	NL IV 85–116 (120–151)	.03–.11	.06	.06	.018	40	8
	NL IV Total	.03–.11	.06	.05	.017	40	8
	CB 55–85	.04–.09	.06	.06	.018	80	16
	CB 114–145	.04–.10	.07	.06, .07	.017	15	3
				.08	.015	20	4
	CB Total	.04–.10	.07	.06	.016	35	7
	HCM	—	—	—	—	—	—
	WB	.05–.08	.07	.07, .08	.012	5	1
	WEST Total	.05–.08	.07	.07, .08	.012	5	1
	TOTAL	.03–.11	.06	.06	.017	120	24
AD (lam/mat)	NL IV 24–61 (59–96)	.04–.09	.06	.06	.012	35	7
	NL IV 85–116 (120–151)	.04–.08	.05	.05	.010	30	6
	NL IV Total	.04–.09	.06	.06	.011	65	13
	CB 55–85	.03–.08	.06	.03, .08	.022	10	2
	CB 114–145	.03–.04	.04	.04	.005	10	2
	CB Total	.03–.08	.05	.04	.018	20	4
	HCM	.03–.06	.05	.05	.011	5	1
	WB	—	—	—	—	—	—
	WEST Total	.03–.06	.05	.05	.011	5	1
	TOTAL	.03–.09	.05	.05	.014	90	18

V-shaped laminae near periphery or cyclically within zoarium (planes of rejuvenation). Diaphragms thin, variable in number, spacing, orientation, absent or sparse proximally becoming more common peripherally and near colony-wide surface of rejuvenation where they are approximately spaced at one-half to one zooecial cavity diameter apart, mainly planar to curved convex outwards and inclined towards colony center, some cystose, wavy, overlapping, few cystiphragms. Mesozooecia fairly common in non-peripheral parts of colony, cavities polygonal in cross-sectional outline being mainly three- and four-sided, decrease in diameter outwards and disappear before reaching colony surface, few become autozooecia. Diaphragms present throughout, mostly evenly spaced at approximately one-half to one mesozooecial cavity diameter apart, thickness similar to autozooecial diaphragms, walls commonly moniliform. Acanthostyles common, mainly in later parts of colony or early parts where walls thicken, mainly at zooecial corners though occasionally found between zooecia, concentric laminae surrounding some styles inflect zooecial cavities. Commonly three to five surround each zooecium. Maculae of megazooecia found throughout colony and flush with colony surface. Zooecia of maculae in earlier portions of colony comparable in diameter to nonmacular zooecia of periphery (though latter polygonal and former subrounded).

Measurements.—Measurements are summarized in Table 10.

Remarks.—*Mesotrypa angularis* typically has angular autozooecial cavity outlines in the peripheral region, inclined and planar to distally curved exozonal diaphragms spaced between one-half to one zooecial cavity diameters apart, numerous exozonal acanthostyles found mainly at zooecial corners, thin walls, absent to rare cystiphragms, common mesozooecia in the endozone which have polygonal cavity outlines and become crowded out peripherally, and distinctive maculae composed of large autozooecia.

The present species is similar to *M. infida* but for lesser numbers of diaphragms colony-wide and in particular early parts of the colony, and for fewer and less pronounced curved oblique cystiphragm-like diaphragms.

Fritz (1957) recognized a subspecies of *M. angularis* called *parvatrypa.*

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 24(59)-B-3-B (M) [USNM 431744], NL IV 49(84)A-3L-X (M) [USNM 431745], NL IV 49(84)A-4L-H (M) [USNM 431746], NL IV 49(84)A-3L-W (M) [USNM 431747], NL IV 49(84)A-2L-A (M) [USNM 431748], NL IV 49(84)A-5R-HH (M) [USNM 431749], NL IV 49(84)A-7R-R (M) [USNM 431750], NL IV 61(96)A-1-C (M) [USNM 431751], NL IV 61(96)A-9-G (M) [USNM 431752], NL IV 61(96)A-8-C (M) [USNM 431753], NL IV 61(96)A-6-K (M) [USNM 431754], NL IV 85(120)A-10L-A (M) [USNM 431755], NL IV 85(120)A-8L-A (M) [USNM 431756], NL IV 93(128)A-13-A (M) [USNM 431757], NL IV 94(129)A-3L-D (M) [USNM 431758], NL IV 96(131)B-4-A (M) [USNM 431759], NL IV 100(135)A-2L-O (M) [USNM 431760], NL IV 100(135)A-10L-A (M) [USNM 431761], NL IV 108(143)A-4-A (M) [USNM 431762], NL IV 108(143)A-17-C (M) [USNM 431763], NL IV 116(151)A-1-E (M) [USNM 431764], NL IV 30(65)C-3L-A [USNM 431765], NL IV 37(72)B-5-L [USNM 431766], NL IV 44(79)E-7-B [USNM 431767], NL IV 61(96)A-7-F [USNM 741768], NL IV 61(96)A-9-C [USNM 431769], NL IV 61(96)A-5-A [USNM 431770], NL IV 63(98)A-5LA-H [USNM 431771], NL IV 63(98)A-6LA-H [USNM 431772], NL IV 72(107)B-4L-B [USNM 431773], NL IV 85(120)A-12L-A [USNM 431774], NL IV 108(143)A-12-E [USNM 431775], NL IV 116(151)A-3-G [USNM 741776], NL IV 117(152)A-2-C [USNM 431777], CB 55A-2-A (M) [USNM 431778], CB 57A-3-A (M) [USNM 431779], CB 62A-5-A (M) [USNM 431780], CB 67B-8-A (M) [USNM 431781], CB 85A-11L-A (M) [USNM 431782], CB 114A-1-B (M) [USNM 431783], CB 128B-4-B (M) [USNM 431784], CB 138A-5-A (M) [USNM 431785], CB 145C-4-A (M) [USNM 431786], CB 145B-2-A (M) [USNM 431787], CB 54A-7-A [USNM 431788], CB 145B-4-B [USNM 431789], CB 50B-4-A (F) [USNM 431790], CB 55A-9-B (F) [USNM 431791], CB 55A-9-A (F) [USNM 431792], CB 72C-2L,a-A (F) [USNM 431793], CB 74A-5L-A (F) [USNM 431794], CB 79A-4-A (F) [USNM 431795], CB 85A-17L-A (F) [USNM 431796], CB 132A-A (F) [USNM 431797], CB 161A-3-C (F) [USNM 431798], HCM 43(82)C-3-II (M) [USNM 431799], WB 38(50)B-3-A (M) [USNM 431800].

Mesotrypa sp. A
Plate 2, Figure 1

Description.—Zoaria encrusting. Zooecia rounded to subrounded in non-peripheral region, subrounded to subpolygonal in periphery. Except for encrusting base, zooecia perpendicular to colony surface. Walls moderately thin, even thickness, composed of U- to V-shaped laminae. Diaphragms variable in orientation, perpendicular to inclined to zooecial walls, curved or planar, thin, some overlapping, spacing variable, two to several within one zooecial cavity diameter. Cystiphragms and/or cystose diaphragms on distal side of zooecial tube. Outwards, attached to zooecial wall, inner end attached to diaphragm or other cystiphragm or cystose diaphragm. Mesozooecia common, angular, fill voids left by contact of rounded to subrounded zooecia in non-peripheral parts of colony, crowded out zooecially outwards, diaphragms mainly perpendicular to walls, some inclined slightly, spaced at one-half to one mesozooecial cavity diameter apart, some thicker than for autozooecia. Acanthostyles prominent throughout colony, laminar sheaths thick and distinct, thicker in periphery where mesozooecia absent, two to three at zooecial corners surround zooecial cavities in non-peripheral region, in periphery three to four surround zooecia mainly at zooecial corners.

Measurements.—Measurements are summarized in Table 11.

Remarks.—Specimens assigned to *Mesotrypa* sp. A have numerous large acanthostyles with thick laminar sheaths found mainly at zooecial corners, subrounded to subpolygonal peripheral zooecial cavity outlines, moderately thin walls, variably oriented diaphragms, some cystiphragms, common angular mesozooecial cavities, and an encrusting habit.

Mesotrypa sp. A differs from *M. spinosa* by having both larger acanthostyles and zooecial cavity diameters, and possibly by the more variable orientation of diaphragms. Ulrich's description (1893, p. 259) noted "mostly oblique curved partitions in zooecial tubes"

Table 11.—Quantitative data, *Mesotrypa* sp. A. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	CB	.23–.28	.26	.28	.018	10	2
	TOTAL	.23–.28	.26	.28	.018	10	2
ZWT	CB	.01–.02	.02	.02	.003	10	2
	TOTAL	.01–.02	.02	.02	.003	10	2
MCD (endo/ht)	CB	.07–.09	.08	.07	.008	10	2
	TOTAL	.07–.09	.08	.07	.008	10	2
MCD (endo/wth)	CB	.05–.08	.06	.05	.010	10	2
	TOTAL	.05–.08	.06	.05	.010	10	2
AD (lam/exo)	CB	.06–.12	.09	.06	.024	10	2
	TOTAL	.06–.12	.09	.06	.024	10	2
AD (lam/endo)	CB	.04–.06	.05	.04	.008	10	2
	TOTAL	.04–.06	.05	.04	.008	10	2

for *M. spinosa,* however, his figured specimen, pl. 17, fig. 12, is not dissimilar from the present species. The small sample size of *Mesotrypa* sp. A further precludes a more precise taxonomic assignment.

Distribution.—Locality CB.

Studied Material.—Hypotypes CB 114A-9-A (M) [USNM 431801], CB 116A-5-A (M) [USNM 431802].

Genus **PERONOPORA** Nicholson, 1881

Type species.—*Chaetetes decipiens* Rominger, 1866.

Peronopora mundula (Ulrich, 1893)
Plate 2, Figures 2–3

Homotrypella mundula Ulrich, 1893, p. 232, 233, fig. 12; Brown, 1965, p. 980, 981, pl. 111, figs. 4–6.

Description—Zoaria mainly ramose, some encrusting. Zooecia initiated throughout inner and outer endozone. Zooecial cavities polygonal in cross-section in endozone, subrounded within inner exozone, becoming increasingly polygonal zooecially outwards. Zooecia curve very shallowly in endozone, curve greatly accelerated near endozonal/exozonal transition with or without a distinct zooecial bend at exozonal base or lower exozone, or intersect colony surface at right angles. Zooecial walls thicken markedly at base of exozone or in lower exozone and formed of distinct V-shaped laminae. Walls commonly thicken and thin zooecially outwards. Occasionally a dark line separates zooecial walls. Endozonal walls even to slightly irregular, parallel. No median layer in zoarium. Diaphragms in endozone planar, thin, perpendicular to zooecial walls, spaced at two to several zooecial cavity diameters apart in inner endozone, one-half to two zooecial cavity diameters in outer endozone. In innermost exozone, diaphragms few, occasionally absent, spaced at approximately one-half to two-thirds of a zooecial cavity diameter, mainly perpendicular to zooecial walls, some inclined, curved slightly, locally overlapping. Absent outwards. Overlapping cystiphragms common in outermost endozone and exozone on distal sides of zooecial tubes. In exozone, cystiphragms usually smaller, more closely and regularly spaced. In some zooecia cystiphragms absent in outer exozone. Some cystiphragms with one or two connected diaphragms in outer endozone and inner exozone. Occasionally cystiphragms absent or one or two isolated. Cystiphragms extend one-third to one-half of the way across zooecial cavity in longitudinal section, greater for innermost cystiphragms. Mesozooecia scattered about exozone, some fairly large and locally abundant, less angular and commonly larger outwardly, with or without loss of diaphragms so as to be indistinguishable from autozooecia in tangential section, diaphragms thicker than for autozooecia. Acanthostyles numerous, found in outermost endozone and in exozone at zooecial corners or between zooecia, diameters of lumen constant, laminar sheaths thickest in outer exozone. Acanthostyles commonly inflect zooecial cavities, usually offset in exozone, three to six around each zooecium, commonly four to five.

Measurements.—Measurements are summarized in Table 12.

Remarks.—*Peronopora mundula* characteristically has subrounded to subpolygonal zooecial apertures in the exozone, distinct V-shaped zooecial wall laminae, endozonal diaphragms spaced at two to several zooecial cavity diameters apart within the inner endozone, and one and one-half to two zooecial cavity diameters apart in the outer endozone, few to sometimes no diaphragms within the inner exozone and none in the outer exozone, overlapping cystiphragms present from outer endozone to colony surface but sometimes ab-

Table 12.—Quantitative data, *Peronopora mundula* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.14–.22	.17	.16	.021	25	5
	TOTAL	.14 .22	.17	.16	.021	25	5
ZWT	NL IV	.04–.10	.06	.08	.019	25	5
	TOTAL	.04–.10	.06	.08	.019	25	5
Z/mm^2	NL IV	22–29	25	—	3.8	3	3
	TOTAL	22–29	25	—	3.8	3	3
AD (lam)	NL IV	.04–.07	.06	.05, .06	.010	25	5
	TOTAL	.04–.07	.06	.05, .06	.010	25	5

sent in outer exozone, mesozooecia scattered about exozone, numerous acanthostyles surrounding each zooecium (commonly four to five), and numerous styles inflecting autozooecial cavities.

P. mundula differs from *P. weirae* in having distinct V-shaped wall laminae, greater numbers of endozonal and exozonal diaphragms, fewer mesozooecia, and increased numbers of inflecting acanthostyles.

In comparing *Homotrypella* with *Peronopora,* Ulrich (1893, p. 228) noted the following differences between the genera. In *Peronopora* the zoaria are bifoliate and, additionally, "the cystiphragms are developed in an almost uninturrupted [sic] series throughout the length of the zooecial tubes." Cystiphragms in *Homotrypella,* on the other hand, are "developed chiefly in the median region of the zooecial tubes, being absent usually just beneath the surface and never present in the axial region."

Boardman and Utgaard (1966, p. 1097) revised *Peronopora* to include forms "differing significantly from the type species only in growth habit" as this "is consistent with present concepts of many other genera of Trepostomata . . . " In addition, they note that cystiphragms are "rare in the endozone of zoaria lacking a median or basal layer." In forms with a median layer, cystiphragms commonly extend from the median layer through most of the exozone. It is assumed that in non-bifoliate growth habits, a cystiphragm distribution conformable with Ulrich's characterization of *Homotrypella* would be applicable. Summarily, then, based on Boardman and Utgaard's emendation of *Peronopora,* Ulrich's differentiation of the genera is not valid.

Further comparison of the above descriptions notes additional similarities between the two genera, namely, generally rounded zooecial cavity outlines; commonly "integrate" wall structure; the sometimes inflection of zooecial cavity outlines by acanthostyles; abundant acanthostyles; maculae that are low or flush with zoarial surface and have a central grouping of mesozooecia (Ulrich described maculae as mesopore clusters). Ulrich and Bassler (1904, p. 21) described *Homotrypella nodosa* and indicated that "sections cutting across zooecia just beneath the surface of an old branch often exhibit no mesopores, the zooecia being polygonal. At deeper levels mesopores can always be detected and generally become so numerous as to isolate the zooecia." While this phenomenon is not noted in Ulrich's original description of *Homotrypella,* Ulrich and Bassler stated that the new species, *H. nodosa* does not modify the generic definition of *Homotrypella.* Boardman and Utgaard (1966) described the same crowding out of mesozooecia in their revision of *Peronopora.* This would suggest further that Ulrich's concept of *Homotrypella* is incorporated into Boardman and Utgaard's *Peronopora.*

The present author is not able to distinguish the two genera and suggests that *Homotrypella* Ulrich, 1886, indeed be a synonym of *Peronopora* Nicholson, 1881.

Distribution.—Localities NL IV, CB, WB.

Studied material.—Hypotypes NL IV 50(85)A-14-B (M) [USNM 431803], NL IV 50(85)A-16-B (M) [USNM 431804], NL IV 61(96)A-4-A (M) [USNM 431805], NL IV 61(96)A-7-I (M) [USNM 431806], NL IV 63(98)B-3LA-M (M) [USNM 431807], NL IV 51(86)A-9L-A [USNM 431808], NL IV 51(86)A-2L-C [USNM 431809], NL IV 61(96)A-6-N [USNM 431810], NL IV 61(96)A-5-W [USNM 431811], NL IV 63(98)B-6LA-B [USNM 431812], NL IV 63(98)B-2LA-R [USNM 431813], NL IV 66(101)A-7-A [USNM 431814], NL IV 66(101)A-5B-A [USNM 431815], NL IV 66(101)A-9-A [USNM 431816], NL IV 72(107)A-3L-E [USNM 431817], NL IV 61(96)A-8-E (F) [USNM 431818], NL IV 63(98)B-3LB-T (F) [USNM 431819], CB 67B-1-A,B [USNM 431820], CB 153B-3-A [USNM 431821], WB 19(31)A-5L-A [USNM 431822], WB 20(32)B-5-B [USNM 431823].

Peronopora weirae, new species
Plate 3, Figures 1–2

Description.—Zoaria mainly ramose, some encrusting. Zooecia initiated homogeneously throughout inner and outer endozone. Zooecial cavities polygonal in

Table 13.—Quantitative data, *Peronopora weirae* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.14–.20	.18	.18	.019	10	2
	CB	.12–.18	.16	.16	.022	5	1
	HCM	.16–.22	.18	.16	.025	10	2
	TOTAL	.12–.22	.17	.16	.023	25	5
MnZCD	NL IV	.07–.14	.11	.12	.020	10	2
	CB	.07–.10	.08	.08	.011	5	1
	HCM	.07–.12	.09	.09, .10	.014	10	2
	TOTAL	.07–.14	.10	.10	.020	25	5
ZWT	NL IV	.05–.12	.07	.06	.022	10	2
	CB	.02–.06	.04	.03	.015	5	1
	HCM	.04–.08	.06	.06	.014	10	2
	TOTAL	.02–.12	.06	.06	.022	25	5
Z/mm²	NL IV	21	21	21	.00	1	1
	CB	30	30	30	.00	1	1
	HCM	26–27	26	—	.71	2	2
	TOTAL	21–30	26	—	3.7	4	4
AD (lam)	NL IV	.04–.05	.04	.04	.005	10	2
	CB	.04–.08	.06	.07	.016	5	1
	HCM	.04–.08	.06	.06	.013	10	2
	TOTAL	.04–.08	.05	.04	.013	25	5

cross-section in endozone, subrounded to subpolygonal in exozone. Sometimes elongate zooecia oblique to colony surface. Zooecia curve shallowly in endozone, curve accelerated near endozonal/exozonal break with or without a zooecial bend at exozonal base or lower exozone. Zooecia intersect colony surface mainly at or near 90°. Zooecial walls commonly thicken abruptly at base of exozone or in lower exozone, granular to formed of poorly defined U- to V-shaped laminae. Occasional dark line marks zooecial boundary in longitudinal section. Endozonal walls even to slightly irregular, parallel. No median layer in zoarium. Diaphragms rare in endozone, few zooecia with one or two. Diaphragms absent to uncommon in lower exozone, one or two, rarely more, thin, planar, sometimes curved, perpendicular to zooecial walls, some inclined. In encrusting forms, diaphragms more common with or without mesozooecia changing to autozooecia and vice-versa. Cystiphragms in most zooecia, overlapping in outermost endozone and exozone, sometimes absent in outer exozone. Occasionally only one or two isolated in zooecial tube. Cystiphragms extend one-third to one-half of the way across zooecial cavity in longitudinal section, greater for innermost cystiphragms. Mesozooecia abundant, commonly separate zooecia in inner exozone, become crowded out outwards by autozooecia, few mesozooecia become autozooecia, diaphragms spaced one-half to one mesozooecial cavity diameter apart, diaphragms distinctly thicker than for autozooecia. Acanthostyles numerous, many slightly inflect zooecial walls, many offset, laminae not thick, found in outermost endozone and exozone at zooecial corners and between zooecia, three to six around each zooecium, commonly four to five.

Etymology.—This species is named for Frances Weir, my spouse, whose encouragement and support have helped keep me in the Ordovician.

Measurements.—Measurements are summarized in Table 13.

Remarks.—*Peronopora weirae* differs from *Peronopora mundula* in having walls that vary from granular to having poorly defined U- to V-shaped laminae, fewer endozonal and exozonal diaphragms (rare in endozone, absent or nearly so in inner exozone, absent in outer exozone), abundant mesozooecia, and less acanthostyles that inflect zooecial cavities.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype NL IV 72(107)A-3L-H (M) [USNM 431824], Paratypes NL IV 72(107)B-2L-G (M) [USNM 431825], NL IV 61(96)A-2-A [USNM 431826], NL IV 61(96)A-3-B [USNM 431827], NL IV 72(107)B-2L-A [USNM 431828], NL IV 72(107)B-2L-I [USNM 431829], NL IV 93(128)A-10-E [USNM 431830], NL IV 93(128)A-10-F [USNM 431831], NL IV 93(128)A-1-O [USNM 431832], NL IV 108(143)A-2-H [USNM 431833], NL IV 61(96)A-5-I (F) [USNM 431834], CB 74–75A-2-A (M) [USNM 431836], CB 72B-6-A [USNM 431837], CB 150B-1-B [USNM 431838], CB 161A-1-A [USNM 431839], CB 62A-10-C (F) [USNM 431840], CB 72C-5L-A (F) [USNM

431841], HCM 43(82)B-7-A (M) [USNM 431842], HCM 43(82)A-3-T (M) [USNM 431843], HCM 43(82)A-1-C [USNM 431844], HCM 43(82)C-6-N [USNM 431845], WB 20(32)B-3-B [USNM 431846], WB 27(39)B-4-A [USNM 431847], WB 44(56)C-2-A (F) [USNM 431848], WB 44(56)B-2-B (F) [USNM 431849].

Genus **ACANTHOLAMINATUS**, new genus

Type species.—*Acantholaminatus typicus* new genus, new species.

Description.—Characterized by the presence of a largely granular wall structure, abundant cystiphragms and diaphragms, plentiful distinctive, well-developed, and commonly inflecting acanthostyles throughout the colony, rare mesozooecia, and subrounded zooecial cavity outlines.

Etymology.—Referring to the prominent acanthostyles having distinct laminar sheaths.

Remarks.—In having abundant cystiphragms and diaphragms this genus is similar to *Monticulipora* as well as *Atactoporella.* It is further similar to *Monticulipora* in having poorly defined (granular) wall structure. It differs from *Monticulipora* in the development of acanthostyles, lack of mesozooecia in maculae, more rounded zooecial cavity outlines, and absence of mural lacunae. It differs from *Atactoporella* in having fewer offset and inflecting acanthostyles and in lacking numerous mesozooecia.

Acantholaminatus typicus, new genus, new species

Plate 3, Figure 3
Plate 4, Figure 1

Description.—Zoaria encrusting. Zooecia initiated from surface of object encrusted by zoarium and rapidly attain an orientation perpendicular to the colony surface. Zooecia with fairly small and subrounded cavity outlines. Zooecial walls of even thickness throughout except at basalmost position where zooecial walls thinner. Walls usually granular, sometimes with faint U- to V-shaped laminae. Diaphragms found throughout colony, commonly attached to adjoining cystiphragms, consistently thin, orientation variable, flat or curved slightly and perpendicular to inclined to zooecial walls, spacing variable, commonly two-thirds of a zooecial cavity diameter apart or less, locally greater or absent (the latter instance being especially so for outermost parts of the exozone), sometimes locally overlapping.

Cystiphragms in nearly all zooecia, usually continuously overlapping and evenly distributed, on distal side of zooecial tubes, approximately one-third of the way across zooecial cavity in longitudinal section, more so at zooecial bend at very base of colony, wrap around one-third to one-half perimeter of zooecial tube. One or two diaphragms usually attached to each cystiphragm, sometimes none.

Mesozooecia very rare, small, some change into autozooecia. Diaphragms spaced at one mesozooecial cavity diameter apart, thicker than autozooecial diaphragms.

Acanthostyles plentiful, present at nearly all zooecial corners and sometimes between zooecia. Commonly five acanthostyles surround any one zooecium (up to eight), often inflect into zooecial cavity, some offset and inflecting. Laminar sheaths surrounding each acanthostyle appear darker than wall laminae in acetate peel replicas.

Maculae present, not distinctive. Walls and zooecial cavities slightly larger than for non-macular areas. Occasionally walls thick between adjacent zooecia where space filled by additional acanthostyles having thicker laminar sheaths.

Etymology.—Indicating that this is the type species of the genus.

Measurements.—Measurements are summarized in Table 14.

Remarks.—*Acantholaminatus typicus* differs from *A. multistylus* primarily in having fewer acanthostyles surrounding each zooecium. *A. typicus* differs further in having thicker walls in non-macular areas and greater numbers of diaphragms in the outer exozone.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype HCM 43(82)B-5-J (M) [USNM 431850], Paratypes NL IV 93(128)A-9-I (M) [USNM 431851], NL IV 93(128)A-9-E (M) [USNM 431852], NL IV 94(129)A-4L-B [USNM 431853], NL IV 100(135)A-10L-I [USNM 431854], NL IV 116(151)B-3-C [USNM 431855], NL IV 117(152)A-5-A [USNM 431856], CB 46C-4-A (M) [USNM 431857], CB 123A-4-A (M) [USNM 431858], CB 122A-24-B [USNM 431859], HCM 18(57)B-4-J (M) [USNM 431860], HCM 43(82)C-1-G (M) [USNM 431861], HCM 43(82)C-2-Q (M) [USNM 431862], HCM 43(82)B-8-J (M) [USNM 431863], HCM 43(82)A-3-J (M) [USNM 431864], HCM 18(57)B-3-A [USNM 431865], HCM 43(82)B-2-C [USNM 431866], HCM 18(57)B-4-I (F) [USNM 431867], WB 44(56)B-3-B (M) [USNM 431868], WB 20(32)B-2-C (F) [USNM 431869].

Acantholaminatus multistylus, new genus, new species

Plate 4, Figure 2

Description.—This species is morphologically similar to *Acantholaminatus typicus* in all respects with the primary exception of acanthostyle number. Differences also exist in exozonal wall thickness and fre-

Table 14.—Quantitative data, *Acantholaminatus typicus* n. gen., n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.14–.20	.17	.18	.017	20	2
	CB	.17–.22	.19	.20	.016	15	2
	HCM	.14–.22	.18	.16	.020	60	6
	WB	.17–.20	.18	.18	.008	10	1
	WEST Total	.14–.22	.18	.18	.018	70	7
	TOTAL	.14–.22	.18	.18	.019	105	11
ZCD (mac)	NL IV	—	—	—		—	—
	CB	—	—	—		—	—
	HCM	.20–.27	.24	.25	.017	21	4
	WB	–	—	—		—	—
	WEST Total	.20–.27	.24	.25	.017	21	4
	TOTAL	.20–.27	.24	.25	.017	21	4
ZWT	NL IV	.02–.05	.03	.02	.010	20	2
	CB	.02–.04	.03	.02	.009	15	2
	HCM	.01–.05	.02	.02	.008	60	6
	WB	.02–.06	.04	.04	.012	10	1
	WEST Total	.01–.06	.03	.02	.010	70	7
	TOTAL	.01–.06	.03	.02	.010	105	11
ZWT (mac)	NL IV	—	—	—		—	—
	CB	–	—	—		—	—
	HCM	.02–.06	.03	.02	.013	31	4
	WB	—	—	—	-	—	—
	WEST Total	.02–.06	.03	.02	.013	31	4
	TOTAL	.02–.06	.03	.02	.013	31	4
Z/mm²	NL IV	32–34	33	—	1.4	2	2
	CB	30–31	30	—	0.71	2	1
	HCM	30–39	33	31	3.0	12	6
	WB	33	33	33	0.0	1	1
	WEST Total	30–39	33	31	2.8	13	7
	TOTAL	30–39	33	31	2.6	17	10
AD (lam)	NL IV	.03–.06	—	—		—	2
	CB	.03–.04	—	—	—	—	2
	HCM	.03–.06	—	—		—	6
	WB	.04–.06	—	—	—	—	1
	WEST Total	.03–.06		—	—	—	7
	TOTAL	.03–.06	—		—		11
AD (lum)	NL IV	.01–.02	—	—	—	-	2
	CB	.01	—	—		—	2
	HCM	.01–.02	—	-		—	6
	WB	.01–.02	—	—		—	1
	WEST Total	.01–.02	—	—	—	—	7
	TOTAL	.01–.02	—	—	—	—	11
AD (lam/mac)	HCM	.04–.09	—	—	—	—	2
	TOTAL	.04–.09	—	—	—	—	2
AD (lum/mac)	HCM	.02	—	—	—	—	1
	TOTAL	.02	—	—	—		1

quency of diaphragms in the outer exozone. *A. multistylus* has eight to twelve, commonly ten, acanthostyles surrounding each zooecium; whereas *A. typicus* has less than eight, commonly five, acanthostyles around each zooecium. In addition, the present species is thinner walled in non-macular areas and exhibits a sparsity of diaphragms in the outer exozone.

Etymology.—Referring to the multitudinous acanthostyles found in this species.

Measurements.—Measurements are summarized in Table 15.

Distribution.—Locality WB.

Studied material.—Holotype WB 38(50)C-2R-A (M) [USNM 433073]

Table 15.—Quantitative data, *Acantholaminatus multistylus* n. gen, n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	WB	.15–.20	.18	.18	.015	10	1
	TOTAL	.15–.20	.18	.18	.015	10	1
ZCD (mac)	WB	.23–.29	.25	.25	.021	8	1
	TOTAL	.23–.29	.25	.25	.021	8	1
ZWT	WB	.01–.03	.02	.02	.006	10	1
	TOTAL	.01–.03	.02	.02	.006	10	1
ZWT (mac)	WB	.03–.04	.03	.03	.005	8	1
	TOTAL	.03–.04	.03	.03	.005	8	1
Z/mm²	WB	31–33	32	—	1.0	3	1
	TOTAL	31–33	32	—	1.0	3	1
AD (lam)*	WB	.03	.03	.03	.000	10	1
	TOTAL	.03	.03	.03	.000	10	1
AD (lum)*	WB	.01	.01	.01	.000	10	1
	TOTAL	.01	.01	.01	.000	10	1

* Measurements from larger, more visible acanthostyles.

Genus **HOMOTRYPA** Ulrich, 1886

Type species.—*Homotrypa curvata* Ulrich, 1882, p. 242–243.

Homotrypa minnesotensis Ulrich, 1886
Plate 6, Figures 1–2

Homotrypa minnesotensis Ulrich, 1886, p. 79; 1893, p. 235, 236, pl. 19, figs. 1–9.

cf. *Homotrypa* cf. *minnesotensis* Ulrich. Fritz, 1957, pl. 14, figs. 1,2.

Description.—Zoaria ramose. Most new zooecia initiated in outer endozone. Exozonal zooecial cavities subrounded to subpolygonal. Endozonal cavities polygonal to subpolygonal. Zooecia curve evenly in outermost endozone and lower exozone before straightening (in mature specimens) to intersect colony surface at approximately 70° to 80°. Zooecial bend occasionally in lower exozone. Surface angle sometimes higher, especially if zooecia curve slightly near periphery. Endozonal walls thin, thickening gradually within zooecial bend attaining a moderate thickness that remains fairly uniform throughout exozone. Exozonal walls even to wavy to commonly crenulate. Sometimes beaded. Crenulation and beading occur before that part of outermost endozone having diaphragms. Endozonal zooecial diameters constricted in outermost endozone. Occasional megazooecium within inner endozone. Exozonal walls and outermost endozonal walls located at zooecial bend, composed of distinct U- to V-shaped laminae. Diaphragms and cystiphragms present in exozone, relative proportions sometimes quite variable both within and among zoaria. In general, zooecia having cystiphragms with attached diaphragms are less common than ones with all or nearly all diaphragms. Both diaphragms and cystiphragms fairly regularly spaced at approximately one-half zooecial cavity diameter. Exozonal diaphragms mainly inclined towards proximal side of zooecial tubes. Few perpendicular to walls. Many diaphragms curved convex outwards. Thickness usually constant throughout. Few diaphragms in outermost endozone numbering approximately three, found either perpendicular to wall or more commonly inclined slightly towards proximal side of zooecium and spaced at about one to one and one-half of a zooecial cavity diameter apart. Many cystiphragms gradually thicken towards side attached to wall. Commonly one to two diaphragms attached to each cystiphragm. Some without attached diaphragms. Mesozooecia uncommon. Tabulation closer and thickness slightly greater than for autozooecia, spacing approximately one mesozooecial cavity diameter apart. Cavity outlines subrounded to subangular. Some autozooecia develop into mesozooecia and vice versa. Also found in maculae. Minute acanthostyles and/or mural lacunae observed in tangential section at many zooecial corners. Obscure in longitudinal section. In some colonies, more obvious than in others. Maculae distinct. Composed of larger autozooecia, thicker autozooecial walls, more mesozooecia though still not common, generally larger acanthostyles (laminar sheaths) in some maculae.

Measurements.—Measurements are summarized in Table 16.

Remarks.—Specimens from the study area agree in all aspects with Ulrich's (1893) description of *Homotrypa minnesotensis* with the possible exception of somewhat thicker walls than depicted in Ulrich's plate 19, figures 1–9. Perry (1962), studying specimens from the Upper Mississippi Valley, faced some diffi-

Table 16.—Quantitative data, *Homotrypa minnesotensis* Ulrich. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 30–43 (65–78)	.18–.27	.22	.21	.021	25	5
	CB 41–75	.14–.21	.17	.17	.020	15	3
	CB 126–145	.17–.22	.19	.18	.0166	10	2
	CB Total	.14–.22	.18	.17, .18	.020	25	5
	TOTAL	.14–.27	.20	.21	.028	50	10
ZCD (mac)	NL IV 30–43 (65–78)	.28–.38	.33	.34	.028	25	5
	CB 41–75	.22–.32	.27	.26	.030	10	2
	CB 126–145	.26–.34	.30	.30	.029	10	2
	CB Total	.22–.34	.28	.26, .30	.032	20	4
	TOTAL	.22–.38	.31	.30	.037	45	9
ZWT	NL IV 30–43 (65–78)	.02–.06	.04	.03	.013	25	5
	CB 41–75	.04–.10	.07	.06	.016	15	3
	CB 126–145	.04–.08	.05	.04	.013	10	2
	CB Total	.04–.10	.06	.06	.016	25	5
	TOTAL	.02–.10	.05	.05, .06	.018	50	10
ZWT (mac)	NL IV 30–43 (65–78)	.05–.10	.07	.06	.013	25	5
	CB 41–75	.04–.10	.08	.09	.019	10	2
	CB 126–145	.04–.08	.06	.07	.014	10	2
	CB Total	.04–.10	.07	.07	.017	20	4
	TOTAL	.04–.10	.07	.07	.015	45	9
Z/mm²	NL IV 30–43 (65–78)	23–32	28	26	2.8	8	5
	CB 41–75	22–26	24	24	1.6	4	3
	CB 126–145	23–24	23	23	0.58	3	2
	CB Total	22–26	24	24	1.2	7	5
	TOTAL	22–32	26	26	2.9	15	10

culty in whether to assign his specimens to *H. minnesotensis* or *H. exilis*. Though many of his specimens displayed the larger branch diameters suggestive of the former species, the presence of thicker walls prompted him to assign the latter designation. Bork and Perry (1968b, p. 1048) note a similar close relationship between the two species. Their specimens were assigned to *H. exilis* (their non-varietal form) because of "uniform development of thick zooecial walls, lack of acanthopores, and extremely narrow peripheral region," although the peripheral region of *H. minnesotensis* is noted by Ulrich (1893, p. 236) to be "very narrow." In wall thickness, the species described herein more closely resembles *Homotrypa exilis*; however, *H. minnesotensis* is distinguished by the presence of conspicuous maculae, acanthostyles, thin and wavy walls in endozone and larger diameter of colony branches. Additional differences between *H. minnesotensis* and *H. exilis* encompass shape of zooecial cavity outlines (angular vs. rounded), curvature of zooecia (gentle throughout vs. abruptly bent peripheral region), relative amounts of mesozooecia (few vs. comparatively numerous), and obliquity of zooecial apertures (commonly oblique vs. direct), though these differences judging from Ulrich's (1893) plate XIX would not seem to be as distinct as indicated in his text, a situation alluded to also by Bork and Perry (1968b). Additionally, Ulrich's plate XIX, figure 19 of *H. exilis* depicts acanthostyle-like features not noted in his text. A reexamination of Ulrich's type material could serve to clarify the comparisons and discrepancies posed above. The overwhelming similarity to Ulrich's written description of *H. minnesotensis*, however, suggests that the single major difference between his specimens and those of the present study area in Tennessee, namely exozonal wall thickness, could be environmentally controlled.

Distribution.—Localities NL IV, CB.

Studied Material.—Hypotypes NL IV 30(65)A-3-A(M) [USNM 431870], NL IV 43(78)B-6L-V(M) [USNM 431871], NL IV 43(78)B-6L-R(M) [USNM 431872], NL IV 43(78)B-5L-HH(M) [USNM 431873], NL IV 43(78)B-5L-JJ(M) [USNM 431874], NL IV 44(79)E-4-A [USNM 431875], NL IV 44(79)D-24L-R [USNM 431876], NL IV 63(98)B-2LB-G [USNM 431877], NL IV 96(131)D-1-C [USNM 431878], CB 41B-2-B(M) [USNM 431879], CB 46A-2-A(M) [USNM 431880], CB 74–75A-5-A(M) [USNM 431881], CB 126A-1-B(M) [USNM 431882], CB 145C-4-D(M) [USNM 431883], CB 41B-8-A [USNM 431884], CB 45.5A-4-A [USNM 431885], CB 122A-18-B [USNM 431886], CB 145B-2-B [USNM 431887], CB 161A-3-B(?) [USNM 431888].

Homotrypa flabellaris var. **spinifera** Bassler, 1903
Plate 5, Figures 1–6

Homotrypa flabellaris var. *spinifera* Bassler, 1903, p. 580, pl. 21, figs 11–15; Cummings, 1908, p. 847, pl. 18, figs. 2; Utgaard and Perry, 1964, p. 51–55, pl. 3, figs. 7, 8, pl. 4, figs 1–4 (partim).

Description.—Zoaria ramose, sometimes encrusting. Zooecia initiated homogeneously throughout inner and outer endozone. Zooecial cavity outlines subpolygonal to subrounded in exozone. Endozonal zooecia polygonal. Zooecia commonly curve smoothly and rapidly from outer endozone, through inner exozone. Surface angle at or nearly at 90°. Sometimes zooecial bend in lower exozone. Endozonal walls even to wavy, commonly crenulate with occasional beading. Walls thicken fairly rapidly in lower exozone, sometimes becoming quite thick, commonly pinch and swell slightly zooecially outwards, sometimes wavy. Walls formed of distinct U- to V-shaped laminae. Locally, apices of laminae joined by dark line. Exozonal diaphragms thin, generally consistent thickness throughout, usually planar but some slightly convex outwards, usually perpendicular to zooecial walls but sometimes locally inclined and overlapping. Diaphragms of many zooecia in endozonal/exozonal transition bend convex outwards and inclined from the perpendicular towards the proximal sides of zooecia. Cystiphragm development generally occurs above these. Diaphragms in exozone spaced approximately two-thirds to one zooecial cavity diameter apart. Endozonal diaphragms planar, exceedingly thin, perpendicular to zooecial walls, subject to recrystallization. Diaphragms of upper endozone spaced apart one to two times zooecial cavity diameter. In inner endozone, spacing is two to three times zooecial cavity diameter. Cystiphragms present in most zooecia, usually found in exozone on distal side of curved portions of zooecia. Largest cystiphragms zooecially inwards. Cystiphragms of middle to upper exozone commonly thickest on upper side attached to wall, gradually thinning towards their bases. Cystiphragms overlapping, locally isolated, commonly one or two diaphragms attached to each cystiphragm. Cystiphragms often fill one half zooecial cavity width in transverse section. Mesozooecia uncommon. When present, diaphragms thicker than for autozooecia and spaced approximately one mesozooecial cavity diameter apart. Acanthostyles variable in number across colony, sometimes scattered with several zooecia having no styles among them and other portions of colony having zooecia surrounded by two or three styles. Acanthostyles usually very large (including surrounding laminar sheaths which are somewhat variable in diameter across zoaria), occur most commonly in exozone and less so in outer endozone. Endozonal styles commonly with surrounding petaloid arrangement of autozooecia. Maculae mainly composed of megazooecia and a few small mesozooecia. Vague indications of minute style-like openings suggested at many zooecial corners.

Measurements.—Measurements are summarized in Table 17.

Remarks.—Specimens assigned herein to *Homotrypa flabellaris* var. *spinifera* are characterized by their variably spaced and usually very large acanthostyles, widely spaced axial diaphragms, common pinching and swelling of moderately thick exozonal walls, generally high surficial angles at approximately 90°, and commonly crenulate endozonal walls.

H. flabellaris var. *spinifera* differs from *H. subramosa* in having granular to laminar exozonal walls, fewer acanthostyles which are larger and more variably spaced, cystiphragms that commonly do not as extensively wrap around the perimeter of zooecial tubes, thicker exozonal zooecial walls, and smaller zooecial cavity diameters.

H. flabellaris var. *spinifera* differs from *H. tuberculata* in having less crowded diaphragms in the exozone, diaphragms within the endozone, fewer mesozooecia, larger, fewer, and more variably spaced acanthostyles, generally larger exozonal widths, and smaller zooecial cavity diameters with generally thinner zooecial walls.

Bassler (1903, p. 580) noted the variety *spinifera* to accommodate forms of *H. flabellaris* Ulrich having "very large acanthopores." Utgaard and Perry (1964) mentioned that their material contained specimens of *Homotrypa* with morphologies that continuously spanned the descriptions of *H. flabellaris* Ulrich and *H. flabellaris* var. *spinifera* Bassler. Consequently, they felt that both morphologies encompassed a single species group. Specimens within the present author's study area possess larger styles in all instances. Therefore, Bassler's varietal designation should be maintained so as to not mask any possible ecophenotypic variation. Additionally, since specimens with large acanthostyles have until now been restricted to the Cincinnatian, the above distinction based on acanthostyle size could also serve to enlighten phylogenetic relationships.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied Material.—Hypotypes NL IV 100(135)A-12L-J(M) [USNM 431889], NL IV 100(135)A-UNK.(M) [USNM 431890], NL IV 100(135)A-4L-BB(M) [USNM 431891], NL IV 100(135)A-4L-BBB(M) [USNM 4319892], NL IV 100(135)A-5L-C(M) [USNM 431893], NL IN 108(143)A-8-F(M) [USNM 431894], NL IV 108(143)A-11-B(M) [USNM 431895], NL IV 116(151)B-3-B(M) [USNM 431896],

Table 17.—Quantitative data, *Homotrypa flabellaris* var. *spinifera* Bassler. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.10–.16	.14	.14	.014	40	8
	CB	.12–.18	.15	.16	.022	5	1
	WB	.16–.18	.17	.16, .18	.010	5	1
	TOTAL	.10–.18	.14	.14	.018	50	10
ZCD (mac)	NL IV	.16–.24	.21	.22	.021	35	7
	CB	.22–.26	.24	.24	.014	5	1
	WB	.23–.26	.25	.24, .26	.013	5	1
	TOTAL	.16–.26	.21	.22	.025	45	9
ZWT	NL IV	.03–.08	.05	.04	.013	40	8
	CB	.04–.06	.05	.04	.008	5	1
	WB	.02–.04	.03	.02	.008	5	1
	TOTAL	.02–.08	.05	.04	.014	50	10
Z/mm^2	NL IV	31–40	34	32	3.0	8	8
	CB	37	37	37	0.0	1	1
	WB	34	34	34	0.0	1	1
	TOTAL	31–40	34	32	2.9	10	10
AD (lam)	NL IV	.05–.14	.09	.09	.019	37	8
	CB	.10–.14	.11	.10	.018	5	1
	WB	.07–.08	.08	.08	.004	5	1
	TOTAL	.05–.14	.09	.08, .09	.020	47	10
AD (lum)	NL IV	.01–.03	.01	.01	.006	31	8
	CB	.01	.01	.01	.000	4	1
	WB	.02	.02	.02	.000	4	1
	TOTAL	.01–.03	.01	.01	.006	39	10
ED (lam)	NL IV	.10–.16	.14	.16	.026	5	1
	CB	.08–.12	.11	.12	.018	5	1
	WB	—	—	—	—	—	—
	TOTAL	.08–.16	.12	.12	.026	10	2

NL IV 50(85)A-2L-C [USNM 431897], NL IV 61(96)A-4-B [USNM 431898], NL IV 61(96)A-2-B [USNM 431899], NL IV 61(96)A-1-B [USNM 431900], NL IV 61(96)A-2-C [USNM 431901], NL IV 61(96)A-5-U [USNM 431902], NL IV 61(96)A-9-I [USNM 431903], NL IV 61(96)A-5-S [USNM 431904], NL IV 61(96)A-9-H [USNM 431905], NL IV 61(96)A-8-B [USNM 431906], NL IV 63(98)B-5LA-F [USNM 431907], NL IV 63(98)B-4LB-SS [USNM 431908], NL IV 63(98)B-3LB-S [USNM 431909], NL IV 63(98)B-3LB-U [USNM 431910], NL IV 63(98)B-6LA-F [USNM 431911], NL IV 72(107)B-5L-A [USNM 431912], NL IV 72(107)B-3L-A [USNM 431913], NL IV 72(107)A-4-B [USNM 431914], NL IV 85(120)A-5L-J [USNM 431915], NL IV 87(122)A-3B-A [USNM 431917], NL IV 93(128)A-7-A [USNM 431918], NL IV 93(128)A-1-L [USNM 431921], NL IV 93(128)A-6-A [USNM 431922], NL IV 93(128)A-1-M [USNM 431923], NL IV 93(128)A-5-E [USNM 431924], NL IV 94(129)A-2L-G [USNM 431925], NL IV 94(129)A-3L-F [USNM 431926], NL IV 94(129)A-3L-E [USNM 431927], NL IV 96(131)B-2-C [USNM 431928], NL IV 96(131)B-1-A [USNM 431929], NL IV 96(131)B-3-C [USNM 431930], NL IV 96(131)B-4-D [USNM 431931], NL IV 100(135)A-6L-E [USNM 431932], NL IV 100(135)A-10L-E [USNM 431933], NL IV 100(135)A-12L-G [USNM 431934], NL IV 100(135)A-10L-G [USNM 431935], NL IV 100(135)A-5L-L=M [USNM 431936], NL IV 100(135)A-5L-E [USNM 431937], NL IV 100(135)A-3L-B [USNM 431939], NL IV 100(135)A-4L-H [USNM 431940], NL IV 100(135)A-6L-A [USNM 431941], NL IV 100(135)A-2L-CC [USNM 431942], NL IV 100(135)A-9L-J [USNM 431943], NL IV 100(135)A-6L-B [USNM 431944], NL IV 100(135)A-9L-CCC [USNM 431945], NL IV 100(135)A-2L-R [USNM 431946], NL IV 100(135)A-9L-BB [USNM 431947], NL IV 100(135)A-2L-F [USNM 431948], NL IV 100(135)A-9L-AA [USNM 431949], NL IV 100(135)A-4L-RR [USNM 431950], NL IV 100(135)A-11L-D [USNM 431951], NL IV 100(135)A-13L-C [USNM 431952], NL IV 100(135)A-6L-C [USNM 431953], NL IV 100(135)A-11L-E [USNM 431954], NL IV 100(135)A-4L-B [USNM 431955], NL IV 100(135)A-11L-G [USNM 431956], NL IV 100(135)A-9L-LL [USNM 431957], NL IV 100(135)A-9L-RR [USNM 431958], NL IV 100(135)A-5L-B [USNM 431959],

NL IV 100(135)A-4L-S [USNM 431960], NL IV 100(135)A-10L-F [USNM 431961], NL IV 100(135)A-4L-LL [USNM 431962], NL IV 100(135)A-10L-J [USNM 431963], NL IV 100(135)A-9L-PP [USNM 431964], NL IV 108(143)A-14-F [USNM 431965], NL IV 108(143)A-5-H [USNM 431966], NL IV 108(143)A-6-L [USNM 431967], NL IV 108(143)A-17-H [USNM 431968], NL IV 108(143)A-6-M [USNM 431969], NL IV 108(143)A-16-D [USNM 431970], NL IV 108(143)A-12-C [USNM 431971], NL IV 108(143)A-2-I [USNM 431973], NL IV 108(143)A-3-C [USNM 431974], NL IV 116(151)A-4-G [USNM 431976], NL IV 116(151)A-5-A [USNM 431977], NL IV 116(151)B-2-A [USNM 431978], NL IV 116(151)B-2-B [USNM 431979], NL IV 116(151)B-3-A [USNM 431980], NL IV 117(152)A-7-R [USNM 431981], NL IV 61(96)A-6-L(F) [USNM 431982], CB 85A-14L-A(M) [USNM 431983], CB 50B-4-B [USNM 431984], CB 50A-3-B [USNM 431985], CB 67B-9-A [USNM 431986], CB 79A-2-A [USNM 431987], CB 85A-2-B [USNM 431988], CB 85A-15L-A [USNM 431989], CB 85A-7-B [USNM 431990], CB 85A-17L-B [USNM 431991], CB 85A-17L-D [USNM 431992], CB 120A-3-B [USNM 431993], CB 138B-2-A [USNM 431994], CB 153A-2L-A [USNM 431995], CB 153B-1-B [USNM 431996], CB 156A-4L-C [USNM 431997], CB 45A-7-A(F) [USNM 431998], CB 50A-4-B(F) [USNM 431999], CB 67B-8-D(F) [USNM 432000], CB 79A-3-A(F) [USNM 432001], CB 79B-5-B(F) [USNM 432002], CB 85A-10-B(F) [USNM 432003], CB 85A-4-A(F) [USNM 432004], CB 85A-13L-A(F) [USNM 432005], CB 122A-14-A(F) [USNM 432006], CB 122A-6-A(F) [USNM 432007], CB 153B-1-C(F) [USNM 432008], HCM 4(44)A-3-A [USNM 432009], HCM 38(77)A-1-G=H [USNM 432010], HCM 43(82)C-6-E,C [USNM 432011], HCM 43(82)C-4-A [USNM 432012], HCM 43(82)B-5-K [USNM 432013], HCM 43(82)C-1-D [USNM 432014], HCM 43(82)B-5-D [USNM 432015], HCM 43(82)C-5-O,P [USNM 432016], HCM 18(57)B-4-K(F) [USNM 432017], HCM 43(82)B-8-P(F) [USNM 432018], WB 44(56)B-2-A(M) [USNM 432019], WB 20(32)B-6-A [USNM 432020], WB 44(56)A-5-B [USNM 432021], WB 44(56)A-1-A [USNM 432022], WB 44(56)A-5-C [USNM 432023], WB 20(32)A-2-B(F) [USNM 432024].

Homotrypa similis Foord, 1883
Plate 7, Figure 3

Homotrypa similis Foord, 1883, p. 10; Ulrich, 1893, p. 242–243, pl. 20, figs. 28–33; Bassler, 1911, p. 185–187, figs 97–98; Bork and Perry, 1968b, p. 1052–1053, pl. 135, figs. 6–9.

cf. *Homotrypa similis* Foord, 1883. Karklins, 1984, p. 128–130, pl. 5, fig. 2, pl. 6, figs. 1–4, 6; Fritz, 1957, p. 23, pl. 14, figs 4, 5.

Description.—Zoaria ramose. Most zooecia initiated in outer endozone. In exozone, zooecial cavity outlines mainly subpolygonal to subrounded and elongate in tangential section due to low surface angle. In endozone, zooecial cavity outlines polygonal. Zooecia curve shallowly towards exozone and intersect surface at low angles (30° to 45°). In some specimens a slight zooecial bend occasionally found in lower exozone whereupon the zooecia will intersect the colony surface at somewhat higher angles than usual. Exozone narrow. Endozonal walls thin. Exozonal walls thicken slowly but continuously from base of exozone to colony surface. Zooecial walls appear granular in longitudinal section but in places exhibit convex outward laminae. Laminae more obvious in tangential section. Endozonal walls sometimes slightly crenulate in places, parallel-sided. Megazooecia present in center of endozone. Diaphragms common in outer endozone and exozone, occasionally present in some inner endozonal zooecia, fairly thin throughout and of even thickness, generally planar and fairly perpendicular to zooecial walls but sometimes inclined slightly. In addition, some exozonal diaphragms gently convex or concave outwards or wavy. Locally, diaphragms sometimes overlap, especially in outermost exozone of mature specimens. Diaphragms of inner endozone spaced at about three zooecial cavity diameters apart, in outer endozone spaced about two zooecial cavity diameters apart, in inner exozone about one zooecial cavity diameter apart. Within the exozone, in general, spaced at two-thirds to one zooecial cavity diameter apart but locally sometimes much closer, especially in the outer exozone. Generally one or two diaphragms attach to a cystiphragm. Cystiphragms common throughout, generally beginning in the outer endozone or inner exozone and continuing throughout the exozone. Cystiphragms usually of even thickness, sometimes slightly thicker towards sides attached to zooecial walls. Cystiphragms overlap and in longitudinal section extend one-third to one-half the distance into the zooecial cavity. Cystiphragms in the outer endozone/inner exozone overlap the previously formed cystiphragm to a lesser extent than do later formed cystiphragms, and therefore appear more elongate parallel to the zooecial axis. Locally, some cystiphragms overlap two other cystiphragms in exozone. Usually one or two diaphragms attach themselves to a cystiphragm. Locally, however, no diaphragms appear to join them. Mesozooecia uncommon in exozone. Diaphragms slightly thicker than for autozooecia and spaced at one mesozooecial cavity diameter apart. During ontogeny, either develop into

Table 18.—Quantitative data, *Homotrypa similis* Foord. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.18–.38	.24	.22, .24, .26	.050	15	3
	CB	.18–.34	.25	.24	.036	20	4
	TOTAL	.18–.38	.25	.24	.042	35	7
MnZCD	NL IV	.09–.16	.13	.12, .16	.024	15	3
	CB	.09–.17	.14	.16	.025	20	4
	TOTAL	.09–.17	.13	.16	.024	35	7
ZWT	NL IV	.02–.06	.04	.04	.015	15	3
	CB	.02–.05	.03	.03	.009	20	4
	TOTAL	.02–.06	.03	.03	.012	35	7
Z/mm²	NL IV	25–29	27	—	2.1	3	3
	CB	24–27	25	24	1.4	4	4
	TOTAL	24–29	26	24, 25	1.8	7	7

autozooecia or terminate. Acanthostyles present in exozone. Commonly two or three distinct styles surround each zooecium. Minute openings of uncertain nature sometimes observed in tangential section within zooecial walls. Laminae surrounding each style commonly inflect into adjacent zooecial cavities and also commonly offset. Maculae present on megazooecia and some mesozooecia.

Measurements.—Measurements are summarized in Table 18.

Remarks.—Homotrypa similis characteristically has zooecia inclined at low angles to the colony surface, a granular appearance of most exozonal zooecial walls in longitudinal section, two to three acanthostyles per zooecium, axial megazooecia in the center of the endozone, diaphragms within both endozone and exozone, and uncommon mesozooecia.

Homotrypa similis differs from *H. minnesotensis, H. tabulata* and *H. tuberculata* in having exozonal zooecia which are more inclined to the colony surface, and exozonal walls which appear granular in longitudinal section. It differs further from *H. minnesotensis* in lacking beading of endozonal walls and in having fewer inclined exozonal diaphragms, more endozonal diaphragms, a less regular spacing of cystiphragms and diaphragms in the exozone, and thinner exozonal walls. *H. similis* differs additionally from *H. tabulata* in possessing many more cystiphragms, a less variable spacing of exozonal diaphragms, and more distinct acanthostyles. The present species differs further from *H. tuberculata* in having generally less rounded apertures, no distinct zooecial bend, no to few mesozooecia, less distinct styles, more regularly spaced diaphragms and cystiphragms, and generally thinner exozonal zooecial walls.

The presence of thin inner endozonal diaphragms is suggested to be obscured in some specimens due to recrystallization. In *H. tabulata*, endozonal diaphragms, in places, were observed to be in various stages or recrystallization so that in the most extreme case entire diaphragms could have been obliterated. Bork and Perry (1968b) noted that one of their four specimens of *H. similis* similarly lacked diaphragms in its inner endozone, however, they did not offer an explanation for this phenomenon.

Distribution.—Localities NL IV, CB, HCM.

Studied Material.—Hypotypes NL IV 108(143)A-8-D(M) [USNM 432025], NL IV 108(143)A-3-B(M) [USNM 432026], NL IV 108(143)A-6-N(M) [USNM 432027], NL IV 94(129)A-4L-E [USNM 432028], NL IV 100(135)A-10L-D [USNM 432029], NL IV 116(151)A-5-F [USNM 432031], CB 46A-3-A(M) [USNM 432032], CB 50A-2-B(M) [USNM 432033], CB 50A-2-C(M) [USNM 432034], CB 50A-2-A(M) [USNM 432035], CB 50A-3-D [USNM 432036], CB 50A-3-C [USNM 432037], CB 50A-2-E,F [USNM 432038].

Homotrypa tabulata, new species
Plate 6, Figure 3

Description.—Zoaria ramose. Budding of new zooecia occurs between mid- to outer endozone. Zooecia curve broadly to colony surface and intersect it at between 50° and 70°. Sometimes a slight zooecial bend in lower exozone. In tangential section, zooecial cavity outline subrounded to subpolygonal and commonly slightly elongate parallel to colony axis due to low surface angle. Polygonal outline in endozone. Endozonal walls thin, thicken gradually in lower exozone before reaching maximum thickness which itself is thin. Exozonal walls laminate, composed of V-shaped laminae. Some walls with dark line connecting apices of laminae. Endozonal walls even to slightly crenulate, fairly parallel-sided. Endozonal zooecia larger in diameter than exozone. Constricted at exozonal base. Endozonal diaphragms planar, perpendicular to zooe-

Table 19.—Quantitative data, *Homotrypa tabulata* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	CB 41–50	.16–.24	.19	.18	.020	15	3
	CB 122	.20–.22	.21	.22	.011	5	1
	CB Total	.16–.24	.19	.20	.020	20	4
	HCM	.14–.18	.16	—	.016	5	1
	TOTAL	.14–.24	.19	.18, .20	.024	25	5
ZWT	CB 41–50	.03–.04	.03	.03	.005	15	3
	CB 122	.02–.03	.02	.02	.004	5	1
	CB Total	.02–.04	.03	.03	.007	20	4
	HCM	.03–.04	.03	.03	.006	5	1
	TOTAL	.02–.04	.03	.03	.007	25	5
Z/mm²	CB 41–50	28–35	31	—	5.0	2	2
	CB 122	28	28	28	0.0	1	1
	CB Total	28–35	30	28	4.0	3	3
	HCM	—	—	—	—	—	—
	TOTAL	28–35	30	28	4.0	3	3
AD (lam)	CB 41–50	.02–.05	.04	.04	.011	15	3
	CB 122	.05–.06	.05	.05	.006	5	1
	CB Total	.02–.06	.04	.04	.013	20	4
	HCM	.02–.03	.03	.03	.006	5	1
	TOTAL	.02–.06	.04	.04	.013	25	5

cial walls, thin. Spaced two zooecial cavity diameters apart. Usually consistent in thickness, but some slightly thicker. Diaphragm spacing decreases to about one zooecial cavity diameter at endozonal/exozonal transition. Diaphragms of exozone perpendicular to zooecial walls to slightly inclined from perpendicular towards proximal side of zooecia, commonly curved slightly, being convex zooecially outwards. Diaphragms occasionally cystose and overlapping. Diaphragms spaced at one-third to one-half of a zooecial cavity diameter apart. Minute acanthostyles with small laminar sheaths present at zooecial corners and between zooecia. Four to six surround each zooecium. Some styles of lower exozone offset in zooecial cavity. Some styles of upper exozone offset within walls, less commonly inflect into zooecial cavity. Maculae composed of megazooecia and of mesozooecia. Diaphragms of mesozooecia perpendicular to wall, spaced at one mesozooecial cavity diameter apart. Some change into autozooecia.

Etymology.—The trivial name refers to the abundance and relatively close tabulation of autozooecial diaphragms.

Measurements.—Measurements are summarized in Table 19.

Remarks.—Specimens assigned to *Homotrypa tabulata* have subrounded to subpolygonal zooecial cavity outlines, surficial angles of between 50° and 70°, relatively wide endozooecial tubes with even to crenulate walls, endozonal diaphragms spaced at about two zooecial cavity diameters apart, exozonal diaphragms commonly curved outwards, perpendicular to inclined to zooecial walls, and spaced at between one-third and one-half of a zooecial cavity diameter, and four to six minute acanthostyles surrounding each zooecium.

Homotrypa tabulata is quite similar to *Homotrypa exilis* variant B of Bork and Perry (1968b, p.1049) but for the presence of definitive acanthostyles (they note that true acanthostyles are "probably lacking" but could be present and represented as dark spots at isolated wall junctions as viewed in tangential section), diaphragms in the endozone, and somewhat smaller zooecial cavity diameters. *H. tabulata* differs from *Homotrypa minnesotensis* Ulrich, 1886 as well in the presence of endozonal diaphragms and smaller zooecial cavity diameters, and also by the absence of numerous exozonal cystiphragms. See the Remarks sections of *Homotrypa exilis* (typical form and two variants) as found in Bork and Perry (1968b) as well as the Remarks section of *H. minnesotensis* described herein (p. 44) for discussions contrasting and comparing *H. exilis* with *H. minnesotensis.*

A few endozonal diaphragms were observed to be in various stages of recrystallization so that, in places, entire diaphragms are suggested to have been removed.

Distribution.—Localities CB, HCM, WB.

Studied Material.—Holotype CB 50A-4-A(M) [USNM 432039], Paratypes CB 41A-3-B(M) [USNM 432040], CB 41B-4-B(M) [USNM 432041], CB 122A-10-A(M) [USNM 432042], HCM 11(50)B-1-

E(M) [USNM 432043], HCM 11(50)A-5-I [USNM 432044].

Homotrypa tuberculata Ulrich, 1893
Plate 7, Figures 1–2

Homotrypa tuberculata Ulrich, 1893, p. 240–241, fig. 14.

Description.—Zoaria ramose. Most zooecia budded in outer endozone. In exozone, zooecial cavity outline subrounded to rounded. In endozone zooecial cavity outline polygonal. Zooecia curve gently from early endozone to inner exozone. Sharp zooecial bend in lower exozone. Zooecia then continue directly outwards to intersect colony surface at right angles. Exozone generally short. Walls thicken slightly in inner exozone. Greater thicknesses occur above zooecial bend. Endozonal walls thin. Exozonal wall microstructure composed of convex V-shaped laminae. Zooecial walls in endozone fairly parallel-sided, even to slightly crenulate, locally wavy. Axial megazooecia in central endozone. Diaphragms present in outermost endozone and exozone. In exozone, diaphragms extremely variable in number. Spacing varies from one-fifth to two-thirds of a zooecial cavity diameter. Thicknesses vary between individual diaphragms. Diaphragms variable in orientation being planar and perpendicular to zooecial walls, to inclined, commonly overlapping. Diaphragms sometimes wavy, or cystose or bulge concave to convex outwards. Commonly one to three flat diaphragms mainly perpendicular or nearly so to walls before zooecial bend. Overlapping cystiphragms present in exozone beginning at the zooecial bend. Found mainly on distal side of zooecium. Variable in number. Thickness varies between individual cystiphragms. Single cystiphragms frequently overlap two others. In longitudinal section, cystiphragms commonly extend one-half to two-thirds of a zooecial cavity diameter into zooecial void, but sometimes greater, especially at zooecial bend. Mesozooecia scattered throughout colony. Small polygonal cavity outline. Diaphragms thicker than for most autozooecia, spaced one to one and one-half mesozooecial cavity diameters apart. Budding initiated in exozone. Where exozone is relatively wide, mesozooecia terminate and zooecial cavity outlines become subrounded to subpolygonal. Acanthostyles common, distinct, usually three to five surrounding each zooecium and located at zooecial corners and between zooecia in the exozone, clearly observed in longitudinal section as clear calcitic rods. Acanthostyle walls commonly inflect autozooecial walls where thin, and sometimes inflect in outer exozone where walls thicken. Some offset and inflecting. Styles almost always originate at zooecial bend. Maculae composed of megazooecia.

Specimens commonly show rejuvenated growth within a portion of the exozone. Initially walls are thin with thin planar diaphragms spaced at two-thirds of a zooecial cavity diameter apart before assuming more typical exozonal morphology.

Measurements.—Measurements are summarized in Table 20.

Remarks.—*H. tuberculata* typically has subrounded to rounded zooecial cavity outlines, zooecia perpendicular to the colony surface, a zooecial bend in the lower exozone, a variable spacing of autozooecial diaphragms which are often quite closely spaced, mesozooecia, commonly three to five acanthostyles around each autozooecium, and a short exozonal width.

It differs from *Homotrypa flabellaris* var. *spinifera* in having a generally narrower exozone with more variably oriented and more closely spaced diaphragms, no diaphragms within the inner endozone, more common mesozooecia, smaller, more common and more regularly spaced acanthostyles, larger zooecial cavity diameters and generally thinner zooecial walls.

Specimens assigned to *H. tuberculata* differ from Ulrich's (1893) original species description in possessing a greater number of acanthostyles. Ulrich's (1893) figure 14c, however, suggests that more styles could be present than alluded to in his text. Until a thorough reexamination of Ulrich's type material is made, however, the present specimens will retain their current designation due to their otherwise overall morphological similarity with Ulrich's description.

Distribution.—Localities NL IV, CB, HCM.

Studied Material.—Hypotypes NL IV 108(143)A-4-E(M) [USNM 432045], NL IV 72(107)B-4L-C [USNM 432046], NL IV 72(107)B-3L-B [USNM 432047], NL IV 85(120)A-9L-C [USNM 432048], NL IV 85(120)A-6L-A [USNM 432049], NL IV 87(122)A-6B-B [USNM 432050], NL IV 87(122)A-6A-H [USNM 432051], NL IV 93(128)A-1-K [USNM 432052], NL IV 93(128)A-2-C [USNM 432053], NL IV 94(129)A-4L-F [USNM 432054], NL IV 96(131)B-3-B [USNM 432055], NL IV 100(135)A-12-D [USNM 432056], NL IV 100(135)A-11-F [USNM 432057], CB 85A-6-C,D(M) [USNM 432058], CB 41B-3-A [USNM 432059], CB 41B-2-C [USNM 432060], CB 41B-7-A [USNM 432061], CB 72C-7L-A [USNM 432062], CB 74–75A-1-A [USNM 432063], CB 82A-3-B [USNM 432064], CB 132C-9-A [USNM 432065], CB 149A-4-A [USNM 432066], CB 156A-4L-A [USNM 432068], CB 161A-2-D [USNM 432069], CB 161A-4-B [USNM 432070], CB 41B-2-D(F) [USNM 432071], CB 50A-2-D(F) [USNM 432072], CB 67B-11-B(F) [USNM 432073], CB 72A-3L-B(F) [USNM 432074], CB 120A-6-A(F)

Table 20.—Quantitative data, *Homotrypa tuberculata* Ulrich. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.18–.22	.20	.20, .22	.017	5	1
	CB	.20–.22	.21	.20, .22	.010	5	1
	HCM	.12–.23	.18	.18	.022	40	8
	TOTAL	.12–.23	.18	.18	.024	50	10
ZWT	NL IV	.02–.03	.02	.02	.006	5	1
	CB	.03–.04	.03	.03	.006	5	1
	HCM	.02–.07	.04	.04	.012	40	8
	TOTAL	.02–.07	.04	.04	.013	50	10
Z/mm²	NL IV	23	23	23	0.0	1	1
	CB	—	—	—	—	—	—
	HCM	24–29	26	—	1.9	5	5
	TOTAL	23–29	26	—	2.2	6	6
MxMCD	NL IV	.05–.10	.07	.06	.020	5	1
	CB	.07–.12	.09	.10	.020	5	1
	HCM	.04–.17	.08	.08	.027	37	8
	TOTAL	.04–.17	.08	.08	.026	47	10
MnMCD	NL IV	.05–.08	.06	.06	.011	5	1
	CB	.05–.06	.06	.06	.004	5	1
	HCM	.02–.08	.05	.05	.016	37	8
	TOTAL	.02–.08	.05	.05	.015	47	10
AD (lam)	NL IV	.06–.07	.07	.07	.006	5	1
	CB	.06–.07	.06	.06	.006	5	1
	HCM	.03–.07	.05	.05	.010	40	8
	TOTAL	.03–.07	.05	.05	.011	50	10

[USNM 432075], CB 120A-7-B(F) [USNM 432076], CB 149A-2-A(F) [USNM 432077], HCM 5(44)A-2-A(M) [USNM 432078], HCM 18(57)B-6L-H(M) [USNM 432079], HCM 43(82)B-8-Q(M) [USNM 432080], HCM 43(82)B-7-L(M) [USNM 432081], HCM 43(82)B-4-G(M) [USNM 432082], HCM 43(82)C-4-B(M) [USNM 432083], HCM 43(82)B-7-B(M) [USNM 432084], HCM 43(82)C-3-DD(M) [USNM 432085], HCM 18(57)B-4-D [USNM 432086], HCM 18(57)B-5-B [USNM 432087], HCM 43(82)C-3-S [USNM 432088], HCM 43(82)C-4-J [USNM 432089], HCM 18(57)B-4-H(F) [USNM 432090], HCM 43(82)C-3-N(F) [USNM 432091], HCM 43(82)A-2-C(F) [USNM 432092], HCM 43(82)C-5-J(F) [USNM 432093], HCM 43(82)B-4-C(F) [USNM 432094].

Homotrypa callosa Ulrich, 1893
Plate 8, Figures 1–2

Homotrypa callosa Ulrich, 1893, p. 243–244, pl. 20, figs. 15–21.

Description.—Zoaria ramose. Zooecia budded throughout colony. Zooecial cavity outline in tangential section subrounded to subpolygonal. In endozone polygonal. Zooecia curve evenly from outer endozone to colony surface. Surface angle varies mainly from 80° to 90°. Slight zooecial bend sometimes in lower exozone. Walls thicken gradually in outermost endozone and lowermost exozone and generally remain of constant thickness zooecially outwards. Sometimes thicken and thin. Walls mainly granular, in few places poorly defined U-shaped laminae (particularly in longitudinal section). Endozonal walls parallel-sided, even. Diaphragms in exozone perpendicular to zooecial walls, planar, spaced one-half to two-thirds of a zooecial cavity diameter apart. Along colony axis, diaphragms spaced two to three zooecial cavity diameters apart. Near endozonal/exozonal transition one zooecial cavity diameter apart. Zooecia mainly have both diaphragms and overlapping cystiphragms. Some zooecia with diaphragms only. Cystiphragms extend across one-half to two-thirds of a zooecial cavity diameter except near bottom of exozone where greater. Commonly one diaphragm, sometimes two, attached to each cystiphragm. Zooecially innermost surface of cystiphragm ("inner edge" of Ulrich, 1893, p. 243) commonly relatively straight across zooecium. Mesozooecia rare in non-macular areas. Styles present in exozone but scattered and very inconspicuous. Obscure in longitudinal section. Maculae composed of megazooecia and some mesozooecia. Subrounded to subangular cavity outline. Diaphragms spaced at one mesozooecial cavity diameter apart, slightly thicker than for autozooecia.

Measurements.—Measurements are summarized in Table 21.

Table 21.—Quantitative data, *Homotrypa callosa* Ulrich. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.10–.17	.14	.15	.024	20	2
	TOTAL	.10–.17	.14	.15	.024	20	2
ZCD (mac)	NL IV	.19–.31	.25	.24	.027	20	2
	TOTAL	.19–.31	.25	.24	.027	20	2
ZWT	NL IV	.03–.08	.06	.05	.016	20	2
	TOTAL	.03–.08	.06	.05	.016	20	2
ZWT (mac)	NL IV	.03–.06	.05	.04, .05	.008	20	2
	TOTAL	.03–.06	.05	.04, .05	.008	20	2
Z/mm^2	NL IV	34	34	34	0.0	3	2
	TOTAL	34	34	34	0.0	3	2
MCD	NL IV	.02–.04	.03	.02	.008	10	1
	TOTAL	.02–.04	.03	.02	.008	10	1

Remarks.—*H. callosa* is characterized by smoothly curving zooecia that intersect the colony surface at or nearly at 90°, the presence of diaphragms within the entire endozone and exozone, a generally granular zooecial wall structure, few, scattered and inconspicuous acanthostyles, and relatively small zooecial cavity diameters.

H. callosa differs from *Homotrypa subramosa* in having fewer and much less conspicuous acanthostyles, smaller zooecial cavity diameters, thicker zooecial walls, and a somewhat more prevalent granular zooecial wall structure.

H. callosa differs from *H. minnesotensis* in that the former species has an endozone in which the walls are non-crenulate and non-beaded and in which diaphragms are present throughout. Exozonal walls are largely non-laminar and thicker. Also, within a smaller zooecial cavity are relatively more cystiphragms and less inclined diaphragms.

Distribution.—Locality NL IV.

Studied Material.—Hypotypes NL IV 96(131)B-2-J(M) [USNM 432095], NL IV 100(135)A-13L-F(M) [USNM 432096].

Homotrypa subramosa Ulrich, 1896
Plate 9, Figures 1–5

Homotrypa subramosa Ulrich, 1886, p. 81; 1893, p. 239, 240, pl. 19, figs. 21–28; Bassler, 1911, p. 187–189, text-figs. 99, 100; Bork and Perry, 1968b, p. 1053–1055, pl. 136, figs. 1–3.

Description.—Zoaria mainly ramose, some encrusting. Budding of zooecia occurs throughout endozone. In exozone, zooecial cavity outline subpolygonal. In endozone, outline polygonal. Zooecia curve smoothly and evenly from endozone to reach colony surface at right angles. No distinct zooecial bend. Exozone begins within the curved portion of zooecial tubes before zooecia attain orientation at right angles to colony surface. Walls thicken gradually in lowermost exozone, maximum thickness in exozone only moderate. Exozonal walls sometimes thicken and thin slightly along length. Walls granular to laminar, laminae more obvious in tangential section. In endozone, zooecial walls fairly parallel-sided, even to crenulate. Walls sometimes thicken slightly and accommodate short acanthostyles. Diaphragms present throughout endozone where thin, planar, perpendicular to zooecial walls and commonly spaced three or more zooecial cavity diameters apart within inner endozone and about one and one-half zooecial cavity diameters apart in outer endozone. Diaphragms of innermost endozone occasionally sparse in some zoaria, when present, commonly associated in zones. Some diaphragms possibly obliterated due to recrystallization. Diaphragms present throughout exozone. Commonly thin, sometimes relatively thick, forming distinct zooecial wall lining units and associated with slight thickening of wall, mainly planar and perpendicular to zooecial walls but sometimes inclined, slightly curved and incomplete (overlapping). Spacing commonly between one-half to two-thirds of a zooecial cavity diameter apart but locally spaced closer or less frequently further. Cystiphragms present in exozone, overlapping, and fairly regularly spaced. In longitudinal section, cystiphragms most commonly found in zoarially distal side of zooecial tube. Maximally extend one-half of a zooecial cavity diameter into zooecial cavity and wrap around two-thirds to three-fourths of zooecial perimeter. Some individual cystiphragms differ slightly in thickness between each other. Within single cystiphragms, gradations in thickness can exist with the top of the cystiphragm being thicker than the bottom, the thickness variation being continuous and gradual. Thicker walled cystiphragms commonly associated with slight thickening of zooecial wall. In lowermost exozone,

Table 22.—Quantitative data, *Homotrypa subramosa* Ulrich. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.22–.28	.24	.22	.026	5	1
	CB	.18–.24	.21	.20	.020	15	3
	HCM	.20–.26	.23	.24	.019	15	3
	WB	.20–.25	.22	.22	.015	15	3
	WEST Total	.20–.26	.23	.22	.017	30	6
	TOTAL	.18–.28	.22	.22	.021	50	10
ZCD (mac)	NL IV	.30–.34	.32	.32	.014	5	1
	CB	.24–.28	.27	.28	.018	5	1
	HCM	.26–.30	.28	.26	.018	10	2
	WB	.28–.34	.31	.30	.024	5	1
	WEST Total	.26–.34	.29	.30	.025	15	3
	TOTAL	.24–.34	.29	.28	.027	25	5
ZWT	NL IV	.02	.02	.02	.000	5	1
	CB	.03–.04	.04	.04	.005	15	3
	HCM	.02–.05	.03	.02	.010	15	3
	WB	.02–.06	.03	.02	.013	15	3
	WEST Total	.02–.06	.03	.02	.011	30	6
	TOTAL	.02–.06	.03	.02	.010	50	10
Z/mm^2	NL IV	21	21	21	0.0	1	1
	CB	22–24	23	—	1.0	3	3
	HCM	22–23	23	23	0.58	3	3
	WB	19–21	20	21	1.2	3	3
	WEST Total	19–23	22	21, 23	1.5	6	6
	TOTAL	19–24	22	23	1.4	10	10
AD (lam)	NL IV	.05–.08	.06	.06	.011	5	1
	CB	.05–.08	.06	.06	.011	15	3
	HCM	.05–.08	.06	.07	.009	15	3
	WB	.06–.08	.07	.06, .07	.006	15	3
	WEST Total	.05–.08	.06	.07	.008	30	6
	TOTAL	.05–.08	.06	.06	.009	50	10
AD (lum)	NL IV	.01	—	—	—	—	1
	CB	.01	—	—	—	—	3
	HCM	.01	—	—	—	—	3
	WB	.01–.02	—	—	—	—	3
	WEST Total	.01–.02	—	—	—	—	6
	TOTAL	.01–.02	—	—	—	—	10

where zooecia bend, cystiphragms usually larger than normal, extending farther into zooecial cavity. In general, each cystiphragm has an accompanying diaphragm attached between it and the zooecial wall. Some cystiphragms have two diaphragms, however, while others have none. Mesozooecia absent to rare. Acanthostyles common throughout exozone. Found mainly at zooecial corners but sometimes found between two zooecia. Two to four styles surround each zooecium, commonly two to three. Laminar sheaths sometimes inflect into zooecial cavities, depending on the wall thicknesses of the autozooecia. Isolated short styles sometimes found in endozone commonly associated with former presumed growth surface (*i.e.*, at a surface of rejuvenation). Maculae present and consist of megazooecia. In many low encrusting forms, walls thinner, acanthostyles with narrower laminar sheaths, and commonly three to five styles surround each zooecium. Zooecial cavity diameter near base somewhat smaller.

Measurements.—Measurements are summarized in Table 22.

Remarks.—Specimens assigned to *H. subramosa* typically have zooecia that curve smoothly and evenly to intersect the colony surface at right angles, diaphragms generally found throughout colony (though some zoaria have sparse diaphragm development in inner endozone), commonly two to three distinct acanthostyles around each zooecium, relatively large zooecial cavity diameters, and cystiphragms which commonly wrap around a large portion of zooecial perimeter.

Homotrypa subramosa differs from *H. callosa* in the presence of common and distinct acanthostyles, larger zooecial cavity diameters, and thinner walls, and a more widespread development of a laminar wall structure.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes (RAMOSE FORMS): NL IV 116(151)A-3-M (M) [USNM 432097], NL IV 87(122)A-2B-A [USNM 432098], NL IV 93(128)A-10-G [USNM 432099], NL IV 93(128)A-9-G [USNM 432100], NL IV 96(131)B-4-F [USNM 432101], NL IV 96(131)B–D [USNM 432102], NL IV 96(131)C-3-E [USNM 432103], CB 82B-3-A (M) [USNM 432105], CB 82A-2-A (M) [USNM 432106], CB 132B-4-B (M) [USNM 432107], CB 41A-5-B [USNM 432108], CB 62A-5-C [USNM 432109], CB 82A-3-A [USNM 432110], CB 82A-4-A [USNM 432111], CB 85B-1-A [USNM 432112], CB 145B-1-D [USNM 432113], CB 153A-4L-C [USNM 432114], CB 116A-4-A [USNM 432115], CB 45A-9-A(F) [USNM 432116], CB 46B-2-A(F) [USNM 432117], CB 54A-2-A(F) [USNM 432118], CB 55A-1-A(F) [USNM 432119], CB 55B-1-B(F) [USNM 432120], CB 70A-4-A(F) [USNM 432121], CB 85A-6-A(F) [USNM 432122], CB 114A-5-B(F) [USNM 432123], CB 114A-4-A(= 5-A)(F) [USNM 432124], CB 114A-13-A(F) [USNM 432125], CB 128A-1-A(F) [USNM 432126], HCM 18(57)B-4-E(M) [USNM 432127], HCM 18(57)B-4-F(M) [USNM 432128], HCM 43(82)B-8-U(M) [USNM 432129], HCM 18(57)B-4-A,B [USNM 432130], HCM 18(57)B-3-A [USNM 432131], HCM 18(57)B-4-G [USNM 432132], HCM 38(77)B-2A-A [USNM 432133], HCM 43(82)A-3-S [USNM 432134], HCM 43(82)B-5-B [USNM 432135], HCM 11(50)A-5-A(F) [USNM 432136], HCM 11(50)B-1-D(F) [USNM 432137], HCM 11(50)B-6-N(F) [USNM 432138], HCM 11(50)B-6-A(F) [USNM 432139], HCM 11(50)B-2-B(F) [USNM 432140], HCM 11(50)A-6-J(F) [USNM 432141], HCM 18(57)A-5L-A(F) [USNM 432142], HCM 43(82)A-8-W(F) [USNM 432143], HCM 43(82)A-2-B(F) [USNM 432144], HCM 43(82)C-3-M(F) [USNM 432145], HCM 50(89)A-5-M(F) [USNM 432146], WB 43(55)C-5L-A(M) [USNM 432147], WB 44(56)B-3-A(M) [USNM 432148], WB 44(56)C-2-C(M) [USNM 432149], WB 2(14)A-2-A [USNM 432150], WB 29(41)A-2-A [USNM 432151], WB 41(53)D-2-A [USNM 432152], WB 27(39)B-8-A(F) [USNM 432153], WB 29(41)A-6-A(F) [USNM 432154], WB 43(55)B-1-A(F) [USNM 432155], WB 43(55)B-4-A(F) [USNM 432156], WB 43(55)B-2-B(F) [USNM 432157], WB 44(56)A-3-A(F) [USNM 432158], WB 44(56)B-5-A(F) [USNM 432159], WB 44(56)B-5-C(F) [USNM 432160], WB 44(56)A-4-A(F) [USNM 432161]. (ENCRUSTING FORMS): NL IV 24(59)B-3-A [USNM 432162], NL IV 24(59)B-3-B [USNM 432163], NL IV 33(64)A-2-B [USNM 432164], NL IV 43(78)B-6L-BB [USNM 432165], NL IV 44(79)E-4-B [USNM 432166], NL IV 50(85)A-11-C [USNM 432167], NL IV 87(122)A-6A-A [USNM 432168], CB 55A-10-A [USNM 432169], CB 138B-7-A [USNM 432170].

Homotrypa sp. A
Plate 8, Figure 3

Description.—Zoaria ramose. Zooecial cavity outlines in exozone subpolygonal to subrounded where walls thick, subpolygonal to polygonal where walls thin. Zooecia curve smoothly from outer endozone to colony surface. Zooecial bend sometimes in lower exozone. Surface angle at or nearly at 90°. Endozonal walls thin, thicken relatively quickly in outer endozone, characteristically thick in inner exozone, then thin somewhat in outer exozone. Wall microstructure of U-shaped laminae convex outwards. Faint dark line sometimes observed to connect apices of laminae. Endozonal walls uneven, wavy, crenulate, and/or beaded in places. Megazooecia in inner endozone. Endozone relatively wide. Diaphragms in exozone planar to curved convex outwards, commonly inclined towards proximal part of colony. Sometimes perpendicular to zooecial walls, overlapping, associated with cystiphragms, or less commonly wavy. Some individual diaphragms thickened especially where adjacent walls maximally thickened. Spacing variable, often between one-half and two-thirds of a zooecial cavity diameter apart. Diaphragms in outermost endozone usually planar and perpendicular to zooecial walls, becoming more inclined and curved towards exozonal base. Spacing varies between one and three zooecial cavity diameters apart with spacing decreasing towards exozone. Diaphragms uncommon in inner endozone. Some cystiphragms present in exozone only and on distal sides of zooecia, frequently gradational with cystose diaphragms, sometimes with attached diaphragm. Mesozooecia absent. Acanthostyles in exozone between zooecia and at zooecial corners. Commonly two to three surround each zooecium. Laminar sheaths larger where surrounding zooecial walls thicken, inflect zooecial tubes where walls thin, less commonly where walls thick. Some offset. Occasional styles in endozone.

Measurements.—Measurements are summarized in Table 23.

Remarks.—*Homotrypa* sp. A is morphologically distinct from other species of the study area and is unlike any other previously described in the literature owing primarily to the exceedingly robust development of laminar, irregularly thickened exozonal walls. Other typical features of this species include a gener-

Table 23.—Quantitative data, *Homotrypa* sp. A. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.08–.15	.11	.10	.026	15	2
	TOTAL	.08–.15	.11	.10	.026	15	2
ZWT	NL IV	.08–.14	.11	.11	.021	15	2
	TOTAL	.08–.14	.11	.11	.021	15	2
AD (lam)	NL IV	.05–.12	.08	.07, .08, .10	.020	15	2
	TOTAL	.05–.12	.08	.07, .08, .10	.020	15	2

ally smooth zooecial curvature with a surficial angle at or nearly at 90°, occasional irregular development of endozonal walls (uneven, wavy, crenulate, and/or beaded), common inclined and cystose diaphragms, two to three acanthostyles around each exozonal zooecium, and endozonal megazooecia.

Homotrypa sp. A differs from *Homotrypa minnesotensis* in its wider and unevenly thickened exozonal walls, slightly higher surficial angle, smaller zooecial cavity diameter, and presence of distinct acanthostyles.

Due to the limited material at hand, a formal species designation is not opted at this time.

Distribution.—Locality NL IV.

Studied material.—Hypotypes NL IV 100(135)A-10L-0(M) [USNM 432171], NL IV 108(143)A-14-N(M) [USNM 432172].

Genus **MONTICULIPORA** d'Orbigny, 1850

Type species.—*Monticulipora mammulata* d'Orbigny, 1850, p. 25.

Monticulipora sp. A
Plate 10, Figures 1–3

Description.—Zoarium encrusting. Zooecial cavity outlines subpolygonal. Zooecial walls generally granular, sometimes with poorly defined laminae, thin, irregularly thickened and thinned. In places, suggestions of dark median line within walls. Cystiphragms overlapping. In more submature portions of zooecia, cystiphragms tend to protrude further into the zooecial cavity than the less inflated cystiphragms found in more peripheral regions of the colony. Zooecially outward cystiphragms not only wrap around a larger portion of each zooecial tube than the inner ones, but also are more overlapping, commonly with between 12 to 14 cystiphragms per mm instead of six to eight. Each of the more inflated cystiphragms usually with an associated planar diaphragm. Relatively fewer diaphragms in outer portions of zooecia with no or one diaphragm associated with each cystiphragm. Mesozooecia absent to rare. Acanthostyles in exozone, small, found within more robust portions of otherwise thin walls, difficult to distinguish in longitudinal section, found at zooecial corners or between zooecial tubes, offset or centered and inflecting adjacent zooecial tubes especially in deep tangential section, commonly four to six surround each zooecium. Zooecial walls and acanthostyle laminar sheaths somewhat more thickened in macular areas.

Measurements.—Measurements are summarized in Table 24.

Remarks.—Only three encrusting specimens were found within the Hermitage Formation. Though not within the realm of the present study area, preliminary examination of the overlying Cannon Formation reveals this species to be fairly common as both a ra-

Table 24.—Quantitative data, *Monticulipora* sp. A. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.18–.20	.18	.18	.008	10	2
	HCM	.18–.23	.19	.18	.022	5	1
	TOTAL	.18–.23	.19	.18	.014	15	3
ZCD (mac)	NL IV	.25–.30	.28	.30	.025	5	2
	HCM	.26–.34	.30	.30	.033	4	1
	TOTAL	.25–.34	.29	.30	.028	9	3
ZWT	NL IV	.01–.03	.02	.02	.005	10	2
	HCM	.02–.03	.02	.02	.004	5	1
	TOTAL	.01–.03	.02	.02	.005	15	3
AD (lam)	NL IV	.03–.04	.04	.04	.005	10	2
	HCM	.03–.04	.03	.03	.006	5	1
	TOTAL	.03–.04	.04	.04	.005	15	3

mose as well as encrusting form. In this latter formation, the lowermost exozone/outer endozone of the ramose forms have no cystiphragms but rather, flat diaphragms which are spaced about one zooecial cavity diameter apart. Spacing increases within the inner endozone. Zooecia curve evenly and gradually to intersect the colony surface at a slightly oblique angle.

Within the endozone, parallel-sided walls are sometimes fairly crenulate or beaded and acanthostyles are absent.

Specimens assigned to *Monticulipora* sp. A are not formally named since the available material is not sufficient to determine specificity. Several characters appear to be consistent with Boardman and Utgaard's (1966, p. 1093) definition of *Monticulipora*, namely, a poorly defined laminar wall structure (*i.e.*, "markedly granular" of many authors), short acanthostyles limited to thick-walled zones, and cystiphragms and planar diaphragms throughout the length of zooecia (this species has only diaphragms in the endozone of ramose forms, not inconsistent with Boardman and Utgaard's generic concept). The present species also possesses rather polygonal zooecial cavity outlines, not mentioned by Boardman and Utgaard, but characteristic of so many species of *Monticulipora*.

Distribution.—Localities NL IV, HCM.

Studied material.—Hypotypes NL IV 72(107)B-4L-A(M) [USNM 432173], NL IV 85(120)A-3RB-A(M) [USNM 432174], HCM 43(82)B-5-N(M) [USNM 432175].

Family **BATOSTOMELLIDAE** Miller, 1889
Genus **BYTHOPORA** Miller and Dyer, 1878

Type species.—*Helopora dendrina* James, 1878 (= *Bythopora fruiticosa* Miller and Dyer).

Bythopora dendrina (James, 1878)
Plate 10, Figures 4–6

Helopora dendrina James, 1878a, p. 3; 1878b, p. 14–15.
Bythopora fruiticosa Miller and Dyer, 1878, p. 6, pl. 4, figs. 6, 6a.
Bythopora dendrina (James). Nickles and Bassler, 1900, p. 185; Bassler, 1906, p. 20; Ross, 1967b, p. 642–644, pl. 67, figs. 1–8, 10–13, pl. 69, fig. 4, pl. 72, fig. 3; Singh, 1979, p. 203–206, pl. 22, figs. 3–5, pl. 23, figs. 1a–1c, 2.

Description.—Zoaria ramose. Slender, cylindrical branches. New zooecia initiated predominantly in outer endozone. Zooecial cavity outline is elliptical (due to low surface angle) in tangential section. Actual cavity outline as viewed perpendicular to zooecial axis is rounded. Endozonal zooecial cavity outlines polygonal and in transverse section, sometimes exhibit a pseudoradial arrangement. Endozone narrow. Zooecia curve evenly to intersect zoarial surface at low angle, commonly between 30° and 45°. Slight zooecial bend sometimes occurs in lower exozone. Endozonal walls even to wavy and fairly parallel sided. Rarely a relatively large zooecium in middle of endozone. Wall thickness increases continuously from endozonal/exozonal transition to the colony surface where it sometimes tapers slightly. Exozone narrow. Wall microstructure generally composed of U- to V-shaped laminae that sometimes appear to possess a median dark line. Diaphragms absent to extremely rare in exozone. If present, thin, even, perpendicular to zooecial wall. Absent in endozone. No mesozooecia. Minute acanthostyles between zooecia and at zooecial corners. Identified by clear calcitic rods. Surrounding laminae thin to indistinct. Obscure in longitudinal section. Styles number mainly three to five around each zooecium.

Measurements.—Measurements are summarized in Table 25.

Remarks.—*Bythopora dendrina* typically has low surface angle, no to very rare diaphragms, three to five minute acanthostyles surrounding each zooecium, an endozonal width varying from 0.5 to 1.0 mm, and colony branch diameters up to 1.5 mm across.

In many respects *Bythopora dendrina* is extremely similar to *Batostomella subgracilis* described herein (p. 61). The two species together form a fairly continuous gradation in morphology, yet the endpoints are so totally different that the validity of placing them within one species grouping would be very suspect. Ross (1967b) also noted a similarity between her Champlainian *B. dendrina* and specimens of *Bythopora subgracilis* from Estonia as described by Bassler (1911) (*Batostomella subgracilis* of this report). The only difference she noted was that the Estonian material had a greater number of zooecia per 2.0 mm than for *B. dendrina* (eight as compared to four to five). Measurements of this type do not reflect size of zooecial tube since measurements must be normalized for wall thickness and surface angle. Measurements of zooecial diameters of *Bythopora subgracilis* figured by Bassler (1911, p. 241) show no significant difference between the two species. Additionally, measurements of zooecia per 2.0 mm made on specimens of *Bythopora dendrina* illustrated by Ross (1967b) do not show four to five but seven to eight. Not mentioned by Ross is the clear difference in colony branch diameter between the two species. Her specimens of *B. dendrina* from New York State have diameters varying from 0.85 to 1.00 mm, while Bassler's *B. subgracilis* varies between 2.0 and 4.0 mm.

Besides the obvious difference in colony size, slight differences that exist between the two species are the common occurrence of slightly larger zooecia within the innermost endozone in specimens of *Batostomella*

Table 25.—Quantitative data, *Bythopora dendrina* (James). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV 30–49 (65–84)	.09–.26	.17	.18	.036	60	6
	NL IV 66–72 (101–107)	.12–.21	.16	.18	.024	20	2
	NL IV 85–116 (120–151)	.11–.30	.20	.20	.040	125	13
	NL IV TOTAL	.09–.29	.18	.18	.040	205	21
	CB 45–85	.12–.22	.17	.16	.024	47	6
	CB 122–149	.11–.21	.15	.12, .13, .15	.028	21	3
	CB TOTAL	.11–.22	.16	.15, .16	.026	68	9
	HCM	.08–.23	.17	.18, .20	.040	43	5
	WB	.17–.27	.20	.19	.028	9	1
	WEST TOTAL	.08–.27	.18	.20	.040	52	6
	TOTAL	.08–.30	.18	.18	.038	325	36
MnZCD	NL IV 30–49 (65–84)	.06–.12	.08	.08	.012	60	6
	NL IV 66–72 (101–107)	.05–.10	.08	.08, .09	.012	20	2
	NL IV 85–116 (120–151)	.05–.12	.08	.08	.015	125	13
	NL IV TOTAL	.05–.12	.08	.08	.014	205	21
	CB 45–85	.06–.10	.08	.07	.008	47	6
	CB 122–149	.05–.10	.08	.08	.013	21	3
	CB TOTAL	.05–.10	.08	.07	.009	68	9
	HCM	.04–.10	.08	.08	.015	43	5
	WB	.07–.10	.08	.08	.009	9	1
	WEST TOTAL	.04–.10	.08	.08	.014	52	6
	TOTAL	.04–.12	.08	.08	.014	325	36
ZCD (endo/long)	NL IV 30–49 (65–84)	.08–.14	.10	.10	.014	29	5
	NL IV 66–72 (101–107)	—	—	—	—	—	—
	NL IV 85–116 (120–151)	.08–.15	.11	.10	.012	49	8
	NL IV TOTAL	.08–.15	.11	.10	.013	78	13
	CB 45–85	.07–.18	.11	.10, .12	.024	31	6
	CB 122–149	.10–.16	.12	.10	.024	12	2
	CB TOTAL	.07–.18	.12	.10	.024	43	8
	HCM	.10–.24	.14	.12	.036	14	2
	WB	—	—	—	—	—	—
	WEST TOTAL	.10–.24	.14	.12	.036	14	2
	TOTAL	.07–.24	.11	.10	.023	135	23
ZWT	NL IV 30–49 (65–84)	.02–.10	.06	.05	.018	60	6
	NL IV 66–72 (101–107)	.02–.12	.07	.06, .10	.029	18	2
	NL IV 85–116 (120–151)	.01–.07	.04	.04	.014	123	13
	NL IV TOTAL	.01–.12	.05	.04	.022	201	21
	CB 45–85	.03–.10	.05	.04	.019	42	6
	CB 122–149	.03–.09	.05	.04	.017	21	3
	CB TOTAL	.03–.10	.05	.04	.018	63	9
	HCM	.02–.17	.06	.04	.028	42	5
	WB	.04–.06	.05	.04	.010	10	1
	WEST TOTAL	.02–.17	.06	.04	.026	52	6
	TOTAL	.01–.17	.05	.04	.022	316	36
Z/mm^2	NL IV 30–49 (65–84)	26–34	31	32	2.8	7	6
	NL IV 66–72 (101–107)	24–34	29	—	7.1	2	2
	NL IV 85–116 (120–151)	28–54	38	34	6.9	12	11
	NL IV TOTAL	24–54	35	34	6.6	21	19
	CB 45–85	48	48	—	0.0	1	1
	CB 122–149	34	34	—	0.0	1	1
	CB TOTAL	34–84	41	—	9.9	2	2
	HCM	36	36	—	0.0	1	1
	WB	36	36	—	0.0	1	1
	WEST TOTAL	36	36	36	0.0	2	2
	TOTAL	24–54	35	34	6.6	25	23
MxMCD*	NL IV 30–49 (65–84)	.04–.14	.06	.05	.025	18	6
	NL IV 66–72 (101–107)	.05–.14	.09	.09	.029	7	2
	NL IV 85–116 (120–151)	.03–.12	.07	.08	.022	39	13
	NL IV TOTAL	.03–.14	.07	.05	.024	64	21

Table 25.—Continued.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
	CB 45–85	.03–.09	.06	.03, .04, .05, .06, .08	.020	11	4
	CB 122–149	.04–.07	.06	.06	.013	7	2
	CB TOTAL	.03–.09	.06	.06	.017	18	6
	HCM	.04–.10	.07	.07	.017	9	4
	WB	.04–.12	.08	—	.033	4	1
	WEST TOTAL	.04–.12	.07	.07	.022	13	5
	TOTAL	.03–.14	.07	.06	.023	95	32
MnMCD*	NL IV 30–49 (65–84)	.02–.04	.03	.02	.009	18	6
	NL IV 66–72 (101–107)	.02–.05	.04	.02, .04, .05	.012	7	2
	NL IV 85–116 (120–151)	.02–.06	.03	.04	.009	39	17
	NL IV TOTAL	.02–.06	.03	.04	.009	64	21
	CB 45–85	.02–.05	.03	.02	.010	11	4
	CB 122–149	.02–.04	.03	.02, .04	.009	7	2
	CB TOTAL	.02–.05	.03	.02	.009	18	6
	HCM	.02–.05	.03	.02, .04	.012	9	4
	WB	.02–.05	.03	.02	.013	4	1
	WEST TOTAL	.02–.05	.03	.02	.012	13	5
	TOTAL	.02–.06	.03	.04	.010	95	32
CD	NL IV 30–49 (65–84)	1.2–1.5	1.4	1.2	.106	5	5
	NL IV 66–72 (101–107)	1.0	1.0	1.0	.000	2	2
	NL IV 85–116 (120–151)	1.0–1.5	1.3	1.4	.170	13	13
	NL IV TOTAL	1.0–1.5	1.3	1.0, 1.4	.173	20	20
	CB 45–85	1.0–1.2	1.1	1.0	.120	6	6
	CB 122–149	1.0–1.4	1.2	—	.202	3	3
	CB TOTAL	1.0–1.4	1.1	1.0	.149	9	9
	HCM	1.1–1.5	1.3	—	.175	4	4
	WB	1.0–1.5	1.2	—	.354	2	2
	WEST TOTAL	1.0–1.5	1.3	1.5	.211	6	6
	TOTAL	1.0–1.5	1.2	1.0	.178	35	35

* = not true mesozooecia (see text).

subgracilis as well as a different range in endozonal width (0.5 to 1.0 mm for *Bythopora dendrina* and 0.6 to 1.5 mm for *Batostomella subgracilis*). Based on these features alone, some overlap does occur, especially where the large zooecia noted above are not obvious.

An approach employed in the discernment of *Bythopora dendrina* as a separate and viable species is to note its preponderance in lithofacies with taxa other than *Batostomella subgracilis*, though at a few stratigraphic levels, both do co-occur (see stratigraphic range charts of individual species occurrences; see Text-figures 7–10). The presence of the latter species is commonly correlated with the presence of relatively low energy environment that includes *Bythopora dendrina* (see text on Trepostome Bryozoan Assemblages, p. 13). Also, *Bythopora dendrina* has been noted to occur elsewhere in assemblages not containing *Batostomella* (*e.g.*, Ross, 1967b). With this in mind, for colonies that fall into either of these two species groupings, those with branch diameters of less than 1.5 mm and without large inner endozonal zooecia are assigned to *Bythopora dendrina*. Specimens with branch diameters greater than 1.5 mm are assigned to *Batostomella subgracilis*. This latter species also commonly has specimens with relatively large zooecia in the inner endozone as well as frequent constrictions along zooecial tubes, a function in part of its wider exozone. Slight constrictions due to thickened exozonal walls are uncommon in specimens assigned to *Bythopora dendrina*.

Ross (1967b) notes the presence of one to two mesozooecia per zooecial opening in tangential section of the holotype of *B. dendrina*. Singh (1979, p. 206) believes that these are not true mesozooecia but represent "small openings . . . 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." Specimens from the present study area show mesozooecia-like openings in tangential section, but, as in the holotype material, do not show mesozooecia in longitudinal section. The observations of the present author concur with those of Singh's.

The presence of this species (or indeed, of species of *Batostomella*) in collections of early workers is unknown due to the lack of description and illustration of microscopic morphology (*e.g.*, McFarlan, 1931), a point alluded to by Ross (1967b, p. 643–644).

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 30(65)A-1-B(M) [USNM 432176], NL IV 30(65)C-3L-D(M) [USNM 432177], NL IV 43(78)-B-6L-Y(M) [USNM 432178], NL IV 44(79)A-14LA-D(M) [USNM 432179], NL IV 49(84)A-6R-Y(M) [USNM 432180], NL IV 49(84)A-8RB-A(M) [USNM 432181], NL IV 66(101)A-10-A(M) [USNM 432182], NL IV 72(107)B-2L-J(M) [USNM 432183], NL IV 85(120)A-7L-D(M),E [USNM 432184], NL IV 85(120)A-2LB-A(M) [USNM 432185], NL IV 89(124)A-5B-C(M) [USNM 432186], NL IV 93(128)A-11-D(M) [USNM 432187], NL IV 93(128)A-3-A (M) [USNM 432188], NL IV 93(128)A-4-L(M) [USNM 432189], NL IV 93(128)A-4-A(M) [USNM 432190], NL IV 93(128)A-2-I(=J)(M) [USNM 432191], NL IV 93(128)A-13-E(M) [USNM 432192], NL IV 96(131)B-6-E (M) [USNM 432193], NL IV 100(135)A-2L-Y(M) [USNM 432194], NL IV 108(143)A-18-C(M),D,E [USNM 432195], NL IV 116(151)A-3-D(M) [USNM 432196], NL IV 19(54)B-5-A [USNM 432197], NL IV 30(65)A-3-C [USNM 432198], NL IV 30(65)A-1-C [USNM 432199], NL IV 30(65)C-5-X [USNM 432200], NL IV 37(72)B-2-H [USNM 432201], NL IV 37(72)B-5-B [USNM 432202], NL IV 49(84)A-11L-P [USNM 432203], NL IV 49(84)A-6R-Z [USNM 432204], NL IV 51(86)A-10L-A [USNM 432205], NL IV 51(86)A-2L-A [USNM 432206], NL IV 61(96)A-4-I [USNM 432207], NL IV 61(96)A-4-D [USNM 432208], NL IV 61(96)A-7-G [USNM 432209], NL IV 61(96)A-9-B [USNM 432210], NL IV 61(96)A-4-G [USNM 432211], NL IV 61(96)A-9-A [USNM 432212], NL IV 63(98)A-4LB-UU [USNM 432213], NL IV 63(98)A-2LB-S [USNM 432214], NL IV 63(98)A-5LA-G [USNM 432215], NL IV 66(101)A-8-A [USNM 432216], NL IV 66(101)A-10-B [USNM 432217], NL IV 66(101)A-5A-B [USNM 432218], NL IV 72(107)B-L-L [USNM 432219], NL IV 72(107)A-4-D [USNM 432220], NL IV 85(120)A-10L-C [USNM 432221], NL IV 85(120)A-7L-F [USNM 432222], NL IV 85(120)A-3RB-B [USNM 432223], NL IV 93(128)A-10-B [USNM 432224], NL IV 93(128)A-11-A [USNM 432225], NL IV 93(128)A-11-B [USNM 432226], NL IV 93(128)A-11-C [USNM 432227], NL IV 93(128)A-4-A [USNM 432228], NL IV 93(128)A-10-A [USNM 432229], NL IV 93(128)A-4-C [USNM 432230], NL IV 93(128)A-1-P [USNM 432231], NL IV 96(131)B-6-D [USNM 432232], NL IV 100(135)A-13L-J [USNM 432233], NL IV 100(135)A-10L-Q [USNM 432234], NL IV 100(135)A-6L-K [USNM 432235], NL IV 100(135)A-4L-G [USNM 432236], NL IV 100(135)A-2L-W [USNM 432237], NL IV 108(143)A-13L-J [USNM 432238], NL IV 108(143)A-12-B [USNM 432239], NL IV 108(143)A-2-O [USNM 432240], CB 45A-4-A(M) [USNM 432241], CB 55A-9-C(M) [USNM 432242], CB 62A-5-B(M) [USNM 432243], CB 72C-7L-C(M) [USNM 432244], CB 72C-5L-D(M) [USNM 432245], CB 85A-7-C(M) [USNM 432246], CB 122A-9-A(M) [USNM 432247], CB 132C-7-A(M) [USNM 432248], CB 149A-6-B(M) [USNM 432249], CB 41A-4-A [USNM 432250], CB 54A-4-B [USNM 432251], CB 55B-2-E [USNM 432252], CB 85A-12L-C [USNM 432253], CB 132C-8-A [USNM 432254], CB 138B-4-A [USNM 432255], CB 161A-1-E [USNM 432256], CB 45A-6-A(F) [USNM 432257], CB 45A-4-B(F) [USNM 432258], CB 45A-3-A(F) [USNM 432259], CB 62A-9-A(F) [USNM 432260], CB 72C-6L-A(F) [USNM 432261], CB 72B-2-A(F) [USNM 432262], CB 72C-2LA-C(F) [USNM 432263], CB 72C-6L-B(F) [USNM 432264], CB 82A-3-C(F) [USNM 432265], CB 82A-2-D(F) [USNM 432266], CB 82A-2-C(F) [USNM 432267], CB 85A-5-A,C(F) [USNM 432268], CB 85A-12L-B(F) [USNM 432269], CB 114A-7-A(F) [USNM 432270], CB 114A-2-A(=3-A)(F) [USNM 432271], CB 114A-6-A(F) [USNM 432272], CB 120A-2-A(F) [USNM 432273], CB 120A-3-A(F) [USNM 432274], CB 122A-18-A(F) [USNM 432275], CB 122A-7-A(F) [USNM 432276], CB 122A-8-A(F) [USNM 432277], CB 122A-2L-A(F) [USNM 432278], CB 122A-15-A(F) [USNM 432279], CB 132B-2-A(F) [USNM 432280], CB 132C-5L-A(F) [USNM 432281], CB 132C-5L-C(F) [USNM 432282], CB 149A-2-B(F) [USNM 432283], CB 149A-2-C(F) [USNM 432284], CB 150B-4-B(F) [USNM 432285], CB 156A-3-B(F) [USNM 432286], CB 159A-2-B(F) [USNM 432287], CB 159B-2-B(F) [USNM 432288], CB 161A-5-A(F) [USNM 432289], HCM 11(50)A-5-R(M) [USNM 432290], HCM 38(77)B-1-A(M) [USNM 432291], HCM 43(82)C-2-I(M) [USNM 432292], HCM 50(89)A-B(M) [USNM 432293], HCM 50(89)A-J (M),K,L [USNM 432294], HCM 5(44)A-3-C [USNM 432295], HCM 38(77)A-3-O [USNM 432296], HCM 50(89)A-A [USNM 432297], HCM 11(50)A-6-H(F) [USNM 432298], HCM 11(50)B-1-L(F) [USNM 432299], HCM 38(77)A-3-P(F) [USNM 432300], WB 44(56)A-2-A(M) [USNM 432301], WB 32(44)A-4-A [USNM 432302], WB 38(50)A-2-A [USNM 432303], WB 4(16)A-5R-A(F) [USNM 432304], WB 19(31)A-2-A(F) [USNM

432305], WB 20(32)B-7-A(F) [USNM 432306], WB 44(56)A-5-A(F) [USNM 432308].

Genus **BATOSTOMELLA** Ulrich, 1882

Type species.—*Chaetetes gracilis* Nicholson, 1874; by subsequent designation, Miller, 1889, p. 294.

Batostomella subgracilis (Ulrich, 1893)
Plate 11, Figures 1–4

Homotrypella (?) *subgracilis* Ulrich, 1893, p. 230, 231, pl. 26, figs. 10–16.

Bythopora subgracilis (Ulrich). Bassler, 1911, p. 241, 242, text-figs. 135a–d, 136a, b.

Description.—Zoaria ramose. Branches cylindrical and 1.5 to 3.5 mm in diameter (non-varietal form). New zooecia initiated predominantly in outer endozone. Zooecial cavity outlines elliptical to elongate in direction of zoarial axis. Actual cavity outlines rounded when observed perpendicular to zooecial axis. Endozonal zooecial cavity outlines polygonal and in transverse section, sometimes exhibit a pseudoradial arrangement. Zooecia curve evenly from endozone and intersect colony surface at generally 45° but sometimes up to 90°. Zooecial bend occasionally occurs in lower exozone. Endozonal walls thin, fairly even and parallel-sided. One to several megazooecia in innermost endozone (= axial zooecia). Wall thickness increases continuously in a zooecially distal direction from endozonal/exozonal transition into lower to mid-exozone, commonly slightly decreasing the diameter of the zooecial cavity, after which wall thickness remains fairly constant with minor periodic thickening or thinning before intersecting the colony surface. Walls composed of U-shaped laminae, the apices of which are connected by a faint dark line. Diaphragms absent to rare in exozone. When present are thin, even and perpendicular to exozone walls. Absent in endozone. No mesozooecia (though thickening of outer wall in places gives the appearance of mesozooecia in tangential section). Minute acanthostyles between zooecia and at zooecial corners. Number about three to five around each zooecium. Obscure in longitudinal section. More obvious in deep tangential cuts.

Measurements.—Measurements are summarized in Table 26.

Remarks.—For many years the concept of *Batostomella* as a genus was clouded. Part of the confusion was a result of Nickles and Bassler (1900) assigning *Chaetetes gracilis* to *Bythopora* Miller and Dyer (1878). Since *Chaetetes gracilis* was considered by Miller (1889) to be the type species of *Batostomella,* this genus would then be a junior synonym of *Bythopora.* Further confusion resulted when the type material of *C. gracilis* was lost. The inability to locate this material prompted Ross (1967b, p. 641) to write "the generic concept of *Batostomella* remains unknown and the name belongs to the list of unrecognizable generic names of ectoprocts." Singh (1979, p. 200), prompted in part by Ross's (1967b) rediscovery of the original type material of *Bythopora* (*Helopora dendrina* James), reestablished the concept of *Batostomella.* He noted that robust, externally smooth zoaria which have thick exozones and thickened zooecial walls, all characteristic of *Chaetetes gracilis* are distinctive and do not fit the concept of *Bythopora* "which is characterized by delicate, slender forms with an extremely thin exozone." Singh (1979, p. 200) added that "in spite of the fact that the types of *C. gracilis* are unavailable for study . . . 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." Singh (1979, p. 196) mentioned that ". . . *Batostomella* includes robust forms that have zooecial openings constricted in the exozone by thickening of zooecial walls, while *Bythopora* has only slightly flared openings." Further, he writes (p. 202) "*Bythopora* differs from *Batostomella* in that the megazooecia are not developed in the endozone." Singh's concept of the genus is followed here.

Ulrich (1893, p. 231) noted that his specimens of *Homotrypella* (?) *subgracilis* from the Middle Ordovician of Minnesota resemble *Chaetetes gracilis* (the type species of *Batostomella*) more than any other species. The species described herein differs from *B. gracilis* of Singh (1979) by lacking mesozooecia and by having less distinctive acanthostyles and a relatively narrow endozone. The reader is referred to the *Remarks* section under *B. dendrina* for further comments concerning its differentiation from *B. subgracilis.*

As in *B. dendrina,* tangential sections of *B. subgracilis* show mesozooecia-like openings. Distinct mesozooecia are difficult to ascertain in longitudinal section. There are many instances of wall thickening within zooecial tubes producing smaller diameters than common. These thickenings are most likely responsible for the mesozooecia-like openings observed in tangential section.

Distribution—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 93(128)A-2-F(M) [USNM 432309], NL IV 93(128)A-11-J(M) [USNM 432310], NL IV 93(128)A-2-L (M) [USNM 432311], NL IV 93(128)A-2-M(M) [USNM 432312], NL IV 93(128)A-3-K(M) [USNM 432313], NL IV 93(128)A-4-I(M) [USNM 432314], NL IV 93(128)A-4-H(M) [USNM 432315], NL IV 93(128)A-6-B (M) [USNM 432316], NL IV 93(128)A-2-H(M) [USNM 432317], NL IV 94(129)A-3L-I(M) [USNM 432318], NL IV 96(131)C-1-C(M) [USNM 432319], NL IV

Table 26.—Quantitative data, *Batostomella subgracilis* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.09–.27	.15	.12	.035	195	20
	CB 55–85	.10–.22	.16	.14, .18	.032	61	7
	CB 132	.12–.20	.16	.14	.025	13	2
	CB TOTAL	.10–.22	.16	.14	.030	74	9
	HCM	.10–.19	.14	.13	.027	20	2
	WB	.10–.24	.16	.17	.034	40	4
	WEST TOTAL	.10–.24	.16	.13	.032	60	6
	TOTAL	.04–.27	.15	.12	.034	329	35
MnZCD	NL IV	.05–.13	.07	.07	.013	195	20
	CB 55–85	.05–.12	.08	.07	.013	61	7
	CB 132	.06–.08	.07	.08	.007	13	2
	CB TOTAL	.05–.12	.08	.07	.012	74	9
	HCM	.06–.14	.09	.07, .11	.020	20	2
	WB	.05–.10	.08	.07	.011	40	4
	WEST TOTAL	.05–.14	.08	.07	.016	60	6
	TOTAL	.05–.14	.08	.07	.014	329	35
ZCD (endo/long)	NL IV	.09–.18	.12	.10	.020	90	14
	CB 55–85	.10–.18	.13	.10	.030	23	4
	CB 132	.08–.26	.12	.12	.048	17	2
	CB TOTAL	.08–.26	.13	.10	.038	40	6
	HCM	.12–.19	.15	—	.036	3	1
	WB	.10–.20	.14	.16	.026	17	4
	WEST TOTAL	.10–.20	.14	.12, .16	.027	20	5
	TOTAL	.08–.26	.12	.10	.028	150	25
ZWT	NL IV	.03–.13	.06	.06, .07	.017	193	20
	CB 55–85	.04–.13	.06	.07	.019	63	7
	CB 132	.06–.10	.08	.07, .08	.012	16	2
	CB TOTAL	.04–.13	.07	.07	.019	79	9
	HCM	.05–.12	.08	.06, .07	.022	20	2
	WB	.01–.12	.07	.05, .09	.027	40	4
	WEST TOTAL	.01–.12	.07	.06	.025	60	6
	TOTAL	.01–.13	.07	.07	.019	332	35
Z/mm²	NL IV	25–40	33	34	4.3	20	19
	CB 55–85	28–39	30	28	4.3	6	4
	CB 132	30	30	—	0.0	1	1
	CB TOTAL	28–39	30	28, 30	3.9	7	5
	HCM	30–38	34	—	5.7	2	1
	WB	16–36	27	—	7.9	6	4
	WEST TOTAL	16–38	29	30	7.8	8	5
	TOTAL	16–40	32	30	5.4	35	29
MxMCD*	NL IV	.02–.13	.06	.05	.019	115	20
	CB 55–85	.03–.16	.07	.06	.026	30	7
	CB 132	.04–.07	.06	.05, .07	.012	8	2
	CB TOTAL	.03–.16	.07	.06, .07	.024	38	9
	HCM	.05–.09	.07	.06, .07	.013	10	2
	WB	.03–.10	.07	.06	.017	20	4
	WEST TOTAL	.03–.10	.07	.06	.016	30	6
	TOTAL	.02–.16	.06	.05	.020	183	35
MnMCD*	NL IV	.02–.06	.03	.03	.010	115	20
	CB 55–85	.02–.05	.03	.04	.010	30	7
	CB 132	.02–.06	.03	.03	.014	8	2
	CB TOTAL	.02–.06	.03	.04	.010	38	9
	HCM	.04–.07	.05	.05	.008	10	2
	WB	.02–.06	.04	.03	.011	20	4
	WEST TOTAL	.02–.07	.04	.04	.012	30	6
	TOTAL	.02–.07	.03	.03	.011	183	35

Table 26.—Continued.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
CD	NL IV	1.8–3.5	2.6	2.0, 2.5, 3.0	.496	20	20
	CB 55–85	1.5–3.5	2.0	1.8, 2.0	.675	7	7
	CB 132	2.0	2.0	—	.000	2	2
	CB TOTAL	1.5–3.5	2.0	2.0	.585	9	9
	HCM	1.8–2.2	2.0	—	.354	2	2
	WB	1.8–3.0	2.4	3.0	.658	4	4
	WEST TOTAL	1.8–3.0	2.3	1.8, 3.0	.579	6	6
	TOTAL	1.5–3.5	2.4	2.0	.579	35	35

* = not true mesozooecia (see text).

96(131)C-5-G(M) [USNM 432320], NL IV 100(135)A-2L-A(M) [USNM 432321], NL IV 100(135)A-12L-H(M) [USNM 432322], NL IV 100(135)A-4L-Z(M) [USNM 432323], NL IV 100(135)A-9L-NN(M) [USNM 432324], NL IV 100(135)A-10L-QQ(M) [USNM 432325], NL IV 100(135)A-5L-G(M) [USNM 432326], NL IV 116(151)A-5-D(M) [USNM 432327], NL IV 116(151)A-2-A(M) [USNM 432328], NL IV 93(128)A-3-F [USNM 432330], NL IV 93(128)A-4-E [USNM 432331], NL IV 93(128)A-2-G [USNM 432332], NL IV 93(128)A-4-F,G [USNM 432333], NL IV 93(128)A-6-C [USNM 432334], NL IV 93(128)A-9-C [USNM 432335], NL IV 93(128)A-2-E [USNM 432336], NL IV 93(128)A-11-K [USNM 432337], NL IV 93(128)A-1-D [USNM 432338], NL IV 93(128)A-12-F [USNM 432339], NL IV 93(128)A-1-E [USNM 432340], NL IV 93(128)A-3-E [USNM 432341], NL IV 93(128)A-9-J,K [USNM 432342], NL IV 93(128)A-6-D [USNM 432343], NL IV 93(128)A-3-C [USNM 432344], NL IV 93(128)A-3-D [USNM 432345], NL IV 96(131)C-5-A [USNM 432346], NL IV 93(128)B-2-A [USNM 432347], NL IV 96(131)B-5-A [USNM 432348], NL IV 96(131)B-4-E [USNM 432349], NL IV 96(131)D-2-D [USNM 432350], NL IV 96(131)C-5-E,D [USNM 432351], NL IV 96(131)C-2-D [USNM 432352], NL IV 96(131)D-4-C [USNM 432353], NL IV 96(131)C-4-A [USNM 432354], NL IV 96(131)B-7-E [USNM 432355], NL IV 100(135)A-2L-C [USNM 432356], NL IV 100(135)A-4L-W [USNM 432357], NL IV 100(135)A-9L-D [USNM 432358], NL IV 100(135)A-9L-DD [USNM 432359], NL IV 100(135)A-5L-J [USNM 432360], NL IV 100(135)A-2L-A [USNM 432361], NL IV 100(135)A-13L-D [USNM 432362], NL IV 100(135)A-5L-N [USNM 432363], NL IV 100(135)A-6L-F [USNM 432364], NL IV 100(135)A-2L-T [USNM 432365], NL IV 100(135)A-2L-B [USNM 432366], NL IV 100(135)A-3L-F,G [USNM 432367], NL IV 108(143)A-2-J [USNM 432369], NL IV 108(143)A-17-I,J [USNM 432370], NL IV 108(143)A-5-L [USNM 432371], NL IV 108(143)A-13-G [USNM 432372], NL IV 108(143)A-14-G [USNM 432373], NL IV 108(143)A-14-D [USNM 432374], NL IV 108(143)A-13-D [USNM 432375], NL IV 108(143)A-17-F [USNM 432376], NL IV 116(151)A-1-A [USNM 432377], CB 55A-7-A(M) [USNM 432378], CB 55B-2-D(M) [USNM 432379], CB 67B-7-G(M) [USNM 432380], CB 72C-2LA-C(M) [USNM 432381], CB 85A-9-C(M) [USNM 432382], CB 85A-8-A(M) [USNM 432383], CB 85A-5-B(M) [USNM 432384], CB 132C-5L-B(M) [USNM 432385], CB 132C-2-A(M) [USNM 432386], CB 79B-5-A [USNM 432387], HCM 38(77)B-2A-B(M) [USNM 432388], HCM 43(82)A-3-B(M) [USNM 432389], HCM 18(57)C-6-A(F) [USNM 432390], HCM 43(82)B-4-J(F) [USNM 432391], WB 44(56)B-5-B(M) [USNM 432392], WB 44(56)B-2-D(M) [USNM 432393], WB 44(56)A-5-D(M),E(M) [USNM 432394].

Batostomella subgracilis (Ulrich)
var. **robusta** new variety
Plate 11, Figure 5
Plate 12, Figures 1–2

Description.—Specimens of this variety are similar in morphology to *B. subgracilis* but for distinctively larger colony branch diameters of about 3.5 to 6.0 mm.

Measurements.—Measurements are summarized in Table 27.

Remarks.—This variety is found only within the 96–108 foot (29.3–32.9 meter) interval at the Norris Lake IV section along with the typical form of *B. subgracilis* (see appropriate sections herein on the stratigraphic distribution of species occurrences) and is most likely an ecological variant. It is the opinion of the present author that it is important to point out such variance lest it lie buried within a static species description. It is only by recognizing the distribution of species variance within a geographical and ecological framework that we can eventually begin to unravel evolutionary histories, even if we do not have an immediate explanation for the adaptational differences.

Distribution.—Locality NL IV.

Table 27.—Quantitative data, *Batostomella subgracilis* (Ulrich) var. *robusta* n. var. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.08–.20	.14	.10, .12, .15, .16	.030	100	10
	TOTAL	.08–.20	.14	.10, .12 .15, .16	.030	100	10
MnZCD	NL IV	.05–.18	.08	.08	.016	100	10
	TOTAL	.05–.18	.08	.08	.016	100	10
ZCD (endo/long)	NL IV	.08–.30	.14	.10	.057	40	6
	TOTAL	.08–.30	.14	.10	.057	40	6
ZWT	NL IV	.04–.11	.07	.07	.017	100	10
	TOTAL	.04–.11	.07	.07	.017	100	10
Z/mm^2	NL IV	24–38	33	34, 37	4.7	11	10
	TOTAL	24–38	33	34, 37	4.7	11	10
MxMCD*	NL IV	.02–.11	.06	.05, .06	.020	59	10
	TOTAL	.02–.11	.06	.05, .06	.020	59	10
MnMCD*	NL IV	.02–.05	.03	.03	.010	59	10
	TOTAL	.02–.05	.03	.03	.010	59	10
CD	NL IV	3.0–6.0	4.8	4.0, 4.5 5.5, 6.0	.978	10	10
	TOTAL	3.0–6.0	4.8	4.0, 4.5 5.5, 6.0	.978	10	10

* = not true mesozooecia (see text).

Studied material.—Hypotypes NL IV 108(143)A-1-B(M) [USNM 432395], NL IV 100(135)A-3L-E(M) [USNM 432396], NL IV 108(143)A-6-A(M) [USNM 432397], NL IV 108(143)A-14-I(M) [USNM 432398], NL IV 108(143)A-1-G(M) [USNM 432399], NL IV 108(143)A-15-D(M) [USNM 432400], NL IV 108(143)A-1-D(M) [USNM 432401], NL IV 108(143)A-3-C(M) [USNM 432402], NL IV 108(143)A-2-F(M) [USNM 432403], NL IV 108(143)A-14-J(M) [USNM 432404], NL IV 108(143)A-6-O [USNM 432405], NL IV 108(143)A-18-B [USNM 432406].

Genus **ERIDOTRYPA** Ulrich, 1893

Type species.—Eridotrypa mutabilis Ulrich, 1893, p. 265, 266, pl. 26, figs. 20–32.

Eridotrypa mutabilis Ulrich, 1893
Plate 12, Figures 3–4

Eridotrypa mutabilis Ulrich, 1893, p. 265, 266, pl. 26, figs. 20–32; Ross, 1967b, p. 637, 638, pl. 69, figs. 1, 5, 6, 9, 11, pl. 71, figs. 1–10; Karklins, 1984, p. I62–I66, pl. 24, figs. 1–3, pl. 25, figs. 1–6.
Eridotrypa aedilis Bassler, 1911, p. 242–244; McFarlan, 1931, p. 103, pl. 2, figs. 13, 15, pl. 8, fig. 13; Brown, 1965, p. 997, 998, pl. 117, figs. 3–6.

Description.—Zoaria ramose. Zooecial cavity outlines mainly subrounded and oval in tangential section with long axis of ovoid ellipse being parallel to zoarial branch axis. Oval outlines most common owing to tendency of zooecial outlines to intersect colony surface at oblique angle. Where more direct, zooecial cavity outlines subrounded to subpolygonal. Endozone zooecial cavity outlines polygonal in cross-section. Zooecia of inner endozone parallel the zoarial branch axis and begin to curve broadly in the outermost endozone. A slight zooecial bend sometimes occurs in lower exozone or at endozonal/exozonal transition. After bend, zooecia either continue to curve slightly, or proceed straight to colony surface. Surface angles generally shallow (approximately 45°), however, some are steeper where zooecial bend is greater than average. Exozonal walls relatively thick and composed of broad U- to V-shaped laminae which occasionally appear to be divided by a median dark boundary line. This is more so in lowermost exozone where walls relatively thin and laminae V-shaped. Commonly walls increase very gradually in thickness in outer endozone. Wall thickness then increases rapidly but evenly in lower exozone, quickly attaining a thick wall that remains consistent in width or gradually increases through remainder of exozone. Endozonal walls fairly parallel and even, though sometimes locally wavy. Endozonal autozooecial cavities generally larger than for exozone. Innermost (=axial) endozonal zooecia largest. For zooecia that bud in outer endozone, widest diameter found where zooecia curve in lower exozone. Cavity width then decreases as walls thicken peripherally. Diaphragms thin, even, perpendicular to zooecial axis. Uncommon and widely spaced in inner endozone, in-

Table 28.—Quantitative data, *Eridotrypa mutabilis* Ulrich. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.14–.24	.18	.18	.024	30	6
	CB	.14–.22	.18	.16	.023	15	3
	TOTAL	.14–.24	.18	.18	.023	45	9
MnZCD	NL IV	.07–.14	.10	.08, .10	.018	30	6
	CB	.08–.12	.10	.10	.014	15	3
	TOTAL	.07–.14	.10	.10	.016	45	9
ZWT	NL IV	.06–.14	.10	.10	.021	30	6
	CB	.10–.14	.12	.14	.015	15	3
	TOTAL	.06–.14	.11	.10	.021	45	9
Z/mm²	NL IV	16–21	19	20	2.0	6	6
	CB	15–19	17	—	2.1	3	3
	TOTAL	15–21	18	16, 20	2.1	9	9
MxMCD	NL IV	.04–.14	.08	.08	.021	27	6
	CB	.06–.09	.07	.08	.011	9	3
	TOTAL	.04–.14	.08	.08	.019	36	9
MnMCD	NL IV	.04–.08	.06	.06	.012	27	6
	CB	.04–.06	.05	.04	.009	9	3
	TOTAL	.04–.08	.05	.06	.012	36	9

crease in frequency in outer endozone (where walls begin to thicken slightly). Here spacing is about one and one-half to two zooecial cavity diameters apart. Exozonal diaphragms spaced at intervals of about one zooecial cavity diameter apart. Sometimes more closely spaced and overlapping. Mesozooecia originate in lower exozone. Variable in abundance, rarely common. Cavity outlines subrounded to ovate as autozooecia. Diaphragms thicker than for autozooecia and spaced at approximately one-half to one mesozooecial cavity diameter apart. Some develop into autozooecia. Acanthostyles minute and located mainly at zooecial corners of exozone. Styles surrounded by laminae which are more prevalent in astogenetically old colonies. Maculae present. Composed of somewhat larger zooecia (megazooecia) with thicker walls.

Measurements.—Measurements are summarized in Table 28.

Remarks.—*E. mutabilis* of the study area is characterized by zooecia with generally low surface angles, commonly elliptical exozonal zooecial cavity outlines, axial megazooecia (see Key, 1990, for a discussion of the evolutionary importance of axial zooecia in *Eridotrypa*) which narrow in the outermost endozone-innermost exozone, flat diaphragms which are perpendicular to zooecial axes and found mainly in the exozone, rarely in endozone, mesozooecia that are generally uncommon, minute acanthostyles present at zooecial corners, and relatively wide and laminar exozonal walls that thicken rapidly within the lower exozone.

Bassler (1911) and subsequently Brown (1965) considered *E. mutabilis* to be junior subjective synonym of *Cladopora aedilis* Eichwald. Bassler (1911) presented copies of Eichwald's figures of *Cladopora aedilis,* external views of two zoaria. Also figured in Bassler (1911) is Dybowski's (1877) diagrammatic representation of the internal morphology of *C. aedilis.* Bassler (1911) did not figure any specimens from the Baltic Provinces that he considered to be members of *Eridotrypa aedilis* and derived his species concept from Ulrich's original description of *E. mutabilis,* commenting that Dybowski's figures in conjunction with Eichwald's was sufficient for identification of Baltic specimens. Ross (1967b) has examined Ulrich's (1893) type material and has amplified the original species description and designated a lectotype. In addition, she noted that as *E. mutabilis* is the type species of a valid genus, a more comprehensive study of Eichwald's material needed to be done before *E. mutabilis* can be placed in synonymy. Karklins (1984), in an effort to clarify the situation, felt that the figured specimens of Dybowski (1877) (also figured in Bassler, 1911) as well as hypotypes collected by Bassler from the Baltic and which were not figured in his 1911 work, illustrate the best possible concept of *E. aedilis* (especially since the primary types of this species have not yet been described). Differences found by Karklins (1984) to exist between *E. mutabilis* and *E. aedilis* included, for the latter species, a more longitudinal arrangement of exozonal zooecia in the general direction of branch growth, subelliptical (vs. generally subpolygonal) autozooecial cross-sections, basal diaphragms throughout the zoaria (vs. generally sparse in endozones and late exozones), and possibly thinner autozooecial wall laminae. Of these criteria documented by Karklins (1984), the distribution of basal diaphragms would appear, by far, to be the most clear-cut, consistent, and therefore, critical, discriminating factor between *E. aedilis* and *E. mutabilis* of the present study area.

Karklins (1984) noted the presence of *Eridotrypa trentonensis* from the Middle Ordovician of Kentucky and mentioned its close relationship to *E. mutabilis.* The two species are morphologically very similar, except that the former was stated by him to have smaller zoarial branch diameters, narrower endozones and exozones, surficial angles at nearly 90°, and mostly subelliptical zooecial cavity outlines. Measurements from the present study area in Tennessee, as well as those by Ross (1970) from the Champlainian of New York State, and by Ulrich (1893) for type material of the species from Minnesota, reveal branch diameters for *E. mutabilis* to range primarily between 1.5 and 4.5 mm. Endozonal widths from the specimens described in this report commonly vary between 1.0 and 2.0 mm while exozonal widths usually range from 0.4 to 0.9 mm. From figured specimens of Ross (1967b, pl. 69, figs. 1, 5, 11, pl. 71, figs. 3, 4, 7, 8) and Ulrich (1893, pl. 26, figs. 28, 31) endozonal diameters vary between 0.9 and 1.5 mm and exozonal measurements range from 0.4 to 0.8 mm. Variation of *E. mutabilis* var. *minor* figured in Ulrich (1893, pl. 26, figs. 20, 29) falls within these ranges. Zooecial cavity outlines for the above material are generally elliptical to subrounded, and zooecia are most commonly inclined to the colony surface. While Karklins' (1984) criteria serve to distinguish his *E. mutabilis* from *E. trentonensis* within Kentucky, they are inconsistent with the above measurements which would appear to more closely overlap the zoarial, endozonal and exozonal widths of *E. trentonensis* (see Karklins, 1984, table 45) as well as the zooecial cavity outline shapes for this species. Because of the morphologic similarity between *E. trentonensis* and both Ulrich's type material and other authors' concepts of *E. mutabilis,* it is suggested that a reevaluation of Ulrich's type material be made in light of both Karklin's discriminating factors and H.A. Nicholson's collection of *E. trentonensis* types (currently being studied by other workers—see discussion in Karklins, 1984).

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 61(96)A-4-F(M) [USNM 432407], NL IV 61(96)A-5-R(M) [USNM 432408], NL IV 61(96)A-4-K(M) [USNM 432409], NL IV 87(122)A-3B-B(M) [USNM 432410], NL IV 93(128)A-9-D(M) [USNM 432411], NL IV 93(128)A-14-E(M) [USNM 432412], NL IV 30(65)A-1-A [USNM 432413], NL IV 30(65)A-3-B [USNM 432414], NL IV 33(68)A-1-B [USNM 432415], NL IV 37(72)B-4-D [USNM 432416], NL IV 43(78)B-6L-KK [USNM 432417], NL IV 43(78)B-2-F [USNM 432418], NL IV 43(78)B-2-D [USNM 432419], NL IV 49(84)A-8RB-J [USNM 432420], NL IV 49(84)A-6R-AA [USNM 432421], NL IV 50(85)A-4-B [USNM 432422], NL IV 51(86)A-5L-A [USNM 432423], NL IV 61(96)A-2-G [USNM 432424], NL IV 61(96)A-4-C [USNM 432425], NL IV 61(96)A-7-C [USNM 432426], NL IV 61(96)A-5-A [USNM 432427], NL IV 61(96)A-5-D [USNM 432428], NL IV 61(96)A-5-E [USNM 432429], NL IV 61(96)A-2-H [USNM 432430], NL IV 61(96)A-7-D [USNM 432431], NL IV 61(96)A-5-Q [USNM 432432], NL IV 61(96)A-9-F [USNM 432433], NL IV 61(96)A-9-E [USNM 432434], NL IV 61(96)A-8-I,J [USNM 432435], NL IV 61(96)A-5-V [USNM 432436], NL IV 61(96)A-9-J [USNM 432437], NL IV 63(98)B-5LA-C [USNM 432438], NL IV 63(98)B-6LA-D,C [USNM 432439], NL IV 63(98)B-6LA-E [USNM 432440], NL IV 63(98)B-5LA-B [USNM 432441], NL IV 66(101)A-7-E [USNM 432442], NL IV 85(120)A-3AR-C [USNM 432443], NL IV 85(120)A-10L-B [USNM 432444], NL IV 85(120)A-8L-D [USNM 432445], NL IV 85(120)A-9L-A [USNM 432446], NL IV 85(120)A-5L-F [USNM 432447], NL IV 85(120)A-6L-D [USNM 432448], NL IV 85(120)A-5L-E [USNM 432449], NL IV 85(120)A-5L-C [USNM 432450], NL IV 85(120)A-6L-N,O,P [USNM 432451], NL IV 85(120)A-12L-B [USNM 432452], NL IV 85(120)A-6L-E [USNM 432453], NL IV 93(128)A-3-H [USNM 432454], NL IV 93(128)A-4-M [USNM 432455], NL IV 94(129)A-2L-C [USNM 432456], NL IV 96(131)C-2-E [USNM 432457], NL IV 100(135)A-5L-F [USNM 432458], NL IV 100(135)A-11L-B [USNM 432459], NL IV 100(135)A-6L-G [USNM 432460], NL IV 100(135)A-13L-I [USNM 432461], NL IV 116(151)A-5-C [USNM 432462], NL IV 117(152)A-8-A [USNM 432463], NL IV 117(152)A-7-B [USNM 432464], NL IV 117(152)A-7-C [USNM 432465], NL IV 50(85)A-16-A(F) [USNM 432466], NL IV 51(86)A-7L(F) [USNM 432467], NL IV 51(86)A-7L-A,B(F) [USNM 432468], NL IV 63(98)B-LB-X(F) [USNM 432469], CB 45A-3-B(M) [USNM 432470], CB 138.5A-14-A(M) [USNM 432471], CB 153B-1-A(M) [USNM 432472], CB 41A-3-C [USNM 432473], CB 41A-3-A [USNM 432474], CB 41A-1-B [USNM 432475], CB 54A-4-A [USNM 432476], CB 55A-8-B [USNM 432477], CB 62A-11-A [USNM 432478], CB 67B-9-C [USNM 432479], CB 79B-2-A [USNM 432480], CB 82A-1-A [USNM 432481], CB 122A-21-B [USNM 432482], CB 132C-3-A [USNM 432483], CB 132C-3-B

Table 29.—Quantitative data, *Heterotrypa rugosa* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.18–.25	.22	.22	.015	60	6
	TOTAL	.18–.25	.22	.22	.015	60	6
ZCD (mac)	NL IV	.25–.45	.35	.34	.036	56	6
	TOTAL	.25–.45	.35	.34	.036	56	6
ZWT	NL IV	.02–.04	.03	.03	.006	60	6
	TOTAL	.02–.04	.03	.03	.006	60	6
ZWT (mac)	NL IV	.02–.08	.04	.03	.012	60	6
	TOTAL	.02–.08	.04	.03	.012	60	6
Z/mm^2	NL IV	18–24	21	21, 22	1.5	19	6
	TOTAL	18–24	21	21, 22	1.5	19	6

[USNM 432484], CB 145B-3-B [USNM 432485], CB 41B-1-A(F) [USNM 432486], CB 46B-3-A(F) [USNM 432487], CB 54A-3-B(F) [USNM 432488], CB 67B-6-E(F) [USNM 432489], CB 67B-9-D(F) [USNM 432490], CB 67B-6-F [USNM 432491], CB 67B-6-D(F) [USNM 432492], CB 76B-8-L-A(F) [USNM 432493], CB 82A-4-C(F) [USNM 432494], CB 85A-12L-A(F) [USNM 432495], CB 120A-5-A(F) [USNM 432496], CB 122A-1-A(F) [USNM 432497], CB 122A-6-B(F) [USNM 432498], CB 122A-24-A(F) [USNM 432499], CB 145B-3-C(F) [USNM 432500], CB 150B-3-B(F) [USNM 432501], CB 153A-4L-B(F) [USNM 432502], CB 153A-4L-A(F) [USNM 432503], HCM 43(82)C-5L-FF [USNM 432504], HCM 43(82)A-3-G [USNM 432505], WB 20(32)B-4-A [USNM 432506], WB 44(56)B-2-C [USNM 432507].

Family **HETEROTRYPIDAE** Ulrich, 1890
Genus **HETEROTRYPA** Nicholson

Type species.—Monticulipora frondosa d'Orbigny, 1850.

Heterotrypa rugosa, new species
Plate 13, Figures 1–2

Description.—Zoaria ramose. Zooecia initiated mainly between middle to outer endozone. Zooecial cavity outline subpolygonal in exozone, polygonal in endozone. Zooecia curve quickly in outer endozone usually accompanied with distinctive zooecial bend found in lower exozone. After bend, zooecia continue directly to surface. Zooecia intersect colony surface at right angles. Walls gradually thicken in lower exozone before zooecial bend. After bend, exozonal wall thickness consistent outwards to slightly thickened and thinned. Walls composed of U- to V-shaped laminae. Endozonal walls characteristically largely crenulate, fairly parallel-sided. In places, walls beaded or extremely crenulate. Endozone relatively wide. Diaphragms in endozone, thin, planar, perpendicular to walls, spaced two to three zooecial cavity diameters apart. In outer endozone spaced at one and one-half zooecial cavity diameters apart. In lower exozone before zooecial bend, spaced at one zooecial cavity diameter apart. In remaining exozone, diaphragms spaced at one-third to one-half zooecial cavity diameter apart. Exozonal diaphragms mainly perpendicular to zooecial walls, usually slightly bowed convex inwards, sometimes inclined with or without overlap, slightly thicker than for endozone, thickness fairly consistent, diaphragm laminae clearly traceable into wall laminae. Mesozooecia rare, subpolygonal to subrounded, diaphragms thicker than for autozooecia, spaced at one mesozooecial cavity diameter. Mural lacunae, infrequently distinct acanthostyles, common at zooecial corners in exozone. Large acanthostyles scattered in outer endozone. Maculae composed of large autozooecia, mesozooecia very few to absent, walls commonly slightly thicker than in non-macular areas.

Etymology.—The name of the species *rugosa* is derived from the Latin *rugosus* meaning wrinkled, and refers to the crenulate endozonal walls and commonly unevenly thickened exozonal walls.

Measurements.—Measurements are summarized in Table 29.

Remarks.—Heterotrypa rugosa is characterized by the combination of subpolygonal exozonal zooecial cavity outlines, crenulate endozonal walls, relatively thin exozonal walls which are many times slightly thickened and thinned, common diaphragms throughout the zoarium that are spaced two to three zooecial cavity diameters apart within the endozone and one-third to one-half zooecial cavity diameters apart within the exozone where they are mainly perpendicular to the zooecial axis, usually slightly bowed convex inwards and locally inclined to overlapping, rare mesozooecia, scattered exozonal acanthostyles, mural lacunae common at zooecial corners, and a relatively wide endozone.

The present species is morphologically similar to *Heterotrypa appressa* (Ulrich). Differences exist in that *H. rugosa* has larger autozooecial cavity diameters, plentiful axial diaphragms, and a consistently closer spacing of diaphragms in the exozone. *H. rugosa* differs from *Heterotrypa parvulipora* Ulrich and Bassler in having larger zooecial cavity outlines in the exozone, a closer spacing of exozonal diaphragms which are commonly bowed convex inwards, and some slightly more distinctive acanthostyles. *Heterotrypa exovaria* (new species designated herein) differs from *H. rugosa* in having greater numbers of subrounded zooecial cavity outlines, smaller autozooecial cavity diameters, thicker autozooecial exozonal walls which are irregularly thickened and thinned, more distinct and regularly spaced acanthostyles, more mesozooecia, endozonal styles with thicker laminae, and generally more variably oriented and irregularly spaced autozooecial diaphragms.

On occasion, recrystallization will obliterate thin endozonal diaphragms of *H. rugosa.*

Distribution.—Localities NL IV, CB.

Studied material.—Holotype NL IV 108(143)A-15-A(M) [USNM 432508], Paratypes NL IV 96(131)F(M) [USNM 432509], NL IV 108(143)A-6-K(M) [USNM 432510], NL IV 108(143)A-14-L(M) [USNM 432511], NL IV 108(143)A-15-B(M,) [USNM 432512], NL IV 108(143)A-16-B(M) [USNM 432513], NL IV 116(151)A-5-B [USNM 432514], CB 132B-4-A [USNM 433074].

?**Heterotrypa subramosa** (Ulrich, 1879)
Plate 14, Figures 1–2

Atactopora subramosa Ulrich, 1879, p. 124, pl. 12, figs. 6–6c.
Heterotrypa prolifica Ulrich, 1890, p. 413, 414, pl. 37, figs. 1–1d.
Dekayia prolifica (Ulrich). Cumings, 1908, p. 820, 821, pl. 15, figs. 4–4b, pl. 29, fig. 3.
Dekayia subramosa (Ulrich). Cumings, 1908, p. 823, 824, pl. 15, figs. 5–5b, pl. 29, fig. 2.
Heterotrypa subramosa (Ulrich). Utgaard and Perry, 1964, p. 78–80, pl. 13, figs. 5–7, pl. 14, figs. 1–4.

Description.—Zoaria ramose, encrusting. Zooecia initiated homogeneously throughout endozone. Zooecial cavity outlines subpolygonal to subrounded less commonly rounded in exozone, polygonal in endozone. Endozonal zooecia curve broadly outwards to zooecial bend at endozonal/exozonal transition or lower exozone and continue directly outwards to intersect colony surface at nearly right angles. Exozonal walls irregularly thickened and thinned. Wall laminae U- to V-shaped. Endozonal walls even to slightly crenulate, fairly parallel-sided. Axial diaphragms (endozone) spaced approximately two to three zooecial cavity diameters apart sometimes absent to few within innermost endozone. Autozooecial diaphragms thin, mainly perpendicular to zooecial axis, some inclined and/or slightly curved and sometimes overlapping. Diaphragms in exozone evenly spaced commonly at about two-thirds of a zooecial cavity diameter apart (locally greater in a few instances), thin (slightly thicker than in endozone). Mesozooecia common in exozone. Some change to autozooecia (and vice-versa). Mesozooecial walls irregularly thickened and moniliform. Polygonal to subpolygonal in cross-sectional outline. Found between many autozooecia but do not completely isolate them. Initiated at base of exozone and either continue to surface, terminate, or change into autozooecia. Mesozooecial diaphragms, in general, thicker than for autozooecia, fairly evenly spaced about 1 mesozooecial cavity diameter apart, mainly perpendicular to walls with some slightly inclined. Sometimes autozooecia change gradually into mesozooecia zooecially outwards. Acanthostyles mainly in exozone, sometimes in outer endozone where commonly forming the center of petaloid cluster of autozooecia. Diameters of styles (laminar sheath and clear axis) fairly consistent. Commonly one to two, less commonly two to three surround each autozooecium and found between adjacent zooecia or at zooecial corners. Some exozonal styles found mostly between zooecia offset and inflecting. Poorly defined maculae present, many times with central mesozooecial cluster.

Measurements.—Measurements are summarized in Table 30.

Remarks.—?*Heterotrypa subramosa* is characterized by subpolygonal to subrounded zooecial cavity outlines in exozone, endozonal diaphragms spaced two to three zooecial cavity diameters apart, more widely spaced to absent in innermost endozone, exozonal diaphragms mainly oriented perpendicular to irregularly thickened and thinned zooecial walls and spaced at approximately two-thirds of a zooecial cavity diameter apart, common mesozooecia which are polygonal to subpolygonal in cavity outline shape, with irregularly thickened moniliform walls, most common in early exozone, one to three acanthostyles (commonly one to two) surrounding each autozooecium in the exozone, and some acanthostyles in the outer endozone.

The present species differs from *Heterotrypa ulrichi* (Nicholson) primarily in having wider zooecial cavities, and larger acanthostyle diameters (this is plainly observed in the figures of Cumings, 1908, pl. 14; Bassler, 1906, pl. 2; and Boardman and Utgaard, 1966, pl. 142). In addition, descriptions by Cumings (1908) and McFarlan (1931) indicate a sparsity of diaphragms in the endozone as a further differentiating factor. While

Table 30.—Quantitative data, ?*Heterotrypa subramosa* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.15–.23	.19	.20	.015	75	8
	TOTAL	.15–.23	.19	.20	.015	75	8
ZCD (mac)	NL IV	.22–.32	.28	.30	.024	52	8
	TOTAL	.22–.32	.28	.30	.024	52	8
ZWT	NL IV	.01–.07	.03	.02	.015	80	8
	TOTAL	.01–.07	.03	.02	.015	80	8
Z/mm²	NL IV	20–31	26	22, 26	3.9	8	8
	TOTAL	20–31	26	22, 26	3.9	8	8
MxMCD	NL IV	.03–.17	.09	.09	.034	72	8
	TOTAL	.03–.17	.09	.09	.034	72	8
MnMCD	NL IV	.02–.13	.06	.08	.024	72	8
	TOTAL	.02–.13	.06	.08	.024	72	8
AD (lam)	NL IV	.03–.12	.07	.08	.020	78	8
	TOTAL	.03–.12	.07	.08	.020	78	8

not describing *H. ulrichi* due, foremost, to the lack of primary types and the inadequate occurrence data for the primary types, Boardman and Utgaard (1966) do illustrate specimens considered by them to be topotypes. Their figures suggest that an additional characteristic of this species is the common offsetting nature of exozonal acanthostyles and relatively straighter and more regularly thickened zooecial walls.

Cumings (1902, 1908) recognized *Dekayella robusta* Foord to be a varietal form of *Dekayia ulrichi* (=*Heterotrypa ulrichi*). Among the internal characteristics used to differentiate the two forms are greater numbers of both diaphragms and acanthostyles (his "spiniform corallites") in *Dekayella robusta*.

Heterotrypa foliacea differs from ?*H. subramosa* in having generally fewer mesozooecia, more common and larger endozonal acanthostyles, somewhat smaller exozonal acanthostyles, and more prevalent straight and evenly thickened autozooecial and mesozooecial walls.

Specimens assigned herein to ?*Heterotrypa subramosa* differ slightly from the description of other authors (see synonymy) in lacking concave outward basal diaphragms and having more widespread and consistently developed irregularly thickened autozooecial and mesozooecial walls and moniliform mesozooecia. As a result, this material has not been definitively placed into this species.

Distribution.—NL IV, CB.

Studied material.—Hypotypes NL IV 108(143)A-6-A(M) [USNM 432515], NL IV 108(143)A-1-C(M) [USNM 432516], NL IV 108(143)A-5-F(M) [USNM 432517], NL IV 108(143)A-6-B(M) [USNM 432518] NL IV 108(143)A-7-C(M) [USNM 432519], NL IV 108(143)A-8-A(M) [USNM 432520], NL IV 108(143)A-13-F(M) [USNM 432521], NL IV 108(143)A-5-G(M) [USNM 432522], NL IV 94(129)A-2L-H [USNM 432523], NL IV 100(135)A-12L-M [USNM 432524].

Heterotrypa subtrentonensis, new species
Plate 16, Figures 1–2

Description.—Zoaria ramose. Zooecia initiate homogeneously throughout endozone. Zooecial cavity outlines subrounded to subangular in exozone. Polygonal in endozone. Zooecia curve broadly in endozone, curve accelerated at endozonal/exozonal transition with or without zooecial bend in lower exozone, zooecia then continue directly outwards to intersect colony surface at or nearly at right angles. Endozonal walls commonly irregularly thickened and thinned, but many times thin and straight to occasionally flexuous, thicken gradually from outermost endozone to lower exozone, either remain of even thickness outwards to colony surface or thin in outer exozone to give a pointed appearance to walls in longitudinal section (especially in zoaria with relatively wide exozone). Walls in outermost endozone and exozone composed mainly of U- to V-shaped laminae whose apices commonly connected by dark line. This line not evident in tangential section. Axial diaphragms thin, flat, perpendicular to zooecial walls, spaced mainly approximately one and one-half to two (or three maximum) zooecial cavity diameters apart. Exozonal diaphragms mainly perpendicular to zooecial walls, slightly thicker than for endozonal ones, commonly spaced one-third to one-half zooecial tube diameter apart; however, in some zoaria many inclined, overlapping, wavy, convex outwards or inwards. Some diaphragms of slightly greater individual thicknesses and form distinct diaphragm-wall

Table 31.—Quantitative data, *Heterotrypa subtrentonensis* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 37–51 (72–86)	.20–.30	.26	.23, .28	.029	58	6
	NL IV 94–116 (129–151)	.17–.32	.24	.25	.027	99	10
	NL TOTAL	.17 .32	.25	.25	.029	157	16
	CB 54–72	.19–.28	.24	.25	.023	40	4
	CB 138.5–154	.16–.30	.24	.22, .25, .26	.035	60	6
	CB TOTAL	.16–.30	.24	.25	.031	100	10
	HCM	.19–.26	.22	.24, .28	.024	10	1
	WB	.22–.31	.27	.20	.028	20	2
	WEST TOTAL	.19–.31	.25	.24	.034	30	3
	TOTAL	.16–.32	.24	.25	.030	287	29
ZWT	NL IV 37–51 (72–86)	.02–.09	.05	.05	.016	60	6
	NL IV 94–116 (129–151)	.02–.09	.05	.05	.015	100	10
	NL TOTAL	.02–.09	.05	.05	.015	160	16
	CB 54–72	.03–.09	.06	.05	.016	40	4
	CB 138.5–154	.02–.16	.07	.07	.030	60	6
	CB TOTAL	.02 .16	.06	.07	.026	100	10
	HCM	.04–.07	.05	.05	.008	10	1
	WB	.03–.08	.05	.04	.014	20	2
	WEST TOTAL	.03–.08	.05	.04	.012	30	3
	TOTAL	.02–.16	.06	.05	.020	290	29
Z/mm²	NL IV 37–51 (72–86)	15–16	15.7	16	0.5	6	6
	NL IV 94–116 (129–151)	12–20	16.4	18	2.5	14	10
	NL TOTAL	12–20	16.2	16	2.1	20	16
	CB 54–72	13–17	14.4	13	1.5	8	4
	CB 138.5–154	13–19	14.7	13, 14, 15	2.1	7	6
	CB TOTAL	13–19	14.5	13	1.7	15	10
	HCM	18	18.0	—	0.0	2	1
	WB	13–15	13.8	13	1.0	4	2
	WEST TOTAL	13–18	15.2	13, 18	2.3	6	3
	TOTAL	12–20	15.4	13	2.1	41	29
AD (lam)	NL IV 37–51 (72–86)	.04–.11	.08	.08	.014	58	6
	NL IV 94–116 (129–151)	.05–.10	.07	.07	.011	100	10
	NL TOTAL	.04–.11	.08	.07	.012	158	16
	CB 54 72	.03–.10	.06	.06	.018	40	4
	CB 138.5 154	.04–.09	.07	.06	.012	60	6
	CB TOTAL	.03–.10	.07	.06	.014	100	10
	HCM	.04–.07	.06	.05, .07	.012	10	1
	WB	.05 .09	.07	.07	.012	20	2
	WEST TOTAL	.04 .09	.06	.07	.013	30	3
	TOTAL	.03–.11	.07	.07	.014	288	29

units. Some zoaria with diaphragms of consistent thickness, parallel and evenly spaced with minor variation noted above. Mesozooecia uncommon. Diaphragms fairly closely tabulated at one-half to one mesozooecial cavity diameter apart. Acanthostyles present, generally three to five surround each zooecium (up to six), found mainly at zooecial corners, inflect into zooecial cavities where walls thin. Lumen generally not distinct, small (.01 mm or less). In endozone, scattered, small, at zooecial corners, developed over short segments of zooecial wall. No definite maculae.

Etymology.—The trivial name of this species refers both to its position in the Trentonian Stage and its close similarity to *Heterotrypa trentonensis* (Ulrich).

Measurements.—Measurements are summarized in Table 31.

Remarks.—Specimens placed with *Heterotrypa subtrentonensis* are characterized by the persistent presence of axial diaphragms, spaced mainly at one and one-half to two (up to three) zooecial cavity diameters apart and exozonal diaphragms spaced one-third to one-half zooecial cavity diameter apart, exozonal diaphragms that are mainly perpendicular to zooecial walls but with many convex outwards, or inclined in some zoaria, zooecial walls commonly with a dark line separating laminae of adjacent zooecia as viewed in longitudinal section, three to four acanthostyles generally with small, non-distinct cores surrounding each exozonal zooecium, scattered small and short styles in the endozone, endozonal walls which in many zoaria are irregularly thickened and thinned, non-distinctive maculae, uncommon mesozooecia, and a zooecial cavity diameter with a mean of 0.24 mm.

The present species is very similar to *H. trentonensis* (Ulrich). A major difference lies in the generally larger zooecial cavity diameters of specimens from the present study area of Tennessee. Ulrich (1883) noted autozooecial diameters of about "$\frac{1}{120}$th of an inch," that is 0.21 mm. Measurements by Karklins (1984) on the holotype and two paratypes of *H. trentonensis* (Ulrich) for maximum autozooecial diameter showed a mean of 0.20 mm with a standard deviation of 0.014 mm and a range of 0.18–0.22 mm. Within the present study area, zooecial cavity diameter measurements from 29 zoaria indicate a mean of 0.24 mm with a standard deviation of 0.030 and a range from 0.16 to 0.32 mm.

Endozonal walls of *H. trentonensis* according to Ulrich (1883, p.274) are "thin and somewhat flexuous." Within *H. subtrentonensis* endozonal walls are also many times irregularly thickened and thinned. Finally, maculae of *H. subtrentonensis* are absent to non-distinctive.

Endozonal width varies mainly from 3.0 to 4.0 mm (absolutely between 2.7 and 4.5 mm) and colony branch diameters vary most commonly from 5.0 to 7.5 mm. With the exception of one specimen with a branch width of 12.0 mm, absolute variation is between 4.5 and 9.0 mm. This single specimen (NL IV 94 (129)A-3L-A) is found at or very nearly at a stratigraphic level containing robust specimens of *Batostomella subgracilis, Tarphophragma multitabulata* and *Parvohallopora granda* whose sizes have been suggested within this study to be ecophenotypic responses (see Remarks sections under appropriate taxa).

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype NL IV 116(151)A-3-A(M) [USNM432525], Paratypes NL IV 37(72)B-6-B(M) [USNM 432526], NL IV 37(72)B-3-J(M) [USNM 432527], NL IV 37(72)B-6-F(M) [USNM 432528], NL IV 49(84)A-3L-H(M) [USNM 432529], NL IV 50(85)A-15-A(M) [USNM 432530], NL IV 51(86)A-25L-B(M) [USNM 432531], NL IV 94(129)A-3L-A(M) [USNM 432532], NL IV 96(131)B-8-A(M) [USNM 432533], NL IV 96(131)B-3-A [USNM 432534], NL IV 96(131)E-1-A(M) [USNM 432535], NL IV 96(131)K(M) [USNM 432536], NL IV 96(131)D-3-A(M) [USNM 432537], NL IV 96(131)G-1-A(M) [USNM 432538], NL IV 96(131)C-2-C(M) [USNM 432539], NL IV 116(151)A-1-C(M) [USNM 432540], NL IV 37(72)B-6-E [USNM 432541], NL IV 72(107)B-3L-F [USNM 432542], NL IV 85(120)A-5L-B [USNM 432543], NL IV 85(120)A-3AR-A [USNM 432544], NL IV 93(128)A-4-P [USNM 432545], NL IV 93(128)A-3-J [USNM 432546], NL IV 94(129)A-3L-H [USNM 432547], NL IV 96(131)C-3-A [USNM 432548], NL IV 96(131)C-5-C [USNM 432549], NL IV 96(131)B-2-F [USNM 432550], NL IV 96(131)C-3-B [USNM 432551], NL IV 96(131)C-4-B [USNM 432552], NL IV 96(131)C-2-B [USNM 432553], NL IV 100(135)A-12L-L [USNM 432554], NL IV 108(143)A-12-F [USNM 432555], NL IV 108(143)A-18-A [USNM 432556], NL IV 116(151)B-1-A [USNM 432557], NL IV 116(151)A-2-G [USNM 432558], NL IV 116(151)B-1-B [USNM 432559], NL IV 116(151)A-4-D [USNM 432560], NL IV 51(86)A-17L-B(F) [USNM 432561], CB 54A-4-C(M) [USNM 432562], CB 55A-8-A(M) [USNM 432563], CB 67B-7-H(M) [USNM 432564], CB 72 D-2-A(M) [USNM 432565], CB 138.5A-10-A(M) [USNM 432566], CB 149A-6-A(M) [USNM 432567], CB 150B-3-A(M) [USNM 432568], CB 150B-4-A(M) [USNM 432569], CB 150B-2-A(M) [USNM 432570], CB 154B-5-A(M) [USNM 432571], CB 41B-2-A [USNM 432572], CB 54A-3-A(F) [USNM 432573], CB 57A-1-A(F) [USNM 432574], CB 67B-8-B(F) [USNM 432575], CB 72B-5-A(F) [USNM 432576], CB 74A-5L-B(F) [USNM 432577], CB 76B-3-A(F) [USNM 432578], CB 82A-2-B(F) [USNM 432579], CB 114A-3-B(F) [USNM 432580], CB 122B-5-A(F) [USNM 432581], CB 132A-4-B(F) [USNM 432582], CB 138A-6-A(F) [USNM 432583], HCM 38(77)B-2B-A(M) [USNM 432584], HCM 11(50)B-2-A [USNM 432585], HCM 11(50)B-4-D [USNM 432586], HCM 11(50)B-2-F(F) [USNM 432587], HCM 43(82)A-3-HH(F) [USNM 432588], WB 20(32)B-3-A [USNM 432589], WB 27(39)B-8-B [USNM 432590].

Heterotrypa magnopora, new species
Plate 17, Figure 1

Description.—Zoaria commonly ramose and quite large (up to 7 mm in branch diameter). Some encrusting. Most new zooecia initiated in mid to outer endozone. Zooecial cavity outlines subrounded in exozone. Polygonal in endozone. Zooecia curve broadly to base of exozone, curvature accelerated through endozonal/exozonal transition, commonly with zooecial bend at base of exozone, rapidly attain orientation perpendicular to surface. Endozonal walls thin, thicken abruptly at base of exozone. Exozonal walls fairly thick, generally irregularly thickened but some even. Zooecial wall of distinct U-shaped laminae. Endozonal walls even to slightly crenulate. Sometimes beaded. Diaphragms flat, perpendicular to zooecial walls, few inclined, curved, overlapping, evenly spaced usually at two-thirds to three-fourths of a zooecial cavity diameter. Diaphragms sparse axially, one or two in outer endozone, locally developed where walls periodically thicken slightly to accommodate endacanthopores. Commonly, diaphragms at base of exozone are thickened as compared with other diaphragms. Diaphragm-wall units are distinct with laminae of diaphragms clearly traced into wall laminae. Mesozooecia rare. Moniliform. Some develop into autozooecia. Diaphragms thicker than for autozooecia, spaced at one mesozooecial cavity diameter apart. Acanthostyles present and distinctive, found mainly in exozone at zooecial corners or between zooecia. Commonly five to six styles (up to nine) surround each zooecium. Few acanthostyles found in endozone with some extending only over a short segment of wall at zooecial corners. In outer endozone, inner exozone, and where exozonal walls thin, acanthostyles inflect into zooecial cavity. Variation in acanthostyle size due primarily to diameter of laminar sheath.

Etymology.—The trivial name *magnopora* is primarily derived from the Latin *magnus* meaning large and refers to the unusually large autozooecial cavity diameters characteristic of this species.

Measurements.—Measurements are summarized in Table 32.

Remarks.—*Heterotrypa magnopora* is distinguished by its unusually large autozooecial cavity diameters, commonly five to six distinct acanthostyles surrounding each zooecium, few endozonal styles and diaphragms, regularly spaced exozonal diaphragms oriented perpendicular to zooecial walls that are straight to slightly unevenly thickened and thinned, and rare mesozooecia. The combination of these morphological features distinguishes it from other species of the genus.

Heterotrypa foliacea differs from the present species in having distinctively smaller zooecial cavity and acanthostyle diameters, somewhat fewer exozonal styles, and more common endozonal styles, more closely spaced exozonal diaphragms, generally straight exozonal walls, and some zoaria with common mesozooecia.

Distribution—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype CB 72A-1-A(M) [USNM 432591], Paratypes NL IV 49(84)A-3L-A(M) [USNM 432592], NL IV 61(96)A-5-J(M) [USNM 432593], NL IV 63(98)B-6LA-A(M) [USNM 432594], NL IV 93(128)A-5-K(M) [USNM 432595], NL IV 96(131)D-1-A(M) [USNM 432596], NL IV 96(131)B-4-B(M) [USNM 432597], NL IV 96(131)D-2-B [USNM 432598], NL IV 108(143)A-6-I(M) [USNM 432599], NL IV 108(143)A-7-A(M) [USNM 432600], NL IV 116(151)A-1-F(M) [USNM 432601], NL IV 43(78)B-6L-NN [USNM 432602], NL IV 61(96)A-6-C [USNM 432603], NL IV 72(109)B-2L-E [USNM 432604], NL IV 85(120)A-5L-D [USNM 432605], NL IV 93(128)A-1-A [USNM 432606], NL IV 93(128)A-13-D [USNM 432607], NL IV 93(128)A-5-J [USNM 432608], NL IV 96(131)C-6-B [USNM 432609], NL IV 96(131)C-6-A [USNM 432610], NL IV 100(135)A-4L-ZZ [USNM 432611], NL IV 100(135)A-9L-S [USNM 432612], NL IV 100(135)A-10L-P [USNM 432613], NL IV 108(143)A-16-F [USNM 432614], CB 72C-2RB-A(M) [USNM 432615], CB 72B-8-A(M) [USNM 432616], CB 72B-7-A(M) [USNM 432617], CB 122A-18-C(M) [USNM 432618], CB 132B-1-A(M) [USNM 432619], CB 54A-1-A [USNM 432620], CB 145B-4-A [USNM 432621], CB 159B-3-A [USNM 432622], CB 159A-2-A [USNM 432623], CB 50A-3-A(F) [USNM 432624], CB 72B-9-A(F) [USNM 432625], CB 79B-3-A(F) [USNM 432626], CB 79B-3-B(F) [USNM 432627], CB 85A-10-A(F) [USNM 432628], CB 145B-3-D(F) [USNM 432629], CB 149A-7-B(F) [USNM 432630], CB 159B-2-A(F) [USNM 432631], CB 159B-3-B(F) [USNM 432632], HCM 32(71)A-2-A(M) [USNM 432633], HCM 38(77)A-1-B(M) [USNM 432634], HCM 43(82)B-3-A(M) [USNM 432635], HCM 43(82)B-4-A(M) [USNM 432636], HCM 43(82)B-5-A [USNM 432637], WB 32(44)A-4-B(M) [USNM 432638], WB 44(56)C-2-D(M)[USNM 432639].

Heterotrypa exovaria, new species
Plate 15, Figures 1–4
Plate 16, Figure 3

Description.—Zoaria ramose, some encrusting. Zooecia initiated primarily in outer endozone. Exozonal zooecial cavity outlines subpolygonal to subrounded. Polygonal in endozone. Zooecia curve shallowly in endozone, curve accelerates greatly in lower exozone, with or without zooecial bend, to quickly attain an orientation at right angles to colony surface. Endozonal walls thin, thicken rapidly in lower exozone, unevenly thickened and thinned in exozone. Walls composed of poorly defined U- to V-shaped laminae to granular. Endozonal walls generally even and parallel-sided, occasionally irregular (crenulate) over short segments. Axial diaphragms thin, commonly two to four zooecial tube diameters apart, perpendicular to walls. Diaphragms increase in thickness slightly as well as in number at the base of the zooecial bend. In general, exozonal diaphragms irregularly spaced at one-half to one zooecial tube diameter apart. Diaphragms mainly subparallel and approximately perpendicular to zooecial walls, but many inclined, incomplete, curved (mainly convex outwards), or combinations thereof. Locally cystose. Mesozooecia few,

Table 32.—Quantitative data, *Heterotrypa magnopora* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 49–63 (84–98)	.26–.36	.31	.30, .32	.025	30	3
	NL IV 93–116 (128–151)	.22–.40	.29	.30	.023	70	7
	NL TOTAL	.22–.40	.30	.30	.031	100	10
	CB 72	.22–.34	.29	.32	.033	40	4
	CB 122–132	.23–.32	.28	.30	.029	20	2
	CB TOTAL	.22–.34	.28	.30	.032	60	6
	HCM	.20–.42	.29	.28	.052	60	6
	WB	.24–.34	.28	.28	.033	10	1
	WEST TOTAL	.20–.42	.29	.28	.050	70	7
	TOTAL	.20–.42	.29	.30	.038	230	23
ZWT	NL IV 49–63 (84–98)	.02–.06	.05	.03	.049	30	3
	NL IV 93–116 (128–151)	.02–.09	.05	.04	.015	70	7
	NL TOTAL	.02–.09	.05	.03	.029	100	10
	CB 72	.03–.08	.05	.06	.012	40	4
	CB 122–132	.02–.06	.03	.04	.006	20	2
	CB TOTAL	.02–.08	.05	.04	.014	60	6
	HCM	.02–.14	.06	.05	.031	60	6
	WB	.04–.12	.07	.05	.025	10	1
	WEST TOTAL	.02–.14	.06	.05	.030	70	7
	TOTAL	.02–.14	.05	.04	.022	230	23
Z/mm^2	HCM	9–10	9.5	—	.71	2	1
	WB	9	9.0	9	.00	1	1
	TOTAL	9–10	9.3	9	.58	3	2
AD (lam)	NL IV 49–63 (84–98)	.05–.10	.07	.07	.012	30	3
	NL IV 93–116 (128–151)	.05–.12	.08	.08	.014	70	7
	NL TOTAL	.05–.12	.08	.08	.014	100	10
	CB 72	.06–.15	.10	.10	.022	40	4
	CB 122–132	.06–.13	.09	.07, .09, .10	.019	20	2
	CB TOTAL	.06–.15	.10	.10	.023	60	6
	HCM	.04–.14	.09	.07	.027	60	6
	WB	.06–.09	.07	.07	.011	10	1
	WEST TOTAL	.04–.14	.09	.07	.026	70	7
	TOTAL	.04–.15	.09	.07	.022	230	23
AD (lum)	NL IV 49–63 (84–98)	.01–.04	.02	.02	.005	30	3
	NL IV 93–116 (128–151)	.01–.04	.02	.02	.005	70	7
	NL TOTAL	.01–.04	.02	.02	.005	100	10
	CB 72	.01–.06	.03	.02	.011	40	4
	CB 122–132	.01–.04	.03	.02	.010	20	2
	CB TOTAL	.01–.06	.03	.02	.010	60	6
	HCM	.01–.04	.02	.02	.007	50	5
	WB	.01–.04	.02	.02	.011	10	1
	WEST TOTAL	.01–.04	.02	.02	.008	60	6
	TOTAL	.01–.06	.02	.02	.008	220	22

scattered. Originate in exozone. Relatively small diameter. Commonly subangular in cavity outline. Mesozooecial diaphragms flat, perpendicular to walls, evenly spaced at one mesozooecial cavity diameter apart, slightly thicker than autozooecial diaphragms. Some transform into autozooecia. Acanthostyles ubiquitous, fairly small, and found mainly in exozone at zooecial corners but some between adjacent zooecia. Commonly four to five surround any one zooecium, sometimes inflect zooecial cavities, especially where zooecial walls thin. Few styles found in outer endozone (endacanthopores) where they are much more laminate, inflect surrounding zooecial cavities, and commonly with petaloid arrangement of autozooecia. Maculae not well defined. Composed mainly of megazooecia with or without mesozooecia and normal sized zooecia. Acanthostyles present. Form monticules raised slightly above colony surface.

Etymology.—The trivial name *exovaria* is a combined derivation from the Latin *exter,* meaning outward, and *varius* meaning diverse or variable, and refers to the common variability in wall thickness as well as diaphragm spacing and orientation within the exozone.

Table 33.—Quantitative data, *Heterotrypa exovaria* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.16–.27	.21	.22	.027	60	6
	TOTAL	.16–.27	.21	.22	.027	60	6
MxZCD (mac)	NL IV	.22–.36	.29	.32	.042	28	3
	TOTAL	.22–.36	.29	.32	.042	28	3
ZWT	NL IV	.01–.06	.04	.05	.012	60	6
	TOTAL	.01–.06	.04	.05	.012	60	6
ZWT (mac)	NL IV	.02–.07	.04	.03, .05	.013	30	3
	TOTAL	.02–.07	.04	.03, .05	.013	30	3
Z/mm^2	NL IV	20–30	23	22, 23	2.6	14	6
	TOTAL	20–30	23	22, 23	2.6	14	6

Measurements.—Measurements are summarized in Table 33.

Remarks.—*H. exovaria* is characterized by generally irregularly oriented exozonal diaphragms which are variably spaced primarily between one-half to one zooecial cavity diameter apart, unevenly thickened and thinned exozonal autozooecial walls, endozonal diaphragms spaced at two to four zooecial cavity diameters apart, ubiquitous small exozonal acanthostyles with commonly four to five surrounding each zooecium, few mesozooecia, subpolygonal to subrounded zooecial cavity outlines, and surficial angles at 90°.

H. exovaria differs from *H. rugosa* and *H. subtrentonensis* by having generally greater and more variably spaced exozonal diaphragms which themselves are largely irregularly oriented, unevenly thickened and thinned exozonal autozooecial walls, and smaller autozooecial cavity diameters. It differs further from *H. rugosa* mainly by having more abundant, distinctive, and regularly spaced exozonal acanthostyles, more even autozooecial walls in endozone, slightly more mesozooecia, thicker autozooecial walls in exozone, and greater numbers of subrounded autozooecial apertures. *H. exovaria* additionally differs from *H. subtrentonensis* in having slightly smaller exozonal acanthostyles, larger and more laminar endostyles, a zooecial boundary not defined by a dark median line, and thinner exozonal walls.

Distribution.—Locality NL IV.

Studied material.—Holotype NL IV 94(129)A-4L-D(M) [USNM 432640], Paratypes NL IV 93(128)A-14-G(M) [USNM 432641], NL IV 94(129)A-4L-C(M) [USNM 432642], NL IV 96(131)H(M) [USNM 432643], NL IV 96(131)F-1-D(M) [USNM 432644], NL IV 108(143)A-6-J(M) [USNM 432645].

Heterotrypa praenuntia var. **simplex** (Ulrich, 1893)
Plate 17, Figure 2

Dekayalla praenuntia var. *simplex* Ulrich, 1893, p. 271, pl. 23, figs. 39–42; Bassler, 1911, p. 207, text-fig. 111c.

Heterotrypa praenuntia var. *simplex* (Ulrich), Bork and Perry, 1968a, p. 345, 346, pl. 46, figs. 4–7, 9.

Description.—Zoaria ramose, encrusting, massive. Zooecia initiated between mid to outer endozone, curve broadly at first, curving accelerated in outermost endozone and lower exozone, intersect colony surface at or nearly at 90°. Zooecial bend sometimes in lower exozone. Zooecial cavity outline subpolygonal in exozone. Polygonal in endozone. Autozooecial walls in exozone somewhat uneven, commonly thickened and thinned slightly along length, sometimes slightly wavy, distinct U- to more commonly V-shaped laminae. Thicker than autozooecial walls in endozone. Walls attain maximum thickness gradually over a short distance of the lower exozone. Autozooecial walls in endozone even to slightly crenulate throughout, parallel-sided. Exozonal diaphragms fairly perpendicular to zooecial walls, sometimes overlapping and/or inclined. Many diaphragms slightly convex outwards or inwards, depending on the individual colony. Diaphragms thicker than in endozone. Individual diaphragms of consistent thickness, but may vary between diaphragms of individual zooecia. Diaphragms spaced at approximately one-half zooecial cavity diameter apart. Sometimes spacing varies from one-quarter to one zooecial cavity diameter apart, but usually spacing is fairly consistent throughout. Axial diaphragms thin, perpendicular to walls. Spaced at three to four zooecial cavity diameters apart, one to two zooecial cavity diameters apart in outer endozone. Some diaphragms obscure due to recrystallization. Endozone relatively wide. Mesozooecia absent. Acanthostyles scattered throughout exozone, initiated in exozone. Found mainly at zooecial corners, sometimes between zooecia. Individual zooecia surrounded by either no styles or one style. Mural lacunae(?) at many zooecial corners of exozone. Wall laminae contained within walls for the most part (that is, they do not inflect into zooecial cavity). Spaced usually three-

Table 34.—Quantitative data, *Heterotrypa praenuntia* var. *simplex* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.18–.28	.23	.24	.023	45	9
	CB	.18–.22	.20	.20, .22	.017	5	1
	TOTAL	.18–.28	.22	.22	.024	50	10
ZCD (mac)	NL IV	.26–.40	.32	.30, .32	.030	45	9
	CB	.28–.34	.30	.28	.026	5	1
	TOTAL	.26–.40	.32	.30, .32	.030	50	10
ZWT	NL IV	.02–.06	.03	.03	.010	45	9
	CB	.02–.03	.03	.03	.006	5	1
	TOTAL	.02–.06	.03	.03	.010	50	10
Z/mm²	NL IV	18–25	22	23	2.3	9	9
	CB	23	23	23	0.0	1	1
AD (lam)	NL IV	.04–.10	.06	.06	.015	45	9
	CB	.04–.06	.05	.06	.011	5	1
	TOTAL	.04–.10	.06	.06	.015	50	10
	TOTAL	18–25	22	23	2.2	10	10

fourths to one mm from another. Few acanthostyles in endozone. Acanthostyles conspicuous due to laminar sheath relatively thick compared to contiguous walls. Acanthostyles commonly surrounded by petaloid arrangement of autozooecia. Styles found at zooecial corners. Maculae marked by larger megazooecia.

Measurements.—Measurements are summarized in Table 34.

Remarks.—*H. praenuntia* var. *simplex* typically has subpolygonal zooecial cavity outlines, exozonal diaphragms fairly perpendicular to commonly irregularly thickened and thinned or wavy zooecial walls, diaphragms commonly bowed slightly and spaced mainly at one-half zooecial cavity diameter apart, axial diaphragms spaced at three to four zooecial cavity diameters apart, mesozooecia absent, acanthostyles scattered in the exozone, few in endozone and having thicker sheaths.

Ulrich (1893, p. 272) in his study of the Minnesota *Dekayella* noted that the typical form of *D. praenuntia* and its four varieties gave him "more trouble than the whole genus *Homotrypa*." Morphological separations were not consistent enough to allow a concrete definition of species boundaries. Bork and Perry (1968a) mentioned a similar problem dealing with notable variability both within and between zoaria of *H. praenuntia* var. *simplex* of Champlainian age. Their material showed a range in morphology between Ulrich's illustrations of the varieties *echinata, simplex,* and *multipora.* Within the present study area, the same can be said for the former two varieties as well as the species *Cyphotrypa acervulosa.*

H. praenuntia var. *simplex* differs from *C. acervulosa* by having thicker exozonal walls which are more commonly thickened and thinned, thicker and more closely spaced exozonal diaphragms, greater numbers and more pronounced acanthostyles, generally less polygonal zooecial cavity outlines, and a less common encrusting growth habit.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 96(131)E-3-B(M) [USNM 432646], NL IV 96(131)G-3-A(M) [USNM 432647], NL IV 100(135)A-5L-O(M) [USNM 432648], NL IV 108(143)A-3-F(M) [USNM 432649], NL IV 108(143)A-7-KK(M) [USNM 432650], NL IV 108(143)A-2-B(M) [USNM 432651], NL IV 108(143)A-7-G(M) [USNM 432652], NL IV 108(143)A-5-D(M) [USNM 432653], NL IV 108(143)A-5-B(M) [USNM 432654], NL IV 43(78)B-4L-E [USNM 432655], NL IV 43(78)B-7-L [USNM 432656], NL IV 51(86)A-11L-A [USNM 432657], NL IV 93(128)A-1-C [USNM 432658], NL IV 93(128)A-3-I [USNM 432659], NL IV 100(135)A-10L-N [USNM 432600], NL IV 100(135)A-11L-C [USNM 432661], NL IV 100(135)A-12L-E [USNM 432662], NL IV 108(143)A-7-B [USNM 432663], NL IV 108(143)A-3-D [USNM 432664], CB 122A-4-A(M) [USNM 432665], CB 55B-5-A [USNM 432666], CB 57A-3-C [USNM 432667], CB 85A-7-A [USNM 432668], CB 132C-7-B [USNM 432669], CB 138B-9-A [USNM 432670], WB 19(31)A-3-A [USNM 432671].

Heterotrypa praenuntia var. **echinata** (Ulrich, 1893)

Plate 18, Figures 1–3

Dekayalla praenuntia var. *echinata* Ulrich, 1893, p. 271–272, pl. 23, figs. 32–38; Loeblich, 1942, p. 426–427, pl. 63, text-figs. 12–14; Fritz, 1957, p. 14–15, pl. 6, figs. 1–2; Perry, 1962, p. 18–19, pl. 3, figs. 1–6.

Table 35.—Quantitative data, *Heterotrypa praenuntia* var. *echinata* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.18–.30	.23	.22	.028	20	4
	CB 67	.24–.26	.26	.26	.009	5	1
	CB 150	.21–.26	.23	.22	.022	5	1
	CB TOTAL	.21–.26	.24	.26	.020	10	2
	HCM	.18–.22	.20	.20, .22	.017	5	1
	WB	.20–.30	.24	.24	.026	15	3
	WEST TOTAL	.18–.30	.23	.22	.028	20	4
	TOTAL	.18–.30	.24	.22	.026	50	10
ZCD (mac)	NL IV	.28–.37	.32	.32	.024	14	3
	CB 67	.30–.32	.31	.30	.011	5	1
	CB 150	—	—	—	—	—	—
	CB TOTAL	.30–.32	.31	.30	.011	5	1
	HCM	.30–.32	.31	.30	.012	3	1
	WB	.30–.44	.35	.32	.045	13	3
	WEST TOTAL	.30–.44	.34	.32	.044	16	4
	TOTAL	.28–.44	.33	.32	.035	35	9
ZWT	NL IV	.01–.03	.02	.02	.007	20	4
	CB 67	.01	.01	.01	.000	5	1
	CB 150	.02 .03	.02	.02	.006	5	1
	CB TOTAL	.01–.03	.02	.01	.008	10	2
	HCM	.03–.04	.04	.04	.005	5	1
	WB	.01–.03	.02	.02	.005	15	3
	WEST TOTAL	.01–.04	.02	0.2	.010	20	4
	TOTAL	.01–.04	.02	.02	.009	50	10
Z/mm²	NL IV	18–26	22	—	3.4	5	4
	CB 67	23	23	23	0.0	1	1
	CB 150	—	—	—	—	—	—
	CB TOTAL	23	23	23	0.0	1	1
	HCM	25	25	25	0.0	1	1
	WB	18–24	21	—	3.0	3	3
	WEST TOTAL	18–25	22	—	3.2	4	4
	TOTAL	18–26	22	18, 21, 24	2.9	10	9
AD (lam)	NL IV	.06–.12	.08	.08	.017	20	4
	CB 67	.06–.08	.07	.06	.009	5	1
	CB 150	.08–.10	.10	.10	.009	5	1
	CB TOTAL	.06–.10	.08	.10	.018	10	2
	HCM	.08–.14	.10	.08, .10	.024	5	1
	WB	.08–.16	.13	.14	.022	15	3
	WEST TOTAL	.08–.16	.12	.14	.027	20	4
	TOTAL	.06–.16	.10	.08	.030	50	10

Heterotrypa praenuntia var. *echinata* Bork and Perry, 1968a, p. 344, 345, pl. 46, figs. 1–3, 8.

Description.—This variety is similar to the variety "*simplex*" with the following exceptions. Acanthostyle laminae are quite pronounced and either inflect into zooecial cavities or simply separate contiguous zooecia further than they would be otherwise. Zooecial cavity outlines are generally polygonal to subpolygonal. Especially in some encrusting forms, walls and diaphragms are sometimes thinner than for "*simplex*" with diaphragm spacing occasionally being greater.

Measurements.—Measurements are summarized in Table 35.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 93(128)A-9-F(M) [USNM 432672], NL IV 100(135)A-12L-K(M) [USNM 432673], NL IV 100(135)A-13L-G(M) [USNM 432674], NL IV 108(143)A-16-E(M) [USNM 432675], NL IV 63(98)B-4LB-J [USNM 432676], NL IV 93(128)A-6-E [USNM 432677], NL IV 100(135)A-4L-PP [USNM 432678], NL IV 108(143)A-14-O [USNM 432679], NL IV 108(143)A-4-D [USNM 432680], NL IV 108(143)A-2-C [USNM 432681], NL IV 108(143)A-7-H [USNM 432682], NL IV 108(143)A-5-I [USNM 432683], NL IV 108(143)A-14-A [USNM 432684], CB 67B-7-D(M) [USNM 432685], CB 150B-3-C(M) [USNM 432686], CB 130A-8-B [USNM 432687], HCM 11(50)A-6-A(M)

[USNM 432688], WB 20(32)A-2-A(M) [USNM 432689], WB 20(32)B-2-B(M) [USNM 432690], WB 43(55)B-2-A [USNM 432691].

Genus **CYPHOTRYPA** Ulrich and Bassler, 1904

Type species.—Leptotrypa acervulosa Ulrich, 1893, p. 318, pl. 27, figs. 24, 25.

Cyphotrypa acervulosa (Ulrich, 1893)
Plate 18, Figures 4–6

Leptotrypa acervulosa Ulrich, 1893, p. 318, pl. 27, figs. 24, 25.
Cyphotrypa acervulosa (Ulrich). Ulrich and Bassler, 1904, p. 30, pl. 8, figs. 1–3; Brown, 1965, p. 986, pl. 113, figs. 1–3; Karklins, 1984, p. 146, 147, pl. 15, figs. 3–5.

Description.—Zoaria most commonly encrusting and subglobular, sometimes ramose. In encrusting forms, zooecia intersect colony surface at 90°. In ramose forms, zooecia initiated between mid to outer endozone. Zooecia curve fairly quickly from endozone to intersect colony surface at or nearly at 90°. Usually no strict zooecial bend, but when present found in lower exozone. Zooecial cavity outline polygonal in exozone, sometimes where walls slightly thicker, subpolygonal. Polygonal cavity outline in endozone. Exozonal walls commonly thin, even, sometimes thickened and thinned along length. Sometimes slightly wavy. Where thickened, laminae U- to more often V-shaped. Endozonal walls parallel-sided, even to slightly crenulate in branching forms, more even-sided walls in encrusting zoaria. Exozonal diaphragms perpendicular to zooecial walls, sometimes overlapping and/or inclined. Many diaphragms slightly convex outwards or inwards. Diaphragms consistently thin. Diaphragms commonly spaced at approximately two-thirds to one zooecial cavity diameter apart, but sometimes one-third to one-half zooecial cavity diameter apart. Endozonal diaphragms thin, perpendicular to walls. In encrusting forms are mainly spaced at one and one-half zooecial cavity diameters apart and commonly between one to two zooecial cavity diameters apart. Within ramose forms, endozonal diaphragms are mainly between two to four zooecial cavity diameters apart. Mesozooecia absent to rare. Acanthostyles scattered throughout exozone, initiated in exozone. Found at zooecial corners. Individual zooecia surrounded by either no acanthostyles or one to two acanthostyles. Definite acanthostyles found where walls are slightly thicker than for colony in general. Very small acanthopore-like mural lacunae(?) at many zooecial corners of exozone. Endacanthostyles uncommon, small, short. Maculae marked by larger autozooecia.

Measurements.—Measurements are summarized in Table 36.

Remarks.—*Cyphotrypa acervulosa* is characterized by polygonal zooecial cavity outlines, thin walls, ubiquitous diaphragms of similar thickness throughout, fairly perpendicular to zooecial walls, more closely spaced in exozone, scattered minute acanthostyles and mural lacunae at many zooecial corners in exozone, endacanthostyles very uncommon, mesozooecia rare to absent, a common encrusting growth mode, and surficial angles at 90°.

C. acervulosa differs from *Heterotrypa praenuntia* var. *simplex* by having thinner and more even exozonal walls, diaphragms of similar thickness throughout, polygonal zooecial cavity outlines, wider spacing of diaphragms in the exozone, fewer and less pronounced acanthostyles, and a more common encrusting habit.

Distribution.—Localities NL IV, CB.

Studied material.—Hypotypes NL IV 43(78)B-4L-D(M;r) [USNM 432692], NL IV 43(78)B-5L-B(M;r) [USNM 432693], NL IV 44(79)E-5-A(M;e) [USNM 432694], NL IV 49(84)A-4L-A(M;r) [USNM 432695], NL IV 66(101)A-5A-A(M;e) [USNM 432696], NL IV 93(128)A-1-B(M;e) [USNM 432697], NL IV 93(128)A-11-I(M;e) [USNM 432698], NL IV 96(131)B-5-C(M;r) [USNM 432699], NL IV 44(79)E-7-A(r) [USNM 432700], NL IV 61(96)A-5-H(e) [USNM 432701], NL IV 85(120)A-9L;chF (e) [USNM 432702], NL IV 94(129)A-2L-D(e) [USNM 432703], NL IV 43(78)B-4L-F(F;e) [USNM 432704], CB 55A-10-B(M;e) [USNM 432705], CB 132B-11-A(M;e) [USNM 432706].

Genus **STIGMATELLA** Ulrich and Bassler, 1904

Type species.—Stigmatella crenulata Ulrich and Bassler, 1904, p. 34, pl. 10, figs. 1–4, pl. 14, figs. 1, 2.

Stigmatella distinctaspinosa, new species
Plate 19, Figures 1–3

Description.—Zoaria encrusting. Zooecial cavity outlines polygonal to subpolygonal, diameters commonly smaller near base. Zooecia intersect colony surface at right angles. Autozooecial walls thin, little to no differentiation of endozone and exozone. Diaphragms thin, commonly perpendicular or nearly so to zooecial walls but sometimes slightly curved, inclined, locally overlapping. Diaphragms spaced one-half to one and one-half zooecial cavity diameters apart, with one to one and one-quarter being most common. Cystiphragms developed locally in some colonies. Mesozooecia absent to rare. Acanthostyles numerous, found at zooecial corners and between zooecia. Acanthostyles at zooecial corners usually with thicker laminar sheaths, both types inflect into surrounding zooecial cavities, some offset. Acanthostyles developed intermittently within zooecial walls throughout colony, usually three to six surround each zooecium.

Table 36.—Quantitative data, *Cyphotrypa acervulosa* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 43–49 (78–84)	.24–.32	.27	.28	.021	20	4
	NL IV 66–96 (101–131)	.23–.30	.26	.24, .26	.021	20	4
	NL IV TOTAL	.23–.32	.27	.26	.022	40	8
	CB 55	.24–.28	.23	—	.030	5	1
	CB 132	.26–.30	.28	—	.016	5	1
	CB TOTAL	.24–.30	.26	.28	.034	10	2
	TOTAL	.23–.32	.26	.26, .28	.025	50	10
ZCD (mac)	NL IV 43–49 (78–84)	.32–.46	.36	.34	.038	20	4
	NL IV 66–96 (101–131)	.28–.40	.34	.34	.034	20	4
	NL IV TOTAL	.28–.46	.35	.34	.036	40	8
	CB 55	.34–.42	.36	.34	.034	5	1
	CB 132	.32–.34	.33	.32	.011	5	1
	CB TOTAL	.32–.42	.34	.34	.030	10	2
	TOTAL	.28–.46	.35	.34	.035	50	10
ZWT	NL IV 43–49 (78–84)	.01–.02	.01	.01	.003	20	4
	NL IV 66–96 (101–131)	.01–.02	.01	.01	.003	20	4
	NL IV TOTAL	.01–.02	.01	.01	.003	40	8
	CB 55	.01	.01	.01	.000	5	1
	CB 132	.01	.01	.01	.000	5	1
	CB TOTAL	.01	.01	.01	.000	10	2
	TOTAL	.01–.02	.01	.01	.003	50	10
Z/mm^2	NL IV 43–49 (78–84)	18–23	19	18	2.5	4	4
	NL IV 66–96 (101–131)	17–26	23	26	3.7	5	4
	NL IV TOTAL	17–26	21	18	3.7	9	8
	CB 55	25	25	25	0.0	1	1
	CB 132	18	18	18	0.0	1	1
	CB TOTAL	18–25	22	—	5.0	2	2
	TOTAL	17–26	21	18	3.6	11	10

Etymology.—The trivial name *distinctaspinosa* refers to the distinctively large and conspicuous acanthostyles found in this species.

Measurements.—Measurements are summarized in Table 37.

Remarks.—*S. distinctaspinosa* is characterized by numerous large inflecting acanthostyles, commonly three to six surrounding each zooecium, thin diaphragms generally perpendicular to zooecial walls and commonly spaced at one to one and one-half zooecial cavity diameters apart throughout the colony, relatively large zooecial cavity diameters, rare to absent mesozooecia, polygonal to subpolygonal zooecial cavity outlines and thin walls.

S. distinctaspinosa is most similar to *S. multispinosa.* It differs in having larger autozooecial cavity diameters and larger acanthostyle diameters. Large acanthostyles for this genus are found in *S. conica* and *S. nicklesi,* however, those of *S. distinctaspinosa* are nearly always larger. The former two species differ additionally in having fewer basal diaphragms and smaller zooecial cavity diameters. *S. conica* differs further by having fewer acanthostyles.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype NL IV 50(85)A-13-B(M) [USNM 432707], Paratypes NL IV 49(84)A-5R-EE(M) [USNM 432708], NL IV 117(152)A-8-D(M) [USNM 432709], NL IV 30(65)C-5-Z [USNM 432710], NL IV 37(72)B-6-H [USNM 432711], NL IV 49(84)A-8RA-Q [USNM 432712], NL IV 49(84)A-8RA-P [USNM 432713], NL IV 61(96)A-5-K [USNM 432714], NL IV 61(96)A-6-M [USNM 432715], NL IV 61(96)A-5-M [USNM 432716], NL IV 66(101)A-7-C [USNM 432718], NL IV 66(101)A-7-D [USNM 432719], NL IV 85(120)A-7L-A [USNM 432720], NL IV 85(120)A-4LB-A [USNM 432721], NL IV 85(120)A-3RA-B [USNM 432722], NL IV 85(120)A-6L-M [USNM 432723], NL IV 85(120)A-9L-G [USNM 432724], NL IV 87(122)A-5B-B [USNM 432725], NL IV 89(124)A-3A-A [USNM 432726], NL IV 93(128)A-3-G [USNM 432727], NL IV 93(128)A-2-D [USNM 432728], NL IV 93(128)A-11-G [USNM 432729], NL IV 94(129)A-2L-B [USNM 432730], NL IV 96(131)D-1-B [USNM 432731], NL IV 100(135)A-10L-KK [USNM 432732], NL IV 108(143)A-17-G [USNM 432733], NL IV 108(143)A-2-N [USNM 432734], NL IV 108(143)A-1-E [USNM 432735], NL IV 117(143)A-2-E [USNM 432736], NL IV 117(143)A-8-C [USNM 432737], NL IV 44(79)D-15L-B(F) [USNM 432738], NL IV

Table 37.—Quantitative data, *Stigmatella distinctaspinosa* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 49–50 (84–85)	.20–.26	.23	.24	.020	10	2
	NL IV 117 (152)	.20–.22	.22	.22	.009	5	1
	NL IV TOTAL	.20–.26	.23	.22	.018	15	3
	CB 72	.19–.24	.21	.22	.015	10	2
	CB 145–150	.20–.26	.23	.24	.019	10	2
	CB TOTAL	.19–.26	.22	.22	.019	20	4
	HCM	.22–.24	.22	.22	.009	5	1
	TOTAL	.19–.26	.22	.22	.018	40	8
ZWT	NL IV 49–50 (84–85)	.01–.02	.01	.01	.003	10	2
	NL IV 117 (152)	.02	.02	.02	.000	5	1
	NL IV TOTAL	.01–.02	.01	.01	.005	15	3
	CB 72	.01–.03	.01	.01	.007	10	2
	CB 145–150	.01–.02	.01	.01	.005	10	2
	CB TOTAL	.01–.03	.01	.01	.006	20	4
	HCM	.01–.03	.02	.01, .02	.008	5	1
	TOTAL	.01–.03	.01	.01	.006	40	8
Z/mm^2	NL IV 49–50 (84–85)	—	—	—	—	—	–
	NL IV 117 (152)	—	—	—	—	—	—
	NL IV TOTAL	—	—	—	—	—	—
	CB 72	25–30	27.5	—	3.5	2	2
	CB 145–150	19–23	21.0	—	2.8	2	2
	CB TOTAL	19–30	24.2	—	4.6	4	4
	HCM	25	25.0	25	0.0	1	1
	TOTAL	19–30	24.4	25	4.0	5	5
AD (lam)	NL IV 49–50 (84–85)	.03–.12	.06	.03, .07	.029	20	2
	NL IV 117 (152)	.03–.10	.07	.08	.025	10	1
	NL IV TOTAL	.03–.12	.07	.04, .08	.028	30	3
	CB 72	.03–.07	.05	.04, .05, .06	.010	20	2
	CB 145–150	.04–.08	.06	.06	.013	21	2
	CB TOTAL	.03–.08	.05	.06	.012	41	4
	HCM	.04–.14	.07	.05, .08	.029	10	1
	TOTAL	.03–.14	.06	.06	.022	81	8
AD (lum)	Varies approximately between .01 to .02.						

44(79)E-7-C(F) [USNM 432739], NL IV 51(86)A-12L-C(F) [USNM 432740], NL IV 51(86)A-25L-A(F) [USNM 432741], CB 72C-4L-E(M) [USNM 432742], CB 72C-2RB-B(M) [USNM 432743], CB 145C-4-C(M) [USNM 432744], CB 150B-2-B(M) [USNM 432745], CB 55A-1-B [USNM 432746], CB 55A-5-A [USNM 432747], CB 72B-3-A [USNM 432748], CB 82A-4-B [USNM 432749], CB 122A-11-A [USNM 432752], CB 150B-6-A [USNM 432753], CB 45A-2-A(F) [USNM 432754], CB 45A-1-A(F) [USNM 432755], CB 67B-6-A(F) [USNM 432756], CB 67B-6-B(F) [USNM 432757], CB 72C-7L-B(F) [USNM 432758], CB 85A-4-B(F) [USNM 432759], CB 132C-11L-A(F) [USNM 432760], CB 132C-5L-D(F) [USNM 432761], CB 138B-4-D(F) [USNM 432762], CB 156A-3-A(F) [USNM 432763], CB 161A-1-C,D(F) [USNM 432764], HCM 18(57)C-3L-D(M) [USNM 432765], HCM 5(44)A-2-C(F) [USNM 432766], HCM 38(77)A-1-X(F) [USNM 432767], WB 27(39)B-3-A [USNM 432768].

Family **HALLOPORIDAE** Bassler, 1911

Genus **TARPHOPHRAGMA** Karklins, 1984

Type species.—*Monotrypella multitabulata* Ulrich, 1886.

Remarks.—The genus *Tarphophragma* was established by Karklins (1984) to include zoaria having particularly distinctive autozooecial budding patterns (similar to the A1 budding pattern of McKinney, 1977, but with regularly spaced endozonal basal diaphragms; similar to the A2 pattern of McKinney, 1977, but for planar walled autozooecia in cross-section and a lack of mesozooecium-like polymorphs in the inner endozone), regular occurrences of abundant basal diaphragms throughout the zoarium, V-shaped wall laminae, exozonal mesozooecia, and a lack of acanthostyles and accessory wall structures (*e.g.*, mural spines, cysts) in the exozone. Key (1991) revised the description of this genus to include some species with closely

Table 38.—Quantitative data, *Tarphophragma multitabulata* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 51 (86)	.24–.26	.25	.26	.011	5	1
	NL IV 87–100 (122–135)	.22–.30	.26	.26	.021	35	7
	NL IV TOTAL	.22–.30	.25	.26	.020	40	8
	CB 85	.24–.30	.27	.26	.023	5	1
	CB 154	.24–.30	27	.28	.023	5	1
	CB TOTAL	.24–.30	.27	.26, .28	.022	10	2
	TOTAL	.22–.30	.26	.26	.021	50	10
ZWT	NL IV 51 (86)	.04–.05	.04	.04	.006	5	1
	NL IV 87–100 (122–135)	.02–.08	.05	.04	.017	35	7
	NL IV TOTAL	.02–.08	.05	.04	.016	40	8
	CB 85	.02–.04	.03	.03, .04	.007	5	1
	CB 154	.04–.06	.04	.04	.007	5	1
	CB TOTAL	.02–.06	.04	.04	.009	10	2
	TOTAL	.02–.08	.05	.04	.015	50	10
Z/mm^2	NL IV 51 (86)	16	16	16	0.0	1	1
	NL IV 87–100 (122–135)	12–19	15	14, 17	2.5	7	7
	NL IV TOTAL	12–19	15	14, 17	2.4	8	8
	CB 85	16	16	16	0.0	1	1
	CB 154	15	15	15	0.0	1	1
	CB TOTAL	15–16	16	—	0.71	2	2
	TOTAL	12–19	15	14, 16, 17	2.1	10	10

spaced diaphragms in earliest and latest ontogeny rather than solely throughout the zoarium.

Tarphophragma multitabulata (Ulrich, 1886)
Plate 20, Figures 1–4

Monotrypella multitabulata Ulrich, 1886, p. 100.

Callopora multitabulata (Ulrich). Ulrich, 1893, p. 280, 281, pl. 23, figs. 11, 12, 16, 17, 24–26, 30, 31; Bassler, 1906, p. 22, 23, pl. 1, figs. 5, 6.

Hallopora multitabulata (Ulrich). Bassler, 1911, p. 326, 327, text-fig. 202a–d; McFarlan, 1931, p. 106, pl. 1, fig. 5, 6; Fritz, 1957, p. 19, pl. 11, figs. 1–4; Brown, 1965, p. 1003, 1004, pl. 18, figs. 5–7.

Tarphophragma multitabulata (Ulrich). Karklins, 1984, p. 177–180, pl. 32, 33.

Description.—Zoaria ramose. Budding pattern extremely regular. Newly formed zooecia with three to four sides found evenly distributed throughout endozone filling interzooecial voids left by slightly older zooecia having larger diameter and increased polygonality of six to eight sides. In exozone, zooecial cavity outline subpolygonal to subrounded. Zooecia curve gently and continuously within endozone. A zooecial bend of increased curvature commonly occurs in lower exozone after which zooecia straighten and continue directly outwards to intersect the colony surface at or nearly at right angles. Walls in exozone moderately thick. Wall laminae commonly V-shaped but broadly U-shaped where walls thicker. Some zooecial boundaries defined by dark line joining apices of laminae. Diaphragms present throughout endozone, more closely spaced in proximal-most parts of zooecial tubes, thin, evenly spaced, perpendicular to zooecial walls, some broadly curved outwards. Diaphragms in exozone closely spaced at between one-half to more commonly one-fifth to one-third a zooecial cavity diameter apart, less evenly spaced than endozone, thickness variable, mainly planar but some curved, inclined, overlapping, cystose on distal side of zooecial tube. Mesozooecia fairly common in exozone, often get crowded out peripherally by autozooecia. Newly budded zooecia have diaphragm spacing similar to mesozooecia but quickly take on characteristics of autozooecia. Diaphragms planar, mainly perpendicular to zooecial walls, on occasion inclined to overlapping, spaced at between one-half to one mesozooecial cavity diameter apart, thicknesses similar to autozooecial diaphragms. Cavity outline subpolygonal to polygonal, diameter small, generally three to four sides. Maculae composed of slightly larger zooecia (megazooecia), some maculae elevated a small amount above colony surface.

Measurements.—Measurements are summarized in Table 38.

Remarks.—*T. multitabulata* is very similar to *T. ampla*. Ulrich (1893) noted several criteria used to distinguish the two species, including primarily the lack of monticules, narrow exozone, slightly larger autozooecia, and more numerous mesozooecia of *Callopora ampla*. He stated further that these two species when found in the Trentonian Galena Shales of the Upper Mississippian Valley "often agree so closely that a rigid distinction between them is almost if not quite impossible" (Ulrich, 1893, p. 281). This would seem to be the case in the present study area, as the two species form a continuous morphological gradient with the main distinction between them being the width of the exozone (Ulrich's peripheral zone). All specimens of both species have maculae (monticules of Ulrich) and similar sized zooecia of all types. Mesozooecia are more common in tangential section of *T. ampla* since they tend to get crowded out with peripheral growth in *T. multitabulata.*

The most striking difference between the two species (one need only to examine the figure of Ulrich, 1893, pl. 23) is the increased number of diaphragms due to a wider exozone in *T. multitabulata.* The exozone of *C. multitabulata* as depicted by Ulrich (pl. 23, fig. 24) is approximately 1.5 mm while for *C. ampla,* it is about 0.5 mm. Specimens that fit Ulrich's concept of *C. ampla* are found without forms resembling *T. multitabulata* at the Howard Cemetery and Wilson Branch sections. This is also true for the lowermost part of the stratigraphic section at Norris Lake IV, suggesting perhaps that this is a meaningful species grouping. Specimens with exozones greater than 1.5 mm are commonly found at Norris Lake IV but only in the uppermost part of the stratigraphic section. Most specimens at the Norris Lake IV and Chamberlain Branch sections would fall in between *C. ampla* and specimens with branch widths as large as depicted by Ulrich for *C. multitabulata.* The actual stratigraphic range of *C. ampla* is not determinable with certainty since the species cannot be distinguished from ontogenetically young fragments of *C. multitabulata.* Ulrich does not mention the range in exozonal width among his specimens of *C. multitabulata.* His colonies average about 7–8 mm in branch diameter. Since colonies of *C. multitabulata* according to Ulrich (1893) are as small as 3.0 mm (4.0 mm in his 1886 report) it is not unreasonable to assume that the species includes specimens with exozonal thicknesses of less than 1.5 mm.

In the present report, the concept of *C. multitabulata* will include specimens with extended exozones greater than 0.5 mm, but most commonly greater than 1.0 mm until it can be shown otherwise from a more thorough reexamination of Ulrich's material or a more geographically and temporally broad scale study of these species.

It is noteworthy that specimens of *T. multitabulata* with the largest branch diameters (and exozonal widths) co-occur with the robust varieties of *Batostomella subgracilis* and *Parvohallopora granda* further suggesting that size variation is ecologically controlled. A separate variety of *T. multitabulata* was not erected since larger forms of this species do not appear to deviate from the typical form to the extent exhibited by the former two robust varieties.

Distribution.—Localities NL IV, CB.

Studied material.—Hypotypes NL IV 51(86)A-17L-A(M) [USNM 432769], NL IV 87(122)A-6B-A(M) [USNM 432770], NL IV 94(129)A-2L-A(M) [USNM 432771], NL IV 96(131)E-1-B(M) [USNM 432772], NL IV 96(131)B-2-H(M) [USNM 432773], NL IV 96(131)C-2-A(M) [USNM 432774], NL IV 96(131)B-7-C(M) [USNM 432775], NL IV 100(135)A-4L-M(M) [USNM 432776], NL IV 61(96)A-8-D [USNM 432777], NL IV 61(96)A-4-E [USNM 432778], NL IV 63(98)B-6LA-G [USNM 432779], NL IV 93(128)A-5-A [USNM 432780], NL IV 93(128)A-5-C [USNM 432781], NL IV 93(128)A-12-A [USNM 432782], NL IV 93(128)A-14-B [USNM 432783], NL IV 93(128)A-11-E [USNM 432784], NL IV 94(129)A-3L-B [USNM 432785], NL IV 94(129)A-3L-C [USNM 432786], NL IV 94(129)A-4L-A [USNM 432787], NL IV 96(131)F-2-B [USNM 432788], NL IV 96(131)C-1-A [USNM 432789], NL IV 96(131)D-4-B(=5-A) [USNM 432790], NL IV 96(131)D-4-A [USNM 432791], NL IV 96(131)B-6-C [USNM 432792], NL IV 96(131)B-5-D [USNM 432793], NL IV 96(131)B-2-G [USNM 432794], NL IV 96(131)B-2-I [USNM 432795], NL IV 96(131)B-2-E [USNM 432796], NL IV 96(131)D-2-A [USNM 432797], NL IV 96(131)C-5-H [USNM 432798], NL IV 96(131)G-4-A [USNM 432799], NL IV 100(135)A-6L-H [USNM 432800], NL IV 100(135)A-5L-A [USNM 432801], NL IV 100(135)A-7L-D [USNM 432802], NL IV 100(135)A-3L-H [USNM 432803], NL IV 100(135)A-3L-C [USNM 432804], NL IV 100(135)A-12L-C [USNM 432805], NL IV 116(151)A-2-B [USNM 432806], CB 85A-3-B(M) [USNM 432807], CB 154A-3-A(M) [USNM 432808], CB 57A-3-B [USNM 432809], CB 62A-8-A [USNM 432810], CB 67B-6-C [USNM 432811], CB 72A-2B-A [USNM 432812], CB 130A-8-A [USNM 432813], CB 138B-9-B [USNM 432814], CB 41A-1-A(F) [USNM 432815], CB 45.5A-2-A(F) [USNM 432816], CB 54A-1-B(F) [USNM 432817], CB 85A-14L-B(F) [USNM 432818], CB 138B-4-E(F) [USNM 432819], CB 153B-3-B(F) [USNM 432820], CB 161A-1-B(F) [USNM 432821].

Tarphophragma ampla (Ulrich, 1893)
Plate 21, Figures 1–2

Callopora ampla Ulrich, 1893, p. 281, 282, pl. 23, figs. 15, 18–20, 22, 23, 27, 28.

Description.—This species is morphologically similar to *Tarphophragma multitabulata* but for a relatively narrow exozone. The concept of *T. ampla* is

Table 39.—Quantitative data, *Tarphophragma ampla* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
MxZCD	NL IV	.22–.38	.29	.26	.037	25	5
	WB	.24–.28	.26	.26	.014	5	1
	TOTAL	.22–.38	.28	.26	.035	30	6
MnMCD	NL IV	.16–.20	.24	.18	.011	10	2
	WB	—	—	—	-	—	—
	TOTAL	.16–.20	.24	.18	.011	10	2
ZWT	NL IV	.02–.06	.03	.02	.011	25	5
	WB	.02–.04	.03	.03, .04	.008	5	1
	TOTAL	.02–.06	.03	.02	.010	30	6
Z/mm²	NL IV	14–18	16	—	2.8	2	2
	WB	17	17	—	0.0	1	1
	TOTAL	14–18	16	—	2.1	3	3
MxMCD	NL IV	.04–.20	.10	.12	.036	25	5
	WB	—	—	—	—	—	—
	TOTAL	.04–.20	.10	.12	.036	25	5
MnMCD	NL IV	.04–.08	.06	.08	.017	25	5
	WB	—	—	—	—	—	—
	TOTAL	.04–.08	.06	.08	.017	25	5

here restricted to colonies that are similar to *T. multitabulata* but have exozones less than or equal to 0.5 mm in thickness. See *Remarks* section of *T. multitabulata* (p. 80) for further comments concerning the identification of these species.

Measurements.—Measurements are summarized in Table 39.

Distribution.—Localities NL IV, CB?, HCM, WB.

Studied material.—Hypotypes NL IV 43(78)B-3L-G(M) [USNM 432822], NL IV 43(78)B-3L-B(M) [USNM 432823], NL IV 49(84)A-5R-AA(M) [USNM 432824], NL IV 49(84)A-7R-B(M) [USNM 432825], NL IV 61(96)A-9-D(M) [USNM 432826], NL IV 33(68)A-2-E [USNM 432827], NL IV 61(96)A-6-A [USNM 432828], NL IV 63(98)B-5LA-D [USNM 432829], NL IV 100(135)A-7L-C [USNM 432830], NL IV 100(135)A-9L-K [USNM 432831], NL IV 100(135)A-7L-B [USNM 432832], HCM 11(50)A-3-A [USNM 432833], WB 43(55)A-1-A(M) [USNM 432834].

Genus **PARVOHALLOPORA** Singh, 1979

Type species.—Monticulipora ramosa d'Orbigny, 1850.

Remarks.—Singh (1979), noting the heterogeneity in morphology of species assigned to *Hallopora* by many authors, studied topotype material of *Calopora elegantula* (the type species of *Hallopora*[1]) and related forms housed at the National Museum of Natural History. The result of his study was the establishment of the new genus, *Parvohallopora,* the concept of which is followed here. *Parvohallopora* is characterized by its ramose colonies with polygonal zooecial cavity outlines in endozone, polygonal or circular to subcircular zooecia in exozone, numerous relatively small rounded to subrounded mesozooecial cavity outlines between most autozooecia, broad U- to V-shaped wall laminae, diaphragms present in the endozone and absent in the exozone of some species, rare to absent cystose diaphragms and no mural spines.

[1] Singh (1979) mistakenly noted *Chaetetes elegantula* as the type of *Hallopora.* He meant to say *Calopora.* See also Karklins (1984).

Parvohallopora pulchella (Ulrich, 1893)
Plate 22, Figures 1–3

Callopora pulchella Ulrich, 1893, p. 283, 284, pl. 22, figs. 1–12.
Callopora pulchella var. *persimilis* Ulrich, 1893, p. 284, pl. 22, figs 13–17.

Description.—Zoaria ramose. Rarely encrusting. New zooecia bud continuously throughout endozone. Zooecial cavity outlines round (circular) in exozone (sometimes subrounded), polygonal in endozone. Zooecia curve rapidly but smoothly from endozone to exozone so that base of exozonal walls perpendicular or nearly so to colony surface. Occasionally a slight zooecial bend at endozonal/exozonal transition. Surface angle of zooecia is 90°. Walls of exozone relatively thin, thickness even, sometimes fairly thick. Endozonal walls thin, thicken at base of exozone. Walls formed of V-shaped laminae, the apices of which connected by dark line in most walls. Exozone narrow. Endozonal walls generally even and parallel-sided. Diaphragms of exozone absent or one, rarely two per zooecium, thin, perpendicular to zooecial walls. In en-

Table 40.—Quantitative data, *Parvohallopora pulchella* (Ulrich). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 100–108 (135–143)	.13–.20	.16	.18	.022	15	3
	NL IV 61–63 (96–98)	.16–.24	.18	.18	.022	25	5
	CB 72	.20–.22	.21	.20	.011	5	1
	CB 149	.14–.20	.17	.17	.022	5	1
	TOTAL	.13–.24	.18	.18	.025	50	10
ZCD (mac)	NL IV 100–108 (135–143)	.19–.24	.22	.22	.017	10	2
	NL IV 61–63 (96–98)	.22–.36	.28	.30	.050	10	2
	CB 72	.26–.30	.27	.26	.018	5	1
	CB 149	—	—	—	—	—	—
	TOTAL	.19–.36	.25	.22	.043	25	5
ZWT	NL IV 100–108 (135–143)	.01–.06	.03	.01, .03	.016	15	3
	NL IV 61–63 (96–98)	.01–.06	.03	.01	.017	25	5
	CB 72	.01	.01	.01	.000	5	1
	CB 149	.05–.07	.06	.05	.009	5	1
	TOTAL	.01–.07	.03	.01	.018	50	10
Z/mm²	NL IV 100–108 (135–143)	29–36	32	—	5.0	2	2
	NL IV 61–63 (96–98)	25–31	28	28	2.4	4	4
	CB 72	30	30	30	0.0	1	1
	CB 149	—	—	—	—	—	—
	TOTAL	25–36	30	28	3.4	7	7
MxMCD	NL IV 100–108 (135–143)	.04–.10	.06	.04	.021	15	3
	NL IV 61–63 (96–98)	.02–.11	.06	.04	.024	20	4
	CB 72	.06–.11	.08	.06	.022	5	1
	CB 149	.03–.06	.04	.03, .06	.015	5	1
	TOTAL	.02–.11	.06	.04	.023	45	9
MnMCD	NL IV 100–108 (135–143)	.02–.05	.03	.03	.010	15	3
	NL IV 61–63 (96–98)	.02–.06	.04	.03, .05	.012	20	4
	CB 72	.04–.06	.05	.04, .05	.008	5	1
	CB 149	.02–.06	.04	.02	.018	5	1
	TOTAL	.02–.06	.04	.05	.012	45	9
MxMCD (mac)	NL IV 100–108 (135–143)	.04–.09	.07	.08	.016	10	2
	NL IV 61–63 (96–98)	.04–.15	.09	.07, .10	.034	10	2
	CB 72	.06–.14	.09	.06	.034	5	1
	CB 149	—	—	—	—	—	—
	TOTAL	.04–.15	.08	.06, .08	.030	25	5
MnMCD (mac)	NL IV 100–108 (135–143)	.03–.07	.05	.05	.013	10	2
	NL IV 61–63 (96–98)	.03–.10	.06	.10	.027	10	2
	CB 72	.04–.08	.05	.04	.018	5	1
	CB 149	—	—	—	—	—	—
	TOTAL	.03–.10	.06	.04	.021	25	5

dozone, diaphragms occur only in the proximal-most ends of zooecial tubes, having formed immediately after new zooecia have budded. Up to three to four diaphragms, spaced at approximately one and one-half zooecial cavity diameters apart, thin, perpendicular to walls. Mesozooecia fairly common and initiated at very base of exozone. Some continue to colony surface, some become autozooecia. Some autozooecia of endozone become mesozooecia within exozone. Mesozooecial cavity outlines polygonal in lower exozone, get progressively rounded in outer exozones of mature specimens. Diaphragms perpendicular to walls, spaced at intervals approximating one mesozooecial cavity diameter apart, often slightly thicker than in autozooecia. Maculae consist of megazooecia, and increased numbers of mesozooecia.

Measurements.—Measurements are summarized in Table 40.

Remarks.—*P. pulchella* typically has circular exozonal and polygonal endozonal autozooecial cavity outlines, relatively thin walls throughout, exozonal diaphragms absent or rarely as many as two, up to three to four endozonal diaphragms found only at the proximal ends of each zooecium, and fairly abundant and well-tabulated mesozooecia in the exozone with outlines that get progressively rounded outwards.

Ulrich (1893) noted that there is no species of *Callopora* known from Minnesota that is likely to be confounded with *C. pulchella.* This is not so in the present study area. *Parvohallopora pulchella* and *P. granda* n. sp. have specimens that would form a gradient between these two species. The latter species almost always has more diaphragms (up to four per zooecium), a generally wider endozone and thicker exozonal walls. Criteria used to confirm this species boundary are (1) the common occurrence of *P. pulchella* in certain lithofacies exclusive, or nearly so, of *P. granda,* (2) the occurrence of specimens with rather long zoarial branches whose zooecia, even those in proximal portions of the colony where ontogenetically older zooecia would have developed, do not exhibit character states found in *P. granda,* (3) the presence of an encrusting and slightly massive zoarium whose walls are persistently thin and diaphragms very few and widely spaced, and finally (4) the lack of *P. granda* in Ulrich's Minnesota study area. All of the above would suggest that the two species are not ontogenetic expressions of a single species.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Hypotypes NL IV 61(96)A-4-H(M) [USNM 432835], NL IV 61(96)A-4-J(M) [USNM 432836], NL IV 61(96)A-7-A(M) [USNM 432837], NL IV 61(96)A-6-J(M) [USNM 432838], NL IV 63(98)B-3LB-Y(M) [USNM 432839], NL IV 100(135)A-13L-A(M) [USNM 432840], NL IV 108(143)A-8-E(M) [USNM 432841], NL IV 108(143)A-7-J(M) [USNM 432842], NL IV 33(68)A-2-I [USNM 432843], NL IV 43(78)B-9-E [USNM 432844], NL IV 43(78)B-4L-Z [USNM 432845], NL IV 50(85)A-7-F [USNM 432846], NL IV 51(86)A-23L-B [USNM 432847], NL IV 61(96)A-6-E [USNM 432848], NL IV 61(96)A-6-G [USNM 432849], NL IV 61(96)A-5-F [USNM 432850], NL IV 61(96)A-7-E [USNM 432851], NL IV 61(96)A-5-G [USNM 432852], NL IV 61(96)A-5-B [USNM 432853], NL IV 61(96)A-8-A [USNM 432854], NL IV 61(96)A-7-B [USNM 432855], NL IV 61(96)A-8-H [USNM 432856], NL IV 61(96)A-6-I [USNM 432857], NL IV 63(98)B-4LB-KK [USNM 432858], NL IV 63(98)B-2LB-J [USNM 432859], NL IV 63(98)B-3LB-B [USNM 432860], NL IV 66(101)A-4B-A [USNM 432861], NL IV 66(101)A-10-C [USNM 432862], NL IV 72(109)B-4L-D [USNM 432863], NL IV 93(128)A-13-B [USNM 432864], NL IV 93(128)A-5-I [USNM 432865], NL IV 93(128)A-9-B [USNM 432866], NL IV 94(129)A-4L-G [USNM 432867], NL IV 96(131)B-1-C [USNM 432868], NL IV 96(131)D-5-B [USNM 432869], NL IV 100(135)A-7L-E [USNM 432870], NL IV 100(135)A-12L-I [USNM 432871], NL IV 100(135)A-10L-QQ [USNM 432872], NL IV 100(135)A-3-H [USNM 432873], NL IV 100(135)A-6L-I [USNM 432874], NL IV 100(135)A-9L-R [USNM 432875], NL IV 108(143)A-2-L [USNM 432877], NL IV 108(143)A-7-K [USNM 432878], NL IV 108(143)A-3-H [USNM 432879], NL IV 108(143)A-16-C [USNM 432880], NL IV 108(143)A-14-M [USNM 432881], NL IV 108(143)A-17-E [USNM 432882], NL IV 1089143)A-8-G [USNM 432883], NL IV 108(143)A-3-I [USNM 432884], NL IV 108(143)A-2-M [USNM 432885], NL IV 108(143)A-9-C [USNM 432886], NL IV 108(143)A-3-K [USNM 432887], NL IV 108(143)A-17-K [USNM 432888], NL IV 117(152)A-8-B [USNM 432889], NL IV 117(152)A-4-A,B,C,D [USNM 432890], NL IV 61(96)A-5-P(F) [USNM 432891], NL IV 61(96)A-6-D(F) [USNM 432892], NL IV 61(96)A-5-N(F) [USNM 432893], CB 72C-4L-C(M) [USNM 432894], CB 149A-7-A(M) [USNM 432895], CB 46A-2L-A [USNM 432896], CB 46A-1-A [USNM 432897], CB 62A-10-B [USNM 432898], CB 67B-9-B(=10-A) [USNM 432899], CB 67B-7-E [USNM 432900], CB 72B-3-B [USNM 432901], CB 72C-4L-D [USNM 432902], CB 72B-5-B [USNM 432903], CB 126A-2-A [USNM 432904], CB 145A-2R-B [USNM 432905], CB 46C-2L-A(F) [USNM 432907], CB 51A-2-B(F) [USNM 432908], CB 72C-2LA-B(F) [USNM 432909], CB 85A-3-C(F) [USNM 432910], CB 132B-10-A(F) [USNM 432911], CB 149A-2-D(F) [USNM 432912], CB 156A-5L-A(F) [USNM 432913], CB 161A-2-C(F) [USNM 432914], HCM 43(82)C-4-D [USNM 432915], WB 15(27)B-3-A [USNM 432916], WB 19(31)A-2-B [USNM 432917], WB 20(32)B-2-A [USNM 432918], WB 15(27)A-3-A(F) [USNM 432919].

Parvohallopora granda, new species
Plate 22, Figure 4

Description.—This species similar to *Parvohallopora pulchella* in all respects except for numerous diaphragms in exozone, commonly two to four per autozooecium (in non-varietal form), some slightly thicker than others, infrequently inclined, commonly spaced at three-fourths to one zooecial cavity diameter apart but some vary from one-half to two zooecial cavity diameters apart; a generally wider endozone; exozonal walls that are more consistently thicker, thickening occurring abruptly at base of exozone or in lower exozone. Where walls thicken or remain thick in zooecially distal direction, mesozooecia end.

Etymology.—The trivial name *granda* refers to the rather smooth and elegant lines and curves of various zoarial parts.

Measurements.—Measurements are summarized in Table 41.

Table 41.—Quantitative data, *Parvohallopora granda* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.12–.18	.16	.16	.015	20	4
	CB 149–161	.14–.18	.17	.18	.013	15	3
	CB 72	.12–.15	.13	.12, .14	.013	5	1
	HCM	.13–.15	.14	.14	.007	5	1
	WB	.18–.20	.20	.20	.009	5	1
	TOTAL	.12–.20	.16	.16	.021	50	10
ZCD (mac)	NL IV	.17–.28	.21	.20, .22	.032	15	3
	CB 149–161	.24	.24	.24	.000	3	1
	CB 72	.19–.24	.22	.24	.023	5	1
	HCM	.16–.22	.18	—	.026	4	1
	WB	.26–.30	.27	.26	.018	5	1
	TOTAL	.16–.30	.22	.24	.036	32	7
ZWT	NL IV	.02–.06	.04	.04	.011	20	4
	CB 149–161	.02–.05	.04	.04	.008	15	3
	CB 72	.06	.06	.06	.000	5	1
	HCM	.04–.06	.05	.04	.009	5	1
	WB	.02–.04	.03	.02, .03	.008	5	1
	TOTAL	.02–.06	.04	.04	.012	50	10
Z/mm²	NL IV	29–32	30	—	1.3	4	4
	CB 149–161	25–30	28	30	2.9	3	3
	CB 72	29	29	29	0.0	1	1
	HCM	32	32	32	0.0	1	1
	WB	27	27	27	0.0	1	1
	TOTAL	25–32	30	30	2.2	10	10
MxMCD	NL IV	.02–.06	.04	.04	.014	15	3
	CB 149–161	.03–.09	.06	.05, .06	.018	10	2
	CB 72	—	—		—	—	—
	HCM	.03–.08	.04	.03, .04	.021	5	1
	WB	.05–.09	.06	.05	.018	5	1
	TOTAL	.02–.09	.05	.05	.018	35	7
MnMCD	NL IV	.01–.05	.03	.03	.011	15	3
	CB 149–161	.02–.06	.03	.04	.012	10	2
	CB 72	—		—	—	—	—
	HCM	.02–.04	.03	.03	.008	5	1
	WB	.04–.07	.04	.04	.015	5	1
	TOTAL	.01–.07	.03	.03	.012	35	7
MxMCD (mac)	NL IV	.04–.12	.08	.08	.021	15	3
	CB 149–161	.06–.07	.06	—	.007	2	1
	CB 72	.06–.10	.09	.10	.017	5	1
	HCM	—		—	—	—	—
	WB	.04–.05	.04	.04	.006	5	1
	TOTAL	.04–.05	.07	.10	.023	27	6
MnMCD (mac)	NL IV	.04–.10	.06	.04	.018	15	3
	CB 149–161	.04–.05	.04	—	.007	2	1
	CB 72	.06–.08	.07	.06, .07	.008	5	1
	HCM	—		—		—	—
	WB	.03–.04	.04	.04	.006	5	1
	TOTAL	.03–.10	.05	.04	.017	27	6

Remarks.—This typical form of the species differs from *Parvohallopora granda* n. sp. *inflata* n. var. by fewer exozonal diaphragms due to a narrower exozone. This species is morphologically close to *P. pulchella* (see Remarks section of the latter species).

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype NL IV 108(143)A-3-E(M) [USNM 432920], Paratypes NL IV 96(131)B-2-B(M) [USNM 432921], NL IV 100(135)A-13L-E(M) [USNM 432922], NL IV 100(135)A-5L-I(M) [USNM 432923], NL IV 72(107)A-4-C [USNM 432924], NL IV 72(107)B-6L-A(=5L-B) [USNM 432925], NL IV 85(120)A-9L-B [USNM 432926], NL IV 87(122)A-6B-C [USNM 432927], NL IV 93(128)A-1-N [USNM

Table 42.—Quantitative data, *Parvohallopora granda* n. sp. var. *inflata* n. var. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV	.10–.18	.14	.14	.014	50	5
	TOTAL	.10–.18	.14	.14	.014	50	5
ZCD (mac)	NL IV	.14–.22	.18	.20	.024	23	5
	TOTAL	.14–.22	.18	.20	.024	23	5
ZWT	NL IV	.04–.10	.06	.06	.014	50	5
	TOTAL	.04–.10	.06	.06	.014	50	5
Z/mm²	NL IV	28–30	29	29, 30	.84	5	5
	TOTAL	28–30	29	29, 30	.84	5	5
MxMCD	NL IV	.03–.06	.04	.04	.011	5	1
	TOTAL	.03–.06	.04	.04	.011	5	1
MnMCD	NL IV	.02–.04	.02	.02	.010	5	1
	TOTAL	.02–.04	.02	.02	.010	5	1
MxMCD (mac)	NL IV	.04–.10	.07	.07	.017	16	4
	TOTAL	.04–.10	.07	.07	.017	16	4
MnMCD (mac)	NL IV	.04–.07	.05	.06	.011	16	4
	TOTAL	.04–.07	.05	.06	.011	16	4

432928], NL IV 93(128)A-4-K [USNM 432929], NL IV 93(128)A-11-H [USNM 432930], NL IV 93(128)A-7-C [USNM 432931], NL IV 93(128)A-12-C [USNM 432932], NL IV 93(128)A-9-A, [USNM 432933], NL IV 93(128)A-5-G [USNM 432934], NL IV 93 (128)A-3-B [USNM 432935], NL IV 93(128)A-4-J [USNM 432936], NL IV 100(135)A-4L-QQ [USNM 432937], NL IV 100(135)A-4L-K [USNM 432938], NL IV 100(135)A-10L-B,C [USNM 432939], NL IV 100(135)A-12L-F [USNM 432940], NL IV 108 (143)A-8-B [USNM 432941], NL IV 108(143)A-5-M [USNM 432942], NL IV 108(143)A-3-L [USNM 432943], NL IV 108(143)A-2-A [USNM 432944], NL IV 108(143)A-14-H [USNM 432945], NL IV 108(143)A-6-C [USNM 432946], NL IV 108(143)A-2-K [USNM 432947], NL IV 108(143)A-12-D [USNM 432948], NL IV 108(143)A-6-E [USNM 432949], NL IV 117(152)A-2-B [USNM 432950], NL IV 117(152)A-4-E [USNM 432951], CB 72C-5L-C(=4L-B)(M) [USNM 432952], CB 149A-8-A(M) [USNM 432953], CB 161A-2-B(M) [USNM 432954], CB 161A-3-A(M) [USNM 432955], CB 130A-2-A(F) [USNM 432956], HCM 43(82)B-5-E(M) [USNM 432957], HCM 18(57)B-5-C(F) [USNM 432958], HCM 43(82)A-4-H [USNM 432959], WB 32(44)A-3-A(M) [USNM 432960], WB 32(44)A-3-B [USNM 432961].

Parvohallopora granda, new species
var. **inflata**, new variety
Plate 23, Figure 1

Description.—This variety is similar to *P. granda*, typical form, in all respects except for increased numbers of diaphragms in exozone (greater than 4), with a few locally overlapping, a wider exozone, sometimes thicker walls that constrict zooecial cavities. Zooecial walls sometimes irregularly thickened in exozone.

Etymology.—The variety *inflata* refers to the inflated and robust appearance of zoaria due to a wide exozone.

Measurements.—Measurements are summarized in Table 42.

Remarks.—This variety is so similar to the typical form of the species, the main difference being the number of diaphragms which is a function of a wider exozone, that to assign a new species here would be unwarranted at this time. It is of interest to note that the variety of *Batostomella subgracilis* var. *robusta* described herein co-occurs with *P. granda* var. *inflata* in beds from a similar stratigraphic level at the Norris Lake IV section. The former variety is also distinguished from the typical form of the species by an extension of the exozonal walls, suggesting a possible ecological control on colony branch diameter.

Distribution.—Localities NL IV, CB, WB.

Studied material.—Hypotypes NL IV 108(143)A-15-C(M) [USNM 432962], NL IV 108(143)A-11-A(M) [USNM 432963], NL IV 108(143)A-2-D(M) [USNM 432964], NL IV 108(143)A-13-A(M) [USNM 432965], NL IV 108(143)A-17-L(M) [USNM 432966], NL IV 93(128)A-12-D [USNM 432967], NL IV 93(128)A-5-F [USNM 432968], NL IV 93(128)A-2-A,B [USNM 432969], NL IV 93(128)A-10-C [USNM 432970], NL IV 93(128)A-14-D [USNM 432971], NL IV 93(128)A-7-B [USNM 432972], NL IV 96(131)G-2-C [USNM 432973], NL IV 96(131)F-2-C [USNM

432974], NL IV 96(131)B-7-A [USNM 432975], NL IV 96(131)C-3-D [USNM 432976], NL IV 96(131)B-5-A [USNM 432977], NL IV 96(131)B-6-A [USNM 432978], NL IV 96(131)E-2-C [USNM 432979], NL IV 100(135)A-4L-V [USNM 432981], NL IV 100(135)A-5L-H [USNM 432982], NL IV 100(135)A-3L-A [USNM 432983], NL IV 100(135)A-3L-D [USNM 432984], NL IV 100(135)A-7L-A [USNM 432985], NL IV 100(135)A-10L-L [USNM 432986], NL IV 100(135)A-9L-B [USNM 432987], NL 100(135)A-9L-C [USNM 432988], NL IV 100(135)A-10L-PP [USNM 432989], NL IV 100(135)A-13L-B [USNM 432990], NL IV 108(143)A-5-E [USNM 432991], NL IV 108(143)A-1-F [USNM 432992], NL IV 108(143)A-7-F [USNM 432993], NL IV 108(143)A-17-D [USNM 432994], NL IV 108(143)A-12-A [USNM 432995], NL 108(143)A-5-J [USNM 432996], NL IV 108(143)A-14-K [USNM 432997], NL IV 108(143)A-14-E [USNM 432998], NL IV 108(143)A-13-B [USNM 432999], NL IV 108(143)A-14-B [USNM 433000], NL IV 108(143)A-6-H [USNM 433001], NL IV 108(143)A-6-D [USNM 433002], NL IV 108(143)A-12-G [USNM 433003], NL IV 108(143)A-8-C [USNM 433004], NL IV 108(143)A-5-C [USNM 433005], NL IV 108(143)A-13-E [USNM 4330006], NL IV 108(143)A-7-D [USNM 433007], NL IV 108(143)A-5-N [USNM 433008], NL IV 108(143)A-3-A [USNM 433009], CB 72C-5L-B(=4L-A) [USNM 433010], CB 85A-17L-E [USNM 433011], CB 85A-8-B [USNM 433012], CB 85A-9-D [USNM 433013], CB 149A-5-A [USNM 433014], CB 85A-17L-F(F) [USNM 433015], WB 43(55)C-8L-A [USNM 433016].

Family **TREMATOPORIDAE** Miller, 1889

Genus **ANAPHRAGMA** Ulrich and Bassler, 1904

Type species.—Anaphragma mirabile Ulrich and Bassler, 1904.

Anaphragma hermitagensis, new species
Plate 24, Figures 1–2

Description.—Zoaria ramose. Some encrust. New zooecia that initiate in the same relative position of the outer endozone alternate with zooecia that initiate in the inner endozone. Exozone zooecial cavities generally rounded to subrounded. In endozone, zooecial cavities polygonal. Cavities subpolygonal in lower exozone where walls begin to become laminate. Zooecial boundaries (delimited by dark median line) angular (polygonal) to subrounded in tangential section. Zooecia curve broadly and shallowly to base of exozone whereupon they very commonly bend abruptly and continue to colony surface at right angles. Infrequently, a secondary zooecial bend occurs in outer endozone. Endozonal walls thin, even to slightly wavy or crenulate. Wall thickness increases rapidly in exozone (*i.e.*, at endozone-exozone transition) and distally remains fairly constant to irregularly thickened and thinned. Walls with distinct V-shaped laminae, the apices of which are joined by an even dark line. Diaphragms rare in exozone, absent in endozone. Mesozooecia few and small. Cavity outlines round to subround. Bud at endozonal/exozonal transition. Minute acanthostyle-like features at some zooecial corners in exozone. Obscure in longitudinal section. Maculae present and flush with colony surface. Mesozooecia without diaphragms occur between megazooecia of maculae. Some mesozooecia completely separate adjacent autozooecia in maculae.

Etymology.—The trivial name *hermitagensis* refers to the Hermitage Formation from which this species was initially described.

Measurements.—Measurements are summarized in Table 43.

Remarks.—This species characteristically has generally rounded to subrounded exozonal zooecial cavity outlines, surface angles of 90°, even to crenulate endozonal walls, constant to irregularly thickened and thinned exozonal walls whose abutting laminae form a V-shaped pattern in longitudinal section and whose zooecial boundaries are delimited by a dark median line, generally few mesozooecia which are more common in maculae, and minute acanthostyle-like structures at many zooecial corners.

A. hermitagensis is very similar to *A. mirabile* but for smaller autozooecial tube diameters, a somewhat more constant development of V-shaped walls with accompanying median dark line, and absence of distinct acanthostyles.

Distribution.—Localities NL IV, CB, HCM, WB.

Studied material.—Holotype HCM 18(57)B-5-E(M) [USNM 433017], Paratypes NL IV 37(72)B-4-C(M) [USNM 433018], NL IV 49(84)A-5R-Z(M) [USNM 433019], NL IV 49(84)A-5R-C(M) [USNM 433020], NL IV 49(84)A-7R-J(M) [USNM 433021], NL IV 49(84)A-5R-I(M) [USNM 433022], NL IV 49(84)A-4L-FF(M) [USNM 433023], NL IV 49(84)A-5R-A(M) [USNM 433024], NL IV 49(84)A-4L-Z(M) [USNM 433025], NL IV 94(129)A-3L-G(M) [USNM 433026], NL IV 108(143)A-9-B(M) [USNM 433027], NL IV 108(143)A-17-B(M) [USNM 433028], NL IV 108 (143)A-9-A(M) [USNM 433029], NL IV 30(65)A-3-D [USNM 433030], NL IV 37(72)B-3A-A [USNM 433031], NL IV 37(72)B-5-I [USNM 433032], NL IV 49(84)A-3L-S [USNM 433033], NL IV 49(84)A-4L-HH [USNM 433034], NL IV 61(96)A-5-L [USNM 433035], NL IV 61(96)A-5-T [USNM 433036], NL

Table 43.—Quantitative data, *Anaphragma hermitagensis* n. sp. See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	NL IV 37–49 (72–84)	.16–.24	.19	.20	.021	80	8
	NL IV 94–108 (129–143)	.14–.24	.20	.20	.026	40	4
	NL IV TOTAL	.14–.24	.19	.20	.023	120	12
	CB 57–67	.15–.26	.19	.18	.025	50	5
	CB 122–153	.14–.24	.19	.20	.024	60	6
	CB TOTAL	.14–.26	.19	.20	.024	110	11
	HCM	.17–.22	.20	.20	.016	20	2
	WB	.20–.24	.21	.20	.014	10	1
	WEST TOTAL	.17–.24	.20	.20	.016	30	3
	TOTAL	.14–.24	.19	.20	.023	260	26
ZCD (mac)	NL IV 37–49 (72–84)	.22–.36	.28	.28, .30	.034	69	8
	NL IV 94–108 (129–143)	.24–.36	.30	.30	.030	33	4
	NL IV TOTAL	.22–.36	.28	.30	.034	102	12
	CB 57–67	.20–.32	.26	.24	.030	29	5
	CB 122–153	.22–.34	.26	.26	.028	30	5
	CB TOTAL	.20–.34	.26	.26	.029	59	10
	HCM	.24–.28	.26	.26	.015	10	1
	WB	.24–.32	.28	.26	.028	10	1
	WEST TOTAL	.24–.32	.27	.26	.024	20	2
	TOTAL	.20–.36	.28	.26	.033	181	24
ZWT	NL IV 37–49 (72–84)	.01–.07	.04	.03	.012	80	8
	NL IV 94–108 (129–143)	.01–.05	.03	.02	.010	38	4
	NL IV TOTAL	.01–.07	.03	.02	.012	118	12
	CB 57–67	.02–.05	.03	.04	.011	50	5
	CB 122–153	.02–.07	.04	.03, .04	.014	60	6
	CB TOTAL	.02–.07	.04	.04	.012	110	11
	HCM	.01–.04	.02	.02	.007	20	2
	WB	.02–.04	.03	.02	.007	10	1
	WEST TOTAL	.01–.04	.03	.02	.007	30	3
	TOTAL	.01–.07	.03	.03	.012	258	26
Z/mm^2	CB	18	18	18	0.0	2	1
	HCM	23–25	24	—	1.4	2	1
	TOTAL	18–25	21	18	3.6	4	2
MCD (mac)	NL IV 37–49 (72–84)	.02–.14	.06	.06	.026	73	8
	NL IV 94–108 (129–143)	.03–.16	.07	.06	.035	41	4
	NL IV TOTAL	.03–.16	.07	.06	.030	114	12
	CB 57–67	.04–.14	.07	.06	.026	29	5
	CB 122–153	.04–.14	.09	.08	.030	30	5
	CB TOTAL	.04–.14	.08	.06	.029	59	10
	HCM	.02–.14	.05	.02, .06	.038	9	1
	WB	.02–.08	.05	.05	.019	10	1
	WEST TOTAL	.02–.14	.05	.06	.029	19	2
	TOTAL	.02–.16	.07	.06	.030	192	24

IV 93(128)A-5-H [USNM 433037], NL IV 93(128)A-2-K [USNM 433038], NL IV 96(131)B-6-B [USNM 433039], NL IV 96(131)C-3-C [USNM 433040], NL IV 108(143)A-9-D [USNM 433041], NL IV 108(143)A-6-F [USNM 433042], NL IV 108(143)A-2-G [USNM 433043], NL IV 33(68)A-2-G(F) [USNM 433044], NL IV 43(78)B-9-B(F) [USNM 433045], NL IV 44(79)D-21L-A(F) [USNM 433046], NL IV 44(79)D-20LA-A(F) [USNM 433047], CB 122A-3-A(M) [USNM 433048], CB 132A-B(M) [USNM 433049], CB 132B-3-A(M) [USNM 433050], CB 145B-1-A(M) [USNM 433051], CB 145B-3-A(M) [USNM 433052], CB 153B-2-A(M) [USNM 433053], CB 57A-2-A(M) [USNM 433054], CB 62A-2-B(M) [USNM 433055], CB 62A-2-A(M) [USNM 433056], CB 67B-7-B(M) [USNM 433057], CB 67A-3-A(M) [USNM 433058], CB 41A-5-A(F) [USNM 433059], CB 50B-2-A(F) [USNM 433060], CB 55A-3-B(F) [USNM 433061], CB 62A-3-B(F) [USNM 433062], CB 62A-3-A(F) [USNM 433063], CB 67B-1-C(F) [USNM 433064], CB 81A-6L-B(F) [USNM 433065], CB 120A-7-A(F) [USNM 433066], CB 130A-1-A(F) [USNM 433067], CB 130A-11-A(F) [USNM 433068], CB 145A-4R-A(F), [USNM 433069], CB 153A-3-C(F) [USNM

Table 44.—Quantitative data, *Hemiphragma ottawaensis* (Foord). See Key to Abbreviations, p. 33, for explanation.

Character		Range	Mean	Mode	S.D.	No. Meas.	No. Spec.
ZCD	CB	.22–.28	.25	.23	.021	10	1
	TOTAL	.22–.28	.25	.23	.021	10	1
ZWT	CB	.05–.09	.08	.08	.014	10	1
	TOTAL	.05 .09	.08	.08	.014	10	1
Z/mm²	CB	14	14	14	.000	2	1
	TOTAL	14	14	14	.000	2	1
AD (lam)	CB and TOTAL	mainly .06–.10	—	—	—	—	—
AD (lum)	CB and TOTAL	mainly .02–.03	—	—	—	—	—

433070], HCM 43(82)C-3-X(M) [USNM 433071], WB 20(32)B-4-B(M) [USNM 433072].

Genus **HEMIPHRAGMA** Ulrich, 1893

Type species.—*Batostoma irrasum* Ulrich, 1886.

Hemiphragma ottawaensis (Foord, 1883)
Plate 23, Figure 2
Plate 24, Figure 3

Batostoma ottawaense Foord, 1883, p. 18, pl. 2, figs. 1–1f.
Hemiphragma ottawense (Foord). Ulrich, 1893, p. 300, 301, pl. 24, figs. 1–4.
Hemiphragma ottawaense (Foord). Fritz, 1957, p. 20, pl. 10, fig. 2, pl. 12, figs. 1–3.

Description.—Zoaria ramose. Zooecial cavity outline rounded to subrounded in exozone, polygonal in endozone. Zooecia curve broadly from endozone to colony surface and intersect surface at approximately 90°. Endozonal walls unevenly thickened. Exozonal walls thicker and uneven. Walls fairly parallel-sided. Exozonal walls composed of distinct broadly arched laminae. Diaphragms and hemiphragms planar to slightly unevenly thickened, perpendicular to zooecial walls. End of hemiphragms sometimes slightly bulbous. In endozone, diaphragms or hemiphragms spaced at one zooecial cavity diameter apart. In exozone, spaced at one-half to one zooecial cavity diameter. In longitudinal section, hemiphragms extend mainly one-half to three-fourths across zooecial cavity (some vary from one-third to five-sixths). Within individual zooecia of exozone, hemiphragms sometimes alternate on proximal and distal sides. Acanthostyles found mainly at zooecial corners, sometimes inflect into zooecial cavity, some offset. Mainly four but sometimes five acanthostyles surround each exozonal autozooecium. No mesozooecia. Maculae indeterminable from material available.

Measurements.—Measurements are summarized in Table 44.

Remarks.—Ulrich (1893) differentiates *Hemiphragma ottawaensis* from *H. irrasum* in that the former (1) is of larger size with respect to branch width and thickness, (2) has a smaller axial region (endozone), (3) has more abundant diaphragms in axial region (endozone), (4) has a wider peripheral region (exozone). Having given the above criteria, Ulrich (1893, p. 300) still notes that "Perhaps the only reliable difference, and that may in part be due to the greater size of Foord's species, is the much smaller number of diaphragms in *H. irrasum.* The largest specimens of the latter do not approach *H. ottawense* [sic] in the width of the closely tabulated peripheral region."

As *H. ottawaensis* has more diaphragms in the endozone, it is suspected here that the difference in maximum size could reflect a real species level characteristic. This view is opposed to Bork and Perry (1968a, p. 343) who feel that the two species "represent two growth stages of one species because structural features that are used for setting *H. ottawense* [sic] apart from *H. irrasum* would be duplicated in larger and more mature forms of *H. irrasum.*" In addition, Ulrich's figures of the two species depict *H. irrasum* with a somewhat greater zooecial bend than for *H. ottawaensis.* The single colony studied in the present report is similar to *H. ottawaensis* in statements (2) and (3) above and similar to *H. irrasum* in numbers (1) and (4). However, the latter two statements are very likely to reflect an astogenetic variation. Consequently, until a large scale study of variations within and among species populations is carried forth, *H. ottawaensis* has been chosen in this study.

Distribultion.—Locality CB.

Studied material.—Hypotype CB 50A-3-X(M) [USNM 433073].

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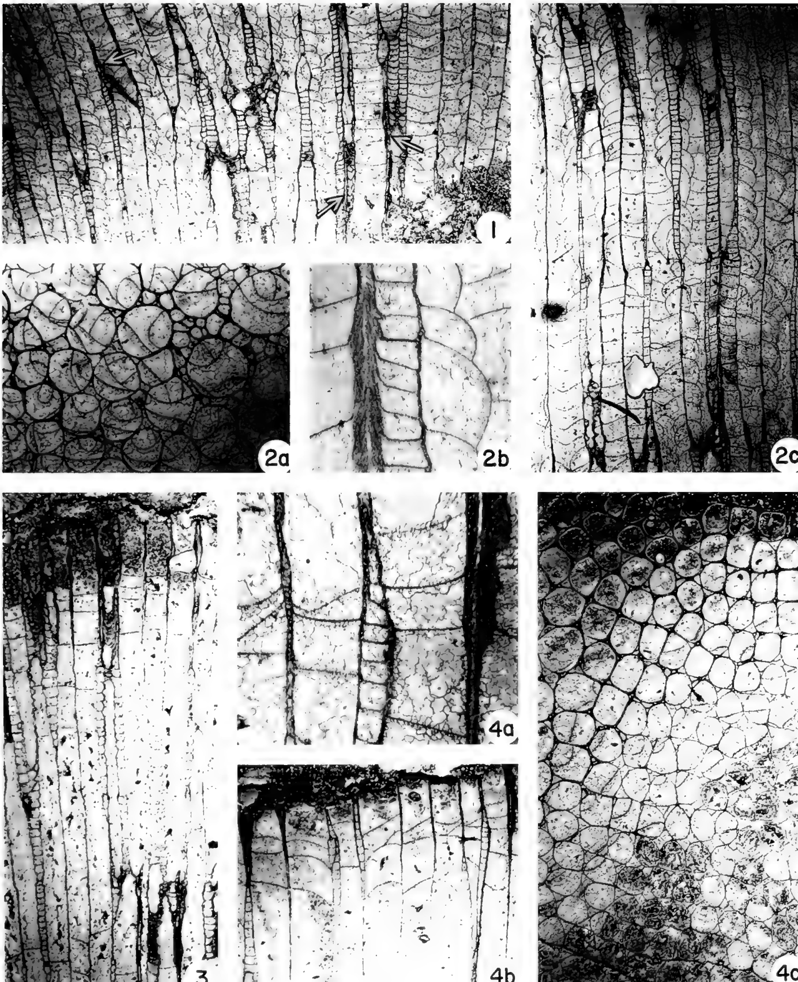
PLATES

EXPLANATION OF PLATE 1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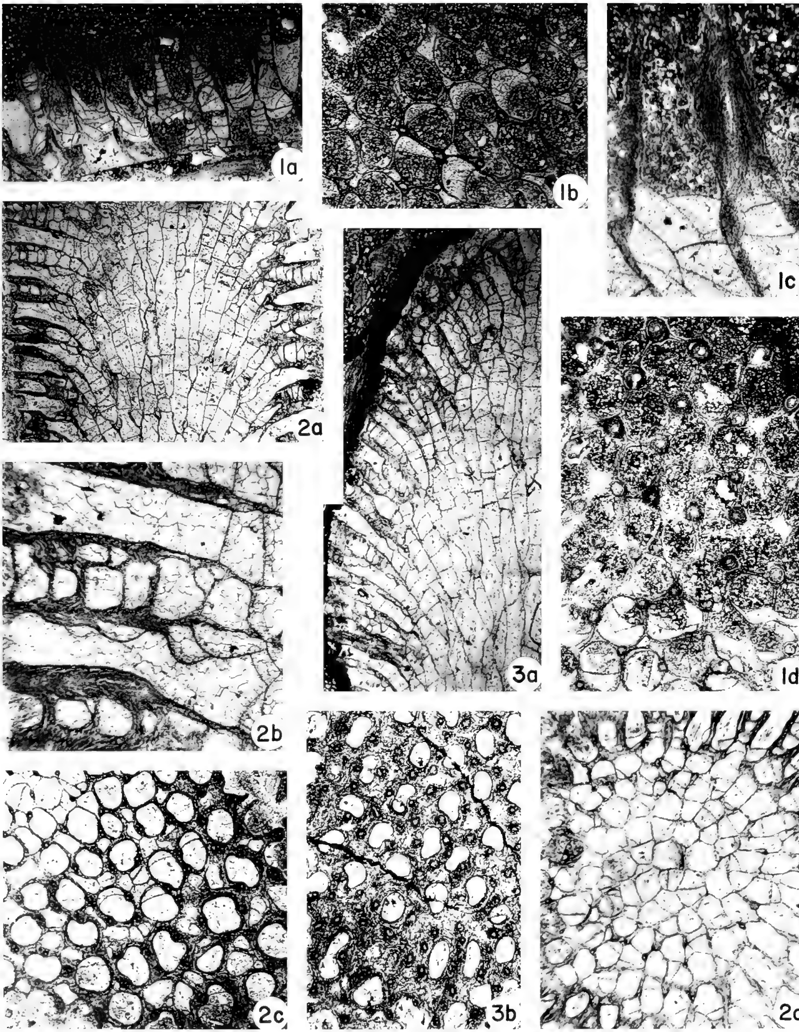
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3b
2d

EXPLANATION OF PLATE 2

Figure Page

1. *Mesotrypa* sp. A. 38
   - 1a. Longitudinal section showing low, encrusting zoarial growth habit, variably oriented and spaced diaphragms and cystiphragms in autozooecia, common tabulated mesozooecia, and prominent acanthostyles having especially thick laminar sheaths in outer part of zoarium, Hypotype USNM 431802 [CB 116A-5-A], ×33.
   - 1b. Tangential section showing mainly subrounded to subpolygonal autozooecial cavity outlines, some with cystiphragms or inclined planar to cystose diaphragms, scattered polygonal mesozooecial cavity outlines, and distinct acanthostyles, Hypotype USNM 431802 [CB 116A-5-A], ×45.
   - 1c. Longitudinal section of exozone showing concentric wall laminae including thick laminar sheath of acanthostyle, Hypotype USNM 431802 [CB 116A-5-A], ×100.
   - 1d. Tangential section showing subrounded to subpolygonal autozooecial cavity outlines and large acanthostyles at zooecial corners in outermost exozone (top of figure). At bottom of figure is slightly deeper tangential cut showing subrounded to rounded autozooecial cavity outlines with cystiphragms or inclined planar to cystose diaphragms, mesozooecia with polygonal cavity outlines filling interzooecial voids, and smaller diameter acanthostyles, Hypotype USNM 431802 [CB 116A-5-A], ×45.

2–3. *Peronopora mundula* (Ulrich) 39
   - 2a. Longitudinal section showing laminar exozonal walls, diaphragms present in endozone, few or absent in innermost exozone and absent outwards, overlapping cystiphragms common in outermost endozone and inner exozone, and interspersed large mesozooecia with diaphragms thicker than for autozooecia, Hypotype USNM 431803 [NL IV 50(85)A-14-B], ×25.
   - 2b. Longitudinal section of exozone showing distinct V-shaped wall laminae, Hypotype USNM 431803 [NL IV 50(85)A-14-B], ×100.
   - 2c. Tangential section, slightly oblique, showing polygonal to subpolygonal cavity outlines of both autozooecia and relatively large mesozooecia, and fairly thick autozooecial walls with inflecting and offset acanthostyles in upper right of figure. Deeper tangential section at lower left shows subrounded autozooecial cavity outlines of inner exozonal zooecia with thinner associated walls, smaller and angular mesozooecial cavity outlines, and acanthostyles with smaller laminar sheaths, Hypotype USNM 431803 [NL IV 50(85)A-14-B], ×45.
   - 2d. Transverse section showing polygonal zooecial cavity outlines within endozone and acanthostyles in outer endozone, Hypotype USNM 431803 [NL IV 50(85)A-14-B], ×40.
   - 3a. Longitudinal section as for Figure 2a, Hypotype USNM 431806 [NL IV 61(96)A-7-I], ×25.
   - 3b. Tangential section of thick-walled fairly polygonal zooecial cavity outlines (autozooecia are indistinguishable from large mesozooecia), and acanthostyles between zooecia and at zooecial corners, usually offset and commonly inflecting, Hypotype USNM 431806 [NL IV 61(96)A-7-I], ×45.

EXPLANATION OF PLATE 3

1a. Longitudinal section showing irregularly thickened and thinned granular to poorly laminated walls, rare to uncommon diaphragms in the endozone and inner exozone, absent outwards, overlapping cystiphragms in the outermost endozone and inner exozone, and common well-tabulated and variably sized mesozooecia with diaphragms thicker than for autozooecia, Holotype USNM 431824 [NL IV 72(107)A-3L-H], ×25.

1b. Tangential section showing subrounded to subpolygonal autozooecial and probably larger mesozooecial cavity outlines, scattered distinctly smaller mesozooecia with angular cavity outlines, and numerous offset acanthostyles with many inflecting, Holotype USNM 431824 [NL IV 72(107)A-3L-H], ×45.

1c. Longitudinal section of exozone showing wall structure to be granular or composed of poorly defined U- to V-shaped laminae, Holotype USNM 431824 [NL IV 72(107)A-3L-H], ×100.

2a. Tangential section showing subrounded to subpolygonal utozooecial cavity outlines with unusually numerous inflecting acanthostyles in thicker zooecial walls in exozone at top of figure. Smaller and angular mesozooecia are especially distinctive in deeper tangential cut at bottom of figure, Paratype USNM 431825 [NL IV 72(107)B-2L-G], ×45.

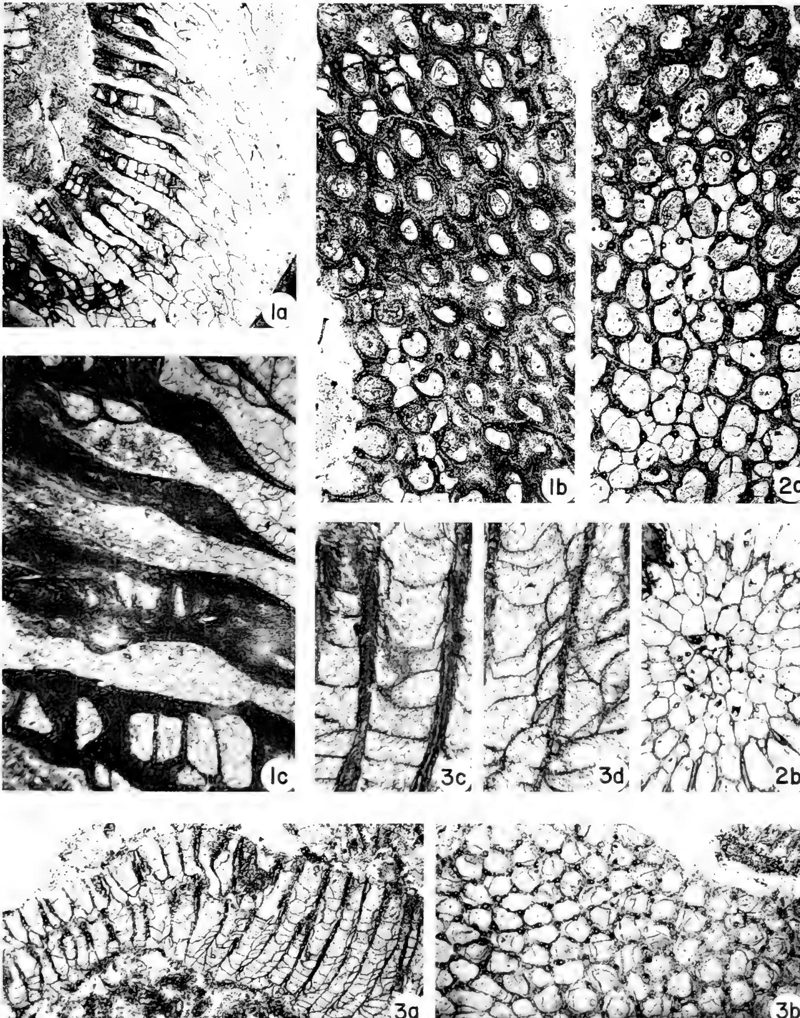
2b. Transverse section showing polygonal zooecial cavity outlines and acanthostyles in endozone, Paratype USNM 431825 [NL IV 72(107)B-2L-G], ×40

3a. Longitudinal section showing encrusting habit, even granular walls, thin and variably oriented diaphragms throughout, nearly ubiquitous overlapping cystiphragms, and plentiful acanthostyles, Paratype USNM 431864 [HCM 43(82)A-3-J], ×33.

3b. Tangential section showing fairly small subrounded autozooecial cavity outlines, numerous acanthostyles found mainly at zooecial corners and secondarily between adjacent zooecia (between corners), laminar sheaths of acanthostyles often centered and inflect slightly into contiguous autozooecial cavities, Paratype USNM 431864 [HCM 43(82)A-3-J], ×33.

3c. Longitudinal section showing laminar microstructure associated with acanthostyles. Note offset style at uppermost right corner of figure, Paratype USNM 431864 [HCM 43(82)A-3-J], ×100.

3d. Longitudinal section showing typical granular nature of autozooecial walls, Paratype USNM 431864 [HCM 43(82)A-3-J], ×100.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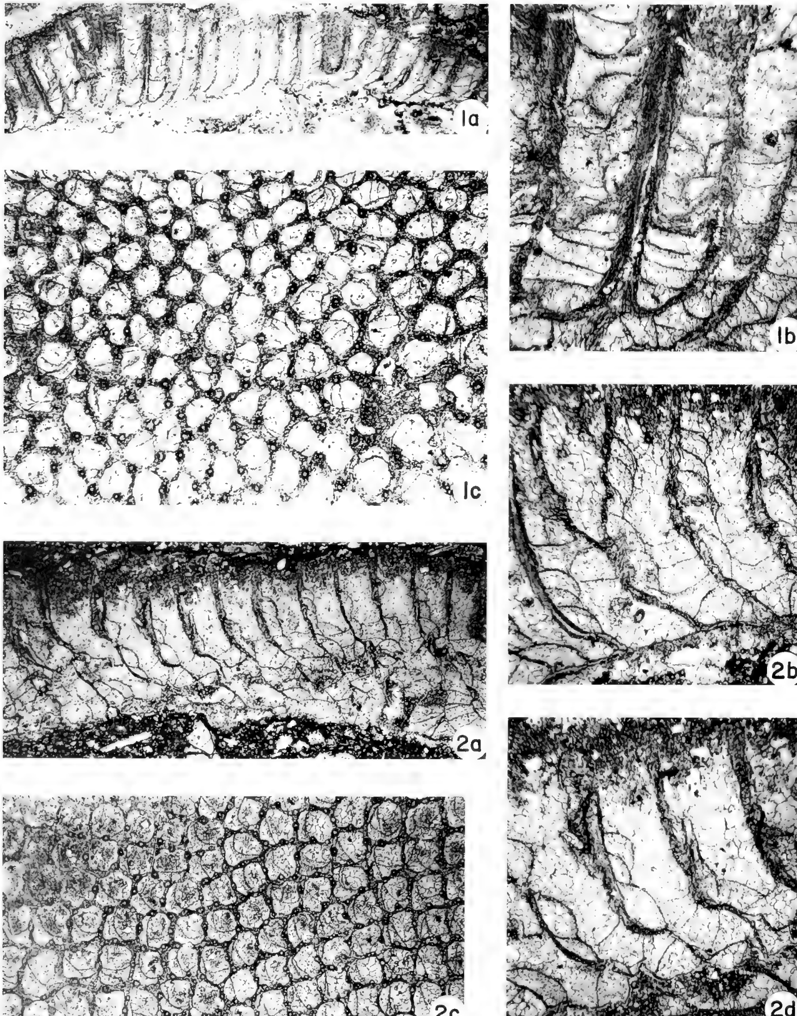
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EXPLANATION OF PLATE 4

Figure Page

1. *Acantholaminatus typicus* n. gen., n. sp. 42
   - 1a. Longitudinal section as Plate 3, Figure 3a, Holotype USNM 431850 [HCM 43(82)B-5-J], ×25.
   - 1b. Longitudinal section showing laminar sheath of acanthostyle and generally granular microstructure of autozooecial walls, Holotype USNM 431850 [HCM 43(82)B-5-J], ×100.
   - 1c. Tangential section as Plate 3, Figure 3b. Note here the macular megazooecia in lower right corner of figure, Holotype USNM 431850 [HCM 43(82)B-5-J], ×45.
2. *Acantholaminatus multistylus* n. gen., n. sp. 42
   - 2a. Longitudinal section showing an encrusting habit, even-sided granular walls, thin and variably oriented diaphragms which are sparse in the outer part of zoarium, fairly common overlapping cystiphragms found throughout the colony, and numerous small acanthostyles, Holotype USNM 433073 [WB 38(50)C-2R-A], ×45.
   - 2b. Longitudinal section showing wall structure as for Figure 1b, Holotype USNM 433073 [WB 38(50)C-2R-A], ×100.
   - 2c. Tangential section showing a great number of small acanthostyles, both at and between zooecial corners, within thin autozooecial walls and inflecting into contiguous zooecial cavities. Many styles are distinctly offset, Holotype USNM 433073 [WB 38(50)C-2R-A], ×45.
   - 2d. Longitudinal section showing wall structure to be generally granular with some poorly defined laminae. Note offset acanthostyles slightly oblique to zooecial walls in center of figure, Holotype USNM 433073 [WB 38(50)C-2R-A], ×100.

EXPLANATION OF PLATE 5

Figure Page

1–6. *Homotrypa flabellaris* var. *spinifera* Bassler . . . 46

1a. Longitudinal section showing a somewhat larger than average exozonal thickness, pinching and swelling of wavy autozooecial walls in exozone, and acanthostyles in the outer endozone and lower exozone (arrows) oblique to the plane of the figure, Hypotype USNM 431896 [NL IV 116(151)B-3-B], ×25.

1b. Tangential section showing subpolygonal autozooecial cavity outlines and scattered large acanthostyles with varying thicknesses of laminar sheaths. Macula is composed of megazooecia, Hypotype USNM 431896 [NL IV 116(151)B-3-B], ×45.

1c. Deep tangential cut in left of figure shows large petaloid arrangement of zooecia and acanthostyles in the inner exozone/outer endozone, Hypotype USNM 431896 [NL IV 116(151)B-3-B], ×45.

2. Tangential section showing subpolygonal to subrounded autozooecial cavity outlines with scattered large acanthostyles. Deeper cut in the bottom left of the figure shows a prominent endozonal acanthostyle. Some zooecial corners exhibit minute acanthostyle-like openings, Hypotype USNM 431895 [NL IV 108(143)A-11-B], ×45.

3a. Longitudinal section showing even and crenulate endozonal walls, a portion of the zoarium with fewer than usual cystiphragms, slight pinching and swelling of autozooecial walls in exozone, and a large acanthostyle in the upper left portion of the figure, Hypotype USNM 431891 [NL IV 100(135)A-4L-BB], ×25.

3b. Transverse section of endozone showing polygonal zooecial cavity outlines and large acanthostyle in the center of petaloid cluster of autozooecia, Hypotype USNM 431891 [NL IV 100(135)A-4L-BB], ×40.

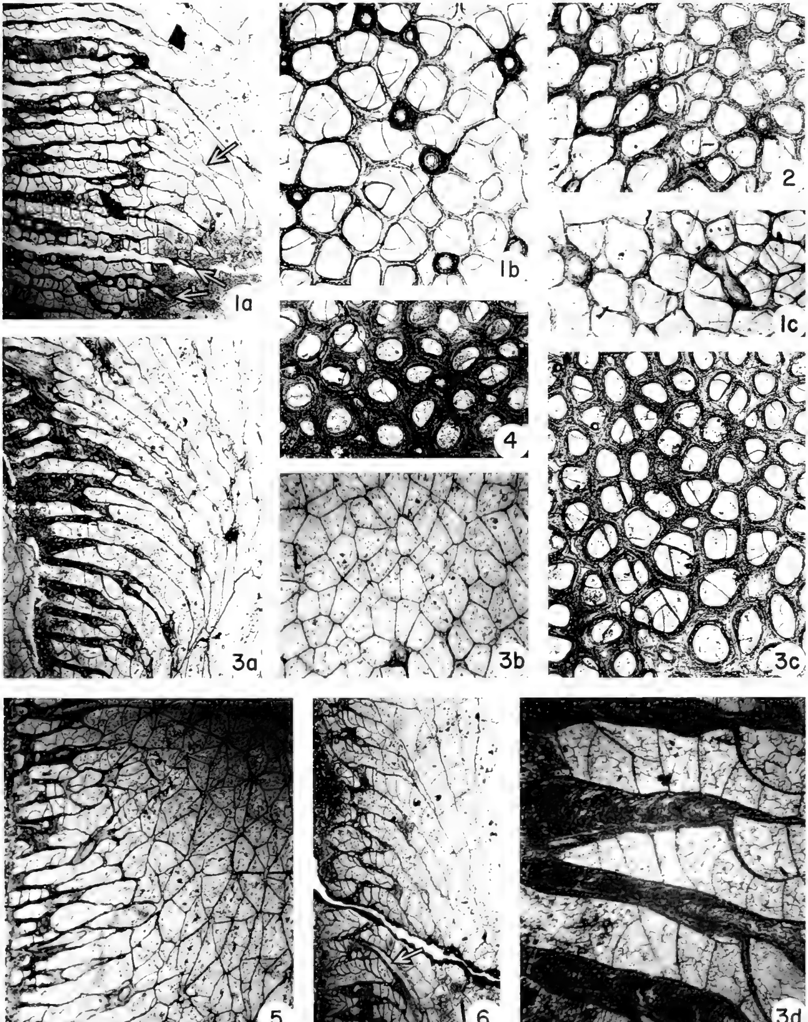
3c. Tangential section showing subpolygonal to subrounded autozooecial cavity outlines and maculae composed of megazooecia. Acanthostyles are few and subtle within fairly thick walls, Hypotype USNM 431891 [NL IV 100(135)A-4L-BB], ×45.

3d. Longitudinal section showing autozooecial walls composed of distinct U- to V-shaped laminae, Hypotype USNM 431891 [NL IV 100(135)A-4L-BB], ×100.

4. Tangential section showing subrounded zooecial cavity outlines, a few large acanthostyles, and mesozooecia, Hypotype USNM 431890 [NL IV 100(135)-UNK], ×45.

5. Oblique section showing large acanthostyle in the lower exozone, and petaloid arrangement of many endozonal zooecia around minute (incipient?) acanthostyles, Hypotype USNM 431978 [NL IV 116(151)B-2-A], ×25.

6. Longitudinal section showing a perpendicular surface angle, endozonal diaphragms, overlapping cystiphragms, and a very large endozonal acanthostyle (arrow), Hypotype USNM 432019 [WB 44(56)B-2-A], ×25.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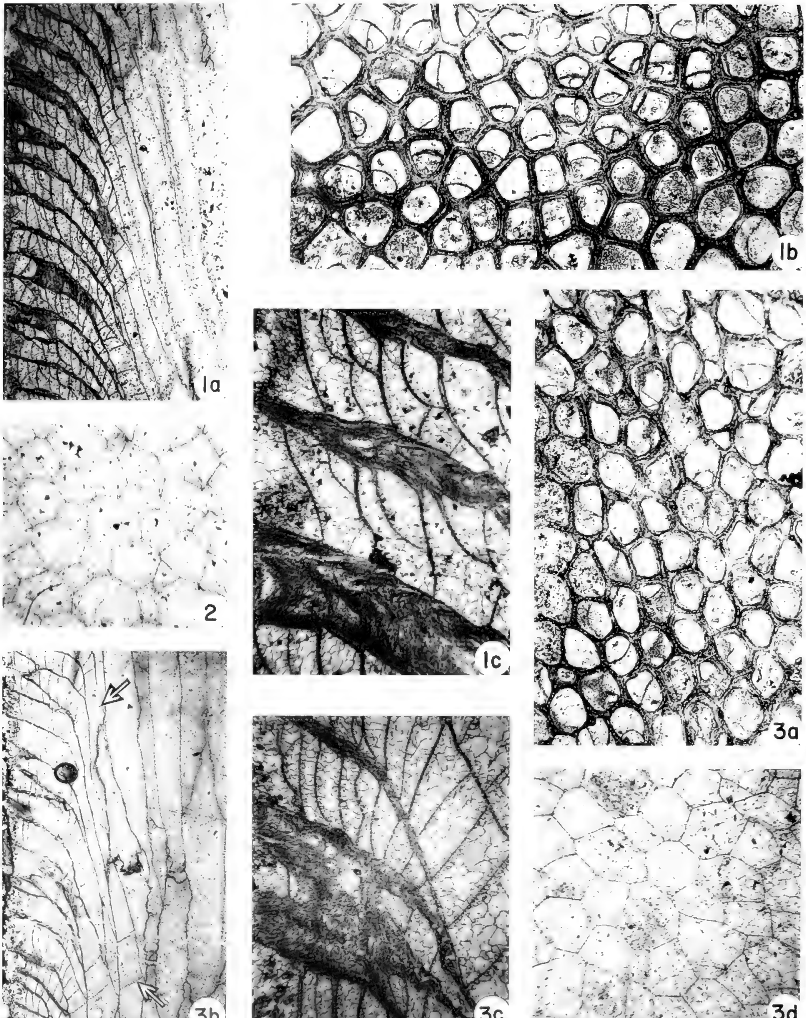
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EXPLANATION OF PLATE 6

Figure Page

1–2. *Homotrypa minnesotensis* Ulrich 44

1a. Longitudinal section showing zooecia intersecting surface at less than 90°, even, crenulate and beaded autozooecial walls in endozone, megazooecium within inner endozone, laminar zooecial walls in exozone, diaphragms absent within endozone except for very outermost endozone, and exozonal zooecia with mainly inclined and curved diaphragms with or without cystiphragms, Hypotype USNM 431883 [CB 145C-4-D], ×25.

1b. Tangential section showing subpolygonal to subrounded zooecial cavity outlines, minute acanthostyles or acanthostyle-like openings at many zooecial corners, and distinctive maculae composed of megazooecia and some mesozooecia, Hypotype USNM 431883 [CB 145C-4-D], ×45.

1c. Longitudinalsection of outer exozone showing wall microstructure of distinct U- to V-shaped laminae, Hypotype USNM 431883 [CB 145C-4-D], ×100.

2. Transverse section showing polygonal zooecial cavity outlines in endozone, Hypotype USNM 431872 [NL IV 43(78)B-6L-R], ×40.

3. *Homotrypa tabulata* n.sp. 49

3a. Tangential section showing laminar walls, slightly elongate subrounded to subpolygonal zooecial cavity outlines, a macula in upper right of figure composed of both megazooecia and mesozooecia, and minute acanthostyles at and between zooecial corners, Holotype USNM 432039 [CB 50A-4-A], ×45.

3b. Longitudinal section showing an oblique zooecial surface angle, relatively thin exozonal walls, even to slightly crenulate zooecial walls in endozone, endozonal megazooecia which are constricted at base of exozone, exozonal diaphragms which are regularly spaced and perpendicular or inclined to zooecial walls and curved convex outwards, and endozonal diaphragms (arrows). Here, diaphragms of the inner endozone are absent in top half of figure probably due to effects of recrystallization. Other colonies of this species show diaphragms to be generally present throughout entire endozone, Holotype USNM 432039 [CB 50A-4-A], ×25.

3c. Longitudinal section of exozone showing laminar wall microstructure, Holotype USNM 432039 [CB 50A-4-A], ×100.

3d. Transverse section across endozone showing polygonal zooecial cavity outlines, Holotype USNM 432039 [CB 50A-4-A], ×40.

EXPLANATION OF PLATE 7

Figure Page

1–2. *Homotrypa tuberculata* Ulrich 51

1a. Transverse section showing polygonal zooecial cavity outlines in endozone, Hypotype USNM 432082 [HCM 43(82)B-4-G], ×40.

1b. Tangential section showing subrounded to rounded autozooecial cavity outlines, laminar walls, small polygonal mesozooecia, and distinct, commonly inflecting, sometimes offset acanthostyles, Hypotype USNM 432082 [HCM 43(82)B-4-G)], ×45.

1c. Longitudinal section showing a fairly sharp zooecial bend in the lower exozone, a generally short exozone with diaphragms which are variable in number, orientation, spacing and thickness, diaphragms in the endozone found only in the outermost portions, irregularly overlapping exozonal cystiphragms of variable number and thickness, small mesozooecia, and common acanthostyles, Hypotype USNM 432082 [HCM 43(82)B-4-G], ×25.

2a. Longitudinal section as for Figure 1c, Hypotype USNM 432058 [CB 85A-6-C], ×25.

2b. Tangential section as for Figure 1b, Hypotype USNM 432058 [CB 85A-6-C], ×45.

2c. Longitudinal section of exozone showing wall microstructure with generally V-shaped laminae, Hypotype USNM 432058 [CB 85A-6-C], ×100.

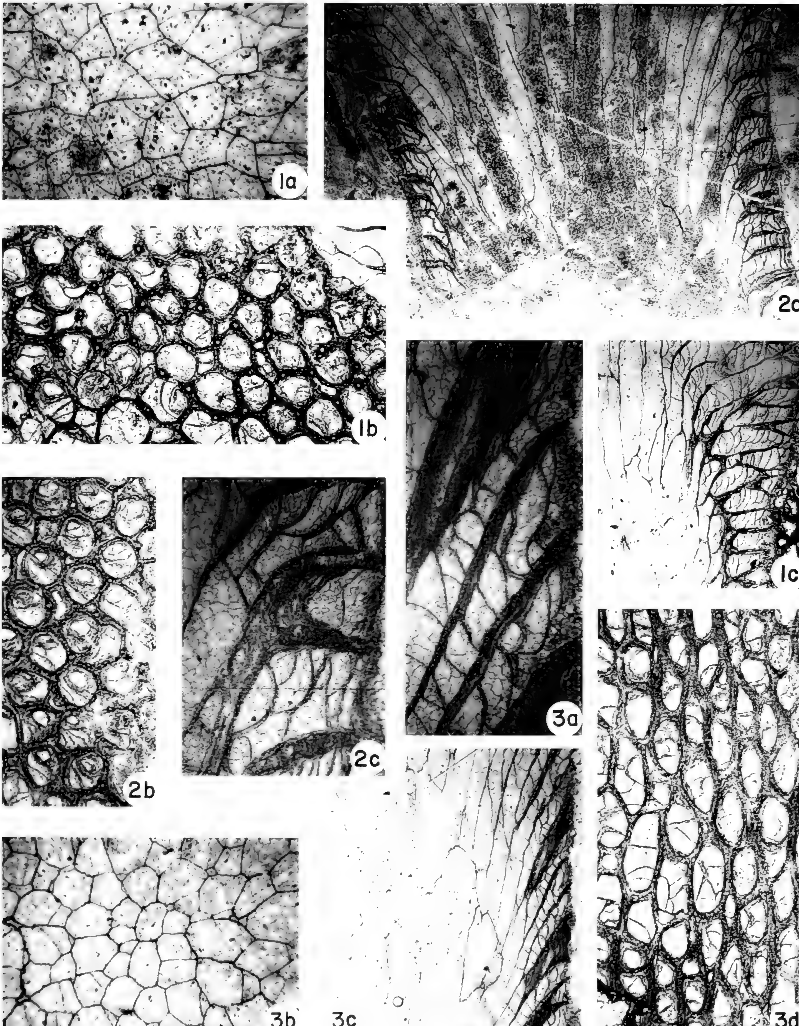
3. *Homotrypa similis* Foord 48

3a. Longitudinal section of exozone showing autozooecial walls with a generally non-laminar appearance. A somewhat more laminar microstructure is associated with an acanthostyle to top of figure, Hypotype USNM 432025 [NL IV 108(143)A-8-D], ×100.

3b. Transverse section of endozone showing polygonal zooecial cavity outlines, Hypotype USNM 432025 [NL IV 108(143)A-8-D], ×40.

3c. Longitudinal section showing a narrow exozone, shallow surface angle, megazooecia in the center of the endozone, diaphragms in the outer endozone and exozone, and overlapping exozonal cystiphragms, Hypotype USNM 432025 [NL IV 108(143)A-8-D], ×25.

3d. Tangential section showing elongate subrounded to subpolygonal zooecial cavity outlines, and a macula in lower center of figure composed of megazooecia and a few mesozooecia. Scattered throughout are small acanthostyles somewhat obscured due to low surface angle, Hypotype USNM 432025 [NL IV 108(143)A-8-D)], ×45.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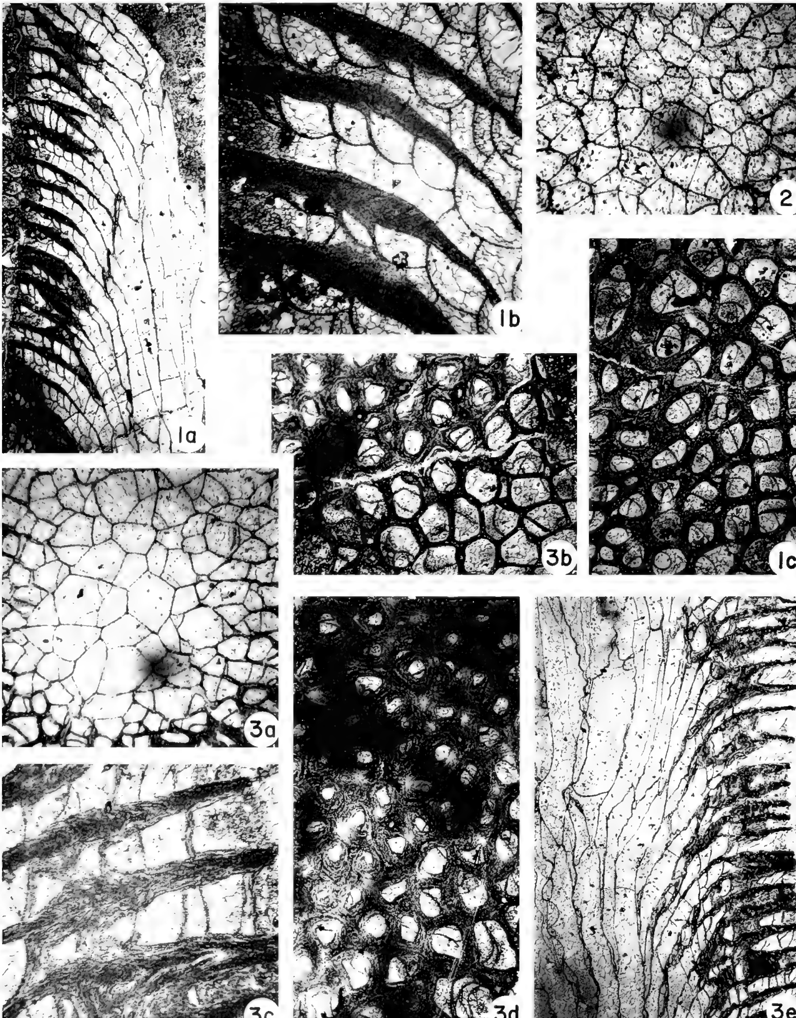
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EXPLANATION OF PLATE 8

Figure | Page

1–2. *Homotrypa callosa* Ulrich 52

1a. Longitudinal section showing evenly curving zooecia, fairly regularly spaced diaphragms throughout colony mainly perpendicular to zooecial walls, and overlapping cystiphragms, Hypotype USNM 432095 [NL IV 96(131)B-2-J], ×25.

1b. Longitudinal section showing predominantly granular wall microstructure with some poorly defined U-shaped laminae in places, Hypotype USNM 432095 [NL IV 96(131)B-2-J], ×100.

1c. Tangential section showing subpolygonal to subrounded zooecial cavity outlines, a macula in upper left of figure composed of megazooecia and small subrounded to subangular mesozooecia, and scattered and inconspicuous acanthostyles, Hypotype USNM 432095 [NL IV 96(131)B-2-J], ×45.

2. Transverse section of endozone showing polygonal zooecial cavity outlines, Hypotype USNM 432096 [NL IV 100(135)A-13L-F], ×40.

3. *Homotrypa* sp. A 55

3a. Transverse section across endozone showing polygonal zooecial cavity outlines and megazooecia mainly within the inner endozone, Hypotype USNM 432172 [NL IV 108(143)A-14-N], ×40.

3b. Tangential section showing portions of the zoarium having thick and thin exozonal walls, subpolygonal to polygonal zooecial cavity outlines where walls are narrow, and acanthostyles at and between zooecial corners which inflect where walls are thin, Hypotype USNM 432172 [NL IV 108(143)A-14-N], ×45.

3c. Longitudinal section showing an autozooecial wall microstructure composed of distinct laminae, Hypotype USNM 432172 [NL IV 108(143)A-14-N], ×100.

3d. Tangential section showing characteristically thick zooecial walls, subrounded to subpolygonal zooecial cavity outlines, and acanthostyles at and between zooecial corners, Hypotype USNM 432172 [NL IV 108(143)A-14-N], × 45.

3e. Longitudinal section showing laminar wall structure, diaphragms limited mainly to both outermost endozone and exozone, exozonal diaphragms commonly inclined and planar to curved convex outwards, scattered cystiphragms and cystose diaphragms, megazooecia within inner endozone, wavy, crenulate and beaded endozonal walls, and acanthostyles, Hypotype USNM 432172 [NL IV 108(143)A-14-N], ×25.

EXPLANATION OF PLATE 9

1a. Longitudinal section showing smoothly curving autozooecia, common endozonal and exozonal diaphragms mainly perpendicular to zooecial walls, overlapping cystiphragms in exozone, and exozonal acanthostyles, Hypotype USNM 432147 [WB 43(55)C-5L-A], ×25.

1b. Tangential section showing subpolygonal zooecial cavity outlines, well developed cystiphragms wrapping around ⅔ to ¾ of zooecial perimeter, relatively thin walls, common and many times inflecting acanthostyles found mainly at zooecial corners, and a macula on right side of figure, Hypotype USNM 432147 [WB 43(55)C-5L-A], ×45.

1c. Longitudinal section as for Figure 1a, Hypotype USNM 432147 [WB 43(55)C-5L-A], ×25.

2a. Tangential section showing subpolygonal zooecial cavity outlines, acanthostyles mainly at zooecial corners, well developed cystiphragms, and a macula on upper right corner of figure, Hypotype USNM 432107 [CB 132B-4-B], ×45.

2b. Longitudinal section showing diaphragms in the outer endozone and exozone mainly planar and perpendicular to the zooecial walls, and overlapping exozonal cystiphragms, Hypotype USNM 432107 [CB 132B-4-B], ×25.

2c. Transverse section showing polygonal zooecial cavity outlines in endozone, Hypotype USNM 432107 [CB 132B-4-B)], ×40.

2d. Longitudinal section of outer exozone showing granular to laminar appearance of autozooecial wall microstructure, Hypotype USNM 432107 [CB 132B-4-B], ×100.

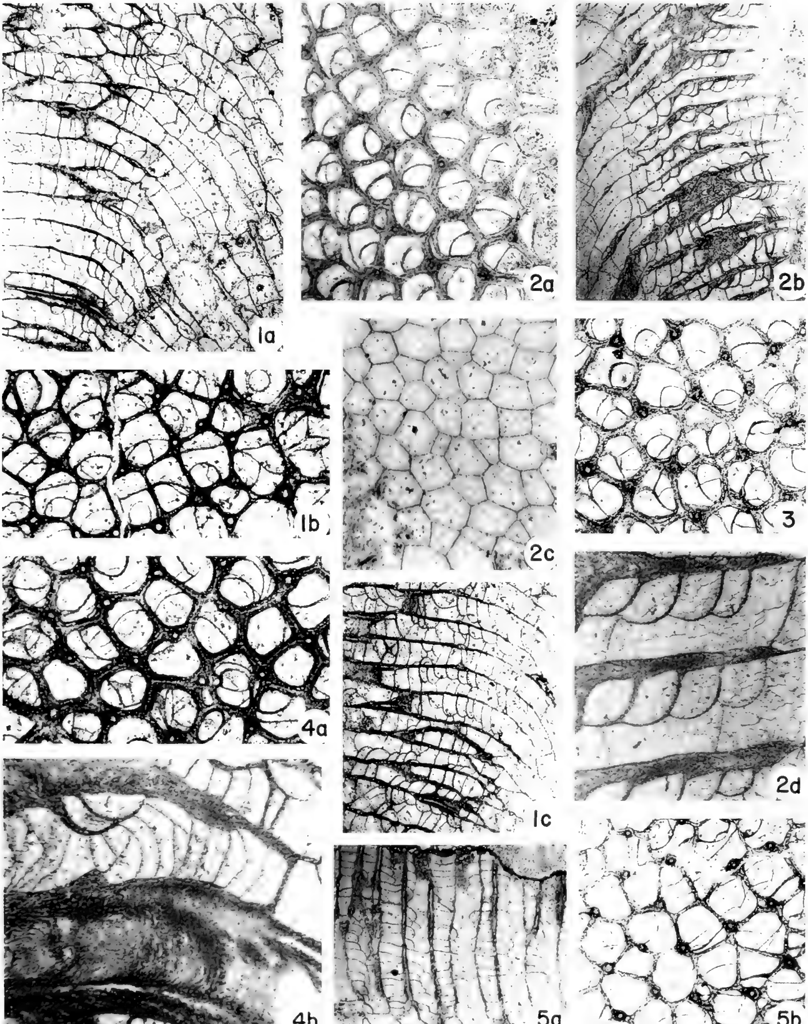
3. Tangential section with subpolygonal zooecial cavity outlines, and few inflecting acanthostyles due to relatively thick walls, Hypotype USNM 432148 [WB 44(56)B-3-A], ×45.

4a. Tangential section as for Figure 3, Hypotype USNM 432149 [WB 44(56)C-2-C)], ×45.

4b. Longitudinal section showing a more laminar appearance of autozooecial walls and acanthostyle sheath, Hypotype USNM 432149 [WB 44(56)C-2-C], ×100.

5a. Longitudinal section of an encrusting zoarium showing diaphragms, cystiphragms, and acanthostyles throughout, and relatively thin walls, Hypotype USNM 432110 [CB 82A-3-A], ×25.

5b. Tangential section of an encrusting form showing subpolygonal to polygonal zooecial cavity apertures, and relatively thin walls with accompanying inflecting acanthostyles, Hypotype USNM 432110 [CB 82A-3-A], ×45.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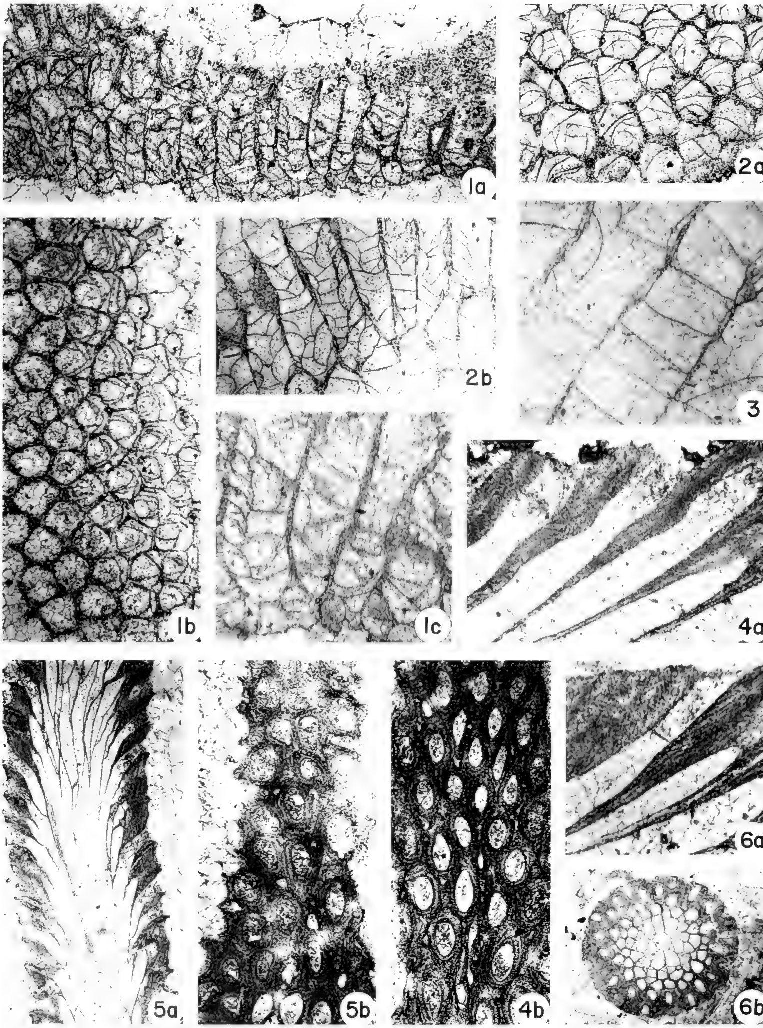
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EXPLANATION OF PLATE 10

Figure Page

1–3. *Monticulipora* sp. A. 56

1a. Longitudinal section showing thin and granular walls, planar diaphragms, and overlapping cystiphragms, Hypotype USNM 432173 [NL IV 72(107)B-4L-A], ×45.

1b. Tangential section showing subpolygonal zooecial cavity outlines, thin and granular walls, and small acanthostyles on left side of figure. On right side is a deeper tangential cut showing a lack of styles and increased intrazooecial structures, Hypotype USNM 432173 [NL IV 72(107)B-4L-A], ×45.

1c. Longitudinal section showing granular wall microstructure, Hypotype USNM 432173 [NL IV 72(107)B-4L-A], ×100.

2a. Tangential section showing subpolygonal zooecial cavity outlines, granular walls, and small acanthostyles, some offset and inflecting, Hypotype USNM 432175 [NL IV 43(78)B-5-N], ×45.

2b. Longitudinal section, slightly oblique, showing thin and granular walls, overlapping cystiphragms, planar to slightly bowed diaphragms, and small acanthostyles, some inflecting, Hypotype USNM 432175 [NL IV 43(78)B-5-N], ×45.

3. Longitudinal section showing thin and granular walls and small acanthostyle near center of figure, Hypotype USNM 432174 [NL IV 85(120)A-3BR-A], ×100.

4–6. *Bythopora dendrina* (James) 57

4a. Longitudinal section showing wall thickness gradually increasing zooecially outwards, and wall laminae more poorly defined than typical for species (cf. Figure 6a), Hypotype USNM 432179 [NL IV 44(79)A-14LA-D], ×100.

4b. Tangential section showing typical elliptical autozooecial cavity outlines, thick walls, and numerous small acanthostyles, Hypotype USNM 432179 [NL IV 44(79)A-14LA-D], ×45.

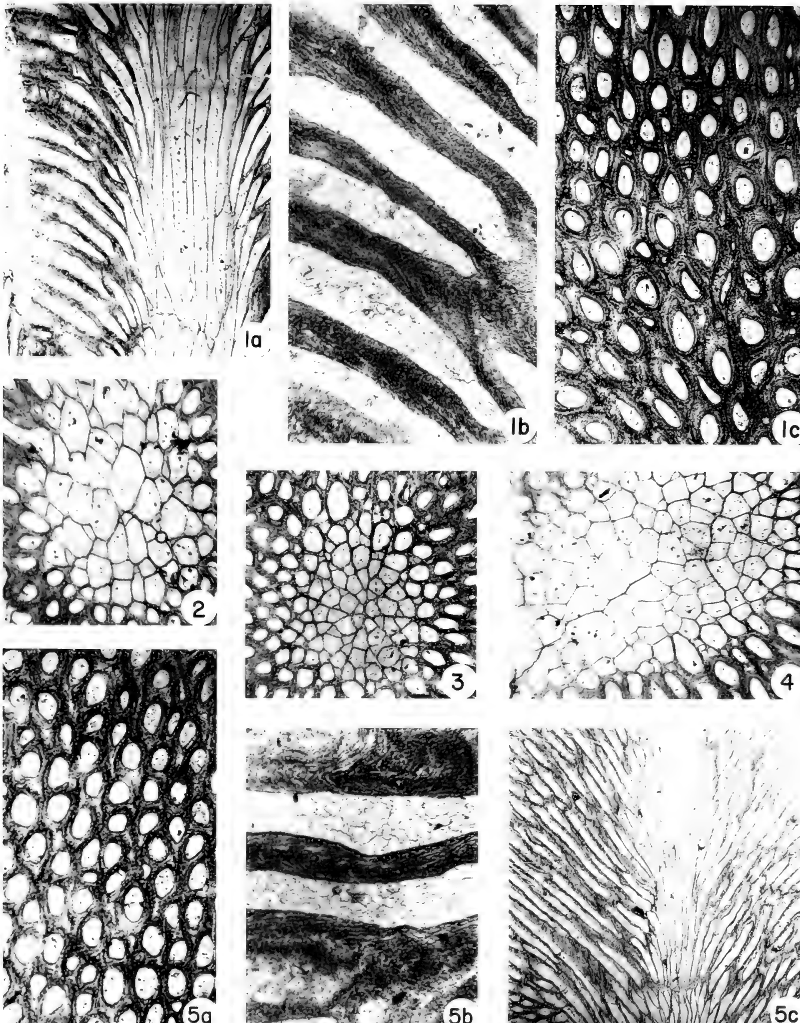
5a. Longitudinal section showing a slender ramose branch, low surface angle, narrow exozone, relatively thick and laminar exozonal walls, and rare diaphragms, Hypotype USNM 432176 [NL IV 30(65)A-1-B], ×25.

5b. Tangential section showing elliptical to subrounded or rounded autozooecial cavity outlines, thick walls, scattered small diameter autozooecia caused by a cut through local zones of constriction (see Remarks section of Systematic Paleontology), and common small acanthostyles, Hypotype USNM 432176 [NL IV 30(65)A-1-B], ×45.

6a. Longitudinal section showing a rare diaphragm and wall microstructure composed of U- to V-shaped laminae with a dark median line, Hypotype USNM 432191 [NL IV 93(128)A-2-I], ×100.

6b. Transverse section showing a narrow exozone, polygonal zooecial cavity outlines in endozone, and a megazooecium and pseudoradial arrangement of zooecia within the inner endozone, Hypotype USNM 432191 [NL IV 93(128)A-2-I], ×25.

EXPLANATION OF PLATE 11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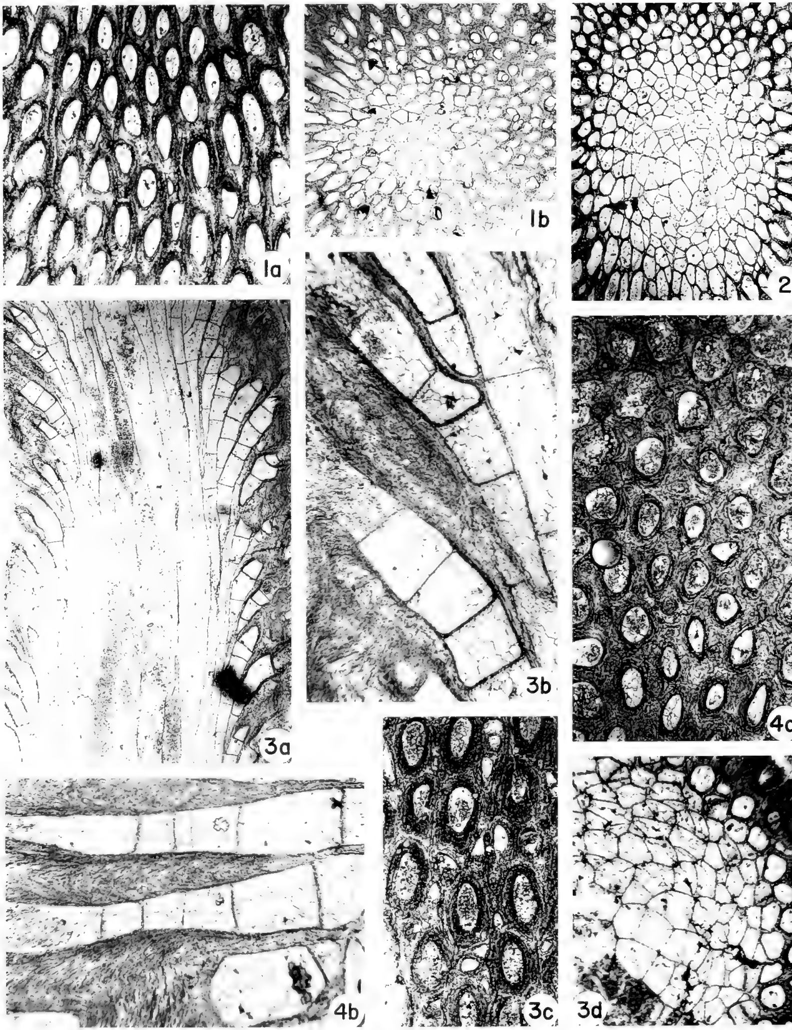
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EXPLANATION OF PLATE 12

Figure Page

1–2. *Batostomella subgracilis* (Ulrich) var. *robusta* n. var. 63

1a. Tangential section similar to non-varietal form of the species showing elliptical autozooecial cavity outlines and minute acanthostyles. Smaller autozooecial openings are products of local outer wall thickening and are not true mesozooecia, Hypotype USNM 432399 [NL IV 108(143)A-1-G)], ×45.

1b. Transverse section showing pseudoradial arrangement of zooecia within inner endozone, Hypotype USNM 432399 [NL IV 108(143)A-1-G], ×25.

2. Transverse section showing larger zooecia within inner endozone than for outer endozone, Hypotype USNM 432406 [NL IV 108(143)A-18-B], ×25.

3–4. *Eridotrypa mutabilis* Ulrich 64

3a. Longitudinal section showing low surface angles, thick laminar autozooecial walls in exozone, subparallel zooecia in endozone, megazooecia within innermost endozone, diaphragms perpendicular to zooecial walls in outer endozone and exozone, and few exozonal mesozooecia, Hypotype USNM 432443 [NL IV 85(120)A-3AR-C], ×25.

3b. Longitudinal section of exozone showing wall microstructure of broad U- to V-shaped laminae, Hypotype USNM 432443 [NL IV 85(120)A-3AR-C], ×100.

3c. Tangential section displaying thick laminar walls, elliptical zooecial cavity outlines, subrounded to ovate mesozooecial cavity outlines, and minute acanthostyles, Hypotype USNM 432443 [NL IV 85(120)A-3AR-C], ×45.

3d. Transverse section of endozone showing polygonal zooecial cavity outlines. Note that endozonal cavities narrow from innermost endozone (lower left of figure) towards inner exozone, Hypotype USNM 432443 [NL IV 85(120)A-3AR-C], ×40.

4a. Tangential section of an ontogenetically advanced colony showing many subrounded to subpolygonal zooecial cavity outlines more direct than typical for the species, very thick walls, large laminar sheaths of acanthostyles, and a macula in upper left corner of figure, Hypotype USNM 432407 [NL IV 61(96)A-4-F], ×45.

4b. Longitudinal section as for Figure 3b, Hypotype USNM 432407 [NL IV 61(96)A-4-F], ×100.

EXPLANATION OF PLATE 13

Figure Page

1–2. *Heterotrypa rugosa* n. sp. 67

1a. Tangential section showing subpolygonal zooecial cavity outlines, a macula in lower center of figure and composed of distinct megazooecia and a mesozooecium, mural lacunae at zooecial corners, and uncommon acanthostyles, Holotype USNM 432508 [NL IV 108(143)A-15-A], ×25.

1b. Longitudinal section showing autozooecial walls composed of U- to V-shaped laminae, Holotype USNM 432508 [NL IV 108(143)A-15-A], ×100.

1c. Longitudinal section showing relatively thin autozooecial walls in exozone, fairly consistent in thickness, locally thickened and thinned slightly, autozooecial walls in endozone commonly crenulate (upper left corner of figure) and locally beaded, pervasive diaphragms usually perpendicular to zooecial walls, in exozone many bowed convex inwards and distinctly traceable into surrounding walls, and large endozonal acanthostyle to the top of the figure, Holotype USNM 432508 [NL IV 108(143)A-15-A], ×25.

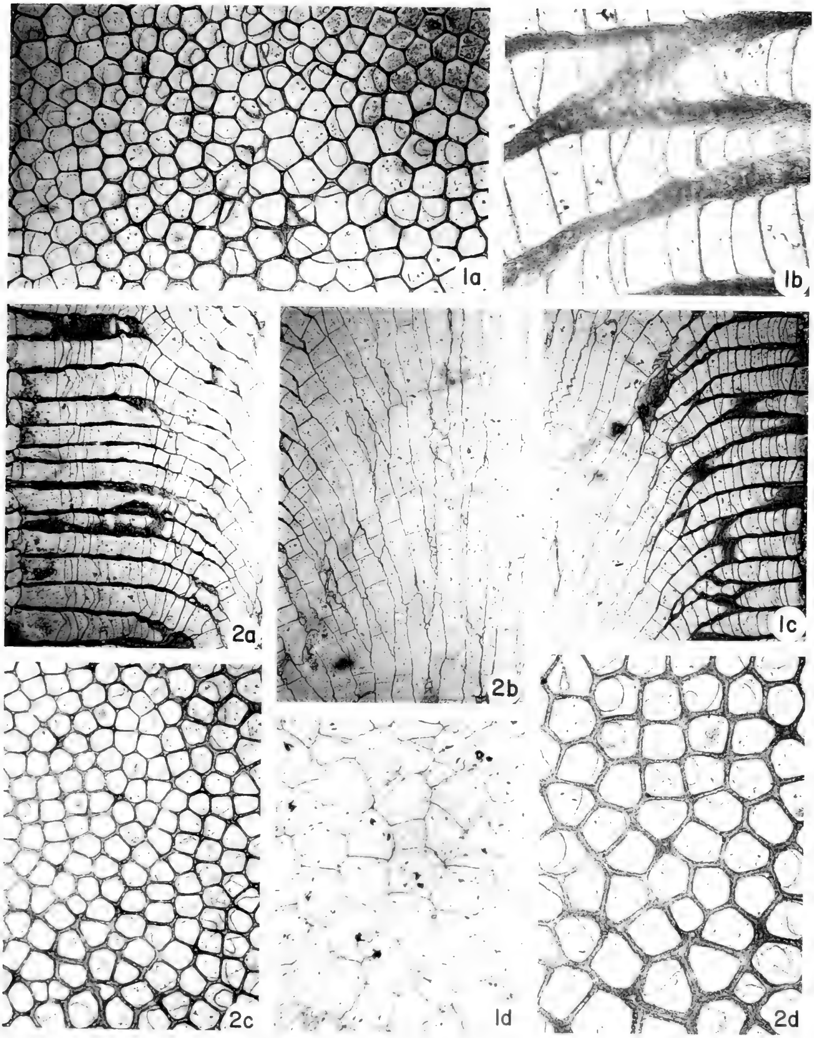
1d. Transverse section showing polygonal endozonal zooecial cavity outlines. Crenulate nature of endozonal walls as observed in longitudinal section is reflected here in unevenness of the cavity walls, Holotype USNM 432508 [NL IV 108(143)A-15-A], ×40.

2a. Longitudinal section showing relatively thin autozooecial walls in exozone, commonly irregularly thickened and thinned slightly, mostly crenulate and locally beaded autozooecial walls in endozone, diaphragms throughout mainly perpendicular to zooecial walls, locally inclined and overlapping, somewhat thinner and less regularly spaced than typical for the species as a whole, Paratype USNM 432510 [NL IV 108(143)A-6-K], ×25.

2b. Longitudinal section showing endozone with commonly crenulate and locally beaded walls, and regularly spaced diaphragms, Paratype USNM 432510 [NL IV 108(143)A-6-K], ×25.

2c. Tangential section showing subpolygonal zooecial cavity outlines, mural lacunae at zooecial corners, maculae, and scattered acanthostyles slightly more numerous than generally typical for the species, Paratype USNM 432510 [NL IV 108(143)A-6-K], ×25.

2d. Enlarged portion of Figure 2c, Paratype USNM 432510 [NL IV 108(143)A-6-K], ×45.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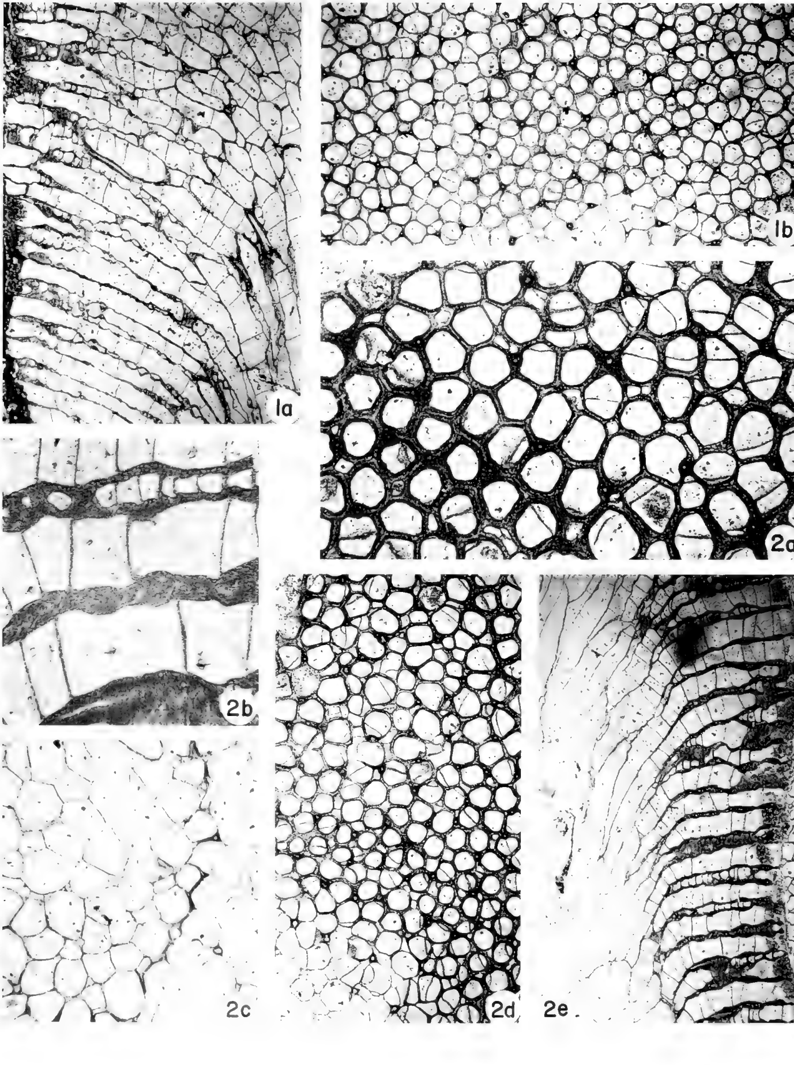
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EXPLANATION OF PLATE 14

Figure Page

1–2. *?Heterotrypa subramosa* (Ulrich) 68

1a. Longitudinal section showing diaphragm spacing in lower exozone greater than usual for the species, irregularly thickened and thinned autozooecial walls which themselves are thin, common moniliform mesozooecia of variable width in the exozone, some coalescing, diaphragms mainly perpendicular to the zooecial axis, and acanthostyles within the outermost endozone and exozone, Hypotype USNM 432519 [NL IV 108(143)A-7-C], ×25.

1b. Tangential section showing subpolygonal to subrounded and rounded autozooecial cavity outlines, polygonal to subpolygonal mesozooecial cavity outlines, and a moderate number of acanthostyles throughout zoarium, Hypotype USNM 432519 [NL IV 108(143)A-7-C], ×25.

2a. Tangential section showing common subpolygonal zooecial cavity outlines with fewer more rounded apertures, polygonal to subpolygonal mesozooecial cavity outlines, and a moderate number of evenly distributed acanthostyles at and between zooecial corners. Note that styles between zooecial corners commonly inflect contiguous zooecia, Hypotype USNM 432515 [NL IV 108(143)A-6-A], ×45.

2b. Longitudinal section showing irregularly thickened and thinned exozonal walls having a microstructure of distinct U-to V-shaped wall laminae, Hypotype USNM 432515 [NL IV 108(143)A-6-A], ×100.

2c. Transverse section of endozone showing polygonal zooecial cavity outlines. Acanthostyles scattered mainly within outer endozone, Hypotype USNM 432515 [NL IV 108(143)A-6-A], ×40.

2d. Zooecial and mesozooecial cavity outlines, and acanthostyles as for Figure 2a. Note the megazooecia associated with an indistinct macular area near upper center of figure, and commonly petaloid arrangements of zooecia around acanthostyles in endozone in lower left of figure, Hypotype USNM 432515 [NL IV 108(143)A-6-A], ×25.

2e. Longitudinal section showing irregularly thickened and thinned laminar walls, diaphragms in autozooecia of outer endozone and exozone fairly regularly spaced and mainly perpendicular to zooecial walls, common mesozooecia in exozone with relatively thick and evenly spaced diaphragms and broadly moniliform walls, and acanthostyles, Hypotype USNM 432515 [NL IV 108(143)A-6-A], ×25.

EXPLANATION FOR PLATE 15

1a. Longitudinal section showing generally planar diaphragms perpendicular to zooecial walls in endozone, perpendicular to inclined slightly in exozone, unevenly thickened exozonal walls, a mesozooecium (lower left corner of figure), common exozonal acanthostyles and a few acanthostyles in outer endozone, Holotype USNM 432640 [NL IV 94(129)A-4L-D], ×25.

1b. Transverse section showing polygonal zooecial cavity outlines in endozone. Acanthostyles found mainly in outer endozone (bottom half of figure), Holotype USNM 432640 [NL IV 94(129)A-4L-D], ×40.

1c. Longitudinal section of exozone showing unevenly thickened and thinned autozooecial walls having poorly defined wall laminae, Holotype USNM 432640 [NL IV 94(129)A-4L-D], ×100.

1d. Tangential section showing subpolygonal to subrounded zooecial cavity outlines, few small commonly subangular mesozooecia, and ubiquitous acanthostyles found mainly at zooecial corners, Holotype USNM 432640 [NL IV 94(129)A-4L-D], ×33.

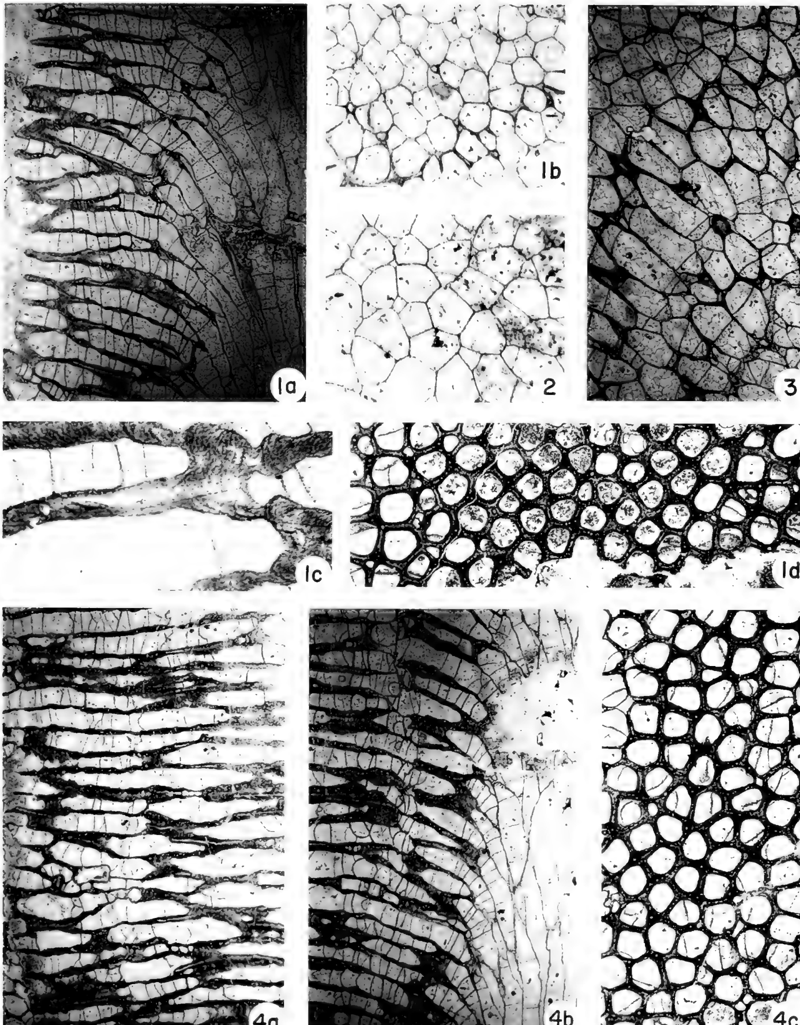
2. Transverse section of endozone showing polygonal zooecial cavity outlines, Paratype USNM 432643 [NL IV 96(129)H], ×40.

3. Oblique section through endozone showing large acanthostyles forming petaloid arrangements with surrounding autozooecia, Paratype USNM 432645 [NL IV 108(143)A-6-J], ×33.

4a. Longitudinal section showing a relatively wide exozone, irregularly thickened and thinned autozooecial walls, variably oriented diaphragms, a few scattered mesozooecia, and acanthostyles (some inflecting), Paratypes USNM 432644 ([NL IV 96(131)F-1-D], ×25.

4b. Longitudinal section showing endozone and lower exozone of specimen in Figure 4a. Note the conspecific growth within exozone in top left corner of figure, Paratype USNM 432644 [NL IV 96(131)F-1-D], ×25.

4c. Tangential section showing subpolygonal to subrounded autozooecial cavity outlines, a few mesozooecia, and common small acanthostyles, Paratype USNM 432644 [NL IV 96(131)F-1-D], ×33.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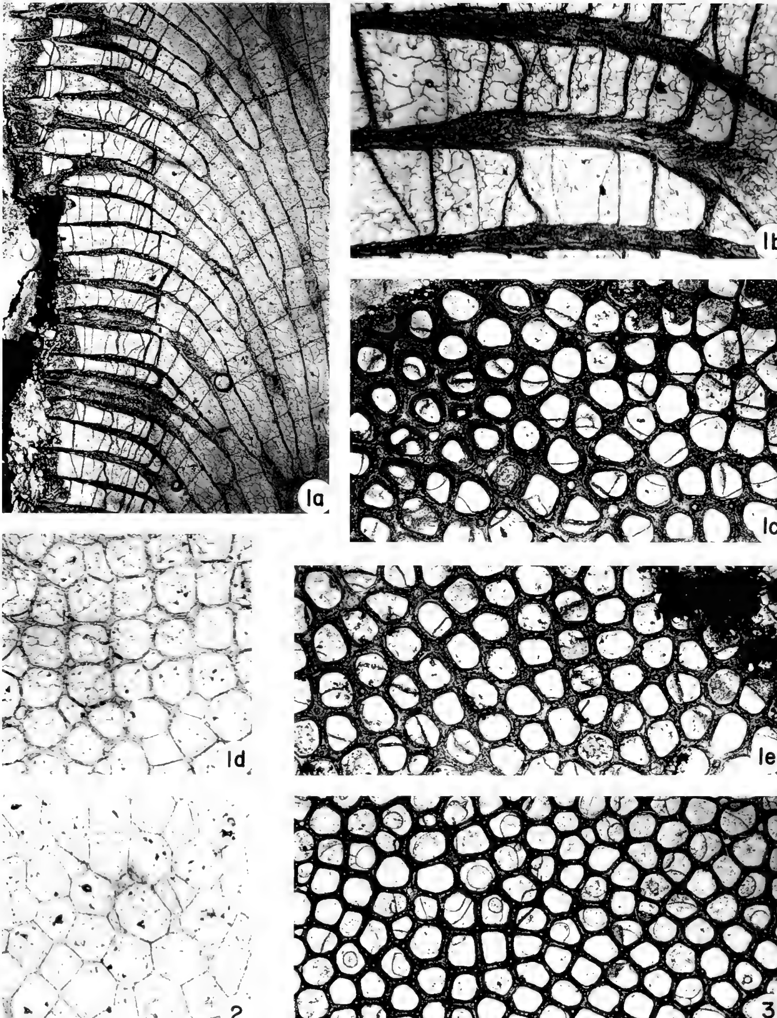
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EXPLANATION OF PLATE 16

Figure	Page

1–2. *Heterotrypa subtrentonensis* n. sp. 69

1a. Longitudinal section showing irregular thickening and thinning of autozooecial walls in endozone, narrowing of laminar autozooecial walls near colony surface to give a "pointed" appearance, zooecial boundaries denoted by a dark line, endozonal diaphragms throughout, exozonal diaphragms thicker and mainly perpendicular to zooecial walls but many inclined, curved, or overlapping, and with thickest diaphragms forming parts of diaphragm-wall units, Holotype USNM 432525 [NL IV 116(151)A-3-A], ×25.

1b. Longitudinal section showing an exozonal wall microstructure of distinct U- to V-shaped laminae. Note diaphragm-wall units where diaphragms thick, Holotype USNM 432525 [NL IV 116(151)A-3-A], ×100.

1c. Tangential section cutting through portions of a colony with thick and thin walls. In the latter instance, acanthostyles are somewhat inflecting, Holotype USNM 432525 [NL IV 116(151)A-3-A], ×33.

1d. Transverse section showing irregular thickening of some autozooecial walls in endozone, Holotype USNM 432525 [NL IV 116(151)A-3-A], ×40.

1e. Tangential section showing subrounded to subangular zooecial cavity outlines, a lack of mesozooecia, and acanthostyles with small cores common and mainly at zooecial corners, Holotype USNM 432525 [NL IV 116(151)A-3-A], ×33.

2. Transverse section of endozone showing polygonal zooecial cavity outlines, Paratype USNM 432569 [CB 150B-4-A], ×40.

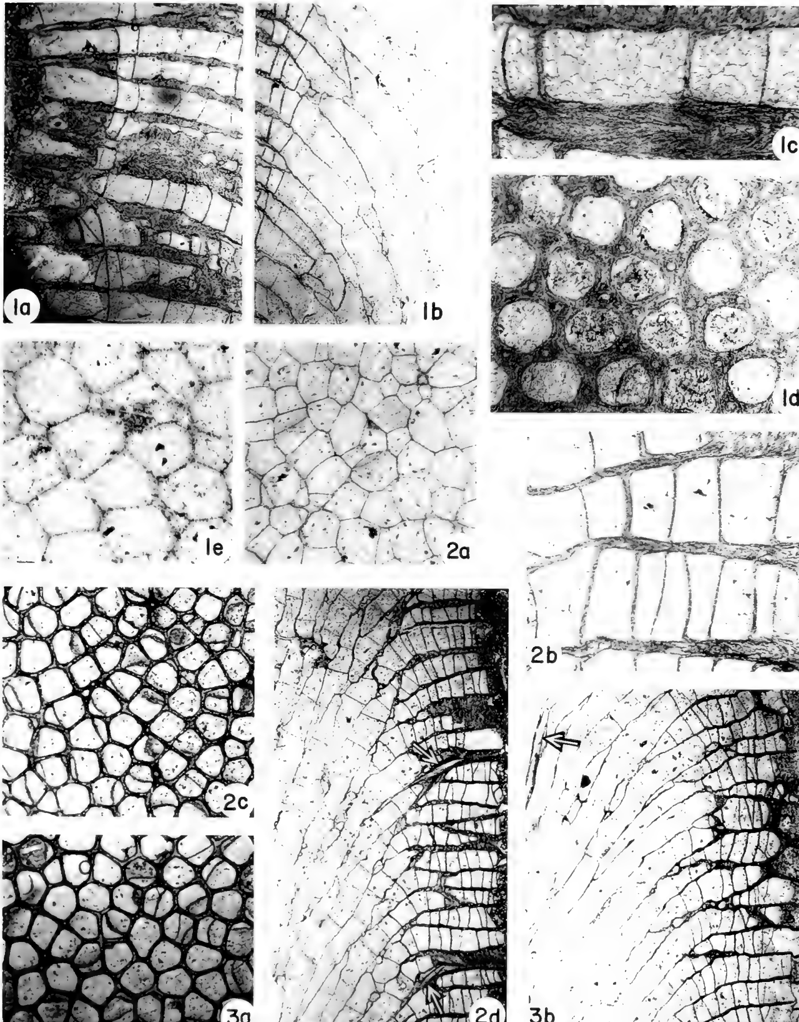
3. *Heterotrypa exovaria* n. sp. 72

3. Tangential section showing subpolygonal to subrounded autozooecial cavity outlines, a few small mesozooecia, small acanthostyles, and a poorly defined macula in left center of figure, Paratype USNM 432643 [NL IV 96(131)H], ×33.

EXPLANATION OF PLATE 17

Figure Page

1. *Heterotrypa magnopora* n. sp. 71
   - 1a. Longitudinal section showing large zooecia, irregularly thickened and thinned autozooecial walls in exozone composed of U-shaped laminae and containing acanthostyles, planar and evenly spaced exozonal diaphragms perpendicular to walls and usually forming distinct diaphragm-wall units, and relatively thick diaphragms at base of exozone, Holotype USNM 432591 [CB 72A-1-A], ×25.
   - 1b. Portion of endozone from same zoarium as in Figure 1a, Holotype USNM 432591 [CB 72A-1-A], ×25.
   - 1c. Longitudinal section of exozone showing autozooecial walls composed of distinct U-shaped laminae, Holotype USNM 432591 [CB 72A-1-A], ×100.
   - 1d. Tangential section showing large subrounded zooecial cavity outlines, fairly thick laminar walls, and common acanthostyles found at and between zooecial corners, Holotype USNM 432591 [CB 72A-1-A], ×45.
   - 1e. Transverse section showing polygonal zooecial cavity outlines of endozone, Holotype USNM 432591 [CB 72A-1-A], ×40.
2. *Heterotrypa praenuntia* var. *simplex* (Ulrich) 74
   - 2a. Transverse section showing polygonal endozonal zooecial cavity outlines, Hypotype USNM 432653 [NL IV 108(143)A-5-D], ×40
   - 2b. Longitudinal section showing distinct U- to V-shaped laminae of autozooecial walls, Hypotype USNM 432653 [NL IV 108(143)A-5-D], ×100.
   - 2c. Tangential section showing subpolygonal zooecial cavity outlines, relatively thin walls, scattered acanthostyles, and possibly mural lacunae at many zooecial corners, Hypotype USNM 432653 [NL IV 108(143)A-5-D], ×33.
   - 2d. Longitudinal section showing slightly uneven exozonal walls, autozooecial walls in endozone crenulate (and beaded) in places, fairly consistently spaced exozonal diaphragms oriented mainly perpendicular to zooecial walls, commonly bowed convex outwards slightly, thin and planar endozonal diaphragms at right angles to walls, and some relatively thick walled acanthostyles (arrows) in area of zooecial bend found within lower exozone, Hypotype USNM 432653 [NL IV 108(143)A-5-D], ×25.
   - 3a. Tangential section as for Figure 2c but for a lack of acanthostyles, Hypotype USNM 432649 [NL IV 108(143)A-3-F], ×33.
   - 3b. Longitudinal section as for Figure 2d but showing a large acanthostyle within endozone (arrow) and fewer exozonal acanthostyles, Hypotype USNM 432649 [NL IV 108(143)A-3-F], ×25.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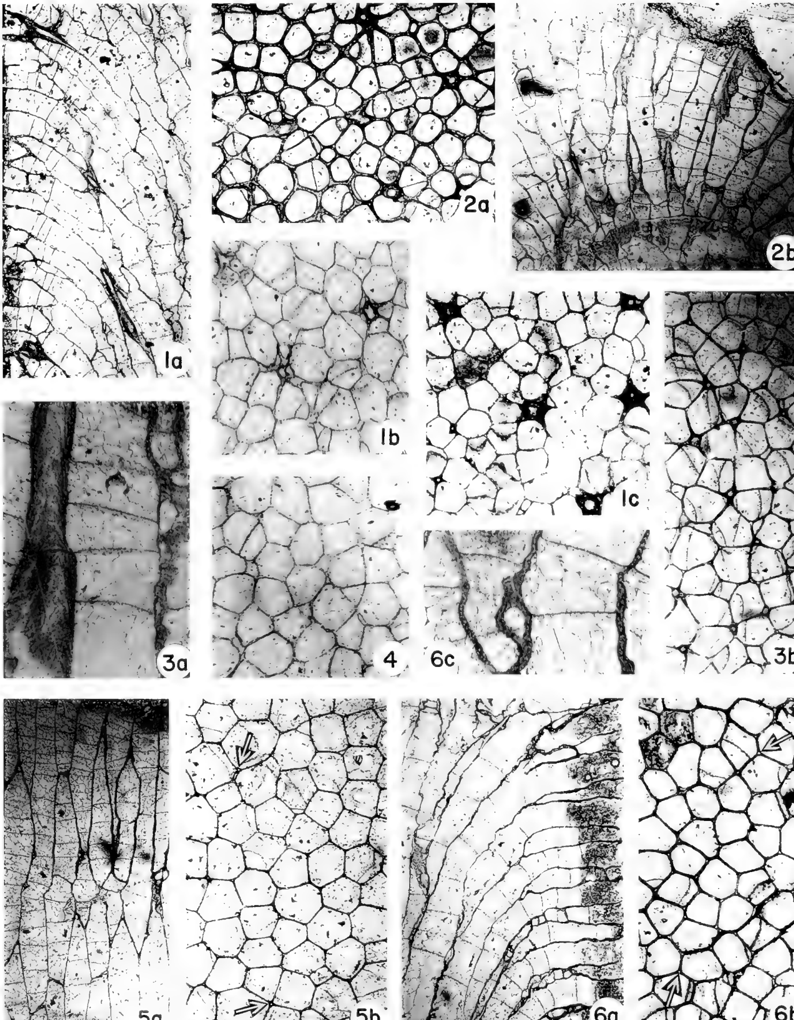
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EXPLANATION OF PLATE 18

Figure | Page
1–3. *Heterotrypa praenuntia* var. *echinata* (Ulrich) 75

1a. Longitudinal section very similar to *H. praenuntia* var. *simplex* (cf. Pl. 17, Fig. 3b) but for an abundance of large acanthostyles in exozone, Hypotype USNM 432690 [WB 20(32)B-2-B], ×25.

1b. Transverse section showing relatively large endozonal acanthostyles in center of petaloid clusters of zooecia, and polygonal zooecial cavity outlines, Hypotype USNM 432690 [WB 20(32)B-2-B], ×40.

1c. Tangential section showing large acanthostyles surrounded by petaloid arrangement of autozooecia, thin walls, and polygonal zooecial cavity outlines, Hypotype USNM 432690 [WB 20(32)B-2-B], ×33.

2a. Tangential section very similar in appearance to *H. praenuntia* var. *simplex* (cf. Pl. 17, Fig. 2c) but for large acanthostyles, Hypotype USNM 432672 [NL IV 93(128)A-9-F], ×33.

2b. Longitudinal section of an encrusting form showing acanthostyles with more pronounced wall laminae, and a somewhat greater spacing of diaphragms than found in *H. praenuntia* var. *simplex*, Hypotype USNM 432672 [NL IV 93(128)A-9-F], ×25.

3a. Longitudinal section showing V-shaped laminae of autozooecial wall in exozone, Hypotype USNM 432685 [CB 67B-7-D], ×100.

3b. Tangential section showing thin walls, relatively large acanthostyles, and polygonal zooecial cavity outlines, Hypotype USNM 432685 [CB 67B-7-D], ×33.

4–6. *Cyphotrypa acervulosa* (Ulrich) 77

4. Transverse section of endozone showing polygonal zooecial cavity outlines, Hypotype USNM 432692 [NL IV 43(78)B-4L-D], ×40.

5a. Longitudinal section of subglobular encrusting form showing thin, even walls, diaphragms thin, planar and commonly perpendicular to walls, and small acanthostyles found where walls thicken slightly, Hypotype USNM 432696 [NL IV 66(101)A-5A-A], ×25.

5b. Tangential section showing very thin walls, polygonal zooecial cavity outlines, infrequent, minute acanthostyles and common mural lacunae (arrows) at zooecial corners, Hypotype USNM 432696 [NL IV 66(101)A-5A-A], ×33.

6a. Longitudinal section of a ramose colony showing thin and relatively widely spaced diaphragms throughout oriented perpendicular to zooecial walls and sometimes bowed convex outwards in exozone, thin walls even to slightly crenulate in endozone, and a surficial angle of 90°, Hypotype USNM 432695 [NL IV 49(84)A-4L-A], ×25.

6b. Tangential section showing polygonal zooecial cavity outlines, thin walls, and common mural lacunae (arrows) and sparse small acanthostyles at zooecial corners, Hypotype USNM 432695 [NL IV 49(84)A-4L-A], ×33.

6c. Longitudinal section of exozone showing wavy exozonal walls composed of V-shaped laminae, Hypotype USNM 432695 [NL IV 49(84)A-4L-A], ×100.

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Figure	Page
1–3. *Stigmatella distinctaspinosa* n. sp.	77

1a. Longitudinal section showing numerous large acanthostyles, and thin and relatively widely spaced diaphragms perpendicular to thin walls, Paratype USNM 432709 [NL IV 117(152)A-8-D], ×25.

1b. Tangential section, oblique, showing polygonal to subpolygonal zooecial cavity outlines, thin walls, and large inflecting acanthostyles in shallowest tangential section on right side of figure and decreasing diameters to the left where zooecia are cut closer to colony base, Paratype USNM 432709 [NL IV 117(152)A-8-D], ×33.

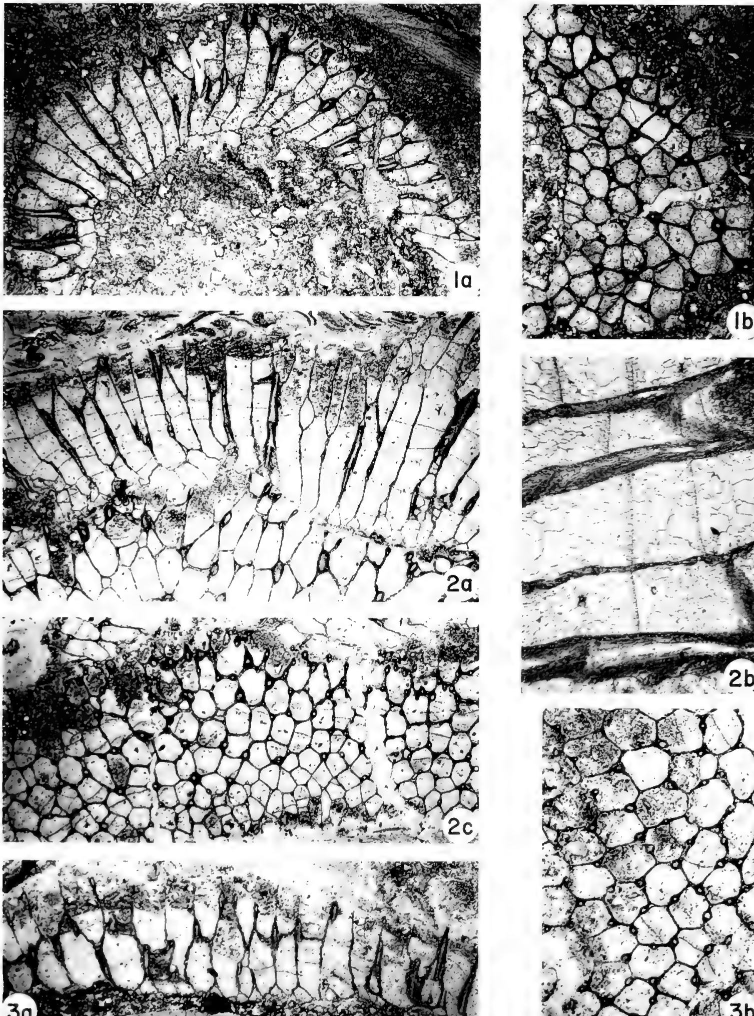
2a. Longitudinal section of a specimen with a conspecific overgrowth showing thin walls, large acanthostyles, and thin, planar, and relatively widely spaced diaphragms perpendicular or inclined slightly to zooecial walls, Holotype USNM 432707 [NL IV 50(85)A-13-B], ×25.

2b. Longitudinal section showing thin wall separating adjacent autozooecia and acanthostyles with thick laminar sheaths, Holotype USNM 432707 [NL IV 50(85)A-13-B], ×100.

2c. Tangential section, oblique, showing numerous inflecting acanthostyles and decreasing diameters of zooecia with a deeper cut near colony base in bottom of figure. Note that largest styles are found at zooecial corners with smaller acanthostyles generally occurring between zooecia, Holotype USNM 432707 [NL IV 50(85)A-13-B], ×25.

3a. Longitudinal section showing very thin diaphragms, many inclined and/or curved, and numerous acanthostyles, Paratype USNM 432744 [CB 145C-4-C], ×33.

3b. Tangential section showing plentiful inflecting acanthostyles at and between zooecial corners, some offset, Paratype USNM 432744 [CB 145C-4-C], ×33.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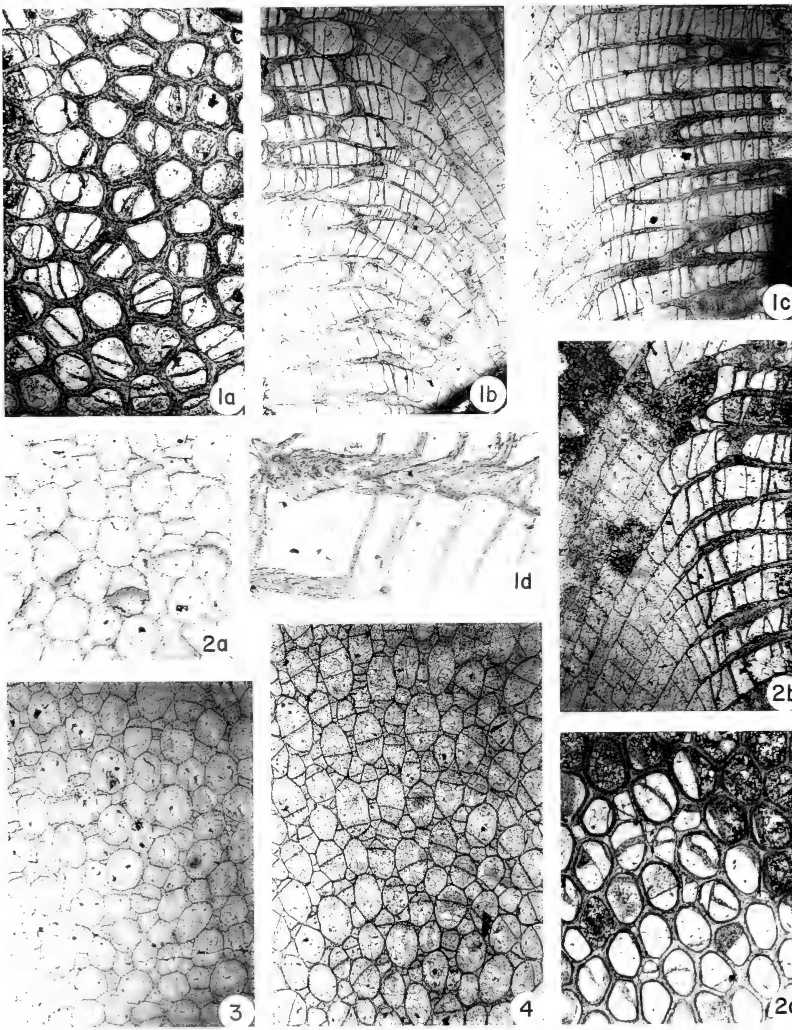
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EXPLANATION OF PLATE 20

Figure | Page
1–4. *Tarphophragma multitabulata* (Ulrich) 80

1a. Tangential section showing subrounded to subpolygonal zooecial cavity outlines, and few small mesozooecia with subpolygonal to polygonal cavity outlines, Hypotype USNM 432772 [NL IV 96(131)E-1-B], ×33.

1b,1c. Longitudinal sections showing laminar walls with a faint dark line defining zooecial boundaries, diaphragms throughout colony, within endozone diaphragms most closely spaced at proximal-most parts of zooecial tubes, planar exozonal diaphragms closely spaced, mainly perpendicular or somewhat inclined to zooecial walls and of variable thickness, and small exozonal mesozooecia cut obliquely in lower exozone with closely spaced diaphragms having thicknesses not greater than for autozooecia, Hypotype USNM 432772 [NL IV 96(131)E-1-B], ×25.

1d. Longitudinal section of outer exozone showing wall microstructure of mostly V-shaped laminae, Hypotype USNM 432772 [NL IV 96(131)E-1-B], ×100.

2a. Transverse section across endozone showing smaller, newly formed zooecia having 3 to 4 sides distributed between larger, older, more polygonal zooecia, Hypotype USNM 432769 [NL IV 51(86)A-17L-A], ×40.

2b. Longitudinal section showing a relatively narrow exozone. Otherwise similar to Figures 1b and 1c, Hypotype USNM 432769 [NL IV 51(86)A-17L-A], ×33.

2c. Tangential section with elongate zooecial cavity outlines due to slightly oblique nature of some zooecia. Otherwise similar to Figure 1a, Hypotype USNM 432769 [NL IV 51(86)A-17L-A], ×33.

3. Oblique section through endozone showing regular budding pattern of autozooecia. Note smaller (relatively younger) zooecia with 3 to 4 sides, and larger (relatively older) more multisided zooecia whose planar walls smoothen out zooecially outwards to form subrounded apertures, Hypotype USNM 432813 [CB 130A-8-A], ×25.

4. Oblique section through endozone as for Figure 3, Hypotype USNM 432785 [NL IV 94(129)A-3L-B], ×25.

EXPLANATION OF PLATE 21

Figure Page

1–2. *Tarphophragma ampla* (Ulrich) 81

1a. Transverse section of endozone showing smaller, ontogenetically younger zooecia with 3 to 4 sides distributed between larger, older, more multisided zooecia whose planar walls have taken on a subrounded appearance, Hypotype USNM 432822 [NL IV 43(78)B-3L-G], ×40.

1b. Tangential section showing subpolygonal to subrounded autozooecial cavity outlines and increased numbers of angular mesozooecia compared to *T. multitabulata*. Hypotype USNM 432822 [NL IV 43(78)B-3L-G], ×25.

1c. Longitudinal section of exozone showing thin walls whose ordinarily laminar microstructure is obscure (cf. Figure 2b), Hypotype USNM 432822 [NL IV 43(78)B-3L-G], ×100.

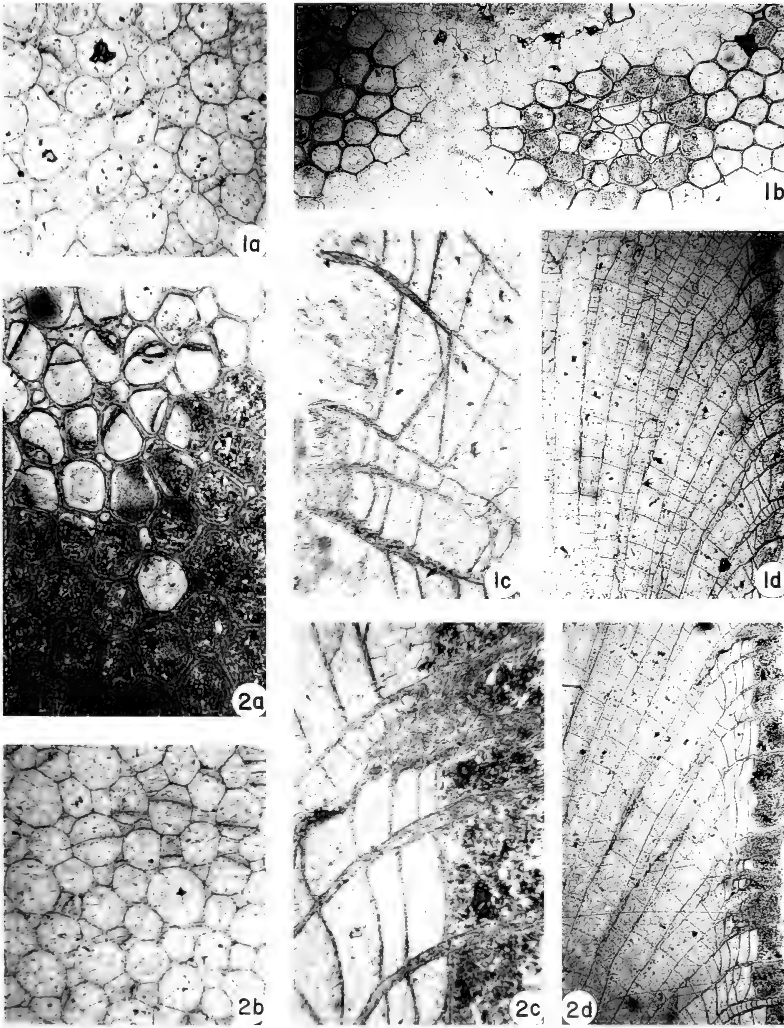
1d. Longitudinal section showing a narrow exozone with thin walls, diaphragms throughout autozooecia thicker and more variably oriented in the exozone, and small exozonal mesozooecia. Note similarity to *T. multitabulata* (cf. Plate 20, Figure 1c) but for absence of thick exozone, Hypotype USNM 432822 [NL IV 43(78)B-3L-G], ×25.

2a. Tangential section showing generally subpolygonal autozooecial cavity outlines and more common mesozooecia than for *T. multitabulata* due to less crowding peripherally by autozooecia, Hypotype USNM 432825 [NL IV 49(84)A-7R-B], ×45.

2b. Transverse section as for Figure 1a, Hypotype USNM 432825 [NL IV 49(84)A-7R-B], ×40.

2c. Longitudinal section of exozone showing V-shaped laminae composing autozooecial walls, Hypotype USNM 432825 [NL IV 49(84)A-7R-B], ×100.

2d. Longitudinal section showing an exozone wider than for Figure 1d and approaching that of *T. multitabulata*, Hypotype USNM 432825 [NL IV 49(84)A-7R-B], ×25.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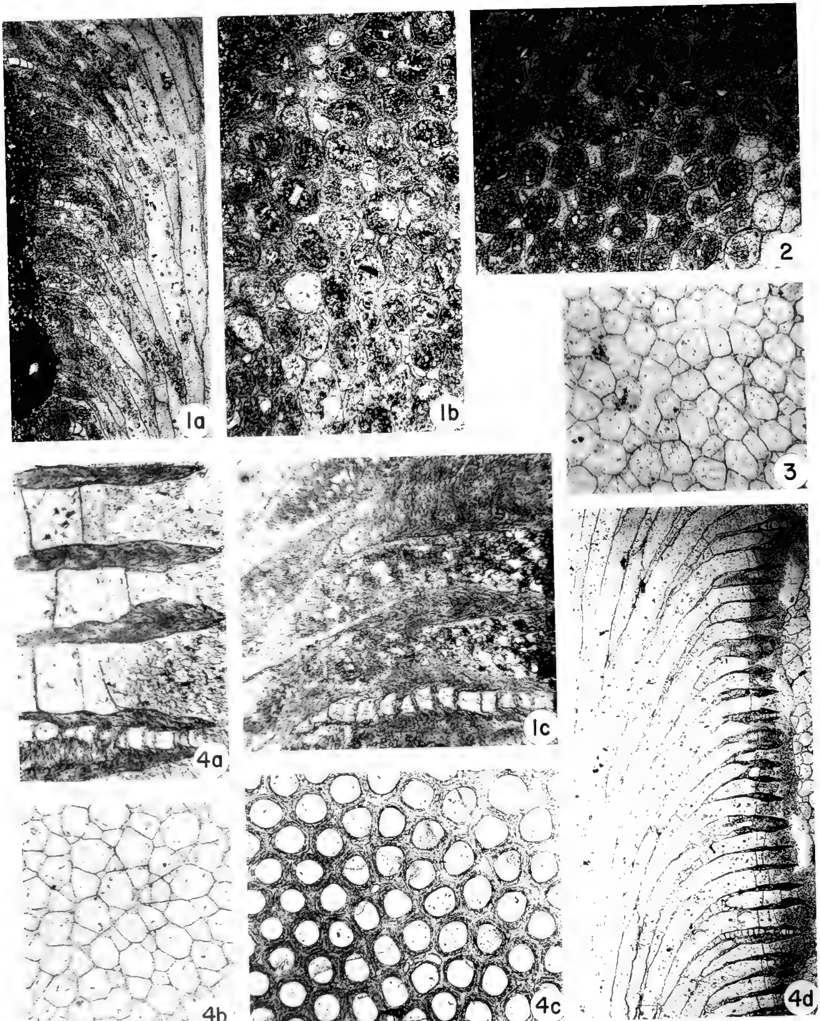
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EXPLANATION OF PLATE 22

Figure Page

1–3. *Parvohallopora pulchella* (Ulrich) 82

1a. Longitudinal section showing very few diaphragms, restricted to proximal-most ends of zooecia in endozone and sometimes exozone, and fairly common mesozooecia in exozone with closely spaced diaphragms, Hypotype USNM 432895 [CB 149A-7-A], ×25.

1b. Tangential section showing rounded zooecial cavity outlines and subrounded to subpolygonal mesozooecial cavity outlines in fairly thick-walled portions of colony. Zooecia are more angular and walls thinner in a slightly deeper tangential cut in lower right corner of figure, Hypotype USNM 432895 [CB 149A-7-A], ×45.

1c. Longitudinal section of exozone showing wall microstructure of distinct V-shaped laminae, Hypotype USNM 432895 [CB 149A-7-A], ×100.

2. Tangential section of a thin-walled specimen showing round to subround autozooecial cavity outlines and polygonal mesozooecial cavity outlines, Hypotype USNM 432894 [CB 72C-4L-C], ×45.

3. Transverse section of endozone showing polygonal zooecial cavity outlines, Hypotype USNM 432841 [NL IV 108(143)A-8-E], ×40.

4. *Parvohallopora granda* n. sp. 84

4a. Longitudinal section of outer exozone showing V-shaped laminar wall microstructure, Holotype USNM 432920 [NL IV 108(143)A-3-E], ×100.

4b. Transverse section of endozone showing polygonal zooecial cavity outlines, Holotype USNM 432920 [NL IV 108(143)A-3-E], ×40.

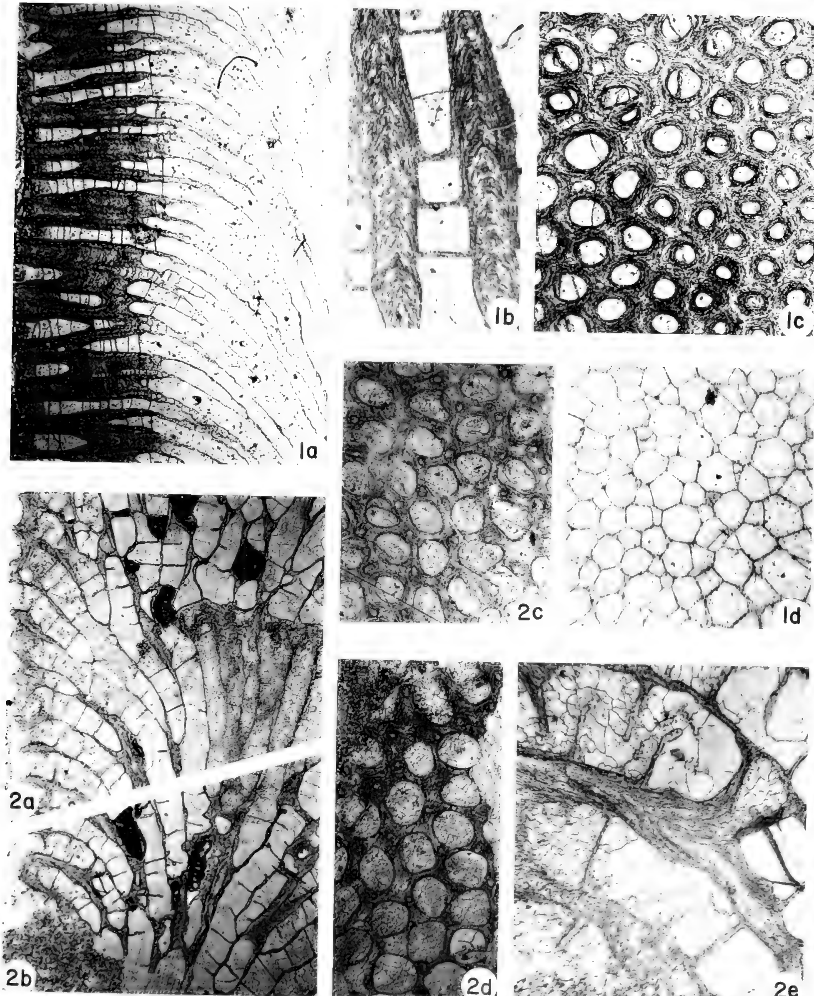
4c. Tangential section showing relatively thick walls, rounded (to subrounded) autozooecial cavity outlines, polygonal zooecia boundaries (appear as white lines), a macula in the upper right corner of figure, and few mesozooecia. The latter appear to have been crowded out peripherally by autozooecia, Holotype USNM 432920 [NL IV 108(143)A-3-E], ×45.

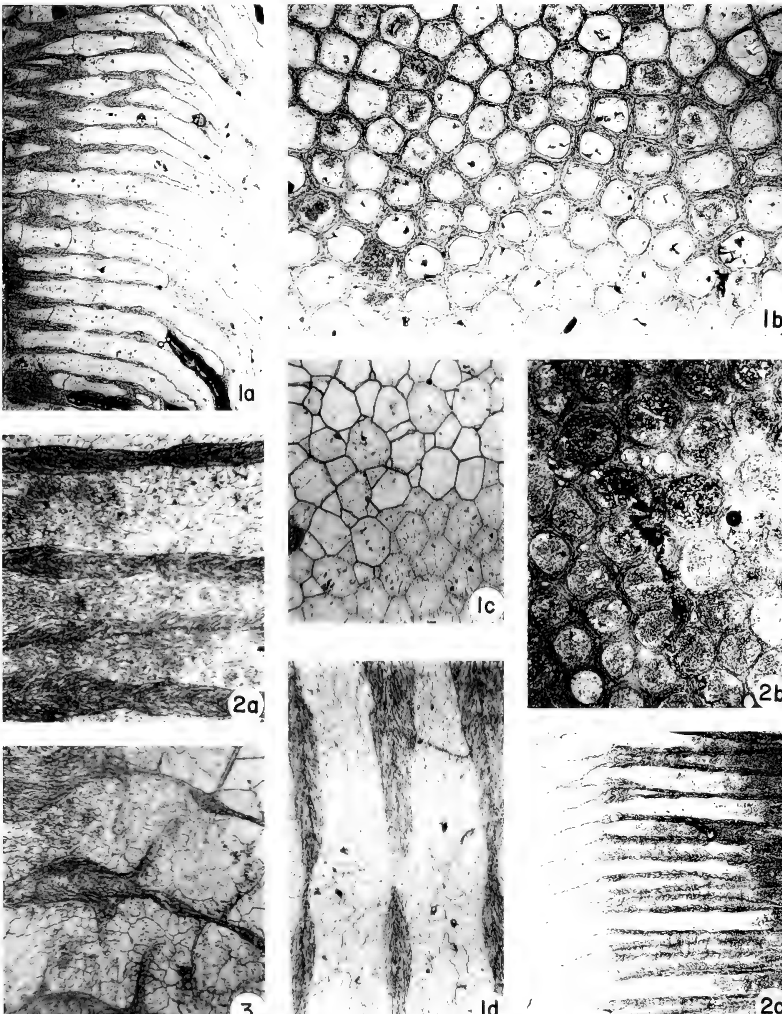
4d. Longitudinal section showing thicker walls and increased numbers of diaphragms in exozone than found in *P. pulchella*. Endozonal diaphragms are restricted to proximal ends of zooecial tubes, mesozooecia present in exozone, Holotype USNM 432920 [NL IV 108(143)A-3-E], ×25.

EXPLANATION OF PLATE 23

Figure | Page

1. *Parvohallopora granda* n. sp. var. *inflata* n. var. 86
   - 1a. Longitudinal section showing wide exozone, increased numbers of diaphragms, and thicker exozonal walls compared to non-varietal form of the species. Note mesozooecia crowded out peripherally, Hypotype USNM 432962 [NL IV 108(143)A-15-C], ×25.
   - 1b. Longitudinal section of exozone showing wall microstructure of V-shaped laminae. Note median line within wall, Hypotype USNM 432962 [NL IV 108(143)A-15-C], ×100.
   - 1c. Tangential section showing very thick walls, rounded (to subrounded) autozooecial cavity outlines, and megazooecia in macula in left center of figure. Note that nearly all mesozooecia present in lower exozone (see Figure 1a) are absent in tangential section (except for macular region), Hypotype USNM 432962 [NL IV 108(143)A-15-C], ×45.
   - 1d. Transverse section of endozone showing polygonal zooecial cavity outlines, Hypotype USNM 432962 [NL IV 108(143)A-15-C], ×40.
2. *Hemiphragma ottawaensis* (Foord) 89
   - 2a,2b. Longitudinal sections showing unevenly thickened laminar walls in both endozone and exozone, and diaphragms and hemiphragms throughout oriented perpendicular to zooecial walls, Hypotype USNM 433073 [CB 50A-3-X], ×25.
   - 2c,2d. Tangential sections showing mainly subrounded zooecial cavity outlines, and numerous acanthostyles mainly at zooecial corners, Hypotype USNM 433073 [CB 50A-3-X], ×33.
   - 2e. Longitudinal section of exozone showing distinct broadly arched wall laminae, and hemiphragms, Hypotype USNM 433073 [CB 50A-3-X], ×100.


1a
1b
1c
2c
1d
2a
2b
2d
2e


1a
1b
1c
2b
2a
3
1d
2c

EXPLANATION FOR PLATE 24

Figure Page

1–2. *Anaphragma hermitagensis* n. sp. 87

1a. Longitudinal section showing irregularly thickened and thinned autozooecial walls in exozone composed of V-shaped laminae, zooecial boundaries delineated by a dark line, even to crenulate autozooecial walls in endozone, and rare exozonal diaphragms, Holotype USNM 433017 [HCM 18(57)B-5-E], ×25.

1b. Tangential section showing rounded to subrounded zooecial cavity outlines, well-defined polygonal zooecial boundaries, uncommon small mesozooecia, minute acanthostyle-like features, and a macula in right side of figure, Holotype USNM 433017 [HCM 18(57)B-5-E], ×45.

1c. Transverse section showing polygonal zooecial cavity outlines in endozone, Holotype USNM 433017 [HCM 18(57)B-5-E], ×40.

1d. Longitudinal section of exozone showing irregularly thickened and thinned walls with distinct V-shaped laminae whose apices are joined by an even dark line, Holotype USNM 433017 [HCM 18(57)B-5-E], ×100.

2a. Longitudinal section as for Figure 1d, Paratype USNM 433058 [CB 67A-3-A], ×100.

2b. Tangential section as for Figure 1b but for somewhat more common mesozooecia, Paratype USNM 433058 [CB 67A-3-A], ×45.

2c. Longitudinal section showing pinching and swelling of autozooecial walls in exozone, a dark median line marking zooecial boundaries within laminar walls, diaphragms absent, zooecial bends at both base of exozone and outer endozone, and several narrow mesozooecia, Paratype USNM 433058 [CB 67A-3-A], ×25.

3. *Hemiphragma ottawaensis* (Foord) 89

3. Longitudinal section of exozone showing distinct broadly arched wall laminae, and hemiphragms, Hypotype USNM 433073 [CB 50A-3-X], ×100.

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