Bryozoan fauna of the upper Clays Ferry, Kopé, and lower Fairview Formations (Edenian, Upper Ordovician) at Moffett Road, northern Kentucky

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Abstract

Bryozoans are abundant and highly diversified in the Kope Formation (Upper Ordovician) of the proposed stratotype section for the Edenian Stage in Kentucky. This section is along Moffett Road in the De Mossville quadrangle, northern Kentucky. The bryozoan fauna consists of 29 species in 23 genera of the orders Trepostomata, Cystoporata, and Cryptostomata. Trepostomes are the major component of the fauna, and the genera Parvohallopora and Heterotrypa constitute about half of the fauna. On the species level, the fauna is virtually endemic to the tristate area of Kentucky, Indiana, and Ohio. Most of the species have overlapping ranges and are transitional between those of the Clays Ferry Formation (Middle-Upper Ordovician) and the overlying Fairview Formation (Upper Ordovician). About half of the species range from well down in the older rocks into the Kope Formation , where most of them become extinct. Others appear for the first time immediately below the Kope Formation, or well down in the Kope; many of these are restricted to the Kope Formation, but some range into the overlying Fairview Formation (Maysvillian).

In ascending order, three bryozoan assemblage zones are recognized on the basis of the first occurrences of the cryptostome Stictoporella interstincta, and the trepostomes Heterotrypa ulrichi, and Batostoma jamesi. The Stictoporella interstincta zone spans the upper part of the Point Pleasant Tongue of the Clays Ferry Formation, which underlies the Kope, and the lower part of the Kope Formation. Within this zone are the first appearances of Edenian age species at the base of the Kope Formation. The Heterotrypa ulrichi zone occupies the middle part of the Kope Formation. The Batostoma jamesi zone spans the upper part of the Kope and the lower part of the Fairview Formation. Within the B. jamesi zone are the disappearances of several late Middle Ordovician bryozoans and the first occurrences of some bryozoans that range into rocks of Maysvillian age. The association of the zonal index species with species restricted to the Kope Formation are useful in recognition of Edenian age rocks in the tristate area of Kentucky, Indiana and Ohio and, possibly, elsewhere. All bryozoan species are described and their synonymies updated.

Introduction

Bryozoans are a major and highly diversified component of the fossil invertebrate fauna in the Kope Formation, Upper Ordovician, of northern Kentucky. In the tristate area of Indiana, Ohio, and Kentucky, the Kope Formation, 70 to 90 percent shale, is distinctive lithologically and significant biostratigraphically. At Cincinnati, it defines the Edenian Stage which forms the base of the Cincinnatian Series. The Cincinnatian Series, consisting of the Edenian, Maysvillian, and Richmondian Stages, is the traditional standard of reference for Upper Ordovician rocks of North America. The base of the Edenian Stage is the biostratigraphic boundary between the Middle and Upper Ordovician. However, the base of the Edenian Stage, as defined on the Kope Formation, is no longer exposed at its type locality in Eden Park, Cincinnati, Ohio, and is not available for biostratigraphic studies.

In northern Kentucky, the entire Kope Formation with its basal and upper contact is virtually continuously exposed along Moffett Road in the De Mossville 1:24,000 quadrangle (fig. 1). This area of outcrop is in geographic proximity of the type locality of the Edenian Stage in Cincinnati, Ohio, and has been proposed to be the reference area for the stratotype of the Edenian State in Kentucky (Pojeta, 1981).

The purpose of this report is to provide comprehensive documentation of the bryozoan fauna in the Kope Formation and its boundaries at the Moffett Road section and is part of the biostratigraphical analysis of the invertebrate faunas in the upper Middle and Upper Ordovician rocks of Kentucky.

Weiss and Norman (1960) reviewed the historical development of the stratigraphical classification of the Ordovician rocks in the tristate area of Kentucky, Ohio, and Indiana. In 1964, Weiss and Sweet proposed the name Kope Formation in Ohio for the dominantly shale unit that had been traditionally known as the Eden Formation (Bassler, 1906), or the Eden Shale, in Kentucky, Indiana, and Ohio. The designation Kope Formation for this lithic unit is now also used in Kentucky (Peck, 1966; Ford, 1968; Cressman, 1973; Swadley, Luft and Gibbons, 1975), Ohio (Ford, 1967), and Indiana (Brown and Lineback, 1966). Sweet, Turco, Warner, and Wilkie (1959) discussed the conodont fauna of the Kope Formation (as Eden Formation) of Ohio and Kentucky. Bergström and Sweet (1966), Sweet and Bergström (1971), and Sweet (1979) discussed the historical development of the biostratigraphy of upper Middle Ordovician and the Upper Ordovician rocks, and redefined the Edenian, Maysvillian, and Richmondian Stages of the standard Cincinnatian Series in their reference areas of Ohio, Indiana, and Kentucky and evaluated the biostratigraphic distribution of conodonts. On the basis of the conodonts of the Kope Formation, Sweet and Bergström (1971, 1976) correlated to other Edenian age rocks in the tristate area of Ohio, Indiana, and Kentucky, in New York, and elsewhere.

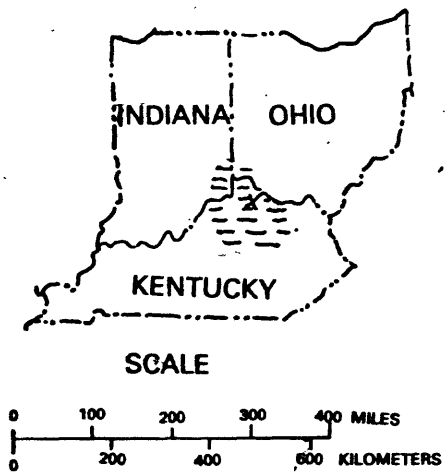
Pojeta (1979) summarized recent studies of Ordovician paleontology and lithostratigraphy of Kentucky and adjacent areas. In 1981, Pojeta proposed the establishment of stratotype sections of the Edenian, Maysvillian, and Richmondian Stages of the Cincinnatian Series, Upper Ordovician for use in Kentucky. In northern Kentucky, exposures of Ordovician rocks are ideally suited for the stratotype reference sections because, 1) there is virtual

Figure 1.-- Index maps of location of the Moffett Road section and the De Mossville 1:24,000 quadrangle in northern Kentucky.

A. Location of the Moffett Road section in the tristate area of Kentucky, Indiana, and Ohio. Dashed lines indicate the approximate geographic distribution of bryozoans in the Kope Formation and equivalent strata.

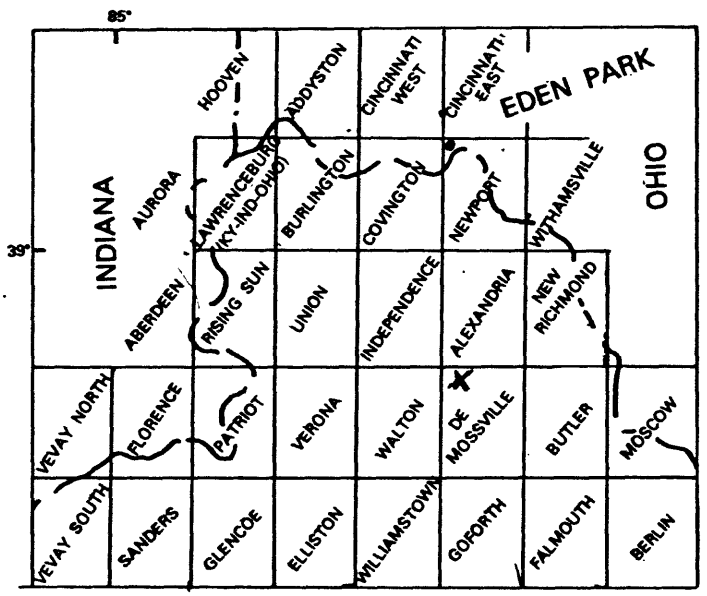
B. Location of the Moffett Road section in the De Mossville quadrangle, northern Kentucky and of the Eden Park in Cincinnati, Ohio.

FIGURE 1



A

X Moffett Road section, De Mossville Quadrangle, Kentucky



B

X Moffett Road section, De Mossville Quadrangle,

• Eden Park, Cincinnati, Ohio

SCALE: 0 10 20 MILES

stratigraphic continuity between the base of the Lexington Limestone (late Middle Ordovician) and the base of the Silurian System, and 2) they are highly fossiliferous. Furthermore, the proposed areas for the reference stratotype sections are in geographic proximity to the classical Cincinnatian type areas near Cincinnati, Ohio. Pojeta (1981) suggested that the exposure of the Kope Formation along Moffett Road, herein termed the Moffett Road section, in the De Mossville quadrangle of northern Kentucky (Fig. 1), be designated the reference section for the stratotype of the Edenian Stage of the Cincinnatian Series in Kentucky. He noted that the Kope Formation is continuously exposed along Moffett Road, as are its boundaries with the underlying Point Pleasant Tongue of the Clays Ferry Formation (Middle and Upper Ordovician) and the overlying Fairview Formation (Upper Ordovician). The Moffett Road section is about 17 air miles from the type area of the Edenian Stage in Eden Park, Cincinnati, Ohio, where these rocks are now poorly exposed and where present exposures do not reveal the lower boundary.

Description of locality.--The Moffett Road section is about 0.5 mi west of Kenton in the De Mossville 7.5 minute geologic quadrangle, Kenton County, in northern Kentucky (fig. 1). The quadrangle has been mapped geologically by Luft (1970). In ascending order the Moffett Road section exposes the upper part of the Point Pleasant Tongue of the Clays Ferry Formation, the Kope Formation, and the lower part of the Fairview Formation. The base of the Moffett Road section is located geographically by a set of coordinates in mm measured first east and then north from the lower left or southwest corner of the De Mossville 1:24,000 quadrangle map (Pojeta, 1979). The base of the Moffett Road section is placed at 118.5 mm east and 547 mm north in the De Mossville quadrangle. The section is about 342 ft thick as measured by J. Pojeta, Jr., A. B. Gibson, and S. J. Luft (written communication, 1969).

Previous work

Bryozoan species of the Kope Formation were studied and described by H. A. Nicholson, U. P. James, J. F. James, and E. O. Ulrich during the late 19th and early 20th centuries. Nickles and Bassler (1900), and Bassler (1906, 1915) provided the early synonymies of the various bryozoan taxa. In 1964, Utgaard and Perry reviewed, in detail, the historical development of studies of bryozoans from the Upper Ordovician rocks of the tristate area of Indiana, Kentucky, and Ohio.

Nickles (1902) provided the first bryozoan zonation of the Kope Formation (as Eden Shale). In ascending order, he recognized three subdivisions: the Aspidopora newberry (Nicholson) bed, the Batostoma jamesi (Nicholson) bed, and the Dekayella ulrichi (Nicholson) (now Heterotrypa) bed. Of these species, only Aspidopora newberry is not found in the area (Anstey and Perry, 1973; or herein). Nickles' subdivisions were based partly on stratigraphically restricted species and partly on abundance of some species. Later, Nickles (1905) described the bryozoan fauna from the Kope Formation (as Eden Formation) of northern Kentucky.

Bassler (1906) renamed Nickles' bryozoan beds as (in ascending order): the Economy Member, the Southgate Member, and the McMicken Member of the Eden Formation. He noted the vertical distance of each lithic member, in feet, above the then low water level of the Ohio River at Cincinnati, Ohio.

Subsequently, Cumings (1908, 1922), and Cumings and Galloway (1913) indicated the stratigraphic distribution of bryozoans in the Upper Ordovician rocks of Indiana, and McFarlan (1931) noted bryozoan distribution in the Middle and the Upper Ordovician rocks of Kentucky.

Anstey and Perry (1973) provided a detailed analysis of the trepostome component of the bryozoan fauna in the Kope Formation (Eden Shale of Anstey and Perry) in southeastern Indiana and adjacent areas of Ohio and Kentucky. In ascending order, they recognized five bryozoan assemblage zones based on association of species thought to be environmentally restricted: the Eridotrypa mutabilis zone, the Stigmatella clavis zone, the Balticoporella whitfieldi zone, the Batostoma jamesi zone, and the Dekayia aspera zone. Anstey and Perry (1973) noted that the Stigmatella clavis assemblage of the lower part of the Kope Formation, and the Batostoma jamesi assemblage and the succeeding Dekayia aspera assemblage of the upper part of the Kope may have resulted from more shallow and more turbulent water than the Balticoporella whitfieldi assemblage in the middle part of the Kope Formation. Furthermore, the boundaries of the upper three bryozoan zones, Balticoporella whitfieldi, Batostoma jamesi and Dekayia aspera, appeared to shift upward stratigraphically in southern direction. According to Anstey and Perry (1973) the southern shift of the boundaries of these zones may have resulted from an increase in shale content in the Kope Formation in a southerly direction.

Materials and methods

This report is based on 205 closely spaced samples collected at Moffett Road in 1969 by J. Pojeta, Jr., R. J. Ross, Jr., and O. L. Karklins of the U.S. Geological Survey, and W. T. Dean of the Geological Survey of Canada. All samples are from strictly in place strata. The bulk of the collections are from the lower 160 ft and the upper 100 ft of the section. Relatively few samples were recovered from an interval between 160 ft and 250 ft above the base of the section because it was partly slumped and covered (pl. 1). Bryozoans are abundant and diverse in most collections. Because of their abundance only a fraction of the available specimens in a sample were prepared for study. Most fragments of bryozoan colonies were removed from shale by breaking it down in the industrial solvent varsol, then washed in a fine mesh sieve in water, dried, and sorted according to their external appearances. Bryozoans embedded in limestone were removed by trimming off excess matrix. Fragments of bryozoan colonies regarded as representative of a sample were prepared for study of their internal skeletal morphology by using standard methods of acetate peel replicas. Some bryozoans were prepared by using standard methods of thin sectioning.

The taxonomic interpretation of fragments of bryozoan colonies is based entirely on internal characters observed in about 3,265 peels and thin sections from about 1,608 specimens. The number of prepared bryozoan specimens and relative abundance of each species is listed in stratigraphic order in table 1. The stratigraphic position of samples in the section and ranges of species are shown in plate 1. Relative abundance of each species stratigraphically is shown in plate 2.

Table 1.--Ranges of species in feet, relative abundance in percent and the number of prepared specimens of each species in stratigraphic order above the base of the Moffett Road section, northern Kentucky.

Species	Feet above base of section	Abundance %	Number of specimens
Homotrypa curvata	at 332	0.06	1
(base of Fairview Formation at 316+ ft)			
Heterotrypa frondosa	310-342	0.37	6
Amplexopora septosa	308-318	0.37	6
Phylloporina variolata	258-286	0.62	10
Batostoma jamesi	186-342	1.06	17
Balticoporella whitfieldi	128-132	0.19	3
Constellaria florida	at 126,274, 332-342	0.44	7
Parvohallopora nodulosa	116-342	17.80	286
Heterotrypa ulrichi	98-326	10.32	166
Atactoporella typicalis	96-130	0.37	6
Amplexopora persimilis	94-274	1.62	26
Monotrypella n. sp.	94-128	1.00	16
Crepipora venusta	88-266	1.43	23
Parvohallopora n. sp.	84-116	3.17	51
Dekayia nicklesi	72-252	0.50	8
Bythopora dendrina	68-292	5.53	89
Ceramoporella distincta	60-298	1.0	16
Stigmatella nana	54-128	1.87	30
(base of the Kope Formation at 54 ft)			
Escharopora acuminata	42-342	2.11	34
Graptodictya cf. G. cleavelandi	24-292	2.92	47
Ceramophylla alternatum	14-278	9.27	149
Stictoporella interstincta	6-122	2.00	32
Escharopora n. sp.	6-98	0.37	6
Peronopora vera	0-332	5.53	89
Stigmatella clavis	0-290	4.66	75
Aspidopora areolata	0-98	1.93	31
Stictopora parallela	0-126	0.87	14
Parvohallopora onealli	0-122	18.10	291
Eridotrypa mutabilis	0-48	2.49	40

The Moffett Road Section

The Kope Formation overlies and regionally intertongues with the Point Pleasant Tongue of the Clays Ferry Formation. In the Moffett Road section, the upper 54 feet of the Point Pleasant Tongue of the Clays Ferry Formation are exposed. The Point Pleasant Tongue (Swadley, Luft and Gibbons, 1975) consists of interbedded limestone (of various types) and shale in various proportions, but on the average is about half limestone and half shale (Cressman, 1973, p. 46). It is lithologically similar to the Clays Ferry Formation of south-central Kentucky (Weir and Greene, 1965), and is correlated with the upper part of the Lexington Limestone of central Kentucky (Cressman, 1973).

Weiss, Edwards, Norman and Sharp (1965) described the Point Pleasant Tongue (as Formation; see also Sweet, 1979, p. G22) in detail.

At the Moffett Road section the Kope Formation rests conformably on the Point Pleasant Tongue and is about 265 ft thick. It varies in thickness between 245 ft and 270 ft in nearby outcrops. The Kope Formation is dominantly blue-gray shale with minor amounts of interbedded limestone. It differs from the Clays Ferry Formation in containing between 70% and 90% shale. Limestones of both formations are similar (Cressman, 1973; Anstey and Fowler, 1969; Pojeta, 1979, p. A9). In Ohio, Ford (1967) divided (in ascending order), the upper part of the Kope Formation into Grand Avenue Member and the Wesselman Tongue. In the Moffett Road section, these units were not differentiated.

The Kope Formation is overlain conformably by the Fairview Formation of which the lower 26 feet are exposed in the Moffett Road section. The Fairview Formation (Peck, 1966; Ford, 1968) is, on the average, between 70 ft and 110 ft thick. It consists of closely interbedded limestone, shale, and minor amounts of siltstone. Limestone makes up 50% to 60% of the formation and is even and thin to medium bedded. Shale constitutes 35% to 40% of the formation and makes up partings and thin beds separating the limestone beds. Limy siltstone accounts for 5% to 15% and is most abundant in the upper part of the formation.

The Point Pleasant Tongue of the Clays Ferry Formation, the Kope Formation, and the Fairview Formation were deposited on a normal marine shelf over which water may have deepened gradually northward. The Clays Ferry Formation is thought to be deposited in slightly more shallow or more agitated water than the Kope Formation (Cressman, 1973; Anstey and Fowler, 1969, as Eden Shale). Anstey and Perry (1973), in their study of the trepostome bryozoan fauna, noted that the depositional environments of the lower and the upper part of the Kope were more shallow than the environment of the middle part of the Kope and that the environment of the Kope may have become more shallow in a southerly direction in southeastern Indiana and adjacent parts of Kentucky.

The Fairview Formation indicates either an environment of deposition having slightly deeper water than the Kope Formation, or a protected area on the shelf with intermittently wave disturbed sediments (Osborne, 1973, p. 145; Weir and Peck, 1968, p. 168). In southwestern Ohio, the Fairview Formation is thought to represent deposits on shallow shoal banks (Ford, 1968, p. 1784).

Composition

The bryozoan fauna of the Moffett Road section consists of 29 species placed in 23 genera that are referred to the three extinct orders: Trepostomata, Cystoporata, and Cryptostomata. The Trepostomata are the dominant and most diverse group making up about 79 percent of the fauna. They are referred to 19 species in 14 genera: Amplexopora, Aspidopora, Atactoporella, Balticoporella, Batostoma, Bythopora, Dekayia, Eridotrypa, Heterotrypa, Homotrypa, Monotrypella, Parvohallopora, Peronopora, and Stigmatella. Two species are new: Monotrypella n. sp. and Parvohallopora n. sp. The Cryptostomata and the Cystoporata are less diverse and comprise

about 21 percent of the fauna. The Cryptostomata are referred to six species placed in five genera: Escharopora, Graptodictya, Phylloporina, Stictopora, and Stictoporella. One species, Escharopora n. sp., is new (Karklins, in press). The Cystoporata include four species in four genera: Ceramophylla, Ceramoporella, Crepipora, and Constellaria. These 23 genera, except for the trepostomes Aspidopora and Peronopora, are distributed globally in widely separated geographic regions (Astrova, 1965, 1978; McKinney, 1969, 1974; Karklins, unpublished data). Peronopora is known only from Ordovician rocks of eastern North America. The concept of Aspidopora is uncertain because the type specimens of its type species, A. areolata Ulrich (1883), have not been reevaluated. Aspidopora is known only from the Upper Ordovician strata of the tristate area of Kentucky, Ohio, and Indiana.

On the species level, the bryozoan fauna from the Moffett Road section is endemic to Ordovician rocks of eastern North America and largely to the tristate area of Kentucky, Ohio, and Indiana. Whether the observed endemism is apparent or real is uncertain for lack of comparative studies of bryozoan faunas from equivalent Ordovician strata outside the tristate area.

Only five species known from Moffett Road have been reported from Ordovician rocks of New York-Ontario region that are mostly older than the Kope Formation. The cystoporate Ceramophylla alternatum (James) occurs for the first time in the Chaumont Formation (Blackriveran Stage) and ranges through the Trenton Group of New York (Ross, 1967). In Kentucky, it is found in the upper part of the Lexington Limestone and the Clays Ferry Formation (Shermanian-Edenian Stages). In Moffett Road, C. alternatum occurs in the Point Pleasant Tongue and the Kope Formation (table 1, pls. 1, 2). Bythopora dendrina (James) and Eridotrypa mutabilis Ulrich appear for the first time at the base of the Trenton Group in the Rockland Formation of Ross, 1967, and range through the Trenton Group (Rocklandian to Edenian) of New York (Ross, 1967, 1969). In Kentucky, Eridotrypa mutabilis is common in the Lexington-Clays Ferry depositional sequence. In Moffett Road, it is found only in the Point Pleasant Tongue. Bythopora dendrina has not yet been found in the Lexington-Clays Ferry sequence of central Kentucky. In Moffett Road, however, it occurs in the Kope Formation (pls. 1, 2). Ross (1969) reported Parvohallopora onealli (James) (as Calopora) from her Shoreham Formation (Shermanian Stage) of the Trenton Group of New York. It is also common in the upper part of the Lexington Limestone and the Clays Ferry Formation of central Kentucky (Karklins, unpublished data). In Moffett Road, it is found in the Point Pleasant Tongue and the lower part of the Kope Formation (table 1, pls. 1, 2). Stigmatella nana Ulrich and Bassler was reported from the Upper Ordovician strata of Manitoulin Island, Ontario, Canada. However, its presence in Ontario cannot be verified from the published illustrations (Caley, 1936). In Moffett Road, S. nana is found in the upper beds of the Point Pleasant Tongue and the lower part of the Kope Formation (table 1, pls. 1, 2).

The remaining 24 species occurring at Moffett Road are known only from the tristate area of Kentucky, Indiana, and Ohio. About one third of these species appear for the first time in the upper part of the Lexington Limestone or its lateral equivalent of the Clays Ferry Formation (Shermanian-Edenian) (Karklins, unpublished data) and are found in the Moffett Road section and adjacent areas. They are the trepostomes Amplexopora persimilis, Monotrypella n. sp., Parvohallopora nodulosa, Peronopora vera, Stigmatella clavis, the cystoporates Ceramoporella distincta and Crepipora venusta, and the

cryptostome Escharopora n. sp. The other 16 species are known only from the Clays Ferry, Kope and Fairview Formations at the Moffett Road section or in equivalent strata in adjacent areas of Kentucky, Indiana, or Ohio.

Abundance and distribution

The trepostomes Parvohallopora and Heterotrypa and the cystoporate Ceramophylla dominate the bryozoan fauna of the Moffett Road section (fig. 2). Parvohalopora is represented by P. onealli, P. n. sp. and P. nodulosa and comprise about 39% of the prepared specimens. Heterotrypa is represented by H. ulrichi and H. frondosa and forms about 11% of the fauna. Ceramophylla is represented by C. alternatum and forms about 9% of the peeled specimens.

In the Moffet Road section, Parvohallopora onealli is abundant in the Point Pleasant Tongue of the Clays Ferry Formation and then diminishes gradually in the lower part of the Kope Formation; it is not known above collection USGS 8650-CO (pls. 1, 2). P. nodulosa occurs persistently in the Kope Formation from about 62 ft (USGS colln. 8499-CO) above the base of the Kope and ranges to 286 ft (USGS colln. 8623-CO) in the overlying Fairview Formation. Heterotrypa ulrichi appears for the first time about 44 ft above the base of the Kope Formation (USGS colln. 8485-CO) and also ranges into the succeeding Fairview Formation (USGS colln. 8618-CO). Ceramophylla alternatum ranges nearly to the top of the Kope Formation (USGS colln. 8586-CO). It is most abundant in the upper part of the Point Pleasant Tongue and the lower part of the Kope Formation and diminishes in the upper part of the Kope (pl. 2).

The remaining 20 genera constitute about 41% of the fauna and each species roughly forms from a fraction of 1% to 6% of the fauna (fig. 2). The trepostome Stigmatella and the cryptostome Escharopora are represented by two species each. The other 18 genera consist of a single species each. Stigmatella clavis and Peronopora vera constitute between 5% and 6% each of the peeled material. Both species are most abundant in the Point Pleasant Tongue and the lower part of the Kope Formation (pl. 2). S. clavis diminishes gradually in the upper part of the Kope (USGS colln. 8592-CO), and P. vera disappears in the Fairview Formation (USGS colln. 8620-CO). Bythopora dendrina forms about 5.5% of the fauna and appears to be distributed evenly in the lower and upper part of the Kope but was not recovered from the slumped part of the Kope. Its absence in the slumped middle section of the Kope is probably because adequate samples could not be obtained. The stratigraphic distribution and relative abundance of the other species is shown in plate 2.

Biostratigraphy

The bryozoan fauna of the Kope Formation from the Moffett Road section is mostly transitional between the fauna of the underlying and regionally partly equivalent Clays Ferry Formation and the regionally overlying Fairview Formation. The change in the environment of deposition between the Point Pleasant Tongue of the Clays Ferry Formation and the Kope Formation is little reflected in the composition of the bryozoan fauna. About half of the fauna consists of species that range from the Clays Ferry Formation into the Kope Formation and continue nearly to its top; others range into the overlying Fairview Formation. The other half of the fauna consist of species that

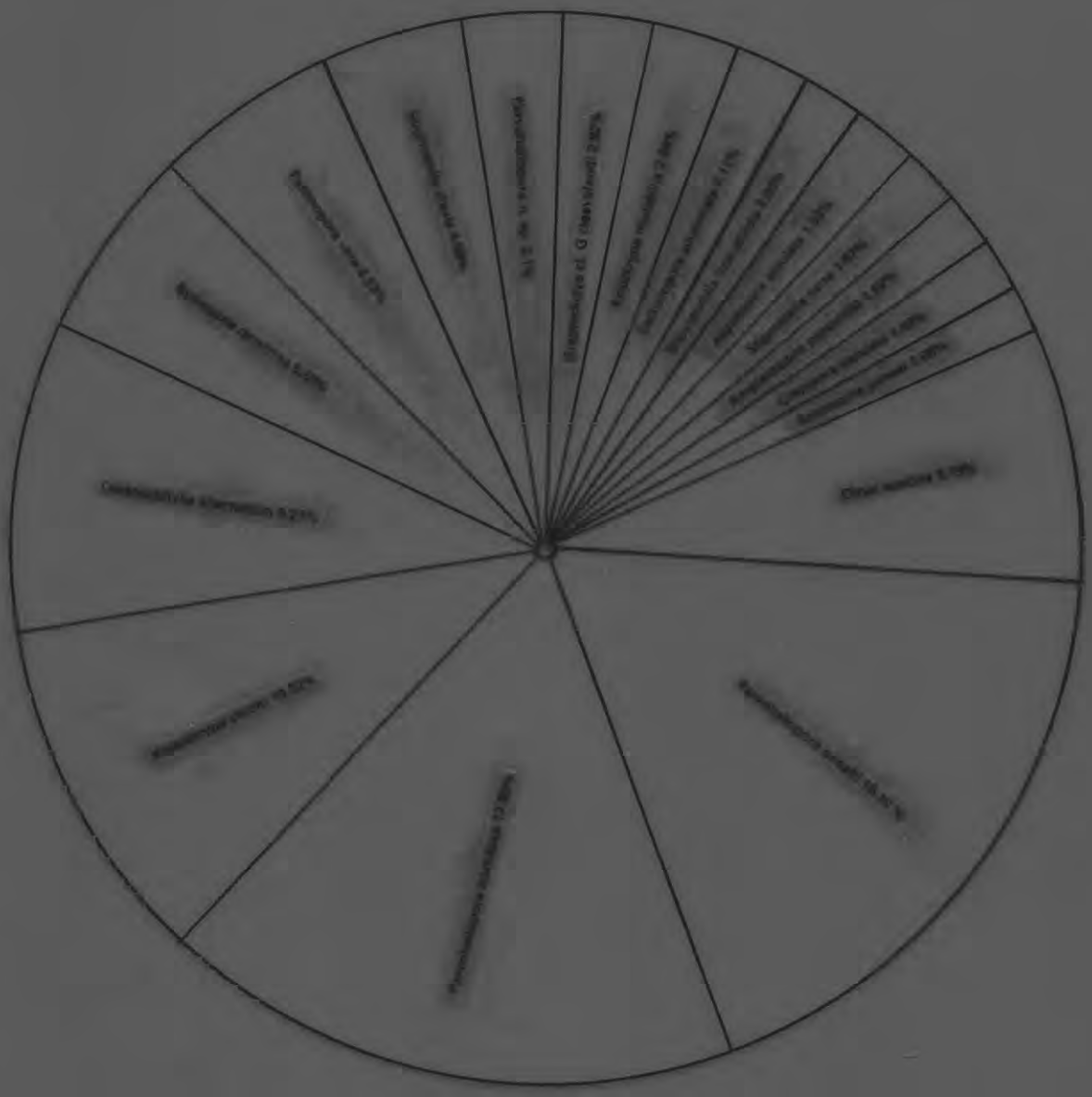


Figure 2.-- Pie diagram of relative abundance of species in the Moffett Road section.

appear for the first time in the Kope and remain restricted to it, and of those species that range into the succeeding Fairview Formation. Most of the species have overlapping ranges and are generally replaced by species of different genera in the succeeding strata.

On the basis of first occurrences, at least three bryozoan assemblage zones are recognized at Moffett Road (pls. 1, 2). In ascending order, the zonal index species are the cryptostome Stictoporella interstincta, and the trepostomes Heterotrypa ulrichi, and Batostoma jamesi. They are common and relatively widespread in the Kope Formation of the tristate area of Kentucky, Ohio, and Indiana.

Stictoporella interstincta assemblage zone. In the Moffett Road section, the first occurrence of S. interstincta defines the base of the zone. It virtually coincides (USGS colln. 8402-CO) with the base of the section. The top of the zone is defined by the first appearance of Heterotrypa ulrichi in the Kope Formation about 44 ft (USGS colln. 8485-CO) above the Point Pleasant-Kope contact. S. interstincta is not found above the lower part of the H. ulrichi zone about 68 ft (USGS colln. 8649-CO) above the Point Pleasant-Kope contact. The S. interstincta zone includes the upper 52 ft of the Point Pleasant Tongue and the lower 44 ft of the overlying Kope Formation. The upper part of the Stictoporella interstincta zone is about equivalent to the Eridotrypa mutabilis and Stigmatella clavis zone (pl. 2) of Anstey and Perry, 1973, in the lower part of the Kope Formation in southeastern Indiana and adjacent area of Kentucky.

In the Moffett Road section, the Stictoporella interstincta zone is characterized by an abundance of species that range into it from the underlying Clays Ferry Formation (pl. 2). They are Eridotrypa mutabilis, Escharopora n. sp., Parvohallopora onealli, Stigmatella clavis, Peronopora vera, Ceramophylla alternatum, Ceramoporella distincta, Crepipora venusta, and Amplexopora persimilis. Eridotrypa mutabilis disappears below the Point Pleasant-Kope contact (USGS colln. 8444-CO) at Moffett Road and its extinction appears to be region-wide (Anstey and Perry, 1973; Karklins, unpublished data). Parvohallopora onealli is abundant throughout the zone and terminates (USGS colln. 8650-CO) in the lower part of the Heterotrypa ulrichi zone (pl. 2). Stigmatella clavis and Peronopora vera occur throughout the zone and are distributed widely in the Kope Formation of the tristate area (Anstey and Perry, 1973; Karklins, unpublished data). They range regionally into the overlying Fairview Formation where they become extinct.

The Stictoporella interstincta zone in the tristates area of Kentucky, Ohio, and Indiana records the first occurrences of Aspidopora areolata (USGS colln. 8068-CO), Bythopora dendrina (USGS 8460-CO), Dekayia nicklesi (USGS colln. 8464-CO), Parvohallopora n. sp. (USGS colln. 8469-CO), Stigmatella nana (USGS colln. 8450-CO), Escharopora acuminata (USGS colln. 8438-CO), Graptodictya cf. G. cleavelandi (USGS colln. 8480-CO), and Stictopora parallela (USGS colln. 8396-CO) S. parallela appears to be restricted to the zone (pl. 2). The other species, except for E. acuminata, disappear in the Kope Formation at various levels (table 1, pls. 1, 2). E. acuminata ranges into the Fairview Formation, where it becomes extinct (USGS colln. 8623-CO).

The geographic distribution of Bythopora dendrina is somewhat irregular. Ross (1967, 1970a) reported that B. dendrina ranges through the Trenton Group (late Champlainian Series) of New York, where it is associated with Eridotrypa mutabilis. In Kentucky, E. mutabilis is common in the upper part of the Lexington Limestone and the Clays Ferry Formation and becomes extinct near the base of the Kope Formation. However, B. dendrina was not found in the Lexington-Clays Ferry depositional sequence (Karklins, unpublished data), or in the Kope Formation of southeastern Indiana (Anstey and Perry, 1973). B. dendrina occurs sparingly in the Kope (pls. 1, 2) and apparently becomes extinct near its top (USGS colln. 8595-CO) because it is not found in rocks of younger ages in the tristate area, or elsewhere.

Heterotrypa ulrichi assemblage zone. The base of the zone is placed at the first occurrence of H. ulrichi (USGS colln. 8485-CO) at 44 ft above the base of the Kope Formation. The top of the zone is defined by the first appearance of Batostoma jamesi (USGS colln. 8547-CO) about 130 ft above the base of the Kope Formation. The H. ulrichi zone ranges across about 96 ft of strata that is mostly slumped or covered in the middle part of the Kope Formation. Relatively few samples were obtained from this interval (pl. 1). H. ulrichi is the third most abundant taxon of the fauna. It ranges through the succeeding B. jamesi zone into the Fairview Formation (USGS colln. 8616-CO) where it becomes extinct. The H. ulrichi zone is characterized by the first occurrence of Balticoporella whitfieldi (USGS colln. 8511-CO). It appears to be restricted to the zone. In addition, H. ulrichi zone records the earliest occurrence of Constellaria florida (USGS colln. 8509-CO) which is a characteristic taxon of Maysvillian age rocks in the tristate area of Kentucky, Indiana, and Ohio (Cutler, 1968). Several species ranging from the underlying Stictoporella interstincta zone into the H. ulrichi zone disappear in the latter. They are S. interstincta (USGS colln. 8649-CO), Parvohallopora onealli (USGS colln. 8650-CO), Parvohallopora n. sp. (USGS colln. 8499-CO) and Stigmatella nana (USGS colln. 8511-CO).

Heterotrypa ulrichi zone roughly corresponds to the Balticoporella whitfieldi zone (Anstey and Perry, 1973) and to the lower part of the Batostoma jamesi zone (Anstey and Perry, 1973) of the Kope Formation in southeastern Indiana and adjacent area of Kentucky (pl. 2).

Batostoma jamesi assemblage zone. The base of this zone is defined at the first occurrence of B. jamesi about 130 ft above the base of the Kope Formation (USGS colln. 8547-CO). The top of the zone is placed arbitrarily at the highest stratigraphic level sampled for bryozoans (USGS colln. 8623-CO) in the Fairview Formation at Moffett Road about 286 ft above the base of the Kope Formation, or about 342 ft above the base of the section (pl. 1). In the Moffett Road section, the B. jamesi zone includes the top 130 ft of the Kope and the basal 26 ft of the overlying Fairview Formation. In addition to B. jamesi, the cryptostome Phylloporina variolata appears to be restricted to this zone (pls. 1, 2).

The Batostoma jamesi zone is especially significant biostratigraphically. It records the disappearance of several species that range into the Kope from the late Middle Ordovician strata of central Kentucky, and the first occurrences of species that later become abundant in the Maysvillian age strata of the tristate area of Kentucky, Indiana, and Ohio. Species of late Middle Ordovician age that disappear in this zone include Ceramophylla alternatum, Amplexopora persimilis, Crepipora venusta and Parvohallopora

nodulosa from Kentucky, and Bythopora dendrina from New York. In New York, Bythopora dendrina ranges through the Trenton Group and disappears near its top in the Cobourg Formation (Ross, 1967), Edenian Stage. Species that become common in succeeding rocks of Maysvillian age include Amplexopora septosa, Heterotrypa frondosa, and Homotrypa curvata. The latter is found in the Moffett Road section only in the Fairview Formation. These taxa range through the Fairview Formation and are found to be abundant in the "Bellevue Limestone" of Singh (1979) (Bellevue Tongue of the Grant Lake Limestone of Luft, 1971) of Maysvillian age.

The Batostoma jamesi zone of the Moffett Road section appears to be an approximate equivalent of the uppermost part of the Batostoma jamesi zone (Anstey and Perry, 1973) and the succeeding Dekayia aspera zone (Anstey and Perry, 1973) in the Kope Formation of southeastern Indiana and adjacent area of Kentucky (pl. 2). However, the zonal index species, Dekayia aspera, has not been found in the Moffett Road section, or in rocks of Edenian age in central Kentucky. It appears to be restricted to the Kope Formation farther north in Indiana and the adjacent area of Ohio.

Bryozoans of the Edenian Stage in the Moffett Road section

The lower boundary of the Edenian Stage, Point Pleasant Tongue-Kope contact, is 54 ft above the base of the stratotype section at Moffett Road. USGS collns. 8448-CO and 8449-CO are from strata immediately below this contact and collns. 8450-CO to 8452-CO are from above the contact (pl. 1).

The Kope Formation - Fairview Formation contact is about 316 ft above the base of the section at Moffett Road and is the upper boundary of the Edenian Stage and the lower boundary of the Maysvillian Stage, Cincinnatian Series, at Moffett Road. This boundary is marked by USGS collns. 8609-CO and 8610-CO below and USGS colln. 8611-CO above the contact at Moffett Road.

In the Moffett Road section, the Stictoporella interstincta assemblage zone spans the boundary of the Edenian Stage (the base of the Kope Formation). Within this zone, Escharopora acuminata (USGS collns. 8438-CO, 8439-CO) appears slightly below the base of the Kope, Stigmatella nana (USGS colln. 8450-CO) at the base of the Kope, and Dekayia nicklesi (USGS colln. 8464-CO) and Parvohallopora n. sp. (USGS colln. 8469-CO) appear slightly above the base of the Kope Formation for the first time. Of these species, E. acuminata ranges through the Kope into the Fairview Formation where it disappears (USGS colln. 8623-CO). It is not known to occur in younger strata. Stigmatella nana ranges into the Heterotrypa ulrichi zone in the Kope Formation where it apparently becomes extinct (USGS colln. 8511-CO). Dekayia nicklesi ranges through the Heterotrypa ulrichi zone into the Batostoma jamesi zone where it disappears in the upper part of the Kope Formation. In addition, Eridotrypa mutabilis, a typical late Middle Ordovician species in central Kentucky, disappears immediately below the base of the Kope Formation (USGS colln. 8444-CO) at Moffett Road and just above the base of the Kope Formation in southeastern Indiana and adjacent area of Kentucky (Anstey and Perry, 1973). Furthermore, Escharopora n. sp. (Karklins, in press) and Parvohallopora onealli that are also typical taxa of late Middle Ordovician in central Kentucky, range across the base of the Kope Formation and disappear in the

Heterotrypa ulrichi zone in the lower part of the Kope Formation at Moffett Road (USGS collns. 8483-CO, and 8650-CO, respectively) (pl. 1).

At Moffett Road, the Batostoma jamesi zone includes the upper part of the Kope Formation and spans the Kope-Fairview contact which is the boundary between the Edenian and Maysvillian Stages (Pojeta, 1981). Within this zone, Amplexopora septosa (USGS colln. 8600-CO) and Heterotrypa frondosa (USGS colln. 8602-CO) appear immediately below the Kope-Fairview contact, and Homotrypa curvata (USGS colln. 8620-CO) above this contact. Homotrypa curvata is a typical species of Maysvillian age (Singh, 1979). Batostoma jamesi, the zonal index species, disappears in the Fairview Formation (USGS colln. 8623-CO).

Furthermore, several typical late Middle Ordovician bryozoans of central Kentucky: Ceramophylla alternatum (USGS colln. 8586-CO), Crepipora venusta (USGS colln. 8573-CO), and Amplexopora persimilis (USGS colln. 8581-CO) disappear in the Batostoma jamesi zone in the upper part of the Kope Formation, and Parvohallopora nodulosa (USGS colln. 8623-CO) in the lower part of the Fairview Formation. Bythopora dendrina, which has not yet been found in central Kentucky, is a typical late Middle Ordovician species in New York, where it disappears in the Cobourg Formation (Ross, 1967) (Edenian Stage). At Moffett Road it disappears in the Batostoma jamesi zone near the top of the Kope Formation (pl. 1).

Species that are restricted to the lower part of the Kope Formation at Moffett Road include Stigmatella nana (USGS colln. 8450-CO), Monotrypella n. sp. (USGS colln. 8488-CO) in the Stictoporella interstincta-Heterotrypa ulrichi zones and Balticoporella whitfieldi in the Heterotrypa ulrichi zone (pl. 2). Phylloporina variolata is found only in the upper part of the Kope Formation in the Batostoma jamesi zone (USGS colln. 8568-CO).

At Moffett Road (this report) and in southeastern Indiana and adjacent area of Kentucky (Anstey and Perry, 1973), Heterotrypa ulrichi appears for the first time in the Kope Formation at a stratigraphic level about 44 ft above the base of the Kope Formation (USGS colln. 8485-CO at Moffett Road). In the same region, Balticoporella whitfieldi (USGS colln. 8511-CO) and Dekayia nicklesi (USGS colln. 8464-CO) also occur for the first time at roughly similar stratigraphic level (pls. 1, 2) (Anstey and Perry, 1973).

The association of the above bryozoan species with the zonal index species Stictoporella interstincta, Heterotrypa ulrichi, and Batostoma jamesi permits recognition of the Edenian Stage in the tristate area of Kentucky, Indiana, and Ohio. However, the transitional component of the bryozoan fauna in the Kope Formation, as noted in this report, requires that strata of uncertain stratigraphic position need to be adequately sampled for bryozoans for determination of their stratigraphic position in a biostratigraphic framework based on distribution of bryozoans. Whether bryozoan associations similar to those of the Kope Formation at Moffett Road can be recognized in equivalent rocks outside the tristate area of Kentucky, Indiana, and Ohio needs to be tested.

Systematic Paleontology

The classification of the Paleozoic bryozoans has had a long and complex

history. A review of this history is beyond the scope of this report. Bryozoan genera in this report are assigned on the ordinal level to the Trepostomata Ulrich 1882, the Cystoporata Astrova 1964, and the Cryptostomata Vine 1884. McKinney (1971) discussed briefly the problems that are associated with the phylogenetic classification of the trepostome bryozoans on the generic and higher taxonomic levels. He noted the inadequacy of previously established concepts for the various trepostome families but concluded that most of the traditional families in the classification of Bassler (1953) probably represent phylogenetic groups that could be placed at familial or some other taxonomic levels in later revisions of the classification of the Trepostomata. Because of the uncertainty of the suprageneric classification, the grouping of the trepostome genera in families as they are generally recognized in the classification of Bassler (1953) is informal.

Astrova (1964) established the order Cystoporata and originally placed in it several bryozoan families including Ceramoporidae Ulrich 1882, and Constellariidae Ulrich 1893 that are found at Moffett Road. The order Cystoporata has gained general acceptance and has been reviewed by Utgaard (in press). In 1968, Utgaard discussed the suprageneric classification of the family Ceramoporidae, and his definition of the Ceramoporidae is followed here. The family Constellariidae, however, is used herein informally.

Blake (1975) briefly reviewed the history of the classification of the order Cryptostomata and the phylogenetic significance of the family Phylloporinidae of the cryptostome suborder Fenestelloidea. Because of the uncertain taxonomic status of the Phylloporinidae (Ross, 1963, 1964; Blake, 1975) this familial name is used herein informally. Karklins (in press) reviewed the taxonomic history of the cryptostome suborder Ptilodictyoidea Astrova and Morozova 1956 and revised concepts for its families including Ptilodictyidae Zittel 1880 and Rhinidictyidae Ulrich 1893 and their genera. His revised classification of the ptilodictyoid bryozoans is followed herein.

The descriptive terminology of bryozoans used here generally follow that of Bassler (1953), Boardman (1959, 1960a, 1971), Ross (1964), Karklins (1969) and Utgaard (1973).

Order Trepostomata

Family Monticuliporidae

Genus Aspidopora Ulrich, 1882

Type species.--Aspidopora areolata Ulrich, 1883, p. 164, by subsequent designation; Kope Formation = ("...in the shales just above low water mark in the Ohio river at Cincinnati, O. "(Ulrich, 1883, p. 165)), Late Ordovician.

Remarks.--Ulrich (1882, p. 155) described Aspidopora and subsequently (Ulrich, 1883, p. 164) designated A. areolata to be its type species. Bassler (1953, p. G95) redefined the genus. Subsequently, Astrova (1978, p. 89) placed Aspidopora in synonymy with the genus Prasopora Nicholson and Etheridge. In this study, however, Aspidopora is retained as a separate and distinct genus until the material of its type species can be reevaluated and compared morphologically with related genera of this family. Bassler's (1953) definition of Aspidopora is used herein.

Aspidopora areolata Ulrich, 1883

Aspidopora areolata Ulrich, 1883, p. 164, pl. 7, figs. 2-2c; Bassler, 1953, text-fig. 55, 3a-d.
Monticulipora areolata (Ulrich). James, 1894, p. 183.

Taxonomic remarks.--Specimens assigned to A. areolata, as defined by Ulrich (1883), are small, thin encrusting zoaria having autozooecia with circular to subelliptical cross sections in exozones. Autozooecia are almost completely separated by mesozooecia in outer exozones. The autozooecial walls are exceedingly thin and locally contain small stereostyles with exceedingly small cores at points of contact between adjacent autozooecial walls in outer exozones. Autozooecia are almost completely separated by mesozooecia. Cystiphragms are common in zoaria of A. areolata and occur in endozones at the basal layer of zoaria and constrict autozooecial chambers in inner exozones. Basal diaphragms are sparse or are lacking in autozooecial chambers. Mesozooecia contain closely spaced diaphragms.

The type material of A. areolata which is the type species of Aspidopora Ulrich 1882, has not been formally reevaluated since Ulrich established the genus in 1882. The specimens found during this study conform with the syntypes USNM 43632 of Aspidopora areolata on file at the U.S. National Museum (USNM).

Geographic and stratigraphic distribution.--A. areolata is known only from the tristate area of Kentucky, Indiana and Ohio where Ulrich (1883) found it, according to Bassler (1915, p. 80), in Bassler's "Fulton strata of the Eden Formation." In the Moffett Road section, A. areolata ranges from the base of the section of the Point Pleasant Tongue into the Kope Formation to about 200 ft. (USGS colln. 8548-CO) above the base of the formation.

Genus Atactoporella Ulrich, 1883

Type species.--Atactoporella typicalis Ulrich, 1883, p. 247, by original designation; Kope Formation ("Cincinnati Group" of Ulrich (1883)), Late Ordovician.

Remarks.--Bassler (1953, p. G95) redefined the genus. Subsequently, Astrova (1978, p. 98) redescribed Atactoporella in her posthumous monograph on the Order Trepostomata. Astrova's definition of Atactoporella is essentially the same as that of Bassler (1953) which is used herein.

Atactoporella typicalis Ulrich, 1883

Atactoporella typicalis Ulrich, 1883, p. 248, pl. 12, figs. 3-3d; 1896, p. 272, fig. 450; James, 1895, p. 80; Bassler, 1953, p. G95, fig. 55-2; Anstey and Perry, 1973, p. 19, pl. 4, figs. 3-7.

Taxonomic remarks.--Anstey and Perry (1973) in a computer oriented study evalutated the zoarial characters of A. typicalis from the Kope Formation. A. typicalis has encrusting and erect zoaria with irregularly subcylindrical branches. The autozooecia of A. typicalis are subcircular and with irregularly petaloid autozooecial chambers in cross section in exozones. The autozooecia generally have thin walls and are nearly isolated by mesozooecia. Stereostyles are common and occur mainly at contacts between autozooecia. They commonly offset and inflect autozooecial chambers. Overlapping cystiphragms occur in regular series in most autozooecia. Cystiphragms commonly decrease in size distally. Basal diaphragms are common, and occur irregularly and are generally oblique to the axis of autozooecial chambers. Maculae consisting of irregularly shaped zooecia occur regularly and generally project slightly above the zoarial surface.

Geographic and stratigraphic distribution.--A. typicalis is known only from the tristate area of Kentucky, Indiana and Ohio where it is restricted to the lower part of the Kope Formation. In Moffett Road, A. typicalis ranges in the Kope Formation from 42 ft to 76 ft above its base, USGS collns. 8482-CO and 8522-CO, respectively.

Anstey and Perry (1973) found it in the approximate interval between 51 and 82 ft above the base of the Kope Formation (Eden Shale of Anstey and Perry) in their area of study in Kentucky, Indiana and Ohio. Ulrich (1883, p. 250) found A. typicalis in his "... the lower 100 feet of strata exposed at Cincinnati, Ohio and Covington, Ky."

Genus Homotrypa Ulrich, 1882

Type species.--Homotrypa curvata Ulrich, 1882, p. 241, by original designation; Fairview Formation ("Cincinnati Group" of Ulrich (1882)), Late Ordovician.

Remarks.--Ross (1970a, p. 373) discussed the genus Homotrypa and her concept for the genus is used herein.

Homotrypa curvata Ulrich, 1882

Homotrypa curvata Ulrich, 1882, p. 242, pl. 10, figs. 7-7d; Bassler, 1903, p. 575; Cumings, 1908, p. 845, pl. 17, figs. 3-3b, pl. 29, fig. 13; McFarlan, 1931, p. 91; Bassler, 1953, text-fig. 56, 1a-d; Singh, 1979, p. 217, pls. 32, 33.

Taxonomic remarks.--Singh (1979) redescribed H. curvata which is the type species of Homotrypa from his "Bellevue Limestone," (Bellevue Tongue of the Grant Lake Limestone of Luft, 1971) Upper Ordovician, of Ohio, Indiana and Kentucky. A single specimen found in the section of this study is consistent

with those specimens described by Singh in having autozooecia with undulating and locally crenulated walls and basal diaphragms in endozones. In exozones, stereostyles are well defined and abundant.

Geographic and stratigraphic distribution.--H. curvata is known only from Kentucky, Ohio, and Indiana where it is restricted to the Fairview Formation (Cumings, 1908; Bassler, 1915; McFarlan, 1931) and the "Bellevue Limestone" as used by Singh (1979) of the Maysvillian Stage, Late Ordovician.

In the Moffett Road section, H. curvata is found only in the Fairview Formation about 16 ft above its base, or about 334 ft above the base of the section (USGS colln. 8620-CO).

Genus Peronopora Nicholson 1881

Type species.--Chaetetes decipiens Röminger, 1866, p. 115; subsequent designation by ICZN (1968, Opinion 838) upon submitted application by Utgaard and Boardman (1965) "Corryville Member of the McMillan Formation, Maysville Group, Upper Ordovician" (Boardman and Utgaard, 1966).

Remarks.--Boardman and Utgaard (1966) discussed the zoarial development of Peronopora and revised the concept for the genus. The definition of the genus Peronopora as given by Boardman and Utgaard (1966) is used herein.

Peronopora vera Ulrich, 1888

Peronopora vera Ulrich, 1888, p. 40 (an indication); Nickles, 1905, p. 46, pl. 2, fig. 1; Cumings, 1908, p. 867, pl. 22, figs. 2-2b, pl. 31, fig. 5; Cumings and Galloway, 1913, p. 52, pl. 17, figs. 2-2a; McFarlan, 1931, p. 96; Boardman and Utgaard, 1966, p. 1096; Anstey and Perry, 1969, p. 245, pls. 31, 32; 1973, p. 22, pl. 19, figs. 1, 2, pl. 20, pl. 21, figs. 1-4; Pachut and Anstey, 1979, p. 178, fig. 3c; Pachut, 1982, p. 712.
?Peronopora vera Ulrich. Parks and Dyer, 1922, p. 7, pl. 1, figs. 4, 5, pl. 5, fig. 3.
?Peronopora vera Ulrich (not Nickles 1905). Fritz, 1976, p. 10, fig. 3a-d.

Taxonomic remarks.--Anstey and Perry (1969) redescribed P. vera on the basis of its primary type material and subsequently determined (Anstey and Perry, 1973) its stratigraphic distribution in the Eden Shale (the Kope Formation of current usage) in their study area of Kentucky, Indiana and Ohio. P. vera is characterized by having erect zoaria with the bifoliate growth habit and can occur locally as irregularly encrusting zoarial layers. P. vera possesses relatively thin mesothecae that lack median rods. Autozooecial walls are generally uneven in thickness in well-defined exozones of P. vera.

Geographic and stratigraphic distribution.--In the Moffett Road section, P. vera occurs in the Point Pleasant Tongue of the Clays Ferry Formation, the Kope Formation, and ranges into the overlying Fairview Formation for about 16 ft (USGS colln. 8620-CO) (fig. 2) above its base. P. vera is widespread in the Kope Formation of Kentucky, Indiana and Ohio (Anstey and Perry, 1973). In central Kentucky, it appears in the Lexington Limestone at about 220 ft above its base and ranges through the Clays Ferry Formation (Karklins, unpublished data). Parks and Dyer (1922), and Fritz (1976) described P. vera from rocks of Upper Ordovician of Ontario, Canada. These occurrences, however, have not

been verified since the revision of the concept for P. vera by Anstey and Perry (1969, 1973).

Family Heterotrypidae

Genus Dekayia Milne-Edwards and Haime 1851

Type species.--Dekayia aspera Milne-Edwards and Haime, 1851, by original designation, Upper Ordovician (Boardman and Utgaard, 1966, p. 1105).

Remarks.--Boardman and Utgaard (1966, p. 1103) redescribed the genus and emended its definition. The definition for the genus Dekayia by Boardman and Utgaard (1966) is used herein.

Dekayia nicklesi (Ulrich and Bassler, 1904)

Stigmatella nicklesi Ulrich and Bassler, 1904, p. 36, pl. 10, figs. 1-3; pl. 14, figs. 9, 10.
Dekayia nicklesi (Ulrich and Bassler). Boardman and Utgaard, 1966, p. 1104.

Remarks.--Boardman and Utgaard (1966) reassigned Stigmatella nicklesi Ulrich and Bassler to Dekayia in their revised definition of Dekayia. D. nicklesi has zoaria with encrusting growth habit in which endozones are exceedingly narrow and indistinctly defined. Autozooecia of D. nicklesi are irregularly subpolygonal in cross section and possess relatively large stereostyles in autozooecial corners in exozones. Smaller stereostyles may occur in walls between the corners of autozooecia. Autozooecial walls in exozones of D. nicklesi are slightly undulating and minutely crenulated locally. One or two basal diaphragms occur in some autozooecia of a zoarium. Stereostyles of D. nicklesi commonly originate within the endozones and exozones and are commonly offset from autozooecial walls in exozones. Mesozooecia are virtually absent in D. nicklesi.

Geographic and stratigraphic distribution.--The known stratigraphic range of D. nicklesi is from the lower part of the Kope Formation (Edenian Stage) to the Fairview Formation (Maysvillian Stage) in the tristate area of Kentucky, Indiana and Ohio. It is not known to occur outside the tristate area. In Moffet Road, D. nicklesi is found between 18 ft and 78 ft, (USGS collns. 8464-CO and 8522-CO respectively), and at 198 ft. (USGS colln. 8564-CO) above the base of the Kope Formation. Ulrich and Bassler (1904) noted that D. nicklesi occurs in the upper part of the Fairmount beds of their "Lorraine strata" (mainly Fairview Formation of current usage). Cumings and Galloway (1913) reported D. nicklesi from the Southgate Member of their Eden Formation at Tanner's Creek, Indiana.

Genus Heterotrypa Nicholson, 1879

Type species.--Monticulipora frondosa d'Orbigny, 1850; subsequent designation by ICZN (1968, Opinion 838) upon submitted application by Utgaard and Boardman (1965). "Fairmount Member of the Fairview Formation of the Maysville Group at Cincinnati, Ohio" (Boardman and Utgaard, 1966, p. 1106).

Remarks.--Boardman and Utgaard (1966) discussed the zoarial development of Heterotrypa and revised the concept for the genus. The definition of the genus Heterotrypa as given by Boardman and Utgaard (1966) is used herein.

Heterotrypa frondosa (d'Orbigny, 1850)

Monticulipora frondosa d'Orbigny, 1850, p. 25; Boule and Thevenin, 1906, pl. 141, fig. 9, p. 6, pl. 2, figs. 9, 10; pl. 3, figs. 1, 2.

Chaetetes frondosus (d'Orbigny). Milne-Edwards and Haime, 1851, p. 267, pl. 19, figs. 5, 5a.

Heterotrypa frondosa (d'Orbigny). Ulrich, 1882, p. 235; 1883, p. 63; Ulrich and Bassler, 1904, p. 25, pl. 11, figs. 1-3; McFarlan, 1931, p. 97; Bassler, 1953, text-fig. 59, 1a-c; Utgaard and Boardman, 1965, p. 115; Boardman and Utgaard, 1966, pl. 140; Singh, 1979, p. 210, pl. 28, 29.

Dekayia frondosa (d'Orbigny). Cumings, 1908, p. 812, pl. 15, figs. 1-1e, pl. 28, fig. 9, pl. 29, fig. 1.

Taxonomic remarks.--Utgaard and Boardman (1965) designated Heterotrypa frondosa (d'Orbigny) under plenary power by the International Commission on Zoological Nomenclature (1968) to be the type species of the genus Heterotrypa Nicholson. Subsequently, Boardman and Utgaard (1966) discussed the concept for the genus Heterotrypa, as based on H. frondosa, and closely related species. Singh (1979) redescribed H. frondosa from his "Bellevue Limestone" (Bellevue Tongue of the Grant Lake Limestone (Luft, 1971)), Upper Ordovician, of Kentucky, Ohio, and Indiana. Specimens found during this study conform closely to those illustrated by Boardman and Utgaard (1966, pl. 140) and by Singh (1979, p. 210, pl. 28, 29).

H. frondosa is related to H. ulrichi and their ranges overlap in the uppermost part of the Kope Formation in the Moffett Road section. H. frondosa differs from H. ulrichi in having large and irregularly branching zoaria with flattened or frondlike branches having abundant endostereostyles and relatively abundant basal diaphragms in endozones, whereas zoaria of H. ulrichi are moderately large, on the average, and with cylindrical zoarial branches. H. ulrichi has well-defined stereostyles of moderate size in autozooecial walls of exozones and generally lack or have sparse endostereostyles in endozones. Basal diaphragms are virtually absent in endozones of H. ulrichi. Fragments of some zoaria of both species that are found in the same collections from the uppermost part of the Kope Formation are difficult to differentiate in the peeled or sectioned material because of their morphological similarity. These zoarial fragments that appear to be morphologically intermediate between H. frondosa and H. ulrichi are assigned to H. frondosa herein.

Geographic and stratigraphic distribution.--H. frondosa is known only from Kentucky, Ohio, and Indiana where it occurs in rocks of late Edenian and Maysvillian Stages.

In the Moffett Road section H. frondosa occurs in the uppermost part of the Kope Formation about 254 ft (USGS colln. 8602-CO) above the base of the formation and ranges into the Fairview Formation (USGS colln. 8623-CO). This is the earliest known occurrence of H. frondosa. Cumings and Galloway (1913) found H. frondosa in the Fairview and McMillan Formations of current usage (lower part of the Dillsboro Formation of authors) at Tanners Creek, Indiana. Singh (1979) established that H. frondosa is abundant in his "Bellevue Limestone," Maysvillian Stage, of Ohio, Indiana, and Kentucky. Whether H. frondosa ranges into rocks of Richmondian Stage has not been verified (Boardman and Utgaard, 1966, p. 1106). Thus, the known range of H. frondosa is late Edenian and Maysvillian Stages.

Heterotrypa ulrichi (Nicholson, 1881)

Monticulipora (Heterotrypa) ulrichi Nicholson, 1881, p. 131, fig. 22; James and James, 1888, p. 179; James, 1894, p. 201.

Monticulipora ulrichi (Nicholson). Hall, 1883, p. 249, pl. 11, fig. 10; James and James, 1888, p. 179; James, 1894, p. 201.

Monticulipora ohioensis James, 1888, p. 183; 1894, p. 207.

Dekayella ulrichi (Nicholson). Ulrich, 1883, p. 91, 153; Nickles and Bassler, 1900, p. 227; Cumings, 1901, p. 374; Nickles, 1905, p. 47, pl. 2, fig. 4; Bassler, 1906, p. 34, pl. 2, figs. 13, 14; Parks and Dyer, 1922, p. 9, pl. 1, figs. 9, 11; pl. 5, fig. 9; Ruedemann, 1925, p. 92; McFarlan, 1931, p. 97, pl. 9, fig. 23.

Dekayella robusta Foord, 1884, p. 341, pl. 12, figs. 2-2d.

Dekayella ulrichi-robusta Foord. Nickles and Bassler, 1900, p. 228.

Dekayia ulrichi (Nicholson). Cumings, 1902, p. 13, pl. 9, fig. 1; 1908, p. 824, pl. 14, figs. 4, 4b; pl. 28, fig. 7.

Dekayia ulrichi - robusta Foord. Cumings, 1902, p. 212, pl. 9, fig. 4; pl. 10, fig. 9; 1908, p. 826, pl. 14, fig. 2, 2b; pl. 27, fig. 22.

Heterotrypa ulrichi (Nicholson). Boardman and Utgaard, 1966, pl. 142, figs. 1a, b, 2, 3a, b, 4a, b; Anstey and Perry, 1973, p. 21, pls. 16-18; Pachut and Anstey, 1979, p. 180, fig. 3d; Pachut, 1982, p. 712.

Taxonomic remarks.--H. ulrichi has ramose zoaria with cylindrical and slightly flattened branches, commonly with conspecific overgrowth. Autozooecia in endozones of H. ulrichi have irregularly polygonal cross sectional shapes and slightly undulating walls longitudinally. In exozones, autozooecia are irregularly subcircular in cross section with slightly moniliform walls of relatively uniform thickness. Basal diaphragms are virtually absent in endozones; they occur regularly and are evenly spaced in inner exozones. Endostereostyles (endoacanthopores of authors) are generally lacking in endozones and are uncommon in exozones. Small stereostyles (exoacanthopores of authors) with distinct cores are common throughout exozones where they occur mostly in corners of autozooecia. Stereostyles in exozones commonly inflect slightly autozooecial walls. Mesozooecia having irregularly cross sectional shapes are common in exozones and partly isolate autozooecia. Mesozooecial diaphragms are closely spaced and are generally thicker than the basal diaphragms of autozooecia. Maculae are common and generally are flush with the zoarial surface. They consist of clusters of mesozooecia and zooecia having thicker walls than those of autozooecia.

Boardman and Utgaard (1966) reviewed the taxonomic history of H. ulrichi and illustrated the distinguishing zoarial characters of the hypotypes on file at the U.S. National Museum (USNM). Until the taxonomic status of specimens of H. ulrichi in the collection of H. A. Nicholson (Perry, Horowitz and Anstey, 1973) is evaluated, the hypotypes in collections at the USNM are the nearest examples for the concept of the species. Specimens assigned to H. ulrichi in this study conform with the hypotypes on file at the USNM.

Geographic and stratigraphic distribution.--H. ulrichi is found in the tristate area of Kentucky, Indiana and Ohio, where it occurs in rocks of Edenian and Maysvillian Stages.

In the Moffet Road section, H. ulrichi occurs in the Kope Formation at 44 ft (USGS colln. 8485-CO) above its base for the first time. It ranges from the Kope Formation (Edenian Stage) into the overlying Fairview Formation for

about 10 ft (USGS colln. 8618-CO). Anstey and Perry (1973) reported H. ulrichi from a similar stratigraphic interval of the Kope Formation (Eden Shale of Anstey and Perry) in their area of study of Indiana, Ohio and Kentucky. Boardman and Utgaard (1966) noted that H. ulrichi is abundant in the upper part of the Kope Formation (Southgate and McMicken Members of the Eden Group of Boardman and Utgaard). Cumings and Galloway (1913) reported H. ulrichi from the upper part of their Eden Formation, and the Mount Hope and Fairmount Members (Maysvillian Stage) of the Fairview Formation at Tanners Creek, Indiana. Nickles (1905) found H. ulrichi in his Eden Formation of Kentucky.

The reported finds of H. ulrichi in the Dundas Formation (Upper Ordovician) of Ontario (Parks and Dyer, 1922) and in the Whetstone Gulf Formation (Upper Ordovician) of New York (Ruedemann, 1925) need to be verified.

Genus Stigmatella Ulrich and Bassler, 1904

Type species.--Stigmatella crenulata Ulrich and Bassler, 1904, p. 33; by original designation; "Richmond Formation," Late Ordovician, Ohio.

Remarks.--The original definition for the genus Stigmatella by Ulrich and Bassler (1904, p. 33) is used herein.

Ulrich and Bassler (1904) characterized Stigmatella as having zoaria with irregularly various growth habits in which autozooecia have polygonal to subrounded cross sectional shapes, relatively few basal diaphragms and numerous but irregularly distributed stereostyles (acanthopores of Ulrich and Bassler). Mesozooecia (mesopores of Ulrich and Bassler) were sparse or irregularly variable in abundance in zoaria of Stigmatella.

Stigmatella clavis (Ulrich, 1883)

Leptotrypa clavis Ulrich 1883, p. 161, pl. 6, figs. 3, 3a.
Stigmatella clavis (Ulrich). Ulrich and Bassler, 1904, p. 34, pl. 10, fig. 4; Cumings, 1908, p. 881, pl. 24, figs. 2, 2a; pl. 25, fig. 3. Armstrong, 1945, p. 151. Anstey and Perry, 1973, p. 22, fig. 6, pl. 22, figs. 2-6.

Taxonomic remarks.--Anstey and Perry (1973) evaluated Stigmatella clavis in their study of trepostomes from the Kope Formation. S. clavis is characterized by having small encrusting subglobular and irregularly shaped zoaria commonly with conspecific overgrowth. Endozones of S. clavis are poorly defined and without basal diaphragms. In exozones, autozooecia have thin walls that are slightly sinuous and may be crenulated. Stereostyles of small size are abundant in most zoaria and commonly inflect autozooecial walls or project slightly into autozooecial chambers. Basal diaghragms in exozones are sparse and occur irregularly. Mesozooecia are uncommon; mesozooecial diaphragms occur irregularly. Maculae are generally indistinct and occur commonly in most zoaria.

Geographic and stratigraphic distribution.--S. clavis is common in Kentucky, Indiana and Ohio where it ranges from the Shermanian Stage (Middle Ordovician) to Maysvillian Stage (Late Ordovician). In Moffett Road, S. clavis occurs in the Point Pleasant Tongue of the Clays Ferry Formation, and in the Kope Formation. However, it is relatively sparse in the upper part of the Kope (figs. 2, 4).

In central Kentucky, S. clavis occurs for the first time in the Lexington Limestone about 216 ft above its base and ranges through the upper part of the formation into the Clays Ferry Formation (Karklins, unpublished data).

Anstey and Perry (1973) noted that S. clavis occurs in the lower part of the Kope Formation (Eden Shale of Anstey and Perry), is virtually absent in the middle part of the formation and occurs again in the upper part of the Kope Formation in the tristate area of Kentucky, Indiana, and Ohio. They attributed the general absence of S. clavis to the muddier environment of deposition in the middle part of the Kope than in the lower or upper part of the formation. Cumings (1908, p. 881) found S. clavis in his "Eden" and lower part of his "Maysville" strata at Tanners Creek, Indiana.

Stigmatella nana Ulrich and Bassler, 1904

Stigmatella nana Ulrich and Bassler, 1904, p. 36, pl. 10, figs. 7-10; pl. 14, figs. 11, 12.

Taxonomic remarks.--S. nana has irregularly branching zoaria that can be encrusting in part. Autozooecia in the endozones are polygonal in cross section having thin undulating and locally crenulated walls. Basal diaphragms are absent in the endozones. In exozones, autozooecia of S. nana are subpolygonal to irregularly subcircular in cross section. The exozones are generally narrow. Autozooecial walls are slightly undulating and locally variable in thickness. Stereostyles in autozooecial walls are common and occur in junctions between autozooecia and between autozooecia and mesozooecia. Stereostyles are small with distinct cores. Basal diaphragms in autozooecia are sparse and occur irregularly. Mesozooecia are sparse and scattered. Mesozooecial diaphragms are sparse.

Geographic and stratigraphic distribution.--S. nana occurs in the Kope Formation of Kentucky, Indiana, and Ohio. In Moffett Road, S. nana ranges from the base of the Kope Formation (USGS colln. 8450-CO) to 74 ft (USGS colln. 8511-CO) above its base. Ulrich and Bassler (1904, p. 36) described it from their "Utica" Formation (Kope Formation of current usage) in Kentucky and near Cincinnati, Ohio. Caley (1936) thought to have found S. nana in the Wekwemikongsing Formation (Upper Ordovician) of Manitoulin Island, Ontario. This formation is included in the Edenian Stage in the biostratigraphic classification of Liberty (1969).

Family Batostomellidae

Genus Bythopora Miller and Dyer, 1878

Type species.--Bythopora dendrina (James, 1878a); subsequent designation by Ross (1967, p. 641); from the "Middle part of the Cincinnati Group" of Miller and Dyer, 1878, p. 6; Upper Ordovician; at Cincinnati, Ohio.

Ross (1967) reviewed the taxonomic history of the genus Bythopora and established that Bythopora dendrina (James) is the valid type species of the genus. Specimens assigned to B. dendrina in this study conform in general with the morphological concept for B. dendrina as defined by Ross (1967).

Bythopora dendrina (James, 1878)

Helopora dendrina James, 1878a, p. 3; 1878b, p. 14.

Bythopora dendrina (James) Nickles and Bassler, 1900, p. 185; Bassler, 1906, p. 20; Ross, 1967, p. 642, pl. 67, figs. 1-8, 10-13; pl. 69, fig. 4, pl. 72, fig. 3.

Bythopora fruticosa (James). Miller and Dyer, 1878, p. 6, pl. 4, figs. 6, 6a; Miller, 1889, p. 295, fig. 461.

Taxonomic remarks.--B. dendrina is characterized by having small ramose zoaria with thin cylindrical branches. In endozone, autozooecia are subparallel to branch axis and generally intercalate at regular intervals, curving gently outwardly. In exozones autozooecia of B. dendrina are mostly contiguous, have subelliptical cross sectional shapes and are aligned alternately in indistinct longitudinal ranges. Small stereostyles having exceedingly thin cores occur locally in walls of some autozooecia in outer exozones. Basal diaphragms in B. dendrina are virtually absent, but they may occur singly in chambers of some autozooecia. Mesozooecia are common in outer exozones of some zoaria and commonly occur in pairs between autozooecia.

B. dendrina (James) is closely related to B. arctipora (Nicholson) which Bassler (1906, p. 19, pl. 2, figs. 1, 2) reviewed in his work on the James type collection. B. dendrina and B. arctipora possess the same zoarial growth habits, budding pattern of autozooecia and autozooecial wall microstructure. Both species are reported (Bassler, 1906, 1915) from the Kope Formation of the tristate area of Kentucky, Indiana and Ohio. The close morphological similarity between B. dendrina and B. arctipora and close geographic proximity of occurrences suggests that these species are conspecific. However, the type specimens in collections of H. A. Nicholson have become available for study only recently (Perry, Horowitz and Anstey, 1973). Until the taxonomic status of B. arctipora in the collection of H. S. Nicholson is evaluated, it is retained as a separate species from B. dendrina (James).

Geographic and stratigraphic distribution.--B. dendrina is a relatively long ranging species in rocks of Late Champlainian and early Cincinnatian Edenian ages of New York and of Edenian age in Kentucky and Ohio. In the Moffett Road section, B. dendrina ranges in the Kope from 16 ft (USGS colln. 8460-CO) to 102 ft (USGS colln. 8542-CO) and from 180 ft (USGS colln. 8557-CO) to 238 ft (USGS colln. 8595-CO) above its base. Bassler (1906, 1915) noted B. dendrina in the Fairview Formation near Cincinnati, Ohio. Ross (1969) established that the range of B. dendrina is from the Rockland Formation (Rocklandian Stage) to the Cobourg Formation (Edenian Stage) in New York. B. dendrina, however, has not yet been found in rocks of Kirkfieldian and Shermanian ages in central Kentucky (Karklins, unpublished data).

Genus Eridotrypa Ulrich, 1893

Type species.--Eridotrypa mutabilis Ulrich, 1893, p. 264; by original designation. "Galena Shales" of Ulrich (1893, p. 266) (=approximate stratigraphical equivalent of the Cummingsville Member of the Galena Dolomite of current usage), Middle Ordovician, Minnesota.

Remarks.--Ross (1967, p. 635) emended the concept for Eridotrypa and her diagnosis of the genus is used herein.

Eridotrypa mutabilis Ulrich 1893

Eridotrypa mutabilis Ulrich 1893, p. 265, pl. 26, figs. 22-28, 31, 32; Sardeson, 1901, p. 13, pl. A, fig. 11, text fig. 1h; Bassler, 1953, text

fig. 63, 5a-e; Ross, 1967, p. 637, pl. 69, figs. 1, 5, 6, 9, 11; pl. 71, figs. 1-10; Anstey and Perry, 1973, p. 21, fig. 6, 8; pl. 11, pl. 12, figs. 1-4; McKinney, 1975, pl. 1, fig. 5; 1976, pl. 5, figs. 2,3.

Eridotrypa aedilis (Eichwald). Bassler, 1911, p. 242, in part, text fig. 138; (?) Eridotrypa aedilis (Eichwald). Wilson and Mather, 1916, p. 55; McFarlan 1931, p. 103, pl. 2, figs. 13, 15; pl. 8, fig. 13; Sardeson, 1936, p. 188, pl. 15, fig. 7; Twenhofel, 1938, p. 43; Fritz, 1957, p. 16, pl. 6, fig. 4; pl. 7, figs. 4, 5.

Taxonomic remarks.--Ross (1967) evaluated the type material of E. mutabilis and established it to be the valid type species of the genus Eridotrypa. E. mutabilis is characterized by having relatively large ramose zoaria having wide endozones and exozones. Autozooecia in exozones of E. mutabilis have polygonal to subpolygonal cross sectional shapes and relatively well-defined autozooecial boundaries. Stereostyles in autozooecial walls in exozones are sparse and indistinct with exceedingly thin cores; they generally occur in outer exozones. Basal diaphragms are common and evenly spaced in middle parts of exozones of most autozooecia of a zoarium. Mesozooecia are sparse and are locally commonly absent in zoaria.

Geographic and stratigraphic distribution.--E. mutabilis is common and widespread in rocks of Late Champlainian Series of eastern North America. Its known biostratigraphic range is from the Rocklandian Stage (New York, Minnesota) (late Middle Ordovician) to the Edenian Stage (early Late Ordovician) of New York and Kentucky. E. mutabilis becomes extinct near the base on the Edenian Stage (Late Ordovician) in New York and the tristate area of Kentucky, Ohio and Indiana (Ross, 1967; Anstey and Perry, 1973; Karklins, unpublished data).

In the Moffett Road section, E. mutabilis occurs in the Point Pleasant Tongue of the Clays Ferry Formation and disappears near the base of the Kope Formation (USGS colln. 8444-CO). In central Kentucky it ranges through the upper half of the Lexington Limestone and the Clays Ferry Formation (Karklins, unpublished data).

Family Amplexoporidae

Genus Amplexopora Ulrich, 1882

Type species.--Atactopora septosa Ulrich, 1879, subsequent designation by Boardman (1960b, p. 16); Fairview Formation, Late Ordovician.

Remarks.--Boardman (1960b, p. 16) emended the definition for the genus Amplexopora Ulrich which is used herein. However, Ross (1969) considered the subsequent designation of A.septosa by Boardman as incorrect and proposed A. cingulata Ulrich 1882 as the correct type species of Amplexopora. Until the taxonomic status of A. cingulata Ulrich is agreed upon, A. septosa is considered herein to be the valid type species of Amplexopora.

Amplexopora persimilis Nickles, 1905

Amplexopora persimilis Nickles, 1905, p. 47, pl. 2, figs. 2, 3; Ruedemann, 1925, p. 98, pl. 9, fig. 2; Boardman, 1960b. p. 18.

Taxonomic remarks.--Nickles (1905, p. 47) described Amplexopora persimilis on the basis of its external appearance. A. persimilis is characterized by having relatively large ramose zoaria that can be partly

encrusting and with conspecific overgrowth. Autozooecia of A. persimilis have irregular polygonal cross sectional shapes and relatively thin and uneven walls in exozones. Stereostyles are small and occur mainly in corners of autozooecia in exozones. Stereostyles slightly inflect walls of autozooecia and are rarely offset from walls of some autozooecia projecting into autozooecial chambers. Basal diaphragms in autozooecia of A. persimilis occur sparingly in endozones and commonly in exozones. Mesozooecia are common in inner exozones and they generally terminate in outer exozones of most zoaria. Maculae are common and consist of irregularly shaped zooecia that are larger than autozooecia and of mesozooecia in various combinations.

A. persimilis is closely related to A. septosa (Ulrich). Both species are similar in zoarial growth habits, autozooecial cross sectional shapes and in distribution of stereostyles. A. persimilis, however, differs from A. septosa in having basal diaphragms in endozones of most zoaria, in lacking strongly inflected autozooecial walls in exozones and in sparsity of offset stereostyles. In addition, autozooecial walls in A. persimilis are commonly of uneven thickness and with indistinct autozooecial linings. The autozooecial linings are well defined in A. septosa.

Geographic and stratigraphic distribution.--A. persimilis is found in Kentucky and Ohio, where it ranges from the late Shermanian Stage into the Edenian Stage. In Kentucky, A. persimilis occurs in the upper part of the Lexington Limestone, the Clays Ferry and the Kope Formations (Karklins, unpublished data). Nickles (1905) found A. persimilis in the "lower two thirds" of his Eden Group in Kentucky and Ohio.

In the Moffett Road section, A. persimilis ranges in the Kope Formation from 40 ft (USGS colln. 8481-CO) to 102 ft (USGS colln. 8542-CO) and from 212 ft (USGS colln. 8574-CO) to 222 ft (USGS colln. 8581-CO) above the base of the formation.

Biostratigraphically, A. persimilis is older than A. septosa. The close morphological similarity between A. persimilis and A. septosa and their geographic proximity suggests that A. persimilis is ancestral to A. septosa. A. septosa replaces A. persimilis in the Kope Formation in the Moffett Road section and in Indiana and Ohio, The reported occurrences of A. persimilis in the Upper Ordovician strata of New York (Ruedemann, 1925) and Ontario (Foerste, 1916) need to be verified.

Amplexopora septosa (Ulrich, 1879).

Atactopora septosa Ulrich, 1879, p. 125, pl. 12, figs. 7-7c.

Amplexopora septosa (Ulrich). Ulrich, 1882, pt. 1, p. 128; pt. 2, p. 255; Nickles, 1905, p. 52, pl. 3, fig. 1; Cumings, 1908, p. 763, pl. 6, fig. 6-6b; pl. 26, fig. 4; McFarlan, 1931, p. 104, pl. 11, fig. 14; Boardman, 1960b, p. 18, 20, pl. 5, figs. 1, 2; pl. 6, figs. 1-3; Boardman and Cheetham, 1969, pl. 27, fig. 4; Ross, 1969, p. 262; Anstey and Perry, 1973, p. 22, pls. 1-3.

Monticulipora septosa (Ulrich). James and James, 1888, p. 180; James, 1894, p. 203.

Taxonomic remarks.--Boardman (1960b) discussed Amplexopora septosa in detail. A. septosa has relatively large ramose zoaria having subcylindrical branches and commonly conspecific overgrowth. In exozones, autozooecia are

irregularly subpolygonal in cross section and with walls of moderate thickness and with well-defined autozooecial linings. Stereostyles are generally abundant and occur in corners of autozooecia and in walls along well-defined autozooecial boundaries. Stereostyles in A. septosa inflect the walls of many autozooecia, are offset from the walls and project into autozooecial chambers paralleling chamber axis. The basal diaphragms are generally absent in endozones; they occur regularly and are closely spaced in exozones of most autozooecia. Mesozooecia are sparse and occur mostly in inner exozones and in maculae. Maculae are distinct and consist of irregularly shaped zooecia larger than autozooecia and mesozooecia in different combinations.

Geographic and stratigraphic distribution.--A. septosa occurs in the Kope Formation (Edenian Stage), and in the Fairview Formation (Maysvillian Stage) of the tristate area of Kentucky, Indiana and Ohio. In Moffett Road, it occurs at 252 ft (USGS colln. 8600-CO) above the base of the Kope Formation and ranges into the overlying Fairview Formation for about 4 ft above its base (USGS colln. 8613-CO). Anstey and Perry (1973) reported A. septosa from the Kope Formation in their area of study in Kentucky, Ohio and Indiana. Boardman (1960b) described A. septosa from his "Mount Hope Member of the Fairview Formation of the Maysville Group," Maysvillian Stage, at Covington, Kentucky. Cumings (1908) noted A. septosa in the upper part of his "Eden Shale" and in the "Mount Hope and the Fairmount Members" of the Fairview Formation of Indiana. Ulrich (1879) found it in strata considered to be the Fairview Formation (Bassler, 1906, p. 8) near Covington, Kentucky.

Family Trematoporidae

Genus Balticoporella Vinassa de Regny, 1921

Type species.--Hemiphragma glabrum Bassler, 1911, p. 287, text-fig. 175; pl. 10, fig. 1 "Wassalem Beds", D3, of Bassler, 1911, Middle Ordovician, Uxnorm, Estonia.

Remarks.--Vinassa de Regny (1921, p. 219) erected the genus Balticoporella to include species of Hemiphragma Ulrich, 1893, that lacked stereostyles (acanthopores of authors). He designated Hemiphragma glabrum to be its type species and placed H. whitfieldi (James) in Balticoporella. Bassler (1953, p. G114), however, included Balticoporella in synonymy with Hemiphragma. Anstey and Perry (1973, p. 19) determined that the primary types of H. whitfieldi and its hypotypes from the Kope Formation (Eden Shale of Anstey and Perry) conform to the generic concept for Balticoporella Vinassa de Regny and that Balticoporella is a separate and distinct genus. The concept for Balticoporella Vinassa de Regny is used until its primary type material becomes available for restudy.

Balticoporella whitfieldi (James, 1881)

Monticuliopora (Chaetetes) whitfieldi James, 1881. p. 34.
Monticulipora whitfieldi James. James and James, 1888; p. 178; James, 1894.
Batostoma (Hemiphragma) whitfieldi (James). Grabau and Shimer, 1909, p. 137;
Hemiphragma whitfieldi (James). Nickles and Bassler, 1900, p. 286; Bassler, 1906, p. 40, pl. 2, figs. 15, 16, pl. 4, figs. 1-4; pl. 5, fig. 5.
Balticoporella whitfieldi (James) Vinassa de Regny, 1921, p. 219; Anstey and Perry, 1973, p. 19, pl. 5, pl. 6, figs. 1-3.

Taxonomic remarks.--Anstey and Perry (1973) evaluated Balticoporella whitfieldi in their study of trepostomes from the Kope Formation. B.

whitfieldi is characterized by having relatively large ramose zoaria with irregularly subcylindrical branches. Autozooecia in endozones have irregularly polygonal cross sectional shapes, with slightly curved and distinctly crenulated walls. In exozones, autozooecia are contiguous and irregularly subpolygonal in cross section. Autozooecial walls are moderately thick and uneven in appearance. Autozooecial wall laminae are broadly curved and form narrow, irregularly serrated autozooecial boundaries. Stereostyles are virtually absent in autozooecial walls. Basal diaphragms are sparse or absent in endozones; they are common and of moderate thickness in exozones. Basal diaphragms are planar and irregularly curved. Cystoidal diaphragms are sparse and irregularly curved. Hemiphragms are common between basal diaphragms throughout exozones and generally project from distal zooecial walls curving proximally and forming bulbous proximal tips. Mesozooecia having irregular cross sectional shapes and locally crenulated walls are generally sparse. Mesozooecial diaphragms occur regularly and are spaced more closely than basal diaphragms of autozooecia. Maculae are common, generally flush with zoarial surface; they consist of irregularly shaped zooecia larger than autozoaecia.

Geographic and stratigraphic distribution.-- B. whitfieldi is known only from Kentucky, Indiana and Ohio where it is restricted to the middle part of the Kope Formation. In Moffett Road, it occurs between 74 ft and 78 ft in the Kope Formation above its base (USGS collns. 8511-CO and 8519-CO, respectively). According to Bassler (1906), James found B. whitfieldi in the Economy and Southgate Members of the Eden Formation of Bassler. Anstey and Perry (1973) reported it from the middle part of the Kope Formation (Eden shale of Anstey and Perry) and made it zonal index species for strata approximately between 62 ft and 125 ft above the base of the Kope Formation.

Genus Batostoma Ulrich 1882

Type species.--Monticulipora (Heterotrypa) implicatum Nicholson 1881, p. 147, by monotypy; "Cincinnati Group, Ohio" of Nicholson, 1881.

Remarks.--Boardman (1960b, p. 5) emended the definition for the genus Batostoma which is used herein.

Batostoma jamesi (Nicholson 1874)

Chaetetes Jamesi Nicholson 1874, p. 506, pl. 29, figs. 10, 10b; 1875, p. 200, figs. 11, 11a; 1876, p. 89, pl. 5, fig. 5.

Monticulipora Jamesi Nicholson 1880, p. 415, fig. 3, 4; James and James, 1888, p. 176; James, 1894, p. 197.

Monticulipora (Heterotrypa) Jamesi Nicholson, 1881, p. 143, pl. 2, text figs. 25, 26.

Batostoma jamesi (Nicholson). Ulrich, 1882, p. 256; 1883, p. 83; Cumings, 1908, p. 775, pl. 7, figs. 8, 8a; pl. 8, fig. 1, pl. 27, figs. 6, 6a; McFarlan, 1931, p. 108, pl. 9, fig. 20; Anstey and Perry, 1973, p. 22, pl. 6, figs. 4-6, pl. 7, pl. 8, figs. 1-3.

Taxonomic remarks.--Anstey and Perry (1973) evaluated semi-quantitatively the primary type material of B. jamesi in the bryozoan type collection of H. A. Nicholson and hypotypes from the Kope Formation (Eden Shale of Anstey and Perry) of Indiana and Ohio. B. jamesi is characterized by having irregularly ramose and locally encrusting zoaria with subcylindrical branches that commonly have conspecific overgrowth. In endozones, autozooecia have

irregularly subpolygonal cross sectional shapes and undulating walls. In exozones, autozooecia are subpolygonal to subcircular in cross section and are almost completely separated by mesozooecia. Autozooecial walls are generally variable in thickness, undulating and locally crenulate in early exozones. Stereostyles are distinct and abundant having well defined and locally notched cores. Stereostyles commonly inflect autozooecial walls and are offset from the walls. They are generally centered along autozooecial boundaries. Basal diaphragms are virtually lacking in endozones. They are common, relatively thick, planar or are concave to zoarial surface in exozones, and are generally more common in inner than outer exozones. Mesozooecia are abundant throughout exozones; they have irregular polygonal cross sectional shapes and commonly possess moniliform proximal tips. Mesozooecial diaphragms are moderately thick and evenly spaced. Mesozooecia in outer exozones are commonly closed by laminate skeleton. Maculae are common; they occur regularly and are flush with zorial surface. Maculae consist of zooecia larger than autozooecia and of mesozooecia having thick diaphragms in various combinations.

Geographic and stratigraphic occurrence.--Although the precise locality data of Nicholson's (1874, 1881) find in Ohio is not determinable, subsequent reports indicate that B. jamesi occurs in Kentucky, Ohio, and Indiana where it is found in the upper two thirds of the Kope Formation and ranges into the lower part of the Fairview Formation (Cumings, 1908; Cumings and Galloway, 1913).

In the Moffett Road section, B. jamesi occurs about 132 ft (USGS colln. 8547-CO) above the base of the Kope Formation and ranges into the lower part of the Fairview Formation to about 26 ft (USGS colln. 8623-CO) above its base. In central Kentucky, one specimen of B. jamesi is found in the Clays Ferry Formation about 410 ft above the base of the Lexington Limestone (Karklins, unpublished data).

Family Caloporidae

Genus Parvohallopora Singh, 1979

Type species.--Monticulipora ramosa d'Orbigny, 1850, p. 25; from the "Blue Lime, Silurian A", locality 59 of d'Orbigny; Cincinnati, Ohio; designated by Singh, 1979, p. 226.

Singh (1979) erected Parvohallopora and designated Parvohallopora ramosa (d'Orbigny) to be its type species. P. ramosa and similar species have been included conventionally in Calopora of which C. elegantula (Hall) is the type species. The nomenclatorial problem regarding the validity of the names Calopora Hall 1851 and Hallopora Bassler 1911 has been discussed by Ross (1969, 1970b) and Singh (1970). Parvohallopora nodulosa (Nicholson), P. onealli (James) and Parvohallopora n. sp. discussed herein are consistent with the proposed definition for the genus Parvohallopora by Singh (1979) and his concept is used herein.

Calopora nodulosa (Nicholson, 1874)

Chaetetes? nodulosus Nicholson, 1874, p. 506, pl. 29, figs. 9, 9a; 1875, p. 200, pl. 21, figs. 10, 10a; 1876, p. 87, pl. 5, fig. 3.

Monticulipora (Heterotrypa) nodulosa (Nicholson). Nicholson, 1881, p. 116, pl. 1, figs. 4-4d.

Monticulipora nodulosa (Nicholson). James and James, 1888, p. 182; James, J. F., 1894, p. 206.

Callopora nodulosa (Nicholson). Ulrich, 1882, p. 252; 1883, p. 83. Nickles, 1905, p. 50, pl. 2, figs. 8, 9; Cumings, 1908, p. 786, pl. 9, figs. 2-2c; pl. 27, fig. 8.
Hallopora nodulosa (Nicholson). Cumings and Galloway, 1913, p. 50; Anstey and Perry, 1973, p. 22, fig. 6, pl. 12, fig. 7, pls. 13-15; Pachut and Anstey, 1979, p. 178, fig. 3e; Pachut, 1982, p. 712.

Taxonomic remarks.--Anstey and Perry (1973) evaluated Parvohallopora nodulosa (as Hallopora) in their study of trepostomes from the Kope Formation. P. nodulosa has ramose zoaria having cylindrical branches that may anastomose and are with conspecific overgrowth locally. Autozooecia in endozones are parallel to subparallel to growth direction of a branch and intercalate at relatively long and irregular intervals. In exozones, autozooecia are elliptical to subcircular in cross section and are partly separated by mesozooecia. Autozooecia generally occur without preferred alignment in exozones. Autozooecial linings are indistinct in most autozooecia. Basal diaphragms are sparse to common and occur at relatively regular intervals in endozones. In exozones, basal diaphragms are common and are evenly spaced. They are planar and curved. Mesozooecia are common to abundant and almost completely separate autozooecia in some zoaria. Mesozooecial diaphragms are closely spaced, variable in thickness and may coalesce filling mesozooecia in late exozones. Maculae are abundant and generally are slightly elevated above the zoarial surface. Macuale coalesce laterally forming indistinct transverse ridges in some zoaria.

P. nodulosa is closely related to C. onealli differing from it in having larger zoaria with thicker branches, in having basal diaphragms in endozones and in having abundant mesozooecia in exozones. Autozooecia in P. nodulosa generally subparallel branch axis in endozones and are without preferred alignment in exozones. In P. onealli, autozooecia are about parallel to branch axis in endozones and basal diaphragms are virtually absent in endozones. Autozooecia in exozones of P. onealli occur in indistinct longitudinal alignment.

Geographic and stratigraphic occurrence.--P. nodulosa is known only from Kentucky, Ohio and Indiana where it ranges from rocks of the Shermanian Stage (Middle Ordovician) to those of the Maysvillian Stage (Late Ordovician). In Moffett Road, it ranges from 62 ft (USGS colln. 8499-CO) above the base of the Kope Formation into the overlying Fairview Formation for about 26 ft (USGS colln. 8623-CO). In central Kentucky, P. nodulosa is widespread in the upper half of the Lexington Limestone (Shermanian and Edenian Stages) and in the Clays Ferry Formation (Edenian Stage).

Nickles (1905) and Cumings (1908) found P. nodulosa (as Hallopora) in the upper part of the Kope Formation and in the lower part of the overlying Fairview Formation (Mount Hope beds of authors) in Kentucky and Indiana, respectively. Anstey and Perry (1973) reported P. nodulosa (as Hallopora) from the Kope Formation (Eden Shale of Anstey and Perry) of Indiana, Ohio, and Kentucky.

Parvohallopora onealli (James 1875)

Chaetetes? O'Nealli James, 1875, p. 2.
(?)Monticulipora o'nealli (James). James and James, 1888, p. 175; James, J. F. 1894, p. 194.

Callopora onealli (James). Miller, 1889, p. 296; Bassler, 1906, p. 23, pl. 6, figs. 1, 2; Cumings, 1908, p. 786, pl. 9, fig. 3 (not 3a, 3b); pl. 27, figs. 9, 10.

Hallopora onealli (James). Ruedemann, 1912, p. 51; 1925, p. 99; Cumings and Galloway, 1913, p. 50; Foerste, 1916, p. 90; Parks, 1925, p. 35, pl. 4, fig. 7 (after Bassler, 1906, pl. 6, fig. 1); McFarlan, 1931, p. 107, pl. 9, figs. 10-12; Anstey and Perry, 1973, p. 22.

Calopora onealli (James). Ross, 1969, p. 271, pl. 43, figs. 1, 6; pl. 44, fig. 1; pl. 45, figs. 1-3, 5.

Taxonomic remarks.--Ross (1969) discussed Parvohallopora onealli (as Calopora) in her study of trepostomes from the Trenton Group of New York. P. onealli is characterized by having small ramose zoaria with cylindrical branches that may anastomose. In endozones, autozooecia approximately parallel the general growth direction of branches intercalating at relatively long intervals. Exozones of P. onealli are relatively narrow. In exozones, autozooecia are subelliptical to elliptical in cross section and generally occur in indistinct longitudinal alignment. Autozooecia are mostly contiguous, and locally partly separated by mesozooecia. Basal diaphragms are virtually absent in endozones of P. onealli. In exozones, basal diaphragms are common to sparse and generally occur regularly in early exozones. Autozooecial linings are rare. Mesozooecia are common and generally occur proximally-distally of autozooecia. Mesozooecial diaphragms are closely spaced; they commonly thicken and fill mesozooecia in outer exozones. Maculae are common and flush or slightly elevated above the zoarial surface.

Geographic and stratigraphic distribution.--P. onealli (James) (Calopora or Hallopora of authors) is widespread geographically in rocks of the Shermanian Stage (Middle Ordovician) and the Edenian Stage (Late Ordovician) of eastern North America. In Moffett Road, P. onealli ranges through the Point Pleasant Tongue of the Clays Ferry Formation into the Kope Formation for about 122 ft above the base of the section, or about 68 ft (USGS colln. 8650-CO) above the base of the Kope Formation. In central Kentucky, it occurs in the upper half of the Lexington Limestone (Shermanian-Edenian Stages), and in the Clays Ferry Formation (Edenian Stage). Bassler (1906) and Cumings (1908) reported P. onealli (as Hallopora or Calopora) from the Kope Formation of Ohio and Indiana, respectively. Ruedemann (1912, 1925) found P. onealli in the Upper Ordovician rocks of New York, and Ross (1969, as Calopora) reported it from her Shoreham Formation, Shermanian Stage (Middle Ordovician) of New York. In Canada, P. onealli is found in rocks of Late Ordovician age of Manitoulin Island (Foerste, 1916) and in the Dundas Formation (Parks, 1925) of Ontario.

Parvohallopora n. sp.

Taxonomic Remarks.--Parvohallopora n. sp. is characterized by having ramose zoaria with thin cylindrical branches. Endozones are exceedingly narrow with autozooecia intercalating subparallel to branch axis. In exozones, autozooecia have elliptical to subelliptical cross sectional shapes, are mostly contiguous and occur in indistinct longitudinal alignment. Basal diaphragms are common in endozones where they are relatively closely and evenly spaced. In exozones, basal diaphragms are sparse to common occurring irregularly and obliquely to autozooecial chamber axis. Mesozooecia are common and partly separate autozooecia in exozones. Maculae are virtually absent.

Parvohallopora n. sp. is closely related to P. onealli and to P. nodulosa. It differs from P. nodulosa and P. onealli in having exceedingly thin branches of zoaria without conspecific overgrowth. P. n. sp. differs from P. onealli in having autozooecia that bud at relatively short interval subparallel to zoarial branch axis and possess evenly spaced basal diaphragms in endozones. Autozooecia of P. onealli generally lack basal diaphragms in endozones and they intercalate at relatively long intervals parallelling zoarial branch axis. P. onealli and P. n. sp. both have autozooecia with similar cross sectional shapes in exozones, but with smaller autozooecial chamber diameters in P. n. sp. than in P. onealli. P. n. sp. is similar to P. nodulosa in having subparallel autozooecia with evenly spaced basal diaphragms in endozones but it differs from P. nodulosa in having smaller zoaria with smaller diameters of autozooecia and in cross sectional shape of autozooecia in exozones. Autozooecia are generally subelliptical to subcircular in cross section in P. nodulosa, whereas they are elliptical in cross section in P. n. sp. Both species differ also in alignment of autozooecia. In P. nodulosa, autozooecia are generally without preferred alignment. In P. n. sp., autozooecia are aligned in indistinct longitudinal ranges in exozones.

Geographic and stratigraphic distribution.--Parvohallopora n. sp. is known only from the Moffett Road section in Kentucky. It ranges in the Kope Formation between 28 ft and 64 ft above its base, USGS collns. 8469-CO and 8499-CO respectively. The restricted stratigraphic and geographic range suggests that P. n. sp. occupied a specialized niche in the depositional environment of the Kope Formation in Kentucky.

Family unknown

Genus Monotrypella Ulrich 1882

Type species.--Monotrypella aequalis Ulrich, 1882, p. 153; p. 247, pl. 11, figs. 3-3a, by original designation, "Cincinnati Group" (Ulrich, 1882, p. 249); from the Economy Member of the Eden Formation of Bassler (1906, 1915), Upper Ordovician, Cincinnati, Ohio.

Remarks.--Ross (1970a) emended the definition for the genus Monotrypella. Her definition of Monotrypella is used herein.

Monotrypella n. sp.

Taxonomic remarks: Monotrypella n. sp. is characterized by having relatively large ramose zoaria with subcylindrical branches having conspecific overgrowth. Autozooecia in endozones are irregularly polygonal in cross section having slightly undulating and locally crenulate walls. In exozones, autozooecia are contiguous, have irregularly subpolygonal cross sectional shapes and generally occur without preferred alignment. Autozooecial walls in exozones are relatively thin and slightly uneven. Laminae of autozooecial walls are narrowly curved in inner exozones and broadly curved in outer exozones. Autozooecial linings are absent or are poorly defined. Autozooecial boundaries are broadly serrated in longitudinal sections, are generally not visible in tangential sections. Stereostyles having distinct cores are exceedingly small; they occur sparingly in corners of some autozooecia in exozones. Basal diaphragms are virtually absent in endozones; they occur throughout exozones. Basal diaphragms are slightly curved or planar, occurring obliquely or at right angles to autozooecial chamber axis. Mesozooecia are exceedingly sparse and commonly have moniliform proximal tips.

Maculae consisting of irregularly shaped zooecia larger than autozooecia and scattered mesozooecia are common.

Specimens assigned to Monotrypella n. sp. differ from known species of Monotrypella and represent a new species of the genus. Monotrypella n. sp. differs from M. aequalis Ulrich (Upper Ordovician of Ohio), its subspecies aequalis grandis Bork and Perry (1967) and from M. normalis Perry (1962) (Middle Ordovician of Iowa) and M. boonvillensis Ross (1970a) (Middle Ordovician of New York) in cross sectional shape of autozooecia, in having stereostyles (acanthopores of authors) in exozones and in virtual absence of basal diaphragms in endozones.

Geographic and stratigraphic distribution.--Monotrypella n. sp. is known only from Kentucky where it occurs (not reported previously) in the Sulphur Well Member of the Lexington Limestone (Shermanian Stage) and in the Kope Formation, Edenian Stage (Karklins, unpublished data).

In Moffett Road, Monotrypella n. sp. is found in the stratigraphic interval between 40 and 74 ft above the base of the Kope Formation, USGS colln. 8481-CO and 8510-CO, respectively.

Order Cystoporata
Family Ceramoporidae
Genus Ceramophylla Ulrich, 1893

Type species.--Ceramophylla frondosa Ulrich, 1893, p. 331, by original designation; "Upper third of Trenton Shales" of Ulrich, 1893; (=upper part of the Decorah Shale of current usage), Middle Ordovician.

Remarks.--Utgaard (1968, p. 1452) redescribed the genus Ceramophylla and emended its definition. The definition for Ceramophylla by Utgaard (1968) is used herein.

Ceramophylla alternatum (James 1878a)

Ceramopora alternata James, 1878a, p. 5.
Monticulipora (Fistulipora) alternata James, 1888, p. 34, pl. 1, figs. 5, 5a, 5b.
Diamesopora vaupeli Ulrich, 1890 p. 468, pl. 39, figs. 3, 3b; pl. 41, figs. 4, 4c. Nickles and Bassler, 1900, p. 24, 212; Bassler, 1953, p. G82.
Diamesopora trentonensis Ulrich, 1893, p. 330, pl. 28, fig. 14.
Coeloclema alternatum (James). Nickles and Bassler, 1900, p. 212; Bassler, 1906, p. 33; 1953, p. G82, text-fig. 46,1; Ross, 1969, p. 278, pl. 46, figs. 2, 4, 7-9; pl. 47, figs. 1-8; pl. 48, figs. 1-13, 15.
Coeloclema vaupeli (Ulrich). Elias, 1954, p. 54.
Ceramophylla vaupeli (Ulrich). Utgaard, 1968, p. 1453, pl. 183, fig. 4; pl. 184, figs. 34; 1973, figs. 34-36.

Taxonomic remarks.--C. alternatum is characterized by having zoaria with axially hollow cylindrical branches. Autozooecia in exozones have subelliptical cross sectional shapes and relatively distinct lunaria. Autozooecial chambers are elliptical to subcircular in cross section and generally without basal diaphragms. Communication pores in autozooecial walls are poorly defined, and locally lacking. Exilazooecia are common in inner exozones and generally terminate in outer exozones.

The taxonomic history of C. alternatum is complex (see synonomy) and it has been discussed in detail by Utgaard (1968) and Ross (1969, as Coeloclema alternatum). Utgaard (1968) and Ross (1969, as Coeloclema alternatum) illustrated the significant zoarial structures and redescribed the concept for the species.

Geographic and stratigraphic distribution.--C. alternatum is widely distributed in eastern North America where it ranges from the Blackriveran to Edenian Stages. In New York (Ross, 1969, as Coeloclema alternatum), C. alternatum occurs in the Chaumont Formation (Blackriveran Stage) and ranges into the Cobourg Formation (Edenian Stage of Sweet and Bergström, 1971) of the Trenton Group. In Minnesota, it occurs in the upper part of the Decorah Shale and the lower part of the Galena Dolomite (Ulrich, 1893), Rocklandian Stage (Bergström and Sweet, 1966). In central Kentucky C. alternatum occurs mostly in the Grier Limestone and Tanglewood Limestone Members (Shermanian Stage) of the Lexington Limestone and sparingly in the Clays Ferry Formation, Edenian Stage (Karklins, unpublished data).

In the Moffett Road section, C. alternatum is found sparingly in the upper part of the Point Pleasant Tongue of the Clays Ferry Formation and in the lower 30 of the overlying Kope Formation (figs. 2, 4). It occurs abundantly (fig. 4) in the Kope Formation in the stratigraphic intervals between 30 ft (USGS colln. 8472-CO) and 78 ft (USGS colln. 8522-CO) and between 196 ft (USGS colln. 8561-CO) and 224 ft (USGS colln. 8586-CO) above its base.

Genus Ceramoporella Ulrich, 1882

Type species.--C. distincta Ulrich, 1890, p. 380; by subsequent designation by Ulrich, 1890, p. 380: "Cincinnati Group" of Ulrich, 1890, Upper Ordovician, Cincinnati, Ohio.

Remarks.--Utgaard (1968, p. 1450) emended the definition for the genus Ceramoporella and this definition is used herein.

Ceramoporella distincta Ulrich 1890

Ceramoporella distincta Ulrich, 1890, p. 464, pl. 39, figs. 6, 6a; Grabau and Shimer, 1909, p. 122; Cumings, 1908, p. 799, pl. 10, fig. 7, pl. 11, figs. 2, 2a; Bassler, 1953, p. G81, text-figs. 44, 2a, 2b (not 2c); Utgaard, 1968, p. 1450, pl. 181, fig. 4, pl. 182, figs. 1-3; 1973, figs. 16, 23.

Not C. distincta Ulrich. Ulrich, 1893, p. 328, pl. 28, fig. 13; 1896, fig. 435; Simpson, 1897, p. 565, fig. 130; Bassler, 1913, fig. 462; 1953, text-figs. 44, 2c. (=Ceramoporella sp.).

Taxonomic remarks.-C. distincta possesses explanate and encrusting zoaria that are commonly multilayered consisting of two to three superimposed layers of autozooecia. Autozooecia have subcircular to subelliptical cross sectional shapes and well-defined lunaria in exozones. Autozooecia in exozones are partly separated by exilazooecia that are locally aligned in indistinct series. Stereostyles are absent in autozooecial walls. Basal diaphragms are uncommon in chambers of autozooecia. Maculae consisting of clusters of irregularly shaped exilazooecia occur commonly in most zoaria.

Utgaard (1968) reviewed the taxonomic history of the genus Ceramoporella

and determined that C. distincta is the valid type species of the genus by subsequent designation.

Geographic and stratigraphic distribution.--C. distincta is known only from the tristate area of Kentucky, Indiana, and Ohio. In the Moffett Road section, C. distincta occurs in the Kope Formation between 46 ft (USGS colln. 8456-CO) and 78 ft (USGS colln. 8524-CO) and between 228 ft and 246 ft above its base (USGS collns. 8589-CO and 8597-CO). In central Kentucky, C. distincta ranges from the upper part of the Lexington Limestone into the Clays Ferry Formation, mainly Shermanian and Edenian Stages, respectively (Karklins, unpublished data). In Indiana (Cumings and Galloway, 1913), C. distincta has been reported from the "Eden," "Maysville," and "Waynesville" strata. The occurrence of C. distincta in Maysvillian and Richmondian age strata need to be verified.

Genus Crepipora Ulrich, 1882

Type species.--Chaetetes venustus Ulrich, 1878, p. 93; by subsequent monotypy by Spjeldnaes, 1963, p. 64; from the "Economy Member of the Eden Formation" of Bassler, 1906, Upper Ordovician, West Covington, Kentucky.

Remarks.--Utgaard (1968, p. 1448) emended the definition for the genus Crepipora Ulrich and his definition of the genus is used herein.

Crepipora venusta (Ulrich 1878)

Chaetetes venustus Ulrich 1878, p. 93, pl. 4, figs. 7, 7a.
Crepipora venusta (Ulrich). Ulrich, 1882, p. 257; Nickles, 1905, p. 49, pl. 2, fig. 7; Foerste, 1914, p. 126; Spjeldnaes, 1963, p. 64, pls. 9, 10; Utgaard, 1968, p. 1448, pl. 181, figs. 1-3; 1973, fig. 46.
Monticulipora (Fistulipora) venusta James and James, 1888, p. 33.

Taxonomic remarks.--Spjeldnaes (1963) redescribed the type specimens of Crepipora venusta. C. venusta is characterized by having ramose zoaria that commonly have axially hollow subcylindrical branches. Autozooecia in exozones are generally contiguous having subpolygonal to subcircular cross sectional shapes and possess relatively distinct lunaria. Autozooecia of C. venusta commonly have communications pores in autozooecial walls of inner exozones and possess a few basal diaphragms. Stereostyles in autozooecial walls are uncommon. Exilazooecia in C. venusta occur mostly in maculae and only sparingly between autozooecia.

Geographic and stratigraphic distribution.--C. venusta is known only from Kentucky and Ohio where it occurs in rocks of Shermanian Stage, (Middle Ordovician) and Edenian Stage, (Late Ordovician).

In the Moffett road section, C. venusta ranges in the Kope Formation from 34 ft (USGS colln. 8475-CO) to 78 ft (USGS colln. 8518-CO) and from 182 ft (USGS colln. 8558-CO) to 212 ft (USGS colln. 8573-CO) above its base. In central Kentucky, it occurs in the upper part of the Lexington Limestone (Shermanian and Edenian Stages) and in the Clays Ferry Formation (Edenian Stage) (Karklins, unpublished data). Bassler (1915) reported C. venusta from "the upper part of the Trenton" strata and "the lower part of the Eden Formation" of Bassler, near Cincinnati, Ohio.

Family Constellariidae

Genus Constellaria Dana 1846

Type species.--Constellaria florida Ulrich, 1882, p. 257; subsequent designation by Ulrich, 1883, p. 266. "Cincinnati Group" of Ulrich, Upper Ordovician, Ohio.

Remarks.--Ross (1963, p. 51) emended the definition for the genus Constellaria and subsequently (Ross, 1969, p. 274) published a diagnosis for Constellaria that is used herein.

Cutler (1973) discussed the morphology and development of acanthorods (acanthopores of authors; termed herein stereostyles) and related nonlaminate skeletal deposits (yellow tissue of authors) in the genus Constellaria. McKinney (1977, p. 323-326) discussed the development of zoaria in several species of Constellaria, including the type species C. florida, and showed that Constellaria characteristically possesses a budding pattern in which autozooecia bud into three sided cone-in-cone groups.

Constellaria florida Ulrich, 1882

Constellaria florida Ulrich 1882, p. 257; 1883, p. 267, pl. 14, figs. 2-2f; Nickles, 1905, p. 54, pl. 3, fig. 5; McFarlan, 1931, p. 100, pl. 6, figs. 1, 2; pl. 10, fig. 1; McKinney, 1977, pl. 9, figs. 1, 2.
Constellaria florida var. prominens Ulrich, 1883, p. 269, pl. 14, fig. 3.
Constellaria florida var. plana Ulrich, 1883, p. 269, pl., 14, fig. 4.
Constellaria plana Nickles and Bassler, 1900, p. 213.
Constellaria constellata prominens Nickles and Bassler, 1900, p. 214.
Constellaria plana Nickles, 1905, p. 32.
Constellaria prominens Nickles, 1905, p. 52, pl. 2, fig. 15.

Taxonomic remarks.--Cutler (1968) redescribed Constellaria florida in detail in his work on the genus Constellaria from Middle and Upper Ordovician strata of Tennessee, Kentucky and adjacent areas. C. florida have ramose zoaria having cylindrical and subcylindrical or slightly flattened branches with local conspecific overgrowth. Autozooecia in exozones are circular to subcircular in cross section having straight to slightly undulating walls. Stellate maculae are relatively small, distinct and irregularly shaped and are generally raised above the zoarial surface. Maculae locally coalesce forming elevated ridges across zoaria. Ray clusters of autozooecia of stellate maculae are generally wedge-shaped having widest parts near the outer end of a ray. Ray clusters are commonly subdivided by distinct longitudinal partitions. Autozooecia within rays are generally contiguous or are locally separated by narrow strips of vesicular deposits, or longitudinal ray partitions.

Autozooecia in interstellar areas occur in clusters and singly. Clustered autozooecia are partly contiguous and are separated by vesicular deposits. Single autozooecia are almost completely isolated by vesicular deposits. Stereostyles are of irregular size and shape and occur commonly in walls of autozooecia and of vesicles. Basal diaphragms are virtually absent in endozones and are sparse in exozones. Vesicular deposits occur throughout exozones in strips and in areas of irregular shape. Vesicles are relatively small and irregularly polygonal or rectangular in cross section having straight to slightly curved walls. Vesicles in outer exozones are partly filled by laminate skeletal deposits. Nonlaminate skeletal deposits (yellow

tissue of authors) occur irregularly between autozooecia in interray areas, locally forming walls of vesicles and ray partitions.

Geographic and stratigraphic distribution.--C. florida is known from rocks of Edenian and Maysvillian Stages of Kentucky, Ohio, Indiana, and Tennessee. In the Moffett Road section, the lowest occurrence of C. florida is about 72 ft above the base of the Kope Formation (USGS colln. 8509-CO). It reappears at about 222 ft (USGS colln. 8581-CO) above the base of the Kope Formation and then occurs in the Fairview Formation about 18 ft and 22 ft above its base (USGS collns. 8620-CO and 8623-CO, respectively). Ulrich (1883, p. 268) reported C. florida from the upper part of the Eden Formation and from the McMillan Formation in the stratigraphic nomenclature of Bassler (1906, p. 8). McFarlan (1931) found C. florida in Kentucky in strata equivalent to the Kope and the Clays Ferry Formations of current usage. Cutler (1968) reported it from the Fairview Formation of Kentucky and Ohio, from equivalent strata in Indiana, and from the Leipers Formation of Tennessee.

Order Cryptostomata
Suborder Fenestelloidea
Family Phylloporinidae
Genus Phylloporina Foerste, 1887

Type species.--Retepora angulata (?) Hall (1852, p. 49) as based on material described by Foerste (1887, p. 151) from the Clinton Group, Silurian, Ohio (Ross, 1963, p. 592).

Remarks.--Ross (1963, 1964) discussed briefly the uncertain taxonomic status of the genus Phylloporina. The name Phylloporina has been used traditionally by authors in descriptions of a group of fenestrate cryptostome bryozoans in which autozooecia are budded from one side of a planar budding surface. Because of the significance of morphology of species assigned to Phylloporina in the evolution of cryptostome bryozoans (Blake, 1975), the name Phylloporina is retained here until its type material is located and evaluated.

Phylloporina variolata (Ulrich, 1882)
Phyllopora variolata Ulrich, 1882, p. 160, pl. 6, fig. 14.
Phylloporina variolata (Ulrich). Ulrich, 1890, p. 639.

Taxonomic remarks.--P. variolata possesses delicate zoaria having irregularly variable, generally elongate fenestrules. Endozones are of moderate widths and with slightly undulating, locally nonlaminated autozooecial walls. In exozones, autozooecia are circular in cross section and are aligned in two or three curving longitudinal ranges. Autozooecial ranges are separated by skeletal partitions locally consisting of nonlaminate skeleton. Stereostyles are abundant and variable in size; they occur sparingly along autozooecial range partitions of obverse zoarial side and abundantly in distinct longitudinal ranges on reverse side of zoaria. Basal diaphragms are generally lacking in autozooecia.

Specimens assigned P. variolata conform generally to zoaria that Ulrich (1882) characterized as having irregularly shaped fenestrules, autozooecia having circular cross sections in exozones and in lacking basal diaphragms.

Geographic and stratigaphic distribution.--P. variolata is known only from Kentucky and Ohio where it occurs in the upper part of the Kope Formation and in the Fairview Formation. In the Moffett Road section it is found in the Kope Formation between 206 ft and 232 ft above its base (USGS collns. 8568-CO and 8590-CO, respectively). Ulrich (1882) described it as Phyllopora from the upper part of the Eden Formation and from the Fairview Formation in stratigraphic nomenclature of Bassler (1906).

Suborder Ptilodictyoidea
Family Ptilodictyidae
Genus Escharopora Hall, 1847

Type species.--Escharopora recta Hall, 1847, p. 73, by original designation; "Trenton Limestone," Middle Ordovician, Middleville, New York.

Remarks.--Phillips (1960) redescribed the type species Escharopora recta Hall and, subsequently, Ross (1964) and Karklins (in press) revised the concept for the genus which is used herein.

Escharopora acuminata (James, 1875)

Ptilodictya acuminata James, 1875, p. 3
Escharopora acuminata (James). Ulrich, 1893, p. 167; Bassler, 1906, p. 36; Cumings, 1908, p. 829.

Taxonomic remarks.--Zoaria of E. acuminata are relatively narrow and unbranched having pointed proximal tips. Autozooecia in exozones are characterized by having thin walls of uniform thickness and by having well-defined, thin and regularly curved superior hemisepta. Small spinelike structures project from walls in chambers of some autozooecia of a zoarium.

Bassler (1906) discussed the type specimens of E. acuminata that are on file at the Field Museum of Natural History without illustrating their morphological characters. Hypotypes of E. acuminata that are marked "authentic," presumably by R. S. Bassler, and are on file at the USNM conform to specimens from the Moffett Road section. Until the type material of E. acuminata can be prepared and reexamined, specimens from the Moffett Road section are considered to belong to E. acuminata.

E. acuminata is closely related to Escharopora n. sp. (Karklins in press) occurring in the Lexington-Clays Ferry depositional sequence (Middle and Upper Ordovician) of central Kentucky. E. acuminata differs from E. n. sp. in having unbranched zoaria with thin exozones and autozooecia having walls of uniform thickness. E. n. sp. possesses explanate growth habit and autozooecia having walls of variable thickness and with knob-like projections and in having irregularly shaped superior hemisepta.

Geographic and stratigraphic distribution. E. acuminata in the Moffett Road section occurs in the upper part of the Point Pleasant Tongue (USGS colln. 8438-CO) of the Clays Ferry Formation and ranges through the Kope Formation into the overlying Fairview Formation (USGS colln. 8623-CO). Bassler (1906, 1915) and Cumings (1908) reported it from their Eden Formation near Cincinnati, Ohio, and from Kentucky.

Escharopora n. sp.

Taxonomic remarks.--Escharopora n. sp. is characterized by having

explanate zoaria. Autozooecia in exozones have walls that are irregularly variable in thickness and form irregular knoblike projections. Superior hemisepta are irregularly shaped in most autozooecia of a zoarium.

E. n. sp. is closely related to E. acuminata and probably is ancestral to it.

Geographic and stratigraphic distribution.--E. n. sp. occurs for the first time at the base of the Lexington Limestone in central Kentucky (Karklins, unpublished data). It occurs sparingly in the lower part of the Lexington Limestone (Kirkfieldian Stage) and is common in the upper part of the Lexington Limestone and the Clays Ferry Formation (Shermanian-Edenian Stages). In the Moffett Road section E. n. sp. occurs in the Point Pleasant tongue of the Clays Ferry Formation (fig. 2) and ranges into the overlying Kope Formation for about 44 ft (USGS colln. 8483-CO) above its base.

Genus Graptodictya Ulrich, 1882

Type species.--Ptilodictya perelegans Ulrich, 1878, p. 94; subsequent designation by Ulrich, 1882, p. 165; "Waynesville Formation, Upper Ordovician, Clarksville, Ohio (Phillips, 1960, p. 19).

Remarks.--Phillips (1960) redescribed the type species Graptodictya perelegans (Ulrich), and subsequently Ross (1964) and Karklins (in press) revised the concepts for Graptodictya which is used herein.

Graptodictya cf. G. cleavelandi (James, 1881)

Taxonomic remarks.--G. cf. G. cleavelandi is characterized by having small ramose zoaria in which secondary branches commonly occur at right angles to the primary branch. Branches of zoaria are generally thin having exceedingly narrow exozones. Autozooecia in exozones are subcircular to elliptical in cross section and are partly separated by extrazooecial skeletal deposits. Short superior hemisepta project commonly into autozooecial chambers at the base of the exozones. Extrazooecial skeletal deposits form distinct curving striae between autozooecia and in lateral margins of zoaria. Indistinct pustules are commonly centered on the curving striae of the extrazooecial skeleton.

These specimens are assigned to Graptodictya cf. G. cleavelandi because the internal characters of zoaria of the type material of G. cleavelandi and of closely similar species G. cincinnatiensis (James, 1881) and G. kentuckiensis (James, 1881) (Bassler, 1906, as Arthropora) have not been reevaluated for lack of thin sectioned material. Specimens assigned to G. cf. G. cleavelandi of this study generally conform to the thin sectioned hypotypes of G. cleavelandi (James) that are on file at the USNM.

Geographic and stratigraphic distribution.--In the Moffett Road section G. cf. G. cleavelandi occurs in the Point Pleasant Tongue of the Clays Ferry Formation between 32 ft (USGS colln. 8418-CO) and 22 ft (USGS colln. 8426-CO) below the base of the Kope Formation, and in the Kope between 40 ft (USGS colln. 8480-CO) and 100 ft (USGS colln. 8541-CO) and between 186 ft (USGS colln. 8559-CO) and 240 ft (USGS colln. 8593-CO) above the base of the formation.

Family Stictoporellidae

Genus Stictoporella Ulrich, 1882

Type Species.--Stictoporella interstincta Ulrich (1882, p. 169), by original designation; ("...river quarries, opposite the city of Cincinnati, Ohio" (Ulrich, 1882, p. 169)); the Economy Member of the Eden Formation (Bassler, 1906), Upper Ordovician, West Covington, Kentucky.

Remarks.--Phillips (1960) redescribed the type species Stictoporella interstincta and subsequently Ross (1960) and Karklins (in press) revised the concept for the genus which is used herein.

Stictoporella interstincta Ulrich, 1882

Ptilodictya flexuosa James, 1878a, p. 4.
Stictoporella flexuosa James. Ulrich, 1882, p. 169; Bassler, 1906, p. 54; 1953, fig. 99-1.
Stictoporella interstincta Ulrich, 1882, p. 169, pl. 8, figs. 9, 9a; 1890, p. 394, figs. 14a, b; Philips, 1960, p. 23, pl. 10, figs. 1-7.

Taxonomic remarks.--S. interstincta possesses small, slender and irregularly ramose zoaria. Autozooecia in endozones are budded from mesotheca in longitudinal ranges resulting in rhombic alignment of autozooecia in exozones. Autozooecia in exozones are subpolygonal in cross section and are proximally and distally separated by paired, or by three exilazooecia. Basal diaphragms and autozooecial wall lateral structures are absent. Exilazooecia are irregularly polygonal and generally elongate in crosssection.

S. interstincta is a significant species taxonomically because it defines the concept for Stictoporella which is the type genus of the family. Phillips (1960) and Karklins (in press) discussed and illustrated the characteristic zoarial structures of the species.

Geographic and stratigraphic distribution.--S. interstincta is known only from near Cincinnati in Ohio and in Kentucky. In the Moffett Road section, S. interstincta occurs for the first time about 50 ft (USGS colln. 8402-CO) below the base of the Kope Formation in the Point Pleasant Tongue of the Clays Ferry Formation and ranges for about 68 ft (USGS colln. 8649-CO) in the overlying Kope above its base. However, it has not yet been found in the equivalent strata of the Clays Ferry Formation of central Kentucky (Karklins, unpublished data). Bassler (1906) reported it from the Economy Member of the Eden Formation and Cumings and Galloway (1913) found it in the Southgate Member of the Eden Formation of Bassler in Kentucky.

Family Rhinidictyidae

Genus Stictopora Hall, 1847

Type species.--Stictopora fenestrata Hall (1847, p. 16); subsequent designation by Ulrich (1886, p. 67) (Phillips, 1960, p. 9); from the Chazy Limestone, Middle Ordovician, New York.

Remarks.--Phillips (1960) redescribed the type species S. fenestrata and emended the definition of the genus. Subsequently, Karklins (in press) revised the generic concept for Stictopora which is used herein.

Stictopora parallela (James, 1878)

Ptilodictya parallela James, 1878a, p. 5.

Rhinidictya parallela (James). Ulrich, 1882, p. 170; Bassler, 1906, p. 52, pl. 2, figs. 5-7, pl. 5, figs. 2, 3; Cumings, 1908, p. 875, pl. 32, fig. 8.

Taxonomic remarks.--S. parallela is characterized by having small ramose zoaria with exceedingly thin branches. Autozooecia in endozones and exozones occur in distinct longitudinal ranges. Autozooecia are contiguous having subelliptical to subrectangular cross sectional shapes in exozones. Mural styles are common in autozooecial walls and locally are aligned along autozooecial boundaries. Basal diaphragms and lateral autozooecial wall structures are absent.

S. parallela is closely related to S. neglecta Ulrich from the Lexington Limestone and the Clays Ferry Formation of central Kentucky. Both species have similar cross sectional shapes of autozooecia and lack superior hemisepta and basal diaphragms. S. parallela differs from S. neglecta in having exceedingly narrow endozones and exozones and in having autozooecia with smaller chamber diameters.

Bassler (1906, as Rhinidictya) discussed and illustrated specimens from the type material of S. parallela on file at the Field Museum of Natural History.

Geographic and stratigraphic distribution.--S. parallela is known only from Kentucky and Ohio. In the Moffett Road section it occurs in the Point Pleasant Tongue of the Clays Ferry Formation (pl. 1) and ranges into the overlying Kope Formation for about 72 ft (USGS colln. 8509-CO). Bassler (1906) reported it from the Economy Member of his Eden Formation at Cincinnati, Ohio, and Cumings and Galloway (1913) reported it from the Southgate Member of the Eden Formation of Bassler in Kentucky.

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