VARIATIONS OF SOME FENESTRATE BRYOZOANS
OF THE GEARYAN SERIES IN EASTERN KANSAS

by

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# INTRODUCTION

## Purpose of the Investigation

This investigation was initiated in an attempt to establish whether systematic evolutionary variations occur in "fenestrate" bryozoans in the upper Gearyan Series of Riley, Geary, Morris and Marion Counties in Kansas (Fig. 1). Because of the many morphological features of these bryozoans, it was hoped that a detailed study incorporating the use of statistical methods would delineate variations helpful in determining evolutionary trends, and possibly lead to the use of these bryozoans in future correlation problems.

Secondary to the main purpose was inevitably the identification of forms and their relative abundance in the units examined. Although these factors are of major importance in a study such as this, it was understood that the primary inquiry would be in the area of evolutionary variations. It was also understood that the collection of specimens from each stratigraphic unit in question would be desirable but highly improbable.

It was hoped that a comparison of faunas from members in Marion and Riley Counties in Kansas would prove the lack of horizontal variations in the forms. This was considered a reasonable assumption because of the cosmopolitan faunas that should be formed by the free swimming larval stage of these bryozoans. Demonstration of a lack of horizontal variation is highly desirable in a study of vertical variations. However since fenestrate bryozoans could not be found in similar units over a large enough geographic area to merit study, no investigation of horizontal variations was made.

## Area Covered by the Investigation

Riley, Geary, Morris and Marion Counties (Fig. 1) are in the eastern third of Kansas. Riley County is in the second tier of counties south of the Nebraska border, Geary is in the third, Morris is in the fourth and Marion is in the fifth tier. Riley, Geary, and Morris Counties are in the fifth tier of counties east of the Missouri border and Marion County is in the sixth tier. Riley, Geary and Morris Counties are bounded on the east by Pottawatomie, Wabaunsee, Lyon and Greenwood Counties, on the north by Washington and Marshall Counties, on the west by Clay, Dickinson and Marion Counties and on the south by Marion and Chase Counties. Marion County is bounded on the east by Chase and Morris Counties, on the north by Morris and Dickinson Counties, on the west by McPherson and Harvey Counties and on the south by Harvey and Butler Counties.

Access Routes. Access routes in the four-county area consist of federal highways, state highways, county roads and unpaved country roads. All roads except the unpaved minor roads are maintained and are passable most of the year. The unpaved roads are less reliable during wet seasons and should not be depended upon as transportation routes.

## Previous Investigation

The previously published material on fenestrate bryozoans is abundant. In this paper only the more important works were mentioned. Each important reference is discussed under a separate heading, based upon its area of major emphasis.

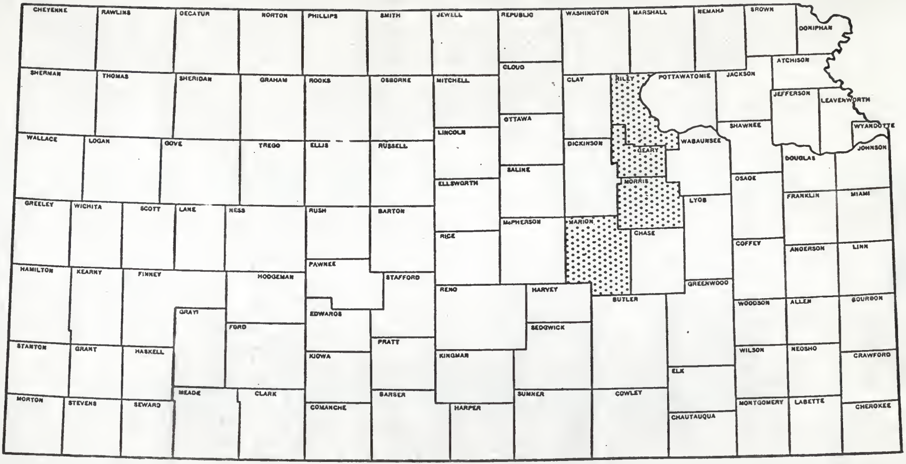



Fig. 1. Index map showing area of investigation.

Descriptions and Identifications. Probably the most comprehensive work published on bryozoans is Ulrichs' study of bryozoans of Illinois (1890). This work includes original descriptions of many species, and references to the original description of others. It includes excellent discussions and descriptions on the family, generic and specific level. Many forms described in his work were found in this study.

Moore (1929, 1930), published descriptions of forms from the Virgilian of North-Central Texas. In these works, many new species and variations were described that proved useful in this investigation. Richards (1955), concludes from these articles that the Permo-Pennsylvanian fenestrate bryozoan population of Kansas is more closely related to the North-Central Texas faunas described by Moore than to faunas described in Nebraska or Illinois; this paper agrees with this conclusion.

Elias (1937) described many new subspecies, one of which was found in this study.

Bassler (1953) proved useful in identification and the family and generic level. This is the most recent index and reference to systematic descriptions of bryozoans.

Richards (1955) proved useful in relating methods of making measurements.

Evolution. Elias (1937) studied evolutionary trends in some fenestrate bryozoans. His work and descriptions proved useful in the preparation of this paper.

Richards (1955) gave the most complete analysis of evolutionary trends of long ranging forms found in the Pennsylvanian Virgilian and the Permian Gearyan Series of eastern Kansas. His work proved useful for the discussion of morphological features that should be measured, and as an indication of the trends discovered in long-ranging forms.

Quantitative Methods. Burma (1948, 1949) presented a most complete description of handling numerical values on a statistical basis.

Richards (1955) discussed quantitative procedure, but on a much more limited basis than Burma.

Ecology. Osburn (1957) described controlling factors in the environment of bryozoans. In it he included: (1) geographic distribution, (2) bathymetric distribution, (3) temperature, (4) light, (5) salinity and (6) biologic associations.

Mounting and Sectioning Techniques. Koenig (1954) presented an excellent "cook-book" procedure for making cellulose peels of undulating fronds of bryozoans. His procedures are applicable, but there is a large amount of time and equipment involved.

Morphology and Classification. Boardman (1955) discussed growth stages in trepostosome bryozoans and why some are split into too many groups.

Sokal and Sneath (1964) discussed the ills of modern taxonomy. They described in detail the principles and methods of modern taxonomy.

## Stratigraphy

Rocks belonging to the Gearyan Series (O'Connor, 1963, p. 1874) of the Lower Permian System crop out along a north-south trending belt that extends across eastern Kansas from the Nebraska border to the Oklahoma border. This belt encompasses most of the four counties in question and excellent outcrops are encountered throughout the area of investigation. In southeastern Riley County, upper units of the Pennsylvanian System crop out, and in the northwest corner there are outcrops of Cretaceous age. In the western half of Marion County are outcrops of Cretaceous age and of Permian rocks belonging to the Wellington Formation. In the eastern half of Marion County rocks of the Chase Group (Fig. 2) crop out. The outcropping rocks in Morris and Geary counties are mostly of Lower Permian age.

In this work only the rock units of the uppermost Council Grove Group and the Chase Group were sampled (Fig. 2). Twelve of the stratigraphic units in these groups contained no bryozoan faunas; nevertheless they were thoroughly examined and described. The examination and description of these bryozoan-poor units was undertaken with the hope future workers could compare the lithology of the barren units to the known factors of bryozoan ecology and determine the reason for the absence of bryozoans.

In general outcrops of the units highest in the stratigraphic sequence are in southern Marion County and in northwestern Riley County. The units lowest in the stratigraphic sequence crop out in southern Riley County and northern Geary County in the vicinity of the Kansas River valley.

## Field Procedure

Randomness in the sampling technique is all important in a study such as this. According to Burma (Burma, B. H., 1948, p. 727), "... a sample is usually taken by going to an outcrop and picking up whatever specimens are available. Under the circumstances, this is the best method of sampling, for the sample will then be as nearly random as possible." This concept of sampling was followed throughout the field investigation.

The main objective of this work was to obtain from a small field sample a representative average for the fenestrate bryozoan population of the unit in question. Because much of the fossil population was buried beyond reach and because only part of the original population was preserved, the small random sample collected represents only a small portion of the original

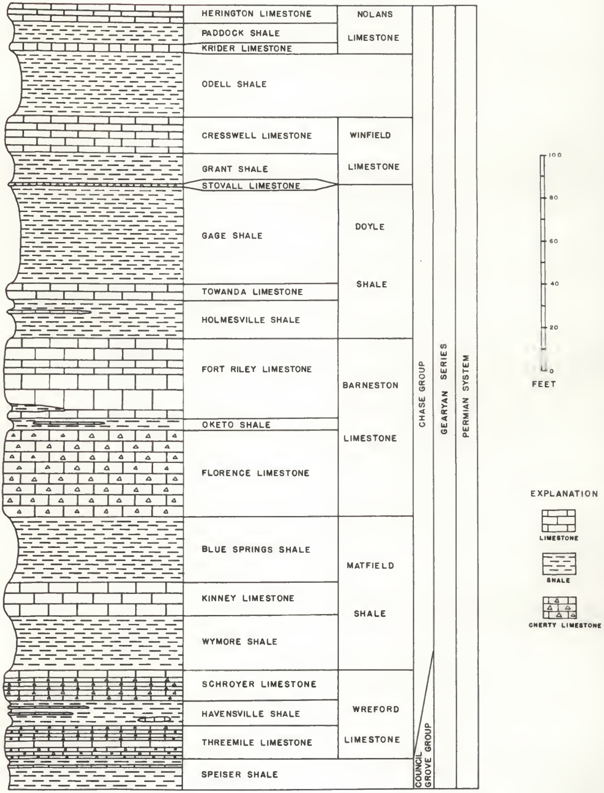



Fig. 2. Generalized stratigraphic section of a part of the Permian System in Riley, Geary, Morris and Marion counties in Kansas.

population. Because of these factors governing the amount of sample obtainable, the characteristics of the entire population were postulated by applying statistical methods to the sample obtained.

Field samples consisted entirely of surface samples collected from outcrops in road cuts, stream banks and railroad cuts. Samples were collected only from fossiliferous units in which it could be determined the fossils were on place and had not been leaked in or deposited by float material.

Each sample was carefully collected, sacked, and numbered, and the sample number assigned was recorded in a field notebook. The name of the stratigraphic unit, the legal description according to the section, township and range system, and a detailed lithologic description of the units were recorded. A notation was made of any fossiliferous zones present, with emphasis on the units that contained fenestrate bryozoans.

Most of the specimens were collected from shales, but in some cases fenestrate bryozoans were found in limestones, as shown in the register of sample localities. These specimens from limestones were prepared as well as possible in the laboratory and then examined. In all cases the specimens showed internal and external deformation by volume changes due to recrystallization of the organically deposited $CaCO_3$ into crystalline $CaCO_3$, and were discarded in the fear they might yield ambiguous values and lead to faulty conclusions. Thus most of the specimens described were obtained from shales.

## Laboratory Procedure

Preparation of Samples. Samples were prepared in a manner designed to harm the specimens the least. Treatment consisted of soaking samples in tap water until the loose clay could be washed off gently and decanted from the container. The samples were then soaked in a 30% solution of sodium hydroxide for two hours, and slowly boiled for thirty minutes. This was done in an attempt to remove any of the shale still adhering to the specimens. The materials were then dried at room temperature and examined under a binocular microscope. If they proved to be clean enough, they were labeled and boxed for future study. If, as in most cases, there was still too much matrix adhering to the forms for detailed study, they were soaked in a 2% solution of acetic acid for no longer than fifteen minutes. The forms were frequently examined to make sure delicate structures such as nodes and peristomes were not being damaged in any way. If any erosion of these structures appeared, the specimens were removed from the solution, washed with clean tap water, and further cleaning was stopped.

Specimens embedded in limestone matrix were soaked in tap water and washed as clean as possible. The specimens were then treated with a 2% solution of acetic acid as in the case of shale, still constantly observing the forms to be sure no erosion of delicate features was taking place.

Some specimens were embedded in chert. They were washed with tap water and treated with a 2% solution of acetic acid. Most of these forms proved to be silica-replaced; therefore the length of immersion in this acid or even a stronger solution of hydrocloric acid proved not to harm them. Not all of the forms in chert matrix were silica-replaced, and caution was required in the acid treatment.

Attempts were made to grind thin sections of the forms embedded in limestones and cherts in order to study internal structures such as zooecial tubes and diaphrams. These attempts proved fruitless because, in all of the sections made, recrystallization had altered internal structures, precluding accurate measurement.

<u>Mounting the Specimens</u>. Specimens were mounted in a manner to provide easy accessibility for future study, and so a minimum of storage space would be required for them. The specimens from each member were grouped together on the basis of morphological similarities and mounted on black strips of 1" x 3" paper glued with rubber base glue to a 1" x 3" blank cardboard slide. It was possible in most cases to mount two specimens on each of these prepared blanks, greatly aiding in the problem of storage. On each of these blanks the name of the unit was written in white ink on the left hand margin. The specimen number was written in white ink directly below the specimen. The specimens were glued to the blank using an ordinary water color brush, a vial of tap water and water soluble glue from gummed paper tape. The advantage of using this type of glue is that the specimen can easily be removed from the blank when measurements are being made, by re-dissolving the glue with water.

<u>Identification of Bryozoa</u>. The criteria most useful in the identification of the bryozoa in question according to previously published descriptions by Moore (1929), Elias (1937), and others include:

1. Diameter of the autopores.
2. Number of autopores in five millimeters.
3. Number of nodes in five millimeters.
4. Number of branches in five millimeters.
5. Number of fenestrules in one centimeter.
6. Branch width.
7. Dissepiment width.
8. Length and width of fenestrules.
9. Arrangement of autopores on the branches.
10. Presence or absence of autopores on dissepiments.

11. Surface characteristics of the reverse face.

12. Presence or absence of autopores on the reverse face.

All of these criteria can be applied to all the forms under question except the number of fenestrules in one centimeter and dissepiment width. On some forms, such as Thamniscus ramulosus, the branches coalesce and form fenestrules not occurring in a straight line. On these forms it was impossible to count the number of fenestrules per unit measurement; also because of the coalition of the branches, dissepiments were not formed; therefore these could not be measured.

## Method of Fossil Measurement

Measurements of specimens include: (1) those necessary for identification as set forth in previous descriptions by Moore, Elias and others, and (2) those necessary to graphically present evolutionary variations.

The measurement of morphological features was on a center-to-center basis (Plate 1, a). It is difficult and somewhat inaccurate to estimate the center of the fossil structures; therefore, the measurements were taken from the edge of a feature to the corresponding edge of the adjacent feature.

All measurements were made by using an ocular micrometer disk inserted in one ocular of a binocular microscope. The powers of magnification used were 22X and 60X. This ocular micrometer was calibrated with a stage micrometer for conversion to a millimeter scale. All measurements in this report are given in millimeters.

Several morphologic structures are suitable for measurement in order to investigate evolutionary trends. They are: (a) apetures, (b) branches, (c) dissepiments, (d) fenestrules and (e) nodes. Twenty-five measurements of each type of structure were made on each individual specimen, where

EXPLANATION OF PLATE I

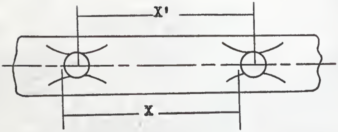
Fig. A. Illustration of the method of measurement used in this work. The distance from the center of one feature to the center of the adjacent feature, X', is the same as the distance from the front edge of the feature to the front edge of the adjacent feature, X.

Fig. B. F is the number of fenestrules in one centimeter; B is the number of branches in five millimeters.

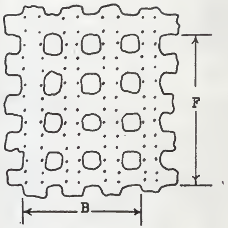
Fig. C. A is the number of apertures in five millimeters; Bw is the branch width; Dw is the dissepiment width.

Fig. D. Aw is the autopore width; N is the number of nodes in five millimeters.

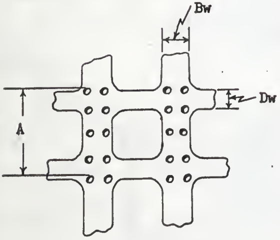
PLATE I



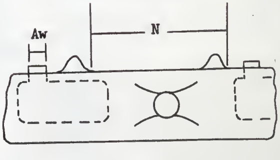

A




B




C




D

possible, in order to obtain a representative set of data. Where it was impossible to obtain twenty-five measurements, as many as possible were taken.

Apertures. Two aspects of apertures were measured: (1) the diameter of the aperture, Aw, and (2) the number of apertures in five millimeters, A, (Plate 1, C and D).

The number of apertures in five millimeters was measured in straight rows parallel to the axis of the branches. If a species had more than one row of apertures on each branch, each of these rows was measured.

The aperture width or diameter was measured on apertures randomly selected from the many present on each specimen. Care was taken to measure only the aperture and not the surrounding peristome.

Branches. Two aspects of branches were measured: (1) branch diameter, Bw, and (2) the number of branches in five millimeters (Plate 1, B and C).

The number of branches in five millimeters, B, varies from the proximal to the distal ends of fronds. On fragments of fronds, only one or two measurements could be taken and averaged; but on complete fronds where the proximal and distal ends were present, measurements at the two extremities were taken and averaged.

Branch diameters, Bw, were measured in a direction perpendicular to the long axis of the branch, and near the transverse axis of the fenestrule. Where secondary branches grew from primary branches, diameters were greatly enlarged and did not follow the representative average for the specimen. These enlarged areas were not measured.

Dissepiments. Dissepiments were measured only on the basis of their diameters, Dw (Plate 1, C). All dissepiments were measured at their narrowest constriction. In most cases this point was at the longitudinal axis of the fenestrule, but this did not always hold true.

Here, as in the branch diameter measurements, areas of secondary branch development produced dissepiments that were larger in diameter than the specimen average. Because of this, measurements in these areas were not taken.

Fenestrules. Fenestrules were measured on the basis of the number occurring in one centimeter, F (Plate 1, B). The fenestrule measurement was made in a direction parallel to the long axis of the branches. The ocular micrometer used in this work did not cover a one centimeter distance; therefore, the number of fenestrules in one millimeter were counted and mathematically converted to the equivalent number in one centimeter.

Nodes. Nodes were measured on the basis of the number occurring in five millimeters, N (Plate 1, D). Because of their delicate nature, many were indistinguishable due to weathering, and the measurement could not be performed.

The data compiled from these measurements and their mean values are shown in the appendix (Tables 10 through 16). The summation of the measurements of each of the five morphological features on each specimen was performed on an adding machine. The mean values were derived by the use of an electric calculator.

It should be noted that many of the measurements were made in such a way that, although a number per unit length is involved, one cannot actually count the number of features per unit measurement desired. The features must be counted from the center of the first feature to the center of another feature that occurs at some definite unit of measurement on the micrometer. The number per unit measurement desired can then be mathematically derived.

## Illustration Technique

For the purpose of illustration, a representative specimen from each species described was used. The obverse and reverse faces were photographed through a binocular microscope against a black background. The obverse and reverse were usually of the same specimen but in some cases the obverse face of one specimen and the reverse face of another specimen, each of the same species, was photographed. This was done in an attempt to produce the best illustrations possible.

The bryozoans were photographed with a 35 mm. camera using Kodak Panchromatic "Plus X" film. A number "1" photo floodlamp was used for lighting; it was placed three feet away from the subject and positioned so the light would be from the upper left hand corner. The settings used on the camera were: (a) infinity on the distance setting, (b) an "f" stop of 16, and (c) a shutter speed of 1/50th of a second.

The negatives were printed on 3" x 5" paper, mounted on a piece of poster board 17" x 22", labeled, photographed and then photographically reduced to page size. On the final print the scale was derived by measuring a feature on the photograph, then measuring the same feature on the actual specimen. The two values were compared and the amount of magnification calculated mathematically.

## Acknowledgment

The author wishes to thank William K. Clark for suggestions on various phases of this problem; Wallace Taylor and other geologists of the Kansas State Highway Commission for aid in obtaining base maps and outcrop locations for this work; Dr. Page Twiss for assistance in making fossil measurements; Carl Crumpton, Kansas State Highway Research Geologist, for suggestions and the use of photographic equipment; and the author's wife, Keran, for help given in tabulating numerical data.

Special thanks go to Virgil Burgat, Chief Geologist of the Kansas State Highway Commission, for part time employment provided the author during preparation of this paper. Without this assistance, the completion of this project would have been extremely difficult.

## REGISTER AND DESCRIPTION OF SAMPLE LOCALITIES

In this register the number assigned to each measured section corresponds to the number appearing on the index map of sample localities (Fig. 3). Not all of the localities listed contain bryozoan faunas but nevertheless all were described. This listing of the unproductive units and localities was done for the purpose of assisting future workers in their field investigation. Those measured sections that were productive of fenestrate bryozoans are indicated by a circle around the number assigned to that measured section. Descriptions of individual stratigraphic units within the measured section indicate which of these units contained the bryozoan faunas.

1. Road cut in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 27, T. 19 S., R. 4 E.

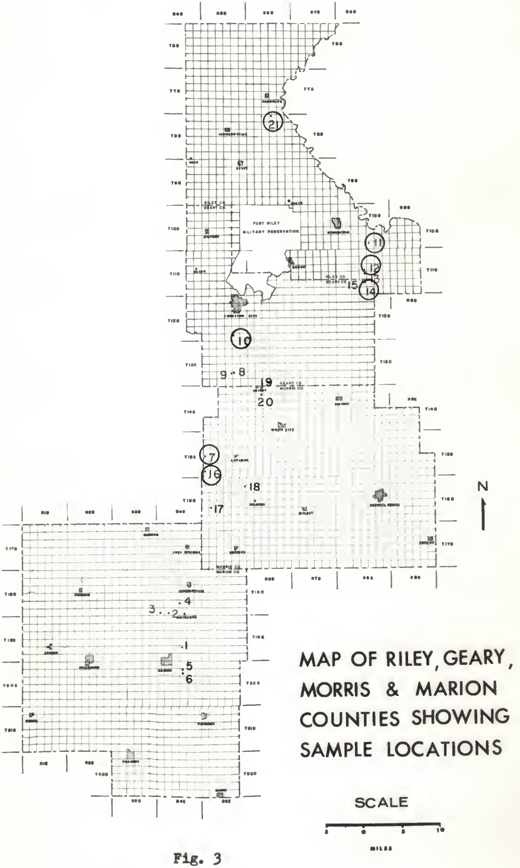
| | thickness (feet) | cum. thickness |
|---|---|---|
| Nolans Limestone | | |
| Herington Limestone Member | | |
| 2. Limestone, platy, soft, light grey to tan, clayey; small calcite geodes abundant; non-fossiliferous . . . . . . . . . . . . . . . . . . . . | 2.2 | 7.0 |
| Paddock Shale Member | | |
| 1. Shale, thin bedded, light grey, calcareous; weathers tan to grey; non-fossiliferous . . . . | 4.8 | 4.8 |

2. Road cut in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 35. T. 18 S., R. 4 E.

| | | |
|---|---|---|
| Odell Shale: | | |
| 3. Shale, thin-bedded, light grey, calcareous; weathers tan; non-fossiliferous . . . . . . . . . . | 2.0 | 7.1 |
| 2. Shale, platy, plates 1 in. to 4 in. thick, very calcareous, grey; weathers tan; non-fossiliferous | 1.1 | 6.1 |
| 1. Shale, thin bedded, light grey, calcareous; weathers tan; non-fossiliferous . . . . . . . . . | 4.0 | 4.0 |

3. Stream bank in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 36, T. 18 S., R. 4 E.

| | | |
|---|---|---|
| Nolans Limestone: | | |
| Krider Limestone Member: | | |
| 3. Limestone, platy, soft, light grey to tan, medium grain size; weathers tan; calcite geodes abundant; micro fossil material abundant, some pelecypod shell fragments . . . . . . . . . . . . . . . . . . . . . . . . | 1.4 | 5.8 |


21
11
12
13
14
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10
9
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19
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7
16
18
17
4
3
2
1
5
6
N
MAP OF RILEY, GEARY, MORRIS & MARION COUNTIES SHOWING SAMPLE LOCATIONS
SCALE
MILES

Fig. 3

| | thickness | cum. thickness |
|---|---|---|
| Odell Shale: | | |
| 2. Shale, platy, light grey; very calcareous, weathers tan; non-fossiliferous . . . . . . . | 2.4 | 4.4 |
| 1. Shale, thin bedded, light grey; calcareous, weathers tan; non-fossiliferous . . . . . . . | 2.0 | 2.0 |

4. Road cut in the NW¼ NW¼ SW¼ sec. 27, T. 18 S., R. 4 W.

| | thickness | cum. thickness |
|---|---|---|
| Nolans Limestone: | | |
| Herington Limestone Member | | |
| 2. Limestone, platy, soft, grey, weathers tan; bedding plates are ½ in. to 4 in. thick; non-fossiliferous . . . . . . . . . . . . . . . . | 1.2 | 7.3 |
| Paddock Shale Member: | | |
| 1. Shale, thin bedded, grey, calcareous; weathers light grey to tan; non-fossiliferous . . . . | 6.1 | 6.1 |

5. Stream bank in the N½ SE¼ NW¼ sec. 10, T. 20 S., R. 4 E.

| | thickness | cum. thickness |
|---|---|---|
| Winfield Limestone: | | |
| Stovall Limestone Member: | | |
| 3. Limestone platy, hard, light grey, fine grained; weathers buff; very fossiliferous, fossils include: "fenestrate type" and Rhombopora Bryozoans, echinoid spines and test plates, crinoid columnals, Dictyoclostus, much fragmental brachiopod and molluscan shell material . . . . . . . . . . . . . . . | 0.5 | 9.1 |
| 2. Limestone, massive, hard, light grey to buff; weathers buff, chert nodules abundant (up to one ft. in diameter); chert nodules contain "fenestrate type" bryozoans . . . . . . . . . . . . . . . . . . . . | 3.6 | 8.6 |
| Doyle Shale: | | |
| Gage Shale Member: | | |
| 1. Shale, blocky, light grey, clayey; weathers buff; chalcedony concretion abundant; non-fossiliferous | 5.0 | 5.0 |

6. Road cut in the NE¼ NE¼ SW¼ sec. 10, T. 20 S/, R. 4 E.

| | thickness | cum. thickness |
|---|---|---|
| Winfield Limestone: | | |
| Stovall Limestone Member: | | |
| 4. Limestone, massive, hard, light grey to buff; weathers buff; chert nodules abundant (up to one ft. in dia.); chert nodules contain "fenestrate type" bryozoans | 3.2 | 14.5 |

| | thickness | cum. thickness |
|---|---|---|
| Doyle Shale: | | |
| Gage Shale Member: | | |
| 3. Shale, thin bedded, light grey, calcareous; weathers tan to buff; horizontal and vertical calcite vein fillings; highly weathered; non-fossiliferous . . . . . . . . . . . . . . . . . . | 9.0 | 11.3 |
| 2. Shale, blocky, grey, calcareous; weathers buff; abundant pelecypod shell fragments. . . . . . . | 0.2 | 2.3 |
| 1. Shale, thin bedded, light grey, calcareous; weathers tan to buff; horizontal and vertical calcite vein fillings; highly weathered; non-fossiliferous . | 2.1 | 2.1 |

7. Road cut in the W$\frac{1}{2}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 19, T. 15 S., R. 5 E.

| | thickness | cum. thickness |
|---|---|---|
| Odell Shale: | | |
| 4. Shale, blocky, green moddled with grey, calcareous; weathers tan to grey; non-fossiliferous . . . . . | 3.0 | 11.2 |
| 3. Shale, blocky, dark green, clayey; weathers grey-green; "fenestrate type" forms abundant . . . | 2.6 | 8.2 |
| 2. Shale, blocky, chocolate brown with thin (1 in. or less) stringers of grey-green and mottled shales, clayey; weathers to bright red; non-fossiliferous . | 1.9 | 5.6 |
| 1. Shale, blocky, grey-green, silty; weathers light green; non-fossiliferous . . . . . . . . . . . . . . | 3.7 | 3.7 |

8. Road cut in the SE$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 26, T. 13 S., R. 5 E.

| | thickness | cum. thickness |
|---|---|---|
| Doyle Shale: | | |
| Gage Shale Member: | | |
| 3. Shale, blocky, grey-green, calcareous; weathers buff; calcite vein fillings; non-fossiliferous . . . . . . | 7.0 | 11.3 |
| 2. Shale, thin bedded, grey banded with green and maroon, calcareous; weathers grey-green; calcite geodes abundant; non-fossiliferous . . . . . . . . . | 3.1 | 4.3 |
| 1. Shale, blocky, drab green, calcareous; weathers buff; calcite crystals and calcite geodes abundant; non-fossiliferous . . . . . . . . . . . . . . . . . . . | 1.2 | 1.2 |

9. Road cut in the SE$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 26, T. 13 S., R. 5 E.

| | thickness | cum. thickness |
|---|---|---|
| Barneston Limestone: | | |
| Fort Riley Limestone Member: | | |
| 5. Limestone, massive, hard, tan to buff; weathers tan to buff; non-fossiliferous . . . . . . . . . . . . . . . . | 5.1 | 10.4 |
| 4. Limestone, platy, hard, buff, weathers buff and platy (plates $\frac{1}{2}$ to 2 in. thick); sparesely fossiliferous, no "fenestrate type" forms . . . . | .7 | 5.3 |

| | thickness | cum. thickness |
|---|---|---|
| 3. Limestone, massive, hard, buff, weathers buff; non-fossiliferous . . . . . . . . . . . . . . . . . | 1.1 | 4.6 |
| Oketo Shale Member: | | |
| 2. Shale, blocky to platy (plates $\frac{1}{2}$ to 4 in. thick), tan to grey, very calcareous; weathers tan; non-fossiliferous . . . . . . . . . . . . . . . . . . . | 1.0 | 3.5 |
| 1. Shale, massive, light grey, very calcareous; weathers light grey; sparsely fossiliferous (no bryozoa) . . . . . . . . . . . . . . . . . . | 2.5 | 2.5 |

(10) Road cut in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 34, T. 12 S., R. 5 E.

| | thickness | cum. thickness |
|---|---|---|
| Barneston Limestone: | | |
| Oketo Shale Member: | | |
| 4. Shale, blocky, buff to light grey, calcareous; weathers grey; sparsely fossiliferous, no bryozoa | 1.0 | 6.1 |
| 3. Shale, blocky, light grey, very calcareous; weathers grey; very fossiliferous, "fenestrate type" and Rhombopora Bryozoans abundant, also much fragmental brachiopod and molluscan shell material along with echinoids, crinoids and much micro-fossil material . . . . . . . . . . . . . . | 0.1 | 5.1 |
| 2. Shale, thin bedded to blocky, tan to light grey, clayey calcareous; weathers light grey; sparsely fossiliferous, no bryozoa . . . . . . . . . . . . | 4.0 | 5.0 |
| 1. Shale, platy (plates $\frac{1}{2}$ to 4 in. thick) tan to light grey, very calcareous; weathers tan; non-fossiliferous . . . . . . . . . . . . . . . . . . | 1.0 | 1.0 |

(11) Road cut in the NE$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 34, T. 10 S/, R. 8 E.

| | thickness | cum. thickness |
|---|---|---|
| Wreford Limestone: | | |
| Threemile Limestone Member: | | |
| 6. Limestone, platy, hard, tan; weathers tan; 0.2 ft. blue chert zone 0.6 ft. from eroded top; much micro-fossil material . . . . . . . . . . . . . . . . . . | 1.2 | 24.5 |
| 5. Shale, thin bedded, light tan, calcareous; weathers light tan; non-fossiliferous . . . . . . . . . . . | .7 | 22.3 |
| 4. Limestone, platy, hard tan to buff, weathers tan; 0.2 ft. blue chert zone 0.2 ft. from top and 0.5 ft. from Speiser Shale contact . . . . . . . . . . | 1.9 | 21.6 |

| | thickness | cum. thickness |
|---|---|---|
| **Speiser Shale:** | | |
| 3. Shale, thin bedded, tan, calcareous; weathers buff; fossiliferous, "fenestrate type" and Rhombopora bryozoans abundant, also crinoid columnals and fragments of brachiopod shells . . . . . . . . . . | 2.3 | 19.7 |
| 2. Limestone, platy, medium hard, tan to very light grey, weathers tan; fine grained and crystalline; much micro-fossil material . . . . . . . . . . . . | 1.2 | 17.4 |
| 1. Shale, thin bedded, upper 3.7 ft. olive green, next 1.9 ft. maroon to purple, next 1.0 ft. olive green, next 0.8 ft. iron red, bottom 8.8 ft. tan-brown; weathers same; sparsely fossiliferous, no bryozoa . . . . . . . . . . . . . . . . . . . . . | 16.2 | 16.2 |

(12) Road cut in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 21, T. 11 S., R. 8 E.

| | thickness | cum. thickness |
|---|---|---|
| **Wreford Limestone:** | | |
| Threemile Limestone Member: | | |
| 7. Limestone, massive, hard, buff, weathers buff; solution pitting common; marker bed; non-fossiliferous . . . . . . . . . . . . . . . . . . . | 1.2 | 16.2 |
| 6. Limestone, massive, hard, tan to buff, weathers tan; many thin (1 in. to 3 in. thick) chert seams; much microscopic organic material, crinoid columnals abundant . . . . . . . . . . . . . . . . . . . . . | 2.2 | 15.0 |
| 5. Shale, thin bedded, tan, calcareous; weathers tan; shale break in limestone; "fenestrate type" bryozoans present near north end of outcrop . . . . | .4 | 12.8 |
| 4. Limestone, massive, medium hard, tan, weathers tan; three chert layers 0.2 ft. thick, one 0.2 ft. from top, one 0.8 ft. from top and one 1.2 ft. from top; much microscopic organic material and many crinoid columnals . . . . . . . . . . . . . . . . . . . . . . | 2.1 | 12.4 |
| **Speiser Shale:** | | |
| 3. Shale, thin bedded, tan, calcareous; weathers tan; fossiliferous, Derbya, Marginifera, Meekella and Dictyoclostus abundant, no bryozoan material apparent . . . . . . . . . . . . . . . . . . . . . | 2.9 | 10.3 |
| 2. Limestone, platy, hard, tan to grey, weathers tan; much microscopic organic material . . . . . . . . | 1.0 | 7.4 |
| 1. Shale, thin bedded, vari-colored, calcareous; upper 2.4 ft. tan to olive green, weathers same, next 0.1 feet white and non calcareous, next 0.4 ft. green to maroon, blocky in part and very calcareous, next 3.6 feet covered with slump material, abundant brachiopod material present, same fauna as in 3 above . . . . . . . . . . . . . . . . . . . . . . | 6.4 | 6.4 |

| | | thickness | cum. thickness |
|---|---|---|---|
| | **13.** Road cut in the NW¼ SW¼ NW¼ sec. 21, T. 11 S., R. 8 E | | |
| Wreford Limestone: | | | |
| Shroyer Limestone Member: | | | |
| 4. | Chert, blue; rubble left on erosional surface . . . | .5 | 6.1 |
| 3. | Shale, blocky almost platy, tan, very calcareous; weathers tan; <u>Composita</u> and <u>Dictoclostus</u> brachiopods common . . . . . . . . . . . . . . . . . . . . . . . . | .3 | 5.6 |
| 2. | Limestone, massive, hard, tan, weathers tan; very fine grained; very fossiliferous, much nicroscopic organic material and fragmental brachipod and molluscan shell material; "fenestrate type" bryozoans present in thin shale stringer 0.3 ft. from top of limestone (in calcareous matrix) . . . . . . . . . . . | 1.1 | 5.3 |
| 1. | Shale, thin bedded, tan, slightly calcareous; weathers tan; <u>Composita</u> common. . . . . . . . . . . . | 4.2 | 4.2 |
| | **14.** Road cut in the NW¼ NW¼ SE¼ sec. 28, T. 11 S., R. 8 E. | | |
| Matfield Shale: | | | |
| Blue Springs Shale Member: | | | |
| 13. | Shale, thin bedded, blue-green, slightly calcareous; weathers grey; non-fossiliferous . . . . . . . . . . . | 9.0 | 54.5 |
| 12. | Shale, thin bedded, maroon, slightly calcareous; weathers maroon; non-fossiliferous . . . . . . . . . . | .4 | 45.5 |
| 11. | Shale, blocky, drab olive green, very calcareous; weathers green; non-fossiliferous . . . . . . . . . . | .2 | 45.1 |
| 10. | Shale, thin bedded, olive green, slightly calcareous; weathers maroon; non-fossiliferous . . . . . . . . . . | 12.1 | 44.9 |
| 9. | Shale, thin bedded, olive green, slightly calcareous; weathers olive green; non-fossiliferous . . . . . . | 5.4 | 32.8 |
| 8. | Shale, thin bedded, black, calcareous in part; weathers black; sparsely fossiliferous throughout except for 0.3 ft. calcareous ledge 5.8 ft. from contact with Kinney Limestone. This zone contains abundant "fenestrate type" forms, brachiopod spines and much fragmental shell material . . . . . . . . . | 10.6 | 27.4 |
| Kinney Limestone Member: | | | |
| 7. | Limestone, massive, hard, tan, weathers tan; fine grained and crystalline; much solution pitting; non-fossiliferous . . . . . . . . . . . . . . . . . . . | 1.1 | 16.8 |
| 6. | Shale, fine bedded to blocky, tan to grey, calcareous; weathers tan to grey; non-fossiliferous | 1.2 | 15.7 |
| 5. | Limestone, massive, hard, tan, weathers tan; fine grained and crystalline; some solution pitting; non-fossiliferous . . . . . . . . . . . . . . . . . . | 1.9 | 14.5 |

| | thickness | cum. thickness |
|---|---|---|
| Wymore Shale Member: | | |
| 4. Shale, blocky, tan, calcareous; weathers buff; non-fossiliferous . . . . . . . . . . . . . . . . . . | 1.5 | 12.6 |
| 3. Shale, thin bedded, olive green, calcareous; weathers drab green; thin calcareous seams directly overlie and underlie this zone and also follow joints through it; non-fossiliferous . . | .5 | 11.1 |
| 2. Shale, thin bedded, tan to grey, calcareous; weathers tan to grey; non-fossiliferous . . . . . . | 7.4 | 10.6 |
| 1. Shale, blocky, tan, very calcareous; weathers tan; non-fossiliferous . . . . . . . . . . . . . . . | 3.2 | 3.2 |

15. Road cut in the NW¼ NW¼ NW¼ Sec. 28, T. 11 S., R. 8 E

| | thickness | cum. thickness |
|---|---|---|
| Barneston Limestone: | | |
| Florence Limestone Member: | | |
| 6. Limestone, platy, hard, tan, weathers tan; fine grained; light grey to blue chert nodules abundant; non-fossiliferous . . . . . . . . . . . . . . . . . . | 3.5 | 12.3 |
| 5. Limestone, massive, hard, tan, weathers tan; small solution pits abundant; many irregularly banded zones of chert nodules; sparsely fossiliferous . . . | 3.2 | 8.8 |
| 4. Shale, blocky, tan, very calcareous; weathers tan; non-fossiliferous . . . . . . . . . . . . . . . . . . | .1 | 5.6 |
| 3. Limestone, irregular bedding planes; hard, tan, weathers tan; grey to blue chert nodules abundant; sparsely fossiliferous . . . . . . . . . . . . . . . . | 4.5 | 5.5 |
| 2. Shale, thin bedded, buff, calcareous; weathers buff; sparsely fossiliferous; in places the upper 0.3 ft. becomes limy and contains abundant microscopic organic material and many crinoid columnals . . . . . . . . . . . . . . . . . . . . . . | .7 | 1.0 |
| 1. Limestone, massive to platy; hard, tan, weathers dark grey; fine grained; much microscopic organic material and many crinoid columnals . . . . . . . . | .3 | .3 |

16. Railway cut in the NW¼ NW¼ sec. 31, T. 15 S., R. 5 E.

| | thickness | cum. thickness |
|---|---|---|
| Nolans Limestone: | | |
| Herington Limestone Member: | | |
| 16. Limestone, massive; soft, tan, weathers tan grey and blocky; many vertical joints, weathered surface pitted; calcite filled cavities; non-fossiliferous . | 2.0 | 24.5 |
| 15. Limestone, platy, medium hard, tan, weathers tan grey; non-fossiliferous . . . . . . . . . . . . . . . | 2.0 | 22.5 |
| 14. Limestone, blocky, medium hard, tan-grey, weathers tan; iron stains on surface; non-fossiliferous . . . | 1.6 | 20.5 |

| | thickness | cum. thickness |
|---|---|---|
| Paddock Shale Member: | | |
| 13. Shale, blocky, grey-green, non-calcareous; weathers tan grey; non-fossiliferous . . . . . . . . | 1.0 | 18.9 |
| 12. Shale, thin bedded, tan-grey to blue-grey, very calcareous; weathers same; many calcareous seams; very fossiliferous; many "fenestrate type" bryozoans . . . . . . . . . . . . . . . . . . . . . . | 1.8 | 17.9 |
| 11. Shale, blocky, tan-grey, calcareous; weathers grey; non-fossiliferous . . . . . . . . . . . . . . . . | 4.3 | 16.1 |
| 10. Shale, thin bedded, grey, very calcareous; weathers grey; very fossiliferous; many "fenestrate type" bryozoans . . . . . . . . . . . . . | .2 | 11.8 |
| 9. Shale, thin bedded, tan-grey to grey-green calcareous; fossiliferous; no "fenestrate" forms . . | 2.9 | 11.6 |
| 8. Shale, thin bedded, dark-grey to grey-green, calcareous; weathers same; some limonite stains; non-fossiliferous . . . . . . . . . . . . . . . . . . . . | 2.3 | 8.7 |
| 7. Shale, thin bedded, dark-grey, calcareous; weathers same; non-fossiliferous . . . . . . . . . . . | .3 | 6.4 |
| 6. Limestone, blocky, hard, dark grey, weathers grey; fossils common but no "fenestrate" forms . . . . . . | .6 | 6.1 |
| 5. Shale, thin bedded, olive green to grey, calcareous; weathers same; fossiliferous in upper part; no "fenestrate" forms . . . . . . . . . . . . . . . . . . | 1.6 | 5.5 |
| 4. Shale, thin bedded, grey-green to grey, calcareous; weathers same; non-fossiliferous . . . . . . . . . . | .9 | 4.9 |
| Krider Limestone Member: | | |
| 3. Limestone, massive, medium hard, grey, weathers tan; much micro-fossil material and <u>Derbya</u> shell fragments . | .9 | 4.0 |
| 2. Shale, ill defined bedding, tan-olive green, calcareous; non-fossiliferous . . . . . . . . . . . . . . | 2.2 | 3.1 |
| 1. Limestone, massive to platy, medium hard, light grey, weathers dark grey to tan; upper contact with shale very fossiliferous; much micro-fossil material and <u>Derbya</u> shell fragments . . . . . . . . . . . . . . . | .9 | .9 |

17. Streambank in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 29, T. 16 S., R. 5 E

| | thickness | cum. thickness |
|---|---|---|
| Nolans Limestone: | | |
| Krider Limestone Member: | | |
| 5. Limestone, blocky, soft, tan, weathers grey; non-fossiliferous . . . . . . . . . . . . . . . . . . . . . | 1.0 | 9.5 |

| | thick-ness | cum. thick-ness |
|---|---|---|
| Odell Shale: | | |
| 4. Shale, thin bedded to blocky, gray-green, calcareous; weathers grey; granular; non-fossiliferous . . . . . | .7 | 8.5 |
| 3. Shale, blocky, grey-green, very calcareous; weathers grey; non-fossiliferous . . . . . . . . . . | .1 | 7.8 |
| 2. Shale, blocky, grey-green, calcareous; weathers grey-green; sparsely fossiliferous . . . . . . . . . | 3.8 | 7.7 |
| 1. Shale, blocky, maroon, calcareous; weathers maroon; non-fossiliferous . . . . . . . . . . . . . | 3.9 | 3.9 |

18. Quarry in the $NE\frac{1}{4}$ $NE\frac{1}{4}$ sec. 12, T. 16 S., R. 5 E

| | | |
|---|---|---|
| Winfield Limestone: | | |
| Cresswell Limestone Member: | | |
| 2. Limestone, massive, medium-hard, light grey, weathers blocky in the lower part and platy in the upper part; geodes abundant and contain both chalcedony and crystals of calcite; non-fossiliferous . . . . . . . | 6.2 | 10.8 |
| 1. Limestone, massive, hard, blue-grey, weathers tan and to large blocks; contains siliceous nodules 1 in. to 3 in. in diameter . . . . . . . . . . . . . . | 4.6 | 4.6 |

19. Road cut in the $NE\frac{1}{4}$ $NE\frac{1}{4}$ sec. 5, T. 14 S., R. 6 E.

| | | |
|---|---|---|
| Barneston Limestone: | | |
| Fort Riley Limestone Member: | | |
| 7. Limestone, blocky, soft, tan, porous; weathers tan grey some limonite stains; non-fossiliferous . . . . . . | .6 | 25.8 |
| 6. Limestone, blocky, soft, tan to tan-grey, weathers light grey and thin bedded in upper part and blocky in lower part; non-fossiliferous . . . . . . . . . . . | 11.6 | 25.2 |
| 5. Shale, thin-bedded, tan, very calcareous; weathers tan; non-fossiliferous . . . . . . . . . . . . . . | .6 | 13.6 |
| 4. Limestone, blocky, medium hard, light tan, porous; weathers tan-grey; highly fractured; some limonite staining; forms "rimrock" outcrop; sparsely fossiliferous, no "fenestrate" forms . . . . . . . . . | 5.4 | 13.0 |
| 3. Shale, thin-bedded to platy, tan-grey, very calcareous; weathers tan; non-fossiliferous . . . . | 1.3 | 7.6 |
| 2. Limestone, blocky, hard, tan-grey; weathers blocky in lower part and platy in upper part; some limonite staining; fossiliferous, no "fenestrate" forms . . . | 1.0 | 6.3 |
| Oketo Shale Member: | | |
| 1. Shale, thin-bedded, tan-grey, very calcareous and silty; weathers tan; fossiliferous, no "fenestrate" forms . . . . . . . . . . . . . . . . . . . . . . . | 5.3 | 5.3 |

20. Road cut in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8., T. 14 S., R. 6 E.

| | thickness | cum. thickness |
|---|---|---|
| **Barneston Limestone:** | | |
| Fort Riley Limestone Member: | | |
| 5. Limestone, massive, medium hard, grey, porous; weathers grey and blocky; forms "rimrock" outcrop; non-fossiliferous . . . . . . . . . . . . . . . . . . . | 3.0 | 9.8 |
| 4. Limestone, blocky, medium hard, tan to grey; weathers tan to grey and platy; fossiliferous, no "fenestrate" forms . . . . . . . . . . . . . . . . . . | 2.0 | 6.8 |
| Oketo Shale Member: | | |
| 3. Shale, thin-bedded, olive green to tan, calcareous; weathers same; non-fossiliferous . . . . . . . . . . . | .5 | 4.8 |
| 2. Limestone, blocky, soft, brown, clayey; weathers brown; sparsely fossiliferous, no "fenestrate" forms | .3 | 4.3 |
| 1. Shale, blocky, olive-tan, calcareous; weathers gray; non-fossiliferous . . . . . . . . . . . . . . . . . | 4.0 | 4.0 |

21. Roadcut in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 3, T. 18 S., R. 6 E.

| | thickness | cum. thickness |
|---|---|---|
| **Winfield Limestone:** | | |
| Grant Shale Member: | | |
| 3. Shale, thin bedded, olive green, slightly calcareous; weathers tan; non-fossiliferous . . . . . | 6.3 | 10.1 |
| 2. Shale, platy, light grey, very calcareous; weathers tan; fossiliferous, contains abundant "fenestrate" bryozoans, brachiopod and pelecypod shell fragments and crinoid columnals . . . . . . . . . | 2.2 | 3.8 |
| 1. Shale, fine bedded, olive green to dark grey; slightly calcareous; weathers tan; sparsely fossiliferous, abundant pelecypod shell fragments . . . | 1.6 | 1.6 |

## SYSTEMATIC DESCRIPTIONS

### Family FENESTELLIDAE King 1849

Fenestellidae, King, 1849, Ann. and Mag. Nat. Hist., 2nd series, v. 3, p. 388.

Synonyms. Enalloporidae, Sphragioporidae, Thamniscidae Miller, 1899; Fenestrellinidae Bassler, 1935.

Range. Ordovician-Permian

Zoaria forming reticulate expansions composed of rigid branches, laterally joined by regularly spaced non-poriferous crossbars (dissepiments) or by coalescence at opposed sinuous bends so as to leave open spaces (fenestrules) of circular, elliptical or quadrangular form extending through the zoarium; branches rarely free, not laterally connected. Zooecia consisting of short recumbent tubes embedded in minutely porous calcareous tissue which is progressively modified by secretion of fine-grained dense laminae (sclerenchyme); proximal part of zooecia commonly de-limited by a superior hemiseptum forming a semi-closed chamber which appears rounded, quadrate or polygonal in longitudinal sections; primary orfice anterior..., external apertures rounded, rimmed by a peristome..., reverse side may be smooth, longitudinally striate, granulose, or nodose. Mesopores lacking but acanthopores represented by spines on the front side of branches, generally regularly spaced along a keel, may occur. (Bassler, 1953, p. G 120).

### Genus Fenestella Lonsdale 1839

Fenestella Lonsdale, 1839, Corals, Silurian System by Sir R. I. Murchinson, p. 667, London, 1839.

Fenestella Nickles and Bassler, 1900, Synopsis Am. Fossil Bryozoa, U. S. Geol. Survey Bull. 173, p. 244.

Fenestella Bassler, 1953, Treatise on Invertebrate Paleontology, pt. G, Bryozoa, p. G 120.

Synonym. Fenestrella d' Orbigny 1849.

Original Type. Fenestella antiqua Lonsdale, 1839

Range. Ordovician-Permian

Zorium funnel or fan shaped. Zooecia in two rows on each branch with 2 to 8 apertures in a single row adjoining one fenestrule. Front of branches with or without mediam keel and acanthopore spines present or absent. (Bassler, 1953, p. G 120).

Discussion. Specimens of this genus were found in the Speiser Shale Formation, the Oketo Shale Member of the Barneston Formation and the Blue Springs Member of the Matfield Shale Formation.

Fenestella pectinis Moore 1929

Plate 2, figures 1a & 1b

F. pectinis Moore, 1929, Jour. Paleo., v. 3, p. 18-19, figs. 8-10, p. 14, (Virgilian, North-Central Texas).

..... The branches are straight about .25 mm. in width, ten and one-half to eleven occuring in five mm. Fenestrules .3 to .35 long by .2 mm. wide, quadrate to rectangular, ten occuring in 5 mm. The dissepiments are less than half the width the branches, measuring about .1 mm. and are only slightly expanded terminally. The zooecia are somewhat unevenly arranged in two alternating rows, an aperture commonly being located at each end of the dissepiment, and one at the mid-length of the fenestrule, 23 occuring in 5 mm. Apertures circular, .075 mm. in diameter, bearing a peristome which is rather prominently elevated on the outside of the branch and, where well preserved, terminating in a spinose projection. Each branch bears a moderately strong rounded carina about one-third the width of the branch. Along the carina is a single row of rather prominent conical or slightly compressed tubercles, .1 mm. in diameter at the base and .2 mm. from one to the next, 25 in 5 mm. The spines rise about .12 mm. above the top of the keel. The reverse side of the zoarium is distinctly but finely granulose, the dissepiments are not depressed below the branches .... (Moore, 1929, p. 18-19.)

Discussion. The specimens collected in this work conformed to the description by Moore closely in most respects except the diameter of the autopores (Table 1).

Table 1. Comparison of measurements of Fenestella pectinis.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Moore, 1929 | .1 | .075 | .25 | 20 | 23 | 10.5-11 | 25-26 |
| This Work | .126 | .102 | .211 | 19.13 | 20.22 | 11.56 | ---- |

The difference in the aperture diameters could be due to variations in measuring techniques; therefore, the difference was not considered significant. The nodes on the specimens were badly eroded and no accurate count could be made of them.

All of the features of this form were well preserved with the exception of the nodes. Only fragments of fronds could be found; therefore, no definite assumption as to the overall shape and size of the colonies could be made.

This species is very similar F. mimica (Ulrich) wellsi Elias 1937, also described in this report. Quadrate appearance of the fenestrules, greater number of nodes, lack of longitudinal striae on the reverse face and undepressed dissepiments on the reverse face are diagnostic criteria most useful in distinguishing F. pectinis from F. mimica wellsi.

Occurrence. Specimens of F. pectinis were found only in the Speiser Shale Formation and the Oketo Shale Member of the Barneston Limestone Formation.

Repository. Kansas State University, Department of Geology, specimens labeled "Speiser Shale", number 1-5, 7, 9, 11-16, and 18; and "Oketo Shale", number 5.

Fenestella mimica (Ulrigh) wellsi Elias 1937

Plate 2, figures 2a, b.

F. mimica wellsi Elias, 1937, Jour. Paleo., v. 11, p. 313, fig. 3, p. 321, Table 1, p. 315.

Zoarium fine, delicate with branches straight and sub-parallel, 0.20 to 0.26 mm., wide average 0.24 mm; 0.24 mm; 0.24 mm. thick, 11 occurring in 5 mm., dividing by bifurcation. Dissepiments minimum width 0.14 mm., deeply recessed below the obverse face, only moderately below the reverse face; expanded terminally. Fenestrules subrectangular, elongate vertically, median portion of each side slightly indented by projecting zooecia. Nineteen fenestrules occur in 1 cm., average dimensions 0.23 by 0.36 mm. Zooecial apertures round, 0.04 to 0.08 mm. in diameter, average 0.06 mm., surrounded completely by low well defined peristomes.

Apertures in two ranges, arranged in alternating rows, commonly one aperture at the end of each dissepiment and one opposite each fenestrule. Average of 20 apertures in 5 mm. Reverse face with coarse granulose striae, obverse with well developed carina on branches, one-third width of branches and containing prominent blunt nodes .... (Richards, 1955, p. 57).

Discussion. Following is a comparison of measured features of *F. mimica wellsi* Elias 1937:

Table 2. Comparison of measurements of *Fenestella mimica wellsi*.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Elias, 1937 | —— | —— | .20 | 20 | 20-23 | 11.5 | —— |
| Richards, 1955 | .14 | .04-.08 | .20-.26 | 19 | 20 | 11 | 20 |
| This Paper (Speiser) | .1762 | .1020 | .2434 | 14.64 | 19.85 | 10.13 | —— |
| This Paper (Blue Springs) | .1111 | —— | .1913 | 21.08 | —— | 17.34 | —— |
| This Paper (Oketo) | .1481 | .0915 | .2100 | 21.97 | 26.56 | 14.72 | —— |
| Mean, This Paper | .1451 | .0968 | .2149 | 19.23 | 23.21 | 13.75 | —— |

As is evident all of the measurements in this report closely approximate the measurements of Elias and Richards with the exception of the number of branches in 5 mm., "B". This deviation may be error in measurement by the author. Only small fragments of fronds were available; therefore, the branches present were measured and the actual number in 5 mm. was mathematically derived. Serious error can be introduced into the study using this method since the number of branches in a unit distance will vary slightly over the frond.

Most of the morphological features of these specimens were well preserved with the exception of the nodes. These showed extreme erosion and, as in F. pectinis, no accurate measurement of them could be made.

The granulose striae of the reverse face, subrectangular fenestrules, and the slight depression of the fenestrules on the reverse face distinguish F. mimica wellsi from F. pectinis.

Occurrence. Specimens of F. mimica wellsi were collected from the Speiser Shale Formation, Blue Springs Shale Member of the Matfield Shale Formation, and the Oketo Shale Member of the Barneston Limestone Formation. The species is especially abundant in the Oketo Shale Member.

Repository. Kansas State University, Department of Geology, specimens labeled "Speiser Shale" numbers 6, 8 and 10; "Blue Springs Shale" numbers 1, 8 and 10; "Oketo Shale" numbers 1-4, 13, 15, 17 and 18.

Fenestella sp., aff. F. modesta Ulrich

Plate 2., figure 3

Fenestella modesta Ulrich, 1890, Geol. Surv. Illinois, v. VIII, p. 550, pl. LII, figs. 3-3b (Coal Measures, Knox County and Seville, Ill.)

Fenestella modesta var. Moore, 1929, Jour. Paleo., v. 3, p. 21, pl. 3, fig. 11 (Pennsylvanian, North-Central Texas).

Only one specimen of this form was found and only the reverse face of it was seen. The features seen on the specimen matched favorably the description of F. modesta Ulrich, 1890, except the branch width and the dissepiment width are appreciably larger.

The specimen more nearly matched F. sp., aff. F. modesta Ulrich, 1890, described by Richards (Richards, 1955, p. 63, pl. 1, fig. 4; pl. 3, fig. 7.), but again the diameter on the branches and dissepiments were found to be appreciably larger.

<u>Discussion</u>. Table 3 gives a comparison of measurements of different forms of <u>F</u>. <u>modesta</u>:

Table 3. Comparison of measurements of <u>Fenestella</u> <u>modesta</u>.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Aff. <u>F</u>. <u>modesta</u> This Paper | .4004 | ----- | .4916 | 7.32 | ----- | 6.70 | ----- |
| Aff. <u>F</u>. <u>modesta</u> Richards | .25 | .10 | .37 | 10 | 18 | 8.0 | 10 |
| Ulrich 1890 | ----- | ----- | .20 | 12-14 | 20-21 | 8.5-10 | ----- |
| Moore 1929 | ----- | .09 | .30 | 5.8 | 21 | 7.7 | ----- |
| var. by Moore, 1929 | ----- | .09 | ----- | 14-17 | 19 | 8-8.5 | 10-11 |

In comparing the specimen of this report to that of Richards' report, it is evident variations are present. Table 3 shows that as the branch and dissepiment width increase the number of branches and fenestrules per unit measurement decrease. If they are the same species the evidence presented here could suggest a definite evolutionary trend in the form. Richards' specimen was collected from the Coal Creek Member of the Pennsylvanian Topeka Formation. The specimen in this report was collected from the Oketo Shale Member of the Permian Barneston Formation.

<u>Occurrence</u>. This form was found only in the Oketo Shale Member in the area under study. Future study and more complete descriptions of the forms would probably prove rewarding.

<u>Repository</u>. Kansas State University, Department of Geology, specimen labeled "Oketo Shale" number 6.

## Genus Polypora McCoy 1844

Polypora Nickles and Bassler, 1900, Synopsis Am. Fossil Bryozoa, U. S. Geol. Surv., Bull. 173, p. 357-358.

Polypora Bassler, 1953, Treatise on Invertebrate Paleontology, pt. G Bryozoa, p. G 125.

Synonyms. Flabelliporella, Polyporella Simpson, 1895

Original type. Polypora dendroides McCoy, 1844.

Zoaria in most respects like Fenestella, but differing in having from two to six or even eight rows of cells (apertures), and in wanting the characteristic median keel. The latter is sometimes represented by a row of strong tubercules......(Geol. Surv. Ill, 1890, Polypora, McCoy, p. 396).

Discussion. Specimens of this genus were found in the Speiser Shale Formation, the Threemile Limestone Member of the Wreford Limestone Formation and the Grant Shale Member of the Winfield Limestone Formation. All specimens were very well preserved, including most delicate features.

## Polypora elliptica Rogers 1900

Polypora elliptica Rogers, 1900, Kansas University Quart., v. 9, no. 1 (A), p. 7-8, pl. 4, fig. 4 (Upper Coal Measures, Eastern Kansas, Western Missouri).

Polypora elliptica Rogers, 1900, Jour. Paleo., v. 11, p. 327 (Paleozoic Fenestrate Bryozoans).

Zoarium a reticulate expansion. Branches slightly flexuous, convex, 0.4 to 0.5 mm. wide, seven to eight in 5 mm. Dissepiments short, subcarnate, about half as wide as the branches. Fenestrules elliptical (especially in worn specimens), averaging about 0.6 by 0.3 mm., with from five to six occuring in 5 mm. Zooecia in three or four alternating ranges, which number is often reduced to two for a very short distance after bifurcation. The typical number of ranges is three when the central row forms the flat median summit of the branch. In this case the number is increased to four shortly before bifurcation.

Apertures small, subcircular, about one and one-half times their diameter apart longitudinally. The rows of apertures are separated by inconspicuous undulating ridges, which are at intervals elevated to form small nodes about as numerous as the apertures. The ridges are more prominent in worn specimens. On the reverse the dissepiments and branches are on the same plane. The latter are finely striated.... (Rogers, 1900, p. 7-8).

Discussion. Only subspecies of P. elliptica were found in this work. The above description is included for comparison with these subspecies.

Polypora elliptica var. B Elias 1937

Plate 2., figures 4 a, b

Polypora elliptica var. B Elias, 1937, Jour. Paleo., v. 11, p. 331 (Late Wolfcampian, Kansas and Oklahoma).

Similar to P. elliptica but possessing a stouter zoarium, this stout zoarium being its regular feature.

> The stout form has very thick branches (one and one-half times as thick as wide) and its nodes, which surround the zooecia of the central row, are very massive, the zooecia being deeply sunk in between. Besides these ordinary nodes the form has also massive node-like elevations on the dissepiments, usually two on each dissepiment. These elevations make the dissepiments nearly as thick as the branches. The following are the average data measured on specimens from the Fort Riley Limestone (Kansas University Coll., no. 860). Branches, 15 per 10 mm.; fenestrules, 8 per. 10 mm.; zooecia, 20 per 5 mm. (3 per fenestrule).... (Elias, 1937, p. 331).

Discussion. The typical three ranges of apertures, the undepressed dissepiments and the fine striations on the reverse face are diagnostic of the species P. elliptica. The stout zoarium with dissepiments nearly as wide as the branches and the node-like elevations on the dissepiments are useful criteria in distinguishing P. elliptica B from other related forms.

A comparison of measurements of Polypora elliptica B described in this paper with measurements of previously published descriptions is given in Table 4.

The measurements in this work agree favorably with the values given by Elias for his specimens from the Deer Creek Limestone near Topeka, Kansas (Elias, 1937, p. 329, Table 6.), in the following table. Elias also describes a form collected from the Fort Riley Limestone in his original description above. The measurements of this form approximate the measurements of this work;

however, his measurements of forms from the Deer Creek Limestone conform even more closely to the measurements in this work.

Table 4. Comparison of measurements of Polypora elliptica B.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Elias, 1937 | near Bw (-) | ----- | 0.4 | 9-10 | 19-19.5 | 6.5-7 | ----- |
| Richards 1955 | ----- | ----- | 0.6 | 8.6 | 17 | 5.3 | 12-14 |
| This Paper (Threemile) | .3355 | .1371 | .3586 | 9.73 | 20.16 | 7.31 | ----- |
| This Paper (Speiser) | ----- | .1397 | ----- | ----- | 20.41 | ----- | ----- |

Neither Elias nor Richards give definite aperture diameter measurements for their described forms of P. elliptica B. Richards does give the average measurement of 0.09 mm. for the aperture diameter of his described forms of P. elliptica and states the measurements of P. elliptica B are similar.

Measurements of the aperture diameter in this work vary widely from Richards' measurements, but may be explained by a difference in measuring techniques.

Occurrence. Specimens of P. elliptica B were found only in the Speiser Shale Formation and the Threemile Limestone Member of the Wreford Limestone Formation. Elias (1937) reported finding the species in the Fort Riley Limestone Member of the Barneston Limestone Formation.

Repository. Kansas State University, Department of Geology, specimens labeled "Speiser Shale" number 19; "Threemile Limestone" numbers 1, 2, 3, 12 and 19.

Polypora elliptica subspecies C n. s sp.

Plate 2, figures 5a, b

Description. Similar to P. elliptica B in appearance except this form lacks the blunt nodes at the ends of the dissepiments. There are usually three ranges of autopores changing to two rows immediately after bifurcation. The two ranges dominate the secondarily formed branches for the approximate length of the fenestrule involved, then three ranges again appear. The measurements vary slightly from P. elliptica B in all of the morphological features involved. Table 5 is a comparison of the measurements of P. elliptica C and P. elliptica B:

Table 5. Comparison of measurements of P. elliptica B and P. elliptica C.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| P. elliptica B (Threemile) | .3355 | .1371 | .3586 | 9.73 | 20.16 | 7.31 | ----- |
| P. elliptica C (Grant) | .2826 | .1036 | .3019 | 11.87 | 23.77 | 10.19 | 22.00 |

Discussion. The lack of blunt nodes at the ends of the dissepiments, the lack of stoutness of the zoarium and the three ranges of apertures changing to two after bifurcation are diagnostic criteria in distinguishing P. elliptica C from P. elliptica B.

Occurrence. This form was found only in the Grant Shale Member of the Winfield Limestone Formation in the area under study.

Repository. Kansas State University, Department of Geology, specimens labeled "Grant Shale" numbers 5, 6, 10, 15, 20, 21 and 23.

Genus Thamniscus King 1849

Thamniscus King, 1849, Ann. & Mag, Nat. Hist. 2d. ser., v. 3, p. 389.

Thamniscus Ulrich, 1890, Geol Surv. Illinois, v. 8, p. 397 and 606.

Thamniscus Bassler, 1953, Treatise Invert. Paleo., pt. G., Bryozoa, p. G 126.

Original Type. Keratophytes dubius Schlotheim 1820.

Range. Silurian-Permian.

Description. "Zoaria differing from those of Polypora in wanting the dissepiments entirely, or in having them recur at very irregular and much longer intervals; besides, the branches bifurcate more freely." (King, 1890, p. 397).

> Zoarium fan or funnel-shaped, composed of frequently dichotomizing branches. Similar to Polypora but with three or more rows of zooecial apertures. Median keel absent, but may be represented by a row of nodes. Dissepiments occur at irregular and infrequent intervals or not at all. (Richards, 1955, p. 85).

Discussion. The numerous nodes on the obverse face and the almost complete lack of dissepiments distinguish this genus from Polypora in the samples in this work.

Thamniscus ramulosus (Ulrich) granti n. s sp.

Plate 2, figures 6a, b.

Thamniscus ramulosus Ulrich, 1890, Geol. Surv. Illinois, v. 8, p. 610, pl. 62, figs. 4a, b (Chesterian, Kentucky).

Thamniscus sp., cf. T. ramulosus Ulrich 1890, Richards, 1955, (Masters Thesis, University of Kansas), p. 89, pl. 2, fig. 8; pl. 5, fig. 3.

Discussion. Zoarium a small delicate frond, bifurcating frequently at intervals of 1 or 2 mm. Branches 0.4290 to 0.5577 mm., mean 0.4649 mm. width, 6.60 to 11.47, mean 8.47 in 5 mm. Apertures round, 0.0938 mm. in diameter, 19.75 to 27.88, mean 24.91 occurring in 5 mm., in 3 to 5 poorly defined ranges. Peristome not prominent. Numerous small irregularly spaced nodes in two to three ill-defined ranges on the obverse face, 18.80 to 28.58, mean 22.91 in 5 mm. Reverse face smooth to fainly granulose. Dissepiments slightly to not depressed on the obverse and reverse faces.

Discussion. The specimens of this work varied from Elias' specimens of T. ramulosus in having no longitudional striae on the reverse face, much larger branches, and a greater number of apertures in 5 mm.

They varied from the specimens of T. sp., cf. T. ramulosus measured by Richards in having a smaller branch width, a greater number of apertures in 5 mm. and no dissepiments that were recognizable as such by the author.

Table 6 compares the specimens measured by Elias, Richards and those of this work:

Table 6. Comparison of measurements of Thamniscus ramulosus.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Elias, 1937 | ----- | 0.08 | .3-.5 | ----- | 20.00 | ----- | ----- |
| Richards, 1955 | ----- | 0.08 | .5-.8 av. .68 | ----- | 15-17 av. 16 | ----- | ----- |
| This Paper | ----- | .0938 | .4649 | ----- | 24.91 | 8.47 | 22.91 |

Occurrence. Specimens of T. ramulosus granti were found only in the Grant Shale Member of the Winfield Limestone Formation and the Paddock Shale Member of the Nolans Limestone Formation.

Repository. Kansas State University, Department of Geology, specimens labeled "Paddock Shale" numbers 1-12; "Grant Shale" number 13.

Family ACANTHOCLADIIDAE Zittel, 1880

Acanthocladiidae Zittle, 1880, Handbuch der Palaeontologie: Munchen und Leipzig, Band I, p. 603.

Range. Silurian-Permian

Zoarium composed of strong stems with branches generally diverging obliquely and remaining free or uniting with adjacent branches, the side branches with or without connecting crossbars (dissepiments) which may bear zooecia (Bassler, 1953, p. G 127).

Discussion. Only one genus of this family, Septopora, was found in this investigation. This genus is distinguished from genera assigned to Family Fenestellidae by the presence of apertures on the dissepiments, which is true of all genera of Family Acanthocladiiae. The genus Septopora is also distinctive in having chevron shaped fenestrules.

Genus Septopora Prout 1859

Septopora Prout, 1859, Trans. St. Louis Acad Sci., v. 1, p. 448.

Septopora Ulrich, 1890, Géol. Surv. Illinois, v. 8, p. 397, 626.

Septopora Bassler, 1953, Treatise on Invert. Paleo., pt. G., Bryozoa, p. G 128.

Synonym. Loculoporella Fredricks, 1920

Original Type. Septopora cestriensis Prout, 1859.

Range. Mississippian-Permian.

Zoaria fenestrated, flabellate or leaf-like. Primary branches numerous, increasing by bifurcation or interpolation, and so arranged that the smaller lateral branches which proceed from their opposite margins unit with those of the adjacent branches. Reverse of non-celluliferous side usually with fine striae, and a variable number of scattered dimorphic pores. Celluliferous side, with two rows of zooecia arranged as in Pinnatopora (Zittel, 1890, p. 397-98).

Primary and secondary branches numerous, the latter joined to adjacent primaries; 2 rows of zooecia on all branches; back with scattered pores; union of secondaries (pinnae) may form dissepiment-like structures with apertures (Bassler, 1953, p. G 128).

Septopora biserialis nervata Ulrich 1890

Plate 2, figures 7a, b

Septopora biserialis nervata Ulrich, 1890, Geol Surv. Illinois, v. 8, p. 632-33 (Upper Pennsylvanian, Illinois).

Zoarium funnel shaped, specimens up to eight cm. high; consisting of primary and secondary branches. Secondaries diverge at an angle of about 20 degrees, and are 0.4 mm. wide but in .5 to 1 cm enlarge to the size of primaries. Primaries 0.5 to 0.7 mm. wide, average 0.6 mm. Dissepiments chevron shaped, somewhat narrower than branches, 0.38 to 0.42 mm. wide, with apertures in two to three poorly defined ranges; subalternating, 10 occuring in 1 cm. Some small nodes usually present on dissepiments. Fenestrules chevron shaped, elongate laterally, with 2½ to 3 apertures opposite. Apertures round, 0.12 mm. in diameter, 10 to 22 in 5 mm., depending on whether Wolfcampian or Virgilian in age. Two ranges fairly well defined on branches. Peristome a low well-defined ridge. Reverse face with fine longitudinal striae and accessory pores 0.08 mm. in diameter, varying somewhat in frequency but confined to marginal areas, especially at dissepiments. Obverse face with slight median carina. Two series of nodes on carina in adults, large blunt ones alternating with a smaller size group; 15 to 17 in 5 mm. Accessory pores one-third to one-half as numerous as apertures....(Richards, 1955, p. 112-113, pl. 2, fig. 17; pl. 6, figs. 11a, b).

Discussion. Following is a comparison of measurements of S. biserialis nervata of this paper and of previously described forms:

Table 7. Comparison of measurements of Septopora biserialis nervata.

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| Elias, 1937 | 2/3X Bw | 0.13 | .3-.8 | 13(±) | 20-21 | 8-11 | .8 or less apart |
| Richards, 1955 | .38-.42 | 0.12 | .4-.7 | ----- | 10-22 | ----- | 15-17 |
| This Paper (Speiser) | .2413 | .1338 | .3589 | 10.00 | 20.00 | 6.25 | 7.50 |
| This Paper (Threemile) | .3462 | .1417 | .4361 | 12.20 | 21.37 | 6.89 | 7.87 |
| This Paper (Blue Springs) | .2319 | .1356 | .3268 | 11.66 | 21.81 | 8.725 | 11.51 |

Table 7 (concl.).

| | Dw (mm.) | Aw (mm.) | Bw (mm.) | F | A | B | N |
|---|---|---|---|---|---|---|---|
| This Paper (Oketo) | .3173 | .1110 | .4014 | 12.48 | 26.10 | 8.15 | 9.03 |
| This Paper (Odell) | .3461 | .1313 | .3848 | 12.01 | 21.39 | 7.54 | 8.53 |
| This Paper (Paddock) | .3480 | .1206 | .4075 | 10.54 | 21.36 | 8.04 | 8.89 |
| This Paper (Grant) | .3373 | .1253 | .3589 | 11.28 | 25.12 | 9.32 | 10.67 |

Table 7 shows that all of the measured values for the specimens of this report match the values of previously described forms closely, with the exception of the number of nodes in 5 mm. This discrepancy may be due to the poor condition of the nodes on the specimens of this report.

Richards, in his description of S. biserialis nervata mentions two rows of nodes on the obverse face. It is probable that not all the smaller set of nodes were seen by the author due to erosion of the specimens.

Occurrence. This was the most widespread form encountered in this investigation. It was found in all of the numbers and formations that contained a fenestrate bryozoan fauna. These include: (1) Speiser Shale, (2) Threemile Limestone, (3) Blue Springs Shale, (4) Oketo Shale, (5) Odell Shale, (6) Paddock Shale, and (7) Grant Shale.

Repository. Kansas State University, Department of Geology, specimens labeled "Speiser Shale" numbers 17, 20, and 21; "Threemile Limestone" numbers 4-11, 13-18, 20-25; "Blue Springs" numbers 2, 3, 4, 5, 6, 7, 10, 11, 12, 13; "Oketo Shale" numbers 7-12, 14, 16: "Odell Shale" numbers 1-24; "Paddock Shale" numbers 13-25; "Grant Shale" numbers 1-4, 7, 8, 9, 11, 12, 14, 16, 17, 18, 22, 24, and 25.

EXPLANATION OF PLATE 2

(All specimens 7 x)

Fig. 1. Fenestella pectinis Moore

a. Obverse face; Speiser Shale, specimen no. 2.
b. Reverse face; Speiser Shale, specimen no. 2.

Fig. 2. Fenestella mimica (Ulrich) wellsi Elias

a. Reverse face; Oketo Shale, specimen no. 15.
b. Obverse face; Oketo Shale, specimen no. 1.

Fig. 3. Fenestella sp., aff. F. modesta Ulrich

Reverse face (obverse not seen); Oketo Shale, specimen no. 6.

Fig. 4. Polypora elliptica subspecies B Elias

a. Obverse face; Threemile Limestone, specimen no. 12.
b. Reverse face; Threemile Limestone, specimen no. 12.

Fig. 5. Polypora elliptica subspecies C n. 5 s p.

a. Obverse face; Grant Shale, specimen no. 15.
b. Reverse face; Grant Shale, specimen no. 5.

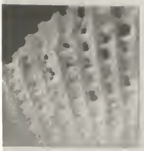
Fig. 6. Thamniscus ramulosus (Ulrich) granti n. 5 s p.

a. Reverse face; Paddock Shale, specimen no. 1.
b. Obverse face; Paddock Shale, specimen no. 1.

Fig. 7. Septopora biserialis nervata Ulrich

a. Obverse face; Odell Shale, specimen no. 2.
b. Reverse face; Odell Shale, specimen no. 2.

PLATE 2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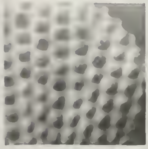
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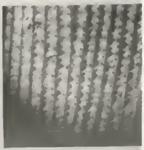
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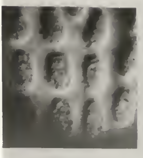
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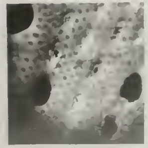
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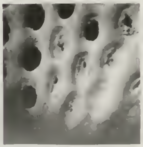
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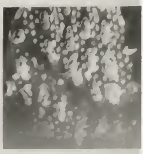
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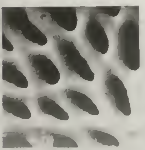
5b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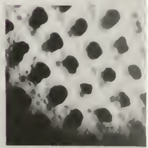
6b


7a


7b

## STATISTICAL METHODS

The statistical methods used in this paper include: (1) two-component diagrams to show population distribution and (2) graphs in which the mean values of the forms in question are plotted against the stratigraphic units in which the forms are found. These latter graphs will be termed "time graphs" in this work.

Two Component Diagrams. These diagrams consist of two variables plotted within a simple coordinate system. The points enclosed by a curve indicate a population of forms. On these graphs it is possible to speciate or subspeciate forms. If all of the points fall in a tight group only one form is indicated; if two separate point clusters are present it suggests separation of the forms in question.

In this work the diagrams were also used to compare variations in populations of the same forms in different stratigraphic units. Variations in position of the clusters suggests trends the population underwent with time.

Time Graphs. Time graphs were used to compare variation of the mean values of the various species with time. These graphs are useful in depicting minute changes, as well as large changes, over a given portion of the stratigraphic section. The major deficiency of these graphs is that they give the reader no idea of population distribution of the forms.

## EVOLUTIONARY TRENDS

Morphological variations of long-ranging species in Virgilian and Gearyan rocks are discussed by Richards (1955). He discovered definite trends in many of the forms he described. This paper explored the possibility of definite variations over a much more limited stratigraphic sequence (Fig. 2).

Each separate species was dealt with singly in studying variations. The variables used were those measured by the author. Time graphs were used to depict variations only in the forms collected from a large enough number of stratigraphic units to make the graph useful. When a form was found in only one or two units, two-component diagrams were used to depict variations. The mean values used in compiling these graphs and diagrams are in the appendix (Appendix, Tables 10 through 16). The mean values for each species described are in the tables under the appropriate descriptions in the Systematic Descriptions section of this paper (Tables 1 through 7).

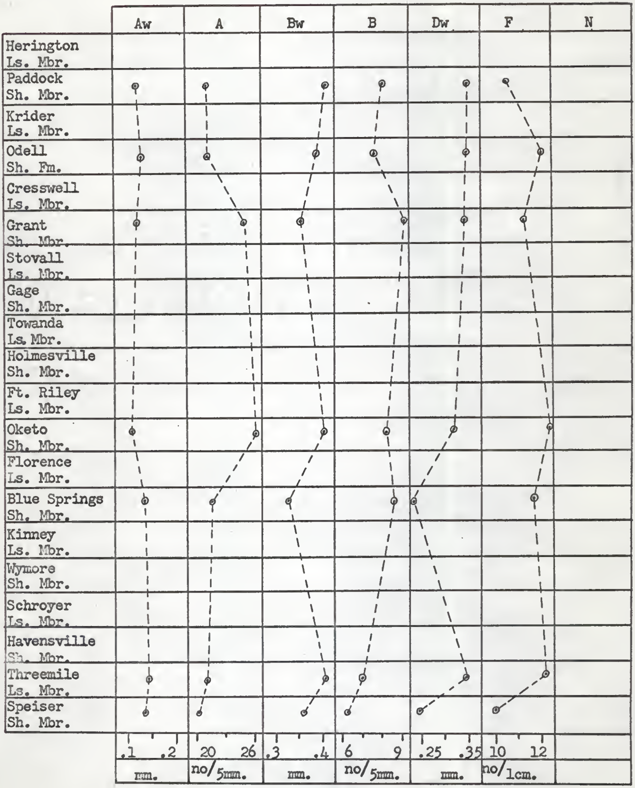
Genus Septopora

Septopora biserialis nervata. Variations of mean values of this form are shown in Table 8. This species was in the greatest number of stratigraphic units; thus it was the best form to be represented on the time graph (Table 8).

Richards (1955, p. 45), found no change in frequency of dissepiments or width of zooecial chambers of specimens collected from widely divergent ages. He did note a definite change in the number of apertures in five millimeters indicated by these values: Virgilian, 21.8 autopores in five millimeters; Wolfcampian (Gearyan) 19.3 apertures in five millimeters. He also states, "The Septopora biserialis nervata population seems to have been undergoing continuous evolution at an extremely slow rate so that statistical methods are required to show changes." (Richards, 1955, p. 46).

Table 8 of this report, although representing a shorter time interval than that dealt with by Richards, seems to substantiate his statement of very slow evolutionary changes. The table does indicate that there were non-systematic changes undergone by the species between certain of the units under study, but that the variations were confined within certain definite limits.

Table 8. Evolutionary trends of Septopora biserialis nervata.



It is interesting to note that between the Blue Springs Shale and the Oketo Shale Members, as autopore diameter decreases the number of autopores in five millimeters increases. The opposite is true between the Grant Shale and the Odell Shale; but between the Speiser shale and the Threemile Limestone as the autopore diameter increases slightly the number of autopores in five millimeters also increases slightly. This corresponds to the increase in the rest of the features measured between these units. This increase in all features indicates the growth of a more robust type of frond in this time. The decrease in size or stabilization of all features between the Threemile Limestone and the Blue Springs Shale Members, with the exception of the number of branches in five millimeters, possibly indicates that the sudden appearance of the cherty limestones in the stratigraphic section may have had an effect upon the growth of the forms. The increase in the number of branches per unit distance mentioned above, varying inversly with the rest of the features possibly indicates that as the branch width decreases the number of branches per unit distance increases.

The only straight line trend shown by this chart is the steady increase in dissepiment width between the Oketo Shale and the Paddock Shale. This was not noted by Richards in his study of long term variations of the form but is very evident in this work. There is no evidence presented here to substantiate the decrease in the number of autopores with time Richards mentions in his study of Septopora biserialis nervata.

It is concluded from this study of Septopora biserialis nervata that, in agreement with Richards, the form is undergoing very slow evolutionary change, but these changes are not constant through the stratigraphic interval investigated. On the contrary, there seem to be alternating progression and regression of structural features. Because of these variations this study of Septopora biserialis nervata, as far as definition of evolutionary trends is concerned, produced inconclusive results.

## Genus Fenestella

Fenestella mimica wellsi. Elias (1937) studied evolutionary trends of the F. mimica group from Virgilian and Wolfcampian (Gearyan) rocks. His studies included the subspecies under study in this paper.

In the F. mimica group the following trends were noted by Elias:

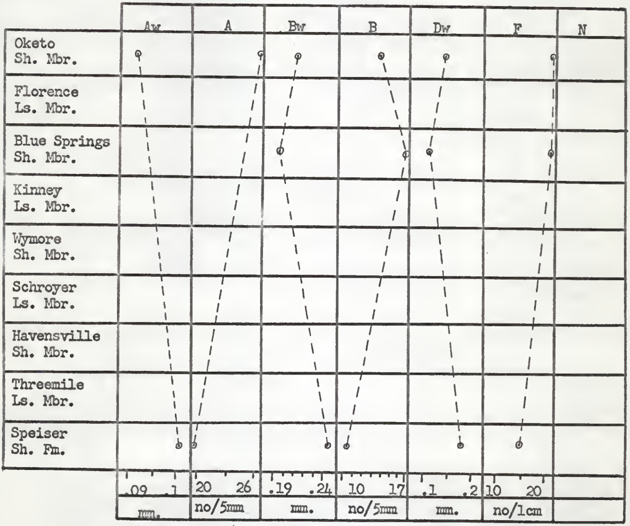
1. Decrease in the number of branches per unit length.
2. Decrease in the number of fenestrules per unit length.
3. Decrease in the number of autopores per unit length.
4. Decrease in the number of nodes per unit length.

Table 9 of this report shows that the number of apertures in five millimeters in the stratigraphic interval from the Speiser Shale to the Oketo Shale indicates a trend that conflicts with trends reported by Elias. The number of branches and the number of fenestrules in five millimeters, from the Speiser Shale to the Blue Springs Shale, also shows trends opposite those reported by Elias. In the stratigraphic interval from the Blue Springs Shale to the Oketo Shale the trend of branches per unit distance reverses and follows that reported by Elias.

It is noted that F. mimica wellsi was not found in units younger than the Oketo Shale. This holds true for all species of genus Fenestella.

Richards (1955, p. 21) employed a triangular graph using as its extremities, the number of branches in five millimeters, the number of autopores in five millimeters and the number of fenestrules in one centimeter.

Table 9. Evolutionary trends of Fenestella mimica wellsi



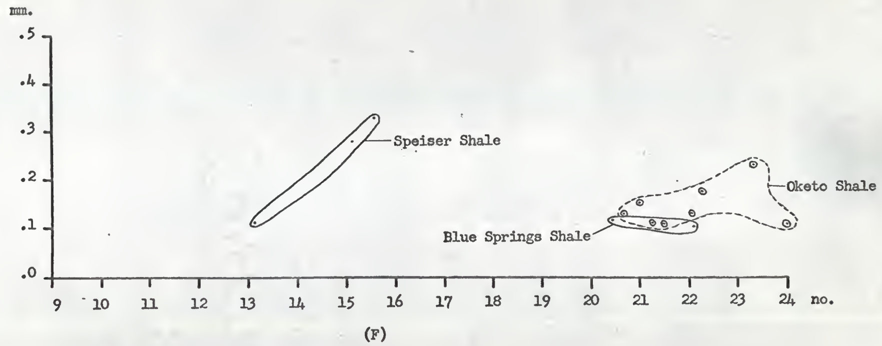



Fig. 4. Comparison of Populations of <u>Fenestella mimica wellsi</u> From the Blue Springs, Oketo and Speiser Shale Members.

He found this graph inconclusive in the separation of Fenestella species. This suggests these features are of little value in depicting evolutionary trends in genus Fenestella. Richards (1955, p. 23) also used a two variable diagram using as the variables: (1) number of apertures in five millimeters and (2) number of nodes in five millimeters. The graph using these variables successfully separated species of genus Fenestella. For this reason, Richards concluded these variables display pronounced trends and are the ones most useful in the study of trends.

It is unfortunate that in the specimens collected in this work, nodes were obscure and could not be counted with any degree of confidence. However it was discovered by the author that by using the variables Dw and F the populations could be separated into distinct groups for each stratigraphic unit in which they were found (Fig. 4).

Fenestella pectinis. Specimens of F. pectinis were found only in the Speiser Shale Formation and the Oketo Shale Member of the Barneston Formation. Only one specimen was found in the Oketo Shale Member; therefore no evolutionary trends could be established.

Richards (1955, p. 24) plotted the three variables A, F, and N of specimens of Virgilian and Wolfcampian (Gearyan) F. pectinis populations on a triangular graph. He found there was almost complete overlap of the closed curves, indicating no subspeciation of F. pectinis in this stratigraphic interval. Richards then constructed an isopleth diagram for each of the faunal assemblages. The diagram showed a shift in the position of maximum density of the points and a decrease in the degree of variability from Virgilian to Wolfcampian (Gearyan) times. As Richards explains, this decrease in variability is a trend not uncommon to species as their age increases.

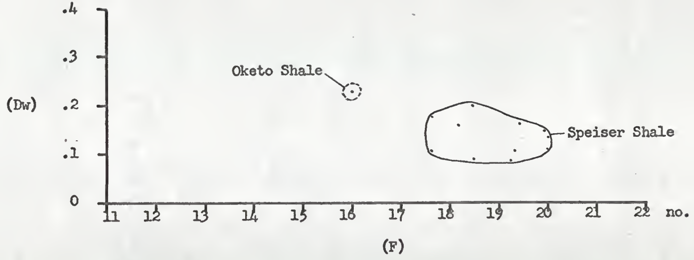



Fig. 5. Comparison of Populations of Fenestella pectinis. From the Speiser Shale and the Oketo Shale.

As in F. mimica wellsi, the variables Dw and F were found to separate the populations of F. pectinis from different stratigraphic units. Figure 5 shows comparison of populations from the Oketo and Speiser Shale.

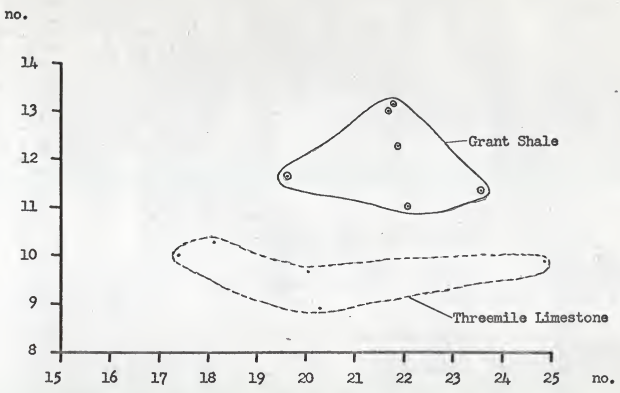
Fenestella sp., aff. F. modesta Ulrich. Only one specimen of this form was found. This was collected from the Oketo Shale Member of the Barneston Formation. Because of infrequent occurrence and because no previous literature was found on evolutionary trends of the form, no review of trends was considered in this report.

## Genus Polypora

Polypora elliptica. One described subspecies and one new subspecies were found in the stratigraphic units studied. P. elliptica subspecies B was found in the Speiser Shale and the Threemile Limestone; P. elliptica subspecies C was found only in the Grant Shale Member of the Winfield Limestone Formation.

Elias (1937) noted two definite trends in populations of P. elliptica in Virgilian and Gearyan rocks. They are: (a) increase in width and length of fenestrules and, (b) increase in zooecial length (decrease in the number of autopores per unit length). These trends could not be established in this report.

Figure 6 is a two-component diagram using these two variables for comparison of populations. The diagram shows that there are no definite trends shown in relation to the number of autopores in 5 mm., (A), but there is an increase in the number of fenestrules in one centimeter, (F), from the Threemile Limestone to the Grant Shale. This conflicts with Elias' statement of increasing size of the fenestrules with time. This study shows there is a decreasing size or an increasing number of fenestrules per unit measurement with time.




(A)

Fig. 6. Comparison of populations of Polypora elliptica. From the Threemile Limestone and the Grant Shale.

## Genus *Thamniscus*

*Thamniscus ramulosus* (Ulrich) *granti* n. ssp. Specimens of this subspecies were found in the Grant Shale Member of the Winfield Limestone Formation and the Paddock Shale Member of the Nolans Limestone Formation. The two variables found most useful in comparison of populations of this form were: (a) autopore width, Aw and (b) branch width, Bw (Fig. 7).

It is evident from figure 7 that the largest population of the form was found in the Paddock Shale; only one specimen was found in the Grant Shale. From the evidence presented here it is concluded that the species *Thamniscus ramulosus granti* evidently underwent no evolutionary change. The evidence presented here is necessarily rather inconclusive, because of the single specimen representing the population of the Grant Shale.

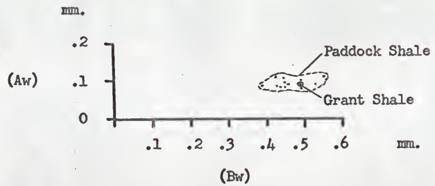



Fig. 7. Comparison of Populations of <u>Thamniscus ramulosus granti</u>. From the Paddock Shale and the Grant Shale Members.

# SUMMARY AND CONCLUSIONS

In order to present a clear picture of the nature and extent of variation of fenestrate bryozoans in the portion of the Gearyan Series investigated, the changes noted in each species and subspecies is discussed separately. The nature of these changes is so varied that an attempt to discuss them in terms of general statements may well be misleading.

## Septopora biserialis nervata

This form was found in the Speiser Shale, Threemile Limestone, Blue Springs Shale, Oketo Shale, Odell Shale, Grant Shale and the Paddock Shale. This form was the most abundant type of "fenestrate" bryozoan found in the stratigraphic units investigated. Measurements of structures matched previously described forms closely; therefore, identification of the form was relatively easy.

Richards (1955, p. 116) shows the upper extent of S. biserialis nervata to be the Matfield Shale Formation. This report extends that range to include stratigraphic units up to and including the Paddock Shale Member of the Nolans Limestone Formation.

S. biserialis nervata has been undergoing evolutionary change at a very slow rate. Previous reports of the form note a definite decrease in the number of apertures in five millimeters from Virgilian to Gearyan age rocks. The summary of evolutionary trends in this report (Table 8) shows non-systematic changes throughout the section studied, in all features except dissepiment width. This table shows a steady increase in the size of the dissepiments through the stratigraphic interval from the Oketo Shale to the Paddock Shale.

It is concluded that S. biserialis nervata is undergoing very slow evolutionary change, but that this is not a constant progression or regression through the stratigraphic section studied. Table 8 shows there are reversals of trends through short stratigraphic intervals. However, these ultimately lead to variations of features in one definite direction over large periods of time, as shown by Richards (1955).

Fenestella mimica wellsi

This form was found in the Speiser Shale, Blue Springs Shale and the Oketo Shale. The published criteria for identification and the close approximation of the structures measured in this report to measurements of previously described forms made the identification of the form relatively easy.

Richards (1955, p. 116) sets the upper limit of the form at the top of the Wreford Shale Formation. This report extends that range to include the Oketo Shale Member of the Barneston Limestone Formation.

F. mimica wellsi, as was the case with Septopora biserialis nervata, shows non-systematic changes from one stratigraphic unit to the next, and no definite trends are established here. The trends shown on Table 9 conflict with those set forth by Elias in all features except the number of branches per unit length. This variable, B, increases from the Speiser Shale to the Blue Springs Shale in conflict with Elias' findings but reverses this trend as the Blue Springs Shale Member decreases to the Oketo Shale Member, agreeing with Elias' findings.

F. mimica wellsi, as well as the rest of the forms assigned to genus Fenestella, were not found higher than the Oketo Shale Member of the Barneston

Formation. This disappearance of an entire genus at the same horizon suggests an environmental change to which the forms could not adapt, resulting in extinction at the end of Oketo deposition.

### Fenestella pectinis

This form was found in the Speiser Shale and the Oketo Shale. No definite trends could be established because only one specimen was found in the Oketo Shale. The limited information available (Fig. 5) suggests there was a slight decrease in the number of fenestrules in one centimeter from the Speiser Shale to the Oketo Shale. Variation of the dissepiment width is inconclusive (Fig. 5) because of the scarcity of specimens.

The occurrence of F. pectinis in the Oketo Shale Member extends the range of this form from the top of the Wreford Limestone Formation (Richards, 1955, p. 116) to the middle of the Barneston Limestone Formation.

### Fenestella sp., aff. F. modesta Ulrich

Only one specimen of this form was found; this occurrence was in the Oketo Shale. The classification of this form is questionable because only the reverse face of the specimen was seen. It had the greatest affinity for the species F. modesta, and was tentatively assigned to it.

### Polypora elliptica subspecies B

Specimens of this form were found in the Speiser Shale and the Threemile Limestone. A closely related form was found in the Grant Shale Member.

Specimens of P. elliptica B in this report matched the previous descriptions of the form very closely; therefore, identification was made with confidence. Specimens from the Grant Shale differed appreciably from the described forms of P. elliptica B and were classified as a new subspecies by the author.

The upper limit of P. elliptica B set by Richards (1955, p. 116) was the Bader Limestone Formation of the Council Grove Group. This work extends the range of P. elliptica B to include the Threemile Limestone Member of the Wreford Limestone Formation. The only observed occurrence of P. elliptica C was in the Grant Shale Member of the Winfield Limestone Formation.

Very little evolutionary change is noted between specimens from the Speiser Shale and from the Threemile Limestone. However in comparing specimens of P. elliptica B with specimens of P. elliptica C, found in the Grant Shale, the following variations were discovered: dissepiment width, autopore width and branch width decrease in P. elliptica C, and the number of fenestrules, autopores and branches per unit measurement increase in P. elliptica C.

It is concluded that Polypora elliptica shows the most definite evolutionary trends of any of the species studied in this report. It is regrettable that specimens could not be found in the stratigraphic units between the Threemile Limestone and the Grant Shale. The finding and study of forms from these units would help ascertain whether variations are non-systematic and reverse themselves from unit to unit as in the case of Septopora biserialis nervata and Fenestella mimica wellsi, or are consistent in their direction of variability over a relatively short period of time.

Thamniscus ramulosus (Ulrich) granti n.ssp.

Specimens of this form were found in the Grant Shale Member of the Winfield Limestone Formation and the Paddock Shale Member of the Winfield Limestone Formation and the Paddock Shale Member of the Nolans Limestone Formation.

The absence of dissepiments enables generic level identification to be made with confidence.

Richards (1955, p. 116) shows the upper limit of Thamniscus sp. aff. T ramulosus to be the Speiser Shale Formation. This work extends the range to include the Paddock Shale Member of the Nolans Limestone Formation.

The form of T. ramulosus studied here has been undergoing evolutionary change at a very slow rate; this is shown in Figure 7. Although only one specimen was found in the Grant Shale, it falls almost in the middle of the population from the Paddock Shale. This indicates that changes, if any, between these two units were very slow, and similar populations existed in the two units.

Suggestions for Future Study. Future research in subspeciation on a numerical basis using multivariate statistical techniques might prove rewarding. Burma (1948, 1949) gave an excellent summation of techniques used in handling large quantities of numerical data pertaining to paleontology. Complex statistical processes and computer techniques were considered beyond the scope of this investigation.

A more detailed study of the new forms discovered might prove rewarding. It is possible these forms, and other new forms, could be found in horizons not studied by the author.

Evolutionary trends in these fenestrate bryozoans appear clear-cut over short stratigraphic intervals. However, these changes appear to be nonsystematic when viewed over a greater stratigraphic interval; they frequently reverse direction from one stratigraphic unit to the next.

This raises the question of sample validity. It is possible that delicate zoaria have less chance of preservation than specimens having thicker branches and dissepiments, and smaller autopores. These fragile zoaria may have been selectively removed from the fossil population. This removal of fragile specimens may have been more pronounced in some stratigraphic units, depending on the environment of deposition, thus producing bias in the sample. Such bias, if present, may be partially responsible for the apparent non-systematic changes reported here. However, a ready solution to this problem is not apparent.

More sophisticated statistical techniques on the order of the multivariate analysis methods suggested by Burma (1948, 1949) might show more clearly whether orderly, systematic evolutionary changes take place in fenestrate bryozoans in Gearyan rocks, or whether as results of this study suggest, these changes are largely non-systematic. In order to facilitate future study of these evolutionary changes, raw data obtained in this investigation are included in this paper as an appendix.

# APPENDIX

Table 10. Mean values of bryozoan structures of specimens from the Speiser Shale

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | .1049 | .1361 | .2746 | 20.00 | 20.67 | 10.00 | none |
| 2. | .1048 | .1541 | .2856 | 18.20 | 18.50 | 11.00 | none |
| 3. | .1034 | .0986 | .2319 | 18.50 | none | 10.00 | none |
| 4. | .1049 | .1510 | .2072 | 19.45 | 20.33 | 12.50 | none |
| 5. | .1003 | .1040 | .1991 | 19.30 | none | 9.50 | none |
| 6. | .0996 | .1157 | .2392 | 13.17 | 20.00 | 9.50 | none |
| 7. | .1017 | .1093 | .2158 | 17.63 | none | 12.50 | none |
| 8. | .1040 | .1833 | .2247 | 15.13 | none | 10.25 | none |
| 9. | .1015 | .1090 | .1847 | 20.00 | 22.50 | none | none |
| 10. | .1023 | .2296 | .2663 | 15.63 | 19.69 | 10.63 | none |
| 11. | .1023 | .1764 | .2496 | 17.69 | 20.63 | 10.31 | 3.50 |
| 12. | none | .1094 | .2025 | none | 19.10 | 12.71 | none |
| 13. | .1032 | .1215 | .1976 | 18.50 | 20.00 | 12.50 | none |
| 14. | none | .0839 | .1564 | 19.38 | none | 11.25 | none |
| 15. | .1040 | .1387 | .2015 | 20.00 | none | 10.00 | none |
| 16. | .0962 | .1422 | .1721 | 20.00 | 20.00 | 15.00 | none |
| 17. | .1250 | .2413 | .3121 | 10.00 | 20.00 | 7.50 | none |
| 18. | .0988 | .1362 | .1706 | 20.00 | none | 13.10 | none |
| 19. | .1397 | none | none | none | 20.41 | none | none |
| 20. | .1392 | none | none | none | 20.00 | none | none |
| 21. | .1373 | none | .4056 | 10.00 | 20.00 | 5.00 | 7.50 |

Table 11. Mean value of bryozoan structures of specimens from the Threemile Limestone.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | .1250 | .4168 | .5044 | 12.00 | 23.20 | 6.50 | none |
| 2. | .1317 | .1413 | .4242 | 11.20 | 21.50 | none | 7.57 |
| 3. | .1219 | .3103 | .3378 | 9.83 | 24.88 | 7.61 | none |
| 4. | .1473 | .3367 | .4576 | 9.41 | 24.50 | 7.30 | 7.05 |
| 5. | .1392 | .2355 | .2541 | 9.69 | 20.00 | 8.13 | none |
| 6. | .1548 | .3244 | .3145 | 8.91 | 20.31 | 6.18 | none |
| 7. | .1407 | .3592 | .4233 | 9.00 | 19.17 | 6.00 | 6.00 |
| 8. | .1589 | .3432 | .4073 | 11.86 | 22.80 | none | 8.25 |
| 9. | .1743 | .3569 | .4347 | 14.25 | 22.13 | none | 8.00 |
| 10. | .1244 | .3266 | .4050 | 13.86 | 20.71 | none | 8.25 |
| 11. | .1335 | .3661 | .4125 | 12.00 | 20.50 | none | 7.25 |
| 12. | .1362 | .3981 | .4372 | 10.00 | 17.44 | none | none |
| 13. | .1516 | .3867 | .4530 | 12.11 | 20.67 | none | 7.63 |
| 14. | .1320 | .3798 | .4735 | 12.80 | 20.90 | none | 11.00 |
| 15. | .1330 | .3508 | .5148 | 14.20 | 21.60 | none | 8.67 |
| 16. | .1362 | .3735 | .4778 | 13.00 | 20.80 | none | none |
| 17. | .1269 | .2746 | .4050 | 15.84 | 22.34 | none | 9.00 |
| 18. | .1789 | .4689 | .4027 | 11.50 | 21.27 | none | none |
| 19. | .1297 | .4067 | .4494 | 10.25 | 18.15 | none | none |
| 20. | .1343 | .3020 | .4063 | 13.00 | 22.00 | none | 8.00 |
| 21. | .1571 | .3604 | .4305 | 14.00 | 21.72 | none | 8.00 |
| 22. | .1380 | .3281 | .3602 | 7.00 | 21.94 | none | 7.00 |
| 23. | .1266 | .3455 | .3733 | 11.60 | 19.58 | none | 6.25 |
| 24. | .1366 | .3068 | .4076 | 12.33 | 20.00 | none | none |
| 25. | .1476 | .4004 | .5476 | 13.00 | 20.00 | none | none |

Table 12. Mean value of bryozoan structures of specimens from the Blue Springs Shale.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | none | .1021 | .1918 | 22.09 | none | 19.05 | none |
| 2. | none | .2431 | .3790 | 10.40 | none | 7.10 | none |
| 3. | .1206 | .2503 | .4114 | 12.23 | 21.62 | 7.63 | 14.70 |
| 4. | none | .2517 | .3432 | 14.00 | none | 7.75 | none |
| 5. | .1490 | .3410 | .4595 | 11.09 | 20.00 | 6.96 | 9.20 |
| 6. | .1398 | none | none | 11.55 | 22.96 | 9.63 | none |
| 7. | none | .2771 | .3557 | 11.73 | none | 9.38 | none |
| 8. | none | .1104 | .1816 | 20.45 | none | 14.50 | none |
| 9. | none | .1211 | .2005 | 20.73 | none | 18.50 | none |
| 10. | .1245 | .1135 | .3432 | 12.20 | 22.72 | 9.75 | 10.55 |
| 11. | .1439 | .0870 | .1107 | 10.50 | 21.76 | 10.00 | 11.60 |
| 12. | none | .2288 | .1900 | 12.50 | none | 10.30 | none |
| 13. | none | .2948 | .3484 | 10.43 | none | 8.75 | none |

Table 13. Mean value of bryozoan structures of specimens from the Oketo Shale.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | none | .1325 | .2219 | 20.67 | none | 14.10 | none |
| 2. | none | .1798 | .2493 | 22.26 | none | 14.60 | none |
| 3. | .0963 | .1335 | .2281 | 22.00 | 27.13 | 13.70 | none |
| 4. | .0899 | .2353 | .2276 | 23.30 | 26.28 | 15.30 | none |
| 5. | none | .2208 | .2607 | 15.73 | none | 11.92 | none |
| 6. | none | .4004 | .4916 | 7.23 | none | 6.70 | none |
| 7. | none | .3900 | .4957 | 11.27 | none | 7.65 | none |
| 8. | none | .3065 | .3628 | 12.02 | none | 7.70 | none |
| 9. | none | .3039 | .3328 | 11.60 | none | 9.13 | none |
| 10. | .1067 | .2861 | .3433 | 12.85 | none | 7.50 | 8.75 |
| 11. | none | .2409 | .3449 | 12.31 | none | 7.88 | none |
| 12. | none | .2150 | .3646 | 16.40 | none | 11.60 | none |
| 13. | none | .1584 | .1779 | 20.93 | none | 15.37 | none |
| 14. | .1153 | .4004 | .5244 | 11.70 | 26.10 | 6.88 | 9.30 |
| 15. | .0855 | .1144 | .1716 | 23.96 | 26.30 | 15.60 | none |
| 16. | none | .2794 | .4413 | 11.70 | none | 6.90 | none |
| 17. | none | .1179 | .1716 | 21.20 | none | 14.45 | none |
| 18. | none | .1135 | .2322 | 21.44 | none | 14.60 | none |

Table 14. Mean values of bryozoan structures of specimens from the Grant Shale.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | .1293 | .3515 | .3909 | 14.33 | 28.98 | 8.16 | 9.88 |
| 2. | .1207 | .3575 | .4118 | 10.33 | 30.44 | 6.55 | 14.25 |
| 3. | .1316 | .3305 | .3862 | 11.69 | 31.23 | 8.75 | 8.75 |
| 4. | .1261 | .3229 | .3862 | 12.18 | 29.11 | 11.20 | 12.95 |
| 5. | .0994 | .2886 | .4004 | 11.35 | 23.61 | 11.65 | none |
| 6. | .1017 | .3054 | .2891 | 10.56 | 34.80 | 9.30 | none |
| 7. | .1467 | .3489 | .3203 | 10.10 | 23.30 | 9.75 | 7.70 |
| 8. | .1284 | .3858 | .3718 | 11.20 | 22.90 | 9.27 | 8.75 |
| 9. | .1217 | .3504 | .3290 | 12.35 | 24.88 | 10.10 | none |
| 10. | .0949 | .2124 | .2340 | 11.58 | 19.65 | 10.73 | none |
| 11. | .1175 | .3883 | .3760 | 10.00 | 22.55 | 8.10 | 8.63 |
| 12. | .1321 | .3546 | .3353 | 11.70 | 23.78 | 8.50 | 11.50 |
| 13. | .0916 | none | .4863 | none | 19.75 | 7.10 | 18.80 |
| 14. | .1421 | .3640 | .3670 | 11.11 | 23.48 | 8.75 | 10.00 |
| 15. | .1076 | .3146 | .3623 | 12.28 | 21.93 | 7.95 | none |
| 16. | .1234 | .2596 | .3330 | 12.90 | 26.80 | 10.17 | 10.08 |
| 17. | .1130 | .3050 | .3203 | 12.43 | 21.56 | 9.58 | none |
| 18. | .1275 | .2733 | .3289 | 12.85 | 24.95 | 10.02 | 9.28 |
| 19. | .1100 | none | .2332 | none | 24.35 | none | none |
| 20. | .1026 | .2860 | .2836 | 13.18 | 21.82 | 11.74 | 22.00 |
| 21. | .1022 | .2931 | .3023 | 13.03 | 21.76 | 12.95 | none |
| 22. | .1157 | .3346 | .3432 | 6.46 | 22.06 | 9.35 | 12.73 |
| 23. | .1103 | .2782 | .3098 | 11.07 | 22.23 | 6.40 | none |
| 24. | .1103 | .3216 | .3980 | 11.10 | 21.86 | 9.23 | 14.17 |
| 25. | .1184 | .3527 | .3361 | 9.70 | 23.97 | 10.00 | none |

Table 15. Mean value of bryozoan structures of specimens from the Odell Shale.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | .1380 | .4211 | .4948 | 11.50 | 22.00 | 5.70 | 7.33 |
| 2. | .1289 | .3888 | .4089 | 13.15 | 22.00 | 7.80 | 9.00 |
| 3. | .1312 | .3016 | .3956 | 13.00 | 22.58 | 6.95 | 9.00 |
| 4. | .1316 | .4397 | .1845 | 12.00 | 20.00 | 5.80 | 7.00 |
| 5. | .1221 | .4003 | .4424 | 12.00 | 19.00 | 8.75 | 9.25 |
| 6. | .1211 | .3232 | .4351 | 12.00 | 20.33 | 8.00 | 8.00 |
| 7. | .1228 | .3950 | .4039 | 11.00 | 21.67 | 6.30 | 8.00 |
| 8. | .1280 | .3524 | .4165 | 11.83 | 21.00 | 6.15 | 8.50 |
| 9. | .1348 | .3832 | .3718 | 11.50 | 21.60 | 6.60 | 9.50 |
| 10. | .1312 | .3446 | .4490 | 12.00 | 22.00 | 6.30 | 9.25 |
| 11. | .1311 | .3283 | .3925 | 12.00 | 21.75 | 6.25 | 8.20 |
| 12. | .1221 | .3588 | .4052 | 10.50 | 22.00 | 8.10 | 8.50 |
| 13. | .1316 | .3476 | .4361 | 11.00 | 22.00 | 6.00 | 9.00 |
| 14. | .1284 | .2932 | .3039 | 12.67 | 22.00 | 10.40 | 6.00 |
| 15. | .1380 | .2665 | .3512 | 13.00 | 20.72 | 9.03 | 9.20 |
| 16. | .1251 | .3487 | .3385 | 11.59 | 21.75 | 8.50 | 8.50 |
| 17. | .1362 | .4612 | .5348 | 11.00 | 22.00 | 6.00 | 11.00 |
| 18. | .1348 | .3432 | .3779 | 11.25 | 20.67 | 7.30 | 9.00 |
| 19. | .1353 | .2415 | .3353 | 14.00 | 22.00 | 9.08 | none |
| 20. | .1425 | .2654 | .3213 | 12.00 | 20.60 | 9.60 | 9.50 |
| 21. | .1430 | .3801 | .4194 | 11.00 | 21.00 | 7.95 | 8.50 |
| 22. | .1375 | .3106 | .3514 | 13.00 | 22.00 | 7.30 | none |
| 23. | .1512 | .2860 | .3105 | 12.13 | 20.90 | 8.75 | none |
| 24. | .1149 | .3238 | .3581 | 13.13 | 21.84 | 8.52 | 7.00 |
| 25. | .0953 | none | none | none | none | none | none |

Table 16. Mean value of bryozoan structures of specimens from the Paddock Shale.

| specimen number | autopore diameter | dissepiment width | branch width | fenestrules in 1 cm. | autopores in 5 mm. | branches in 5 mm. | nodes in 5 mm. |
|---|---|---|---|---|---|---|---|
| 1. | .1054 | none | .4408 | none | 21.95 | 6.73 | 22.30 |
| 2. | .0881 | none | .4225 | none | 24.65 | 8.77 | 23.40 |
| 3. | .1026 | none | .5577 | none | 27.88 | 8.50 | 28.58 |
| 4. | .0994 | none | .4896 | none | 23.76 | 8.00 | 21.09 |
| 5. | .0994 | none | .5244 | none | 25.35 | 6.60 | 20.69 |
| 6. | .0949 | none | .4976 | none | 27.33 | 6.87 | none |
| 7. | .1012 | none | .4290 | none | 25.31 | 8.50 | 24.30 |
| 8. | .0890 | none | .3943 | none | 24.81 | 8.75 | 21.80 |
| 9. | .0931 | none | 4576 | none | 25.81 | 11.12 | none |
| 10. | .0830 | none | .4576 | none | 24.46 | 9.50 | 22.46 |
| 11. | .0944 | none | .4576 | none | 25.50 | 9.25 | none |
| 12. | .0825 | none | .4290 | none | 27.32 | 11.47 | 25.70 |
| 13. | .1229 | .3718 | .4027 | 10.14 | 24.75 | 9.24 | 10.51 |
| 14. | .1270 | .3952 | .4372 | 12.10 | 29.10 | 6.37 | 10.33 |
| 15. | .1180 | .3718 | .4562 | 10.72 | 24.12 | 9.55 | 7.69 |
| 16. | .1229 | .2496 | .3280 | 9.99 | 22.62 | 8.86 | 10.05 |
| 17. | .1302 | .3226 | .3993 | 11.46 | 23.46 | 7.98 | 7.10 |
| 18. | .1170 | .3541 | .4347 | 11.30 | 22.45 | 7.47 | 9.50 |
| 19. | .1125 | .3369 | .3882 | 10.40 | 22.14 | 8.20 | 10.21 |
| 20. | .1198 | .2974 | .3333 | 10.44 | 22.28 | 6.90 | 9.38 |
| 21. | .1135 | .4143 | .4802 | 9.30 | 20.00 | 8.58 | 8.75 |
| 22. | .1224 | .2932 | .4061 | 9.68 | 21.37 | 7.45 | 8.80 |
| 23. | .1189 | none | .3463 | 11.00 | 22.28 | 9.14 | 8.13 |
| 24. | .1267 | .4004 | .4720 | 9.63 | 22.45 | 6.90 | 6.81 |
| 25. | .1166 | .3689 | .4138 | 10.95 | 22.98 | 7.84 | 8.36 |

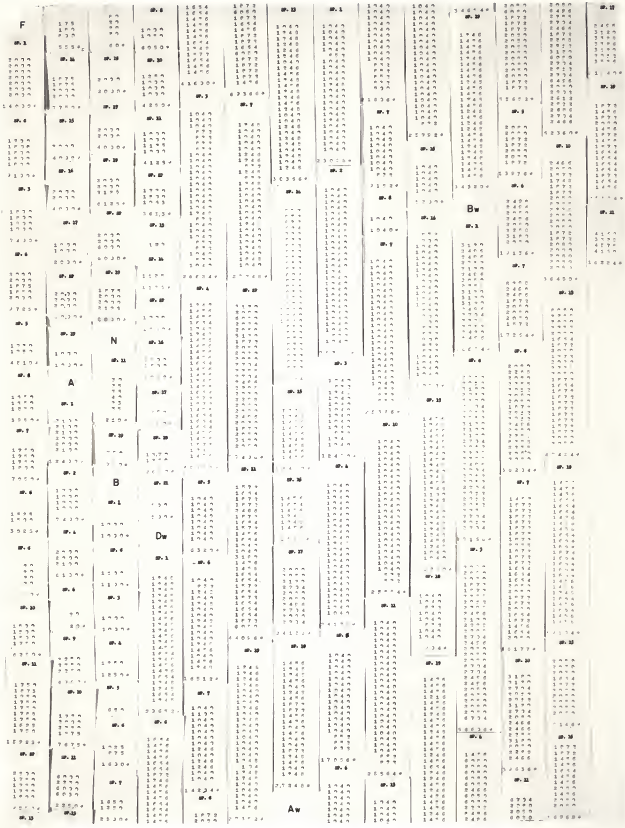


**Fig. 8. Measured values of bryozoan specimens from the Speiser Shale Formation.**

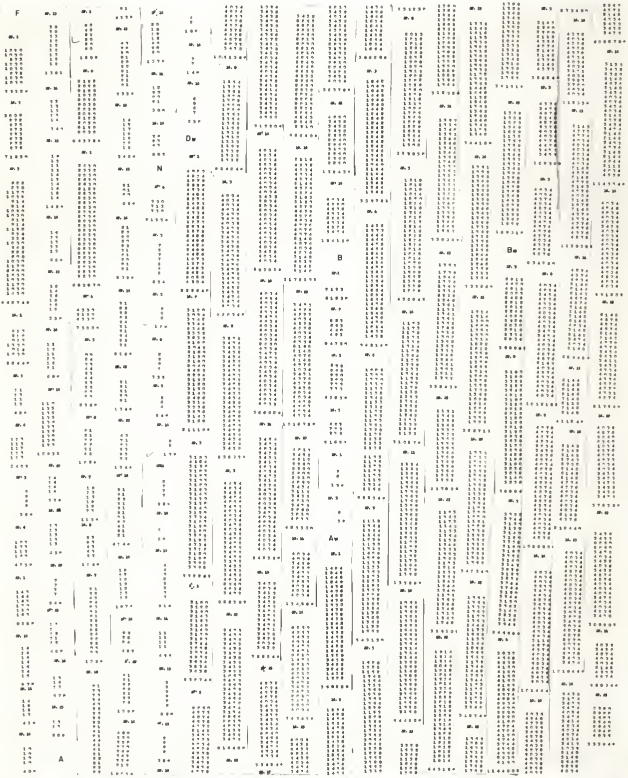


Fig. 9. Measured values of bryozoan specimens from the Threemile Limestone Member of the Wreford Formation.

F

SP. 1

225
215
218
222
230
218
218
218
218
221

2209*

SP. 2

1050
950
1120

3120*

SP. 3

1250
1250
1170

3670*

SP. 4

1400

1400*

SP. 5

1130
1130
1110
1100
1100
1080

6650*

SP. 6

1150
1160

2310*

SP. 7

116
116
120
117

469*

SP. 8

210
193
190
212
212
210

1227*

SP. 9

208
208
206

622*

SP. 10

1230
1300
1150

5650*

SP. 11

1050
1050

2100*

SP. 12

1250

1250*

SP. 13

104
104
105

313*

A

SP. 3

219
224
224
219
204
219
224
204
219
224
219
204
208

2811*

SP. 5

190
186
206
206
206
206

1200*

SP. 6

235
232
215
220
246

1148*

SP. 10

212
230
232
232
232
218
234

1590*

SP. 11

230
204
219

653*

N

SP. 3

1890
1050

2940*

SP. 5

92

92*

SP. 10

105
106

211*

SP. 12

116

116*

B

SP. 1

175
175
206
206

762*

SP. 2

71

71*

SP. 3

770
770
750

2290*

SP. 4

775

775*

SP. 5

695
800
530
760

2785*

SP. 6

94
101
94

289*

SP. 7

970

905

1875*

SP. 8

145

145*

SP. 9

1850

1850*

SP. 10

975

975*

SP. 11

100

100*

SP. 12

103
103

206*

SP. 13

875

875*

Dw

SP. 1

908
908
908
908
908
1135
908
908
1135
1135
908
905
1135
908
908
908
908
1135
1135
1135
1135
1135
1246
1135
1135

25532*

SP. 2

2860
2288
2860
5452
1716
1716
2288
2288

14448*

SP. 3

1716
2288
2850
2288
2288
2288
2851
3432

20021*

SP. 4

2850
2288
3432
2288
1716

12534*

SP. 5

4004
4004
3432
3432
3432
3432
2850
5718
3432
2850
3432
2850
3432

44530*

SP. 7

2850
2850
2850
2850
2850
2288
2850
2288
2850
2850
3432
2850
2288
2288
2850
3146

44330*

SP. 8

1362
1135
908
1589
1135
1816
908
1135
908
1135
1362
908
1135
1135
1262
908
681
1135
908
1135
908
908
908
1132
1135

27591*

SP. 9

1362
1135
1135

1562
1362
1135
1362
1135
1362
1135
1135
1135
1135
1135
1135

18150*

SP. 10

1155

1155*

SP. 11

795
908
905
795
908
908

5219*

SP. 12

2288
2288
2288
2288

9152*

SP. 13

2860
2850
2850
3146
2850
2850
2850
2850
2850
4576
2288
2288
5146

38324*

Aw

SP. 3

1246
1135
1246
681
1135
1246
1246
1246
1246
1246
1362
1135
1246
1362
1552
1246
1135
1246
1246
1246
1246
1246
1246
1246
908

30151*

SP. 5

1476
1476
1352
1476
1476
1476
1476
1589
1589
1589
1589
1589
1589
1589
1589
1589
1589
1353
1589
1352
1603
1589
1135
1135
1352

37245*

SP. 6

1476
1352
1476
1476
1476
1352
1352
1246
1476
1352
1476
1352
1352
1476
1362
1352
1246
1476
1589
1589
1352
1135
1362
1352
1363

34957*

SP. 10

1135
1135
1135
1135
1135
1135
1135
1246
1589
1352
1135
1252
1352
1352
1476
1589
1352
1252
1246
1135
1135
1135
1362
1135
1022

51128*

SP. 11

1246
1352
1352
1352
1352
1589

1476
1476
1476
1476
1589
1589
1135
1589
1589
1352
1132
1352
1350
1362
1352
1589
1589
1589
1589

35974*

Bw

SP. 1

2043
2043
2043
2043
2270
2043
2043
1816
1816
1816
1859
1816
1816
1816
1816
1816
1816
2043
1816
1816
2270
1816
1816
1816
1816

47940*

SP. 2

3718
4004
4004
4004
4004
3718
3718
3146

30316*

SP. 3

3432
3432
4576
3432
4576
5432
4862
5148
5148
5148
5148
2288
2850

53482*

SP. 4

2850
3432
4004
3432

13728*

SP. 5

5148
5148
4576
4004
4004
4004
5148
5148
5148
4576
5148
4852
5148
3432
3432

68926*

SP. 7

5145
3432
3146
3432
4004
3432
2850
2850
2850
2850
2860
3452
4004
4004
4004
4576

56914*

SP. 8

1589
2270
2043
2043
1816
1589
1816
1816
1816
1816
1816
1362

21752*

SP. 9

2043
2043
2043
1816
1930
2043
2043
2043
2043

18047*

SP. 10

5452

3432*

SP. 11

1135
1135
1135
908
1135
1135
1135
1135

8853*

SP. 12

1155
1155
5452

5702*

SP. 13

3432
3432
4004
3432
2850
4576
4576
3432
2850
2850
2850

38524*

Fig. 10. Measured values of bryozoan specimens from the Blue Springs Shale Member of the Matfield Shale Formation.

F

SP. 1
2050 2080 2000 2040 2100 2100
12400*

SP. 2
2180 2220 2280
6680*

SP. 3
2200 2200 2200 2200 2200
11000*

SP. 4
2340 2140 2320 2320
9320*

SP. 5
1570 1570 1530 1620
2290*

SP. 6
1456 1430 1480
4336*

SP. 7
1110 1180 1110
3320*

SP. 8
1170 1270 1153
3605*

SP. 9
1150 1150
2320*

SP. 10
1230 1340
2570*

SP. 11
1240 1252 1240 1240 1240 1164
7386*

SP. 12
1640
1640*

SP. 13
2040 2180 2080
2280*

SP. 14
1170 1170
2340*

SP. 15
2500 2400 2350 2300 2420
11980*

SP. 16
1080 1280 1170
3510*

SP. 17
2180 2140 2040
2380*

SP. 18
2180 2130 2180 2180 2040 2180 2160 2100
17150*

A

SP. 3
2740 2700 2630 2730
10850*

SP. 4
2500 2600 2700 2600 2650 2700 2650 2600 2650
23650*

SP. 15
2630 2630 2630
7890*

N

SP. 10
875 800 950
2625*

SP. 14
900 1050 900 800 1000

4630*

B

SP. 1
1410 1410
2620*

SP. 2
150 155 133
438*

SP. 3
1390 1450 1300 1340
5480*

SP. 4
1520 1630 1420
4590*

SP. 5
1192 1192
2384*

SP. 6
670
670*

SP. 7
750 780
1530*

SP. 8
745 795
1540*

SP. 9
1050 795
1225*

SP. 10
750
750*

SP. 11
790 785
1575*

SP. 12
1150
1160*

SP. 15
1530 1620 1450
4610*

SP. 14
825 750
1375*

SP. 15
1590 1530
3120*

SP. 16
690 690
1380*

SP. 17
1490 1400
2890*

SP. 18
1450 1450
2920*

Dw

SP. 1
1352 1560 1352 1246 1352 1352 1135 1352 1352 1352 1352 1352 1246 1135 1352 1352 1246 1352 1135 1246 1352 1352 1352 1352 1362
33132*

SP. 2
2288 1716 1716 1716 1716 1716 1716
12584*

SP. 3
1352 1352 1246 1246 1352 1352 1352 1352 1352 1352 1352 1352 1352 1246
17358*

SP. 4
2288 2288 2574 1902 2288 2268 2288 2268 2830 2650 2288 2288 2238

2288 2268 2288
37652*

SP. 5
2260 2574 2288 2830 1716 2888 2250 2230 2288 2286 2850 2574 2288 2256 2574 2258 1716 1716 1716 1716 1716 1716 1716 1716 1716
55158*

SP. 6
4576 4004 4001 4004 4576 4004 4004 4004 4004 4004 4004 3432 3432 4004 4004
60057*

SP. 7
3432 3432 3432 4004 5148 3432 4004 4004 4004 4004 4004
42930*

SP. 8
3432 3432 3432 3718 2288 2250 2288
21450*

SP. 9
3432 3146 3432 2660 3432 2288 2250 2850
24310*

SP. 10
2280 2280 2830 2830 2860 2250 30
17160*

SP. 11
2250 1902 1718 1716 2288 2288 2288 2288 2288 2280 2280 3438 2250 2550 2650 2288 2288 2288 2288 1716 2258 2574 2238 2250
50232*

SP. 12
2266 2286 1902 1902 1902 1902 2280
18044*

SP. 13
1716 1716 1716 1716 1144 1144 1144 1712 1716 1716 1716 1716 1716
20352*

SP. 14
4004 4004 4004 4004 4004
20020*

SP. 15
1144
1144*

SP. 16
2283 2268 2280 2250 2288 2288 2286 2286 3432 2860 2288 3432 3432 3432 3432 3432 2258 2280 3132 2266 3432 2288
61472*

SP. 17
1246 1246 1135 1135 1135

1135 1135 1135 1135 1246 1246 1246 1246 1246 1246 1246 1246 1135 1135 1135 1135 1135 1135 1135 1135
22483*

SP. 18
1135
1135*

Aw

SP. 3
1022 1133 1135 1022 908 906 908 906 908 908 908 1022 908 908 908 906 906 908 908 1022 1022 1135 906 1022 908
24065*

SP. 4
908 1022 1022 933 1135 908 1022 1022 908 908 1022 908 908 908 661 795 1022 908 908 1133 795 681 681 631 681
22477*

SP. 10
933 1135 1332 1246 1135 681 1135 1135 908 908 1135 1135 1135

1135 908 908 1132 1135 1135 1135 795 1246 1135 1135 908
26665*

SP. 14
1135 1135 1135 1135 1135 1022 1135 1246 1246 1135 1135 1246 1135 1135 1135 1135 1135 1135 1133 1133 1135 1135 1133 1352
28822*

SP. 15
908 908 908 908 908 908 1022 908 908 908 681 908 681 631 908 908 908 908 908 908 906 908 908 908
22133*

Bw

SP. 1
2258 2288 2574 1716 2288 2268 2288 2574 2888 2574 1902 2288 2288 2574 2288 2574 2574 1902 1716 1716 1718 2288 2288 1902 2262
58470*

SP. 2
2250 2574 2258 2262 2282 2288 2250
17448*

SP. 3
2288 2288 2286 1902 2574 2288 2288 2258 2288 2256 2288 2258 2258 2255
31932*

SP. 4
2280 2288 2288 2288 2280 2280 2280 2288 2288 2286 1902 2258 2288 2288 2288 1902 2282
32696*

SP. 5
2258 2280 2280 2250 2250 2574 2268 1716 2280 2280 2230 2250 2250 2250 2250 2250 2258 2250 2268 2250 2288 2574 2288 2253 2288
65178*

SP. 6
5720 4576 4004 3718 5720 5720 5720 5720 4004 4004 3148 3720 5148 4578 4576 4576
72850*

SP. 7
5720 5720 4001

4004 4004 5146 5720 5148 5148
44813*

SP. 8
4001 3432 4004 4004 4004 2280 4004 4004 3718 3718 3146 2880 4004 3432 3432 3432
38055*

SP. 9
4004 2250 3432 3432 2250 4001 2250 2280 2280 4004 3432
32695*

SP. 10
2280 2250 4004 3433 4004 3432 3432
24084*

SP. 11
3716 3716 4004 4004 3432 2574 3432 4004 4004 4004 4004 4004 2280 2280 1004 4576 4290 3432 3432 3432 3433 3432 2830 2830
66232*

SP. 12
4001 4004 4004 2574
14583*

SP. 13
2288 1712 1144 2288 1716 1716 1716 1716 1716
16016*

SP. 14
5148 5148 5146 5146 5146 3720
31450*

SP. 15
1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716 1716
42900*

SP. 16
5143 5146 4576 5720 5720 4576 4004 3432 3432 4004 4004 4004 4004 4004
61776*

SP. 17
1716
1716*

SP. 18
2283 2288 2260 2288 2268 2288 2288 2574 2888 2268 2288 2288 2238 2288 2288 2238 2238 2238 2288 2288 2282 2288 2288 2268 2288
56057*

Fig. 11. Measured values of bryozoan specimens from the Oketo Shale Member of the Barneston Limestone Formation.

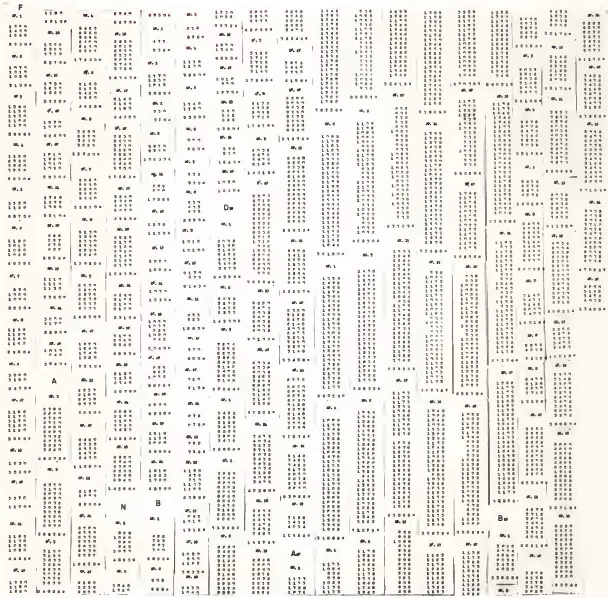



**Fig. 12. Measured values of bryozoan specimens from the Grant Shale Member of the Winfield Limestone Formation.**

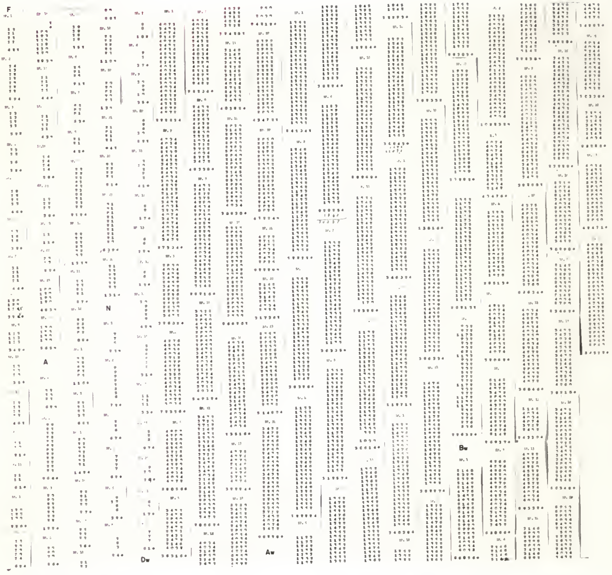


Fig. 13. Measured values of bryozoan specimens from the Odell Shale Formation.

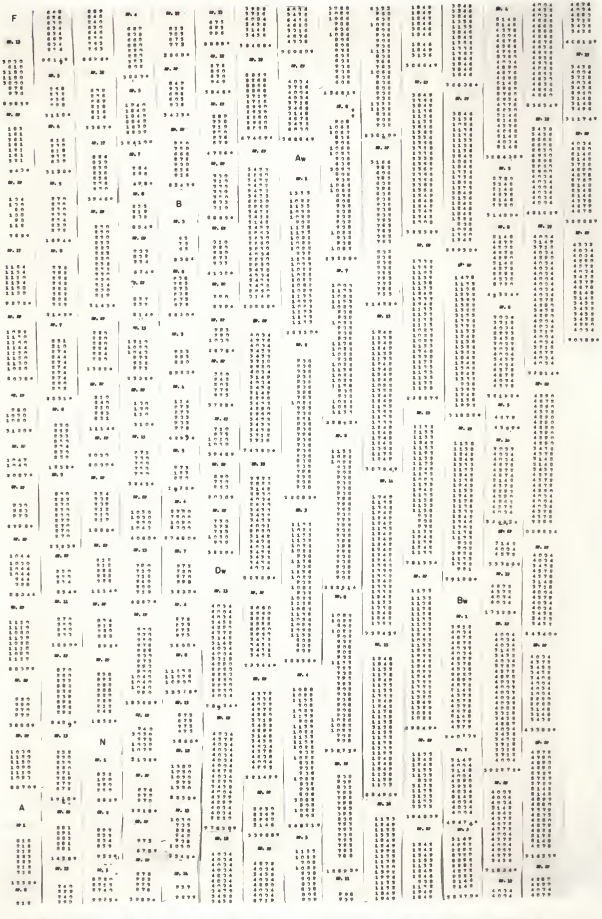


Fig. 14. Measured values of bryozoan specimens from the Paddock Shale Member of the Nolans Limestone Formation.

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VARIATIONS OF SOME FENESTRATE BRYOZOANS
OF THE GEARYAN SERIES IN EASTERN KANSAS

by

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ABSTRACT

Fenestrate Bryozoan assemblages were collected from seven members of the upper Council Grove Group and the Chase Group in Marion, Morris, Geary and Riley Counties in Kansas. Detailed measurements of seven features of the bryozoans in question produced information concerning the evolutionary variations of previously described species. Two new subspecies were discovered. The ranges of almost all the species under study were extended and the possible extinction horizon of one genus was discovered.

The features of the bryozoans were measured using an ocular micrometer inserted in one ocular of a binocular microscope. The measurements were made directly using the scale of the ocular micrometer, and then converted to millimeter values. The values obtained were summed and the mean derived for the purpose of description of the forms and for graphical presentation.

Two types of statistical methods were used to depict population distributions and evolutionary variations of the bryozoans. They were: (1) two-component diagrams and (2) charts plotting variations in each feature studied against the stratigraphic units in which the form was found. These charts are excellent for depicting minute variations in forms but give no information as to population distribution; population distribution was depicted by the two-component diagrams.

This study of short term variations of "fenestrate" type bryozoans discovered: (1) variations of features of all forms collected from the stratigraphic interval investigated proved to be non-systematic. This is in direct contrast to the results of studies by past workers who worked with variations over a long span of the forms. (2) Specimens of the genus Fenestella were

not found in units higher than the Oketo Shale Member of the Barneston Formation. This may be the horizon where this genus became extinct.

(3) Two new subspecies, one of Polypora elliptica and one of Thamniscus ramulosus, were described.

From the information in this report it is concluded that systematic short term variations of the bryozoan faunas in question do not occur. It is probable that there are systematic variations over a long period of time. The data presented here suggest these variations are not of a straight line nature.