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FILIRAMOPORINA KRETAPHILIA—A NEW GENUS AND SPECIES  
OF BIFOLIATE TUBULOBRYOZOAN (ECTOPROCTA)  
FROM THE LOWER PERMIAN WREFORD MEGACYCLOTHEM  
OF KANSAS<sup>1</sup>

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ABSTRACT

Diminutive bifoliate tubulobryozoans restricted to chalky limestones (representing shallow-marine carbonate mud banks) of the Threemile Limestone Member (Wreford Limestone, Lower Permian) in northern and central Kansas represent a hitherto undescribed genus and species, *Filiramoporina kretaphilia*, tentatively referred to the cystoporates. The skeletal morphology and variability of this new form are described with the aid of large population samples, standardized morphological measurements, and paleobiologic species concepts.

INTRODUCTION

Bryozoan fossils found abundantly in late Paleozoic deposits in the central United States are being studied by application of modern paleobiologic approaches, in order to gain greater insight into these interesting animals. Several bryozoan groups, tabuliporoids (Cuffey, 1967), rhomboporoids (Newton, 1971), and fistuliporoids (Warner & Cuffey, 1973), occurring in the Lower Permian Wreford Megacyclothem in southern Nebraska, Kansas, and northern Oklahoma, have

been investigated in this fashion thus far, as part of a major effort to improve understanding of morphologic and paleoecologic characteristics of Permian bryozoans.

This paper concerns the Wreford bifoliate tubulobryozoans (Fry & Cuffey, 1975; Fry, 1975), one of the least frequently encountered groups within the Wreford bryozoan fauna, but one of the most intriguing because of their unusual paleoenvironmental distribution and because they

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represent a hitherto undescribed genus and species.

References to general summaries (Ryland, 1970; Cuffey, 1971, 1973) indicate the relationships of these bifoliates to other bryozoans. Stratigraphic, petrographic, and paleoecologic features of the Wreford Megacyclothem have been described previously (Hattin, 1957; Cuffey, 1967; Newton, 1971; Garihan, 1973; Garihan & Cuffey, in press), as have the localities from which our specimens were collected (Cuffey, 1967, p. 18-20, 89-94; Newton, 1971, p. 15-16; Garihan, 1973, p. 57-62; Garihan & Cuffey, in press; Lutz-Garihan, 1976).

## ACKNOWLEDGMENTS

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## METHODS

Preparation, measurements, and analysis of the Wreford bifoliates followed standard procedures for Paleozoic bryozoan studies (Cuffey, 1967; Foerster, 1970; Karklins, 1969; Newton, 1971; Warner & Cuffey, 1973), as detailed by Fry (1975, p. 3-9, 33). In this present paper, measurements are integrated where appropriate within

the morphologic description (their acronyms relate these to their graphic representation in Fig. 1); their statistics, extracted from Fry (1975, p. 13, 35-121), follow this format: (range/arithmetic mean, standard deviation; number of specimens measured, total number of measurements).

## SYSTEMATICS OF WREFORD BIFOLIATES

Because of their tiny bifoliate branching colonies, short elbow-shaped zooecia, and thick solid exozones, the new taxa represented by the Wreford zoaria were initially assigned to the bifoliate cryptostomes as traditionally understood (Bassler, 1953, p. G136-145; Fry & Cuffey, 1975). However, current studies connected with revision of the bryozoan volume of the *Treatise on Invertebrate Paleontology* suggest classification among the cystoporids instead. Particularly important

are similarities in wall microstructure and colony construction between the Wreford forms and goniocladidiids or cystodictyonids (O. Karklins and J. Utgaard, 1975, pers. commun.). Consequently, higher taxa (after Cuffey, 1973; Warner & Cuffey, 1973, p. 8) are combined with intermediate-level taxa (as suggested by J. Utgaard, 1975, pers. commun.) to set the Wreford bifoliates in proper taxonomic perspective.

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FIG. 1. Reconstruction of zoarial branch of *Filiramoporina kretaphilia* Fry & Cuffey, n. sp., showing orientation of thin sections and standard morphological measurements. [Values presented in text; *CHL-LO* and *CHL-TR*, cystopore height in longitudinal and transverse sections; *CRTL*, cystopore roof thickness; *ENA* and *EXA*, endozone and exozone angles; *IWT*, interzooecial wall thickness; *LZAD* and *TZAD*, longitudinal and transverse zooecial aperture diameters; *MST*, mesotheca thickness; *MWZJ* and *MWZN*, major and minor transverse axes of zoarial branch; *NCD*, minimum cystopore diameter in tangential section; *RN*, number of zooecial ranges; *TP*, exozone or periphery thickness; *XCD*, *XCDL-LO*, and *XCDL-TR*, maximum cystopore diameter in tangential, longitudinal, and transverse section; *Z1* and *Z2*, number of zooecial apertures in 1-square-mm area and on 2-mm line; *ZD* and *ZHM*, zooecium depth and height; *ZSL* and *ZST*, longitudinal and transverse interzooecial spacing.]

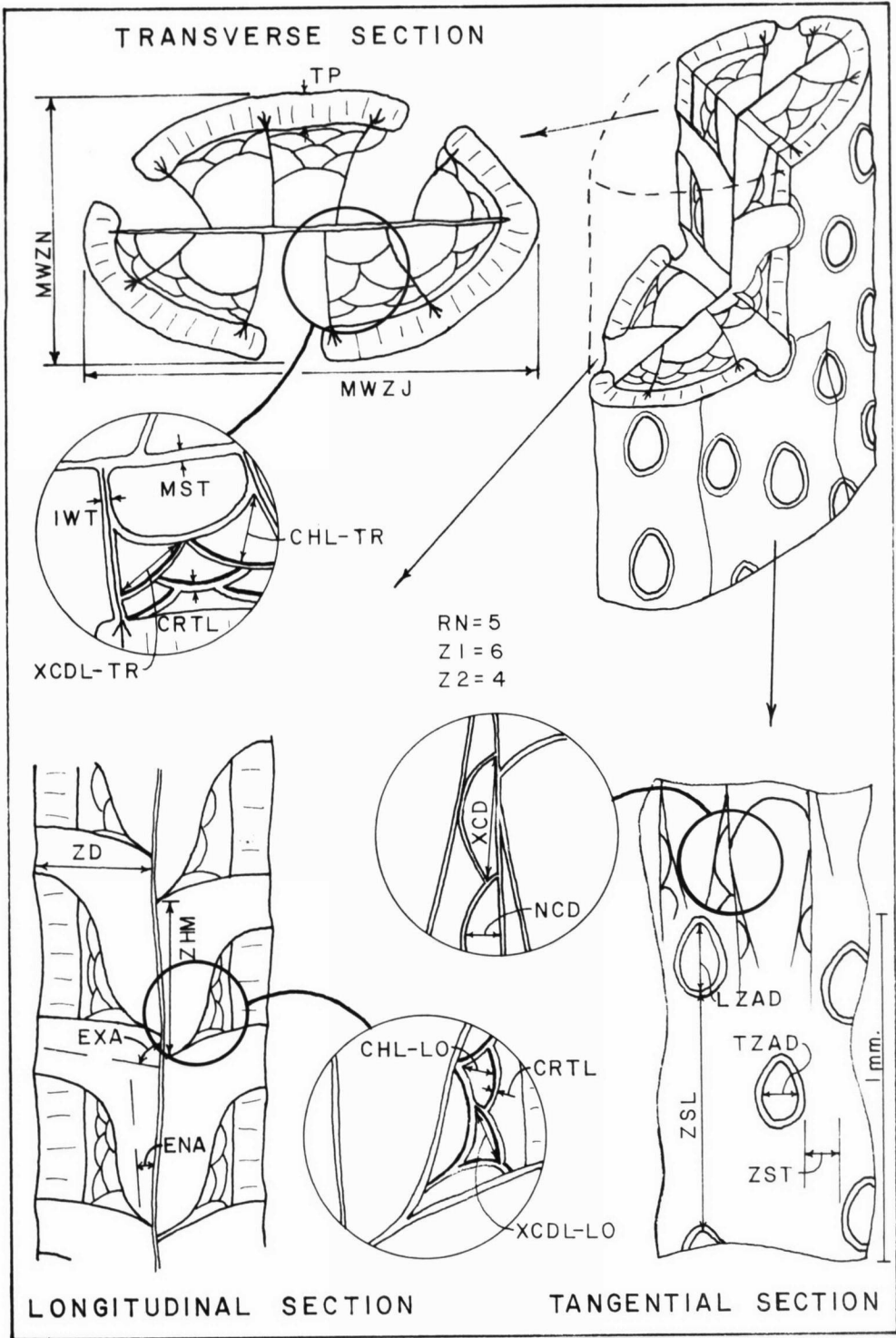


FIG. 1. (Explanation on facing page.)

**Superphylum BRYOZOA Ehrenberg, 1831****Phylum ECTOPROCTA Nitsche, 1869****Superclass TUBULOBRYOZOA Cuffey, 1973****Class STENOLAEMATA Borg, 1926****Subclass LEPTAULATA Cuffey, 1973****Infraclass EXPLETOCYSTATATA Cuffey, 1973****Order CYSTOPORIDA Astrova, 1964****Suborder FISTULIPOROIDEA Astrova, 1964****Family CYSTODICTYONIDAE Ulrich, 1884****Genus FILIRAMOPORINA Fry & Cuffey, new genus**

*Type species.*—*Filiramoporina kretaphilia* Fry & Cuffey, new species.

*Diagnosis.*—Zoarium very small, ramose, dichotomously branching; branches very thin, ovate or fusiform in transverse section, externally lacking maculae or monticules. Colony construction bifoliate, with endozone (composed of thin-walled zooecia and cypostores) sharply distinct from thick solid exozone (surrounding zooecial tubes). Zooecia short, sharply bent; apertures ovoid, arranged in longitudinal rows (but not also in diagonally intersecting rows); wall microstructure finely granular to vaguely fibrous. Some zooecia ending in terminal diaphragms. Mesopores, lunaria, acanthorods, and intrazooecial diaphragms absent.

The name of this new genus is taken from *filum* (thread), *ramus* (branch), *pore* (bearing pores or zooecia), and *-ina* (diminutive ending stressing very small size); freely: "very small threadlike pore-bearing branches."

**FILIRAMOPORINA KRETAPHILIA Fry & Cuffey, new species**

Figure 1; Plate 1, figures 1-9; Plate 2, figures 1-8

*Skeletal morphology.*—Zoarium bifoliate, very small (most fragments 5-8 mm long), ramose and dichotomously branched at 3- to 6-mm intervals (Pl. 1, fig. 1; Pl. 2, fig. 1,2,4,5).

Branches ovate in transverse cross section (Pl. 1, fig. 2; Pl. 2, fig. 3,7,8) and quite diminutive, with major and minor axes averaging about 1.0

by 0.7 mm (MWZJ by MWZN; Fig. 1). External surface relatively smooth, bearing minor protuberances produced by subdued peristomes surrounding zooecial apertures (Pl. 1, fig. 1,7; Pl. 2, fig. 1,2,4,5).

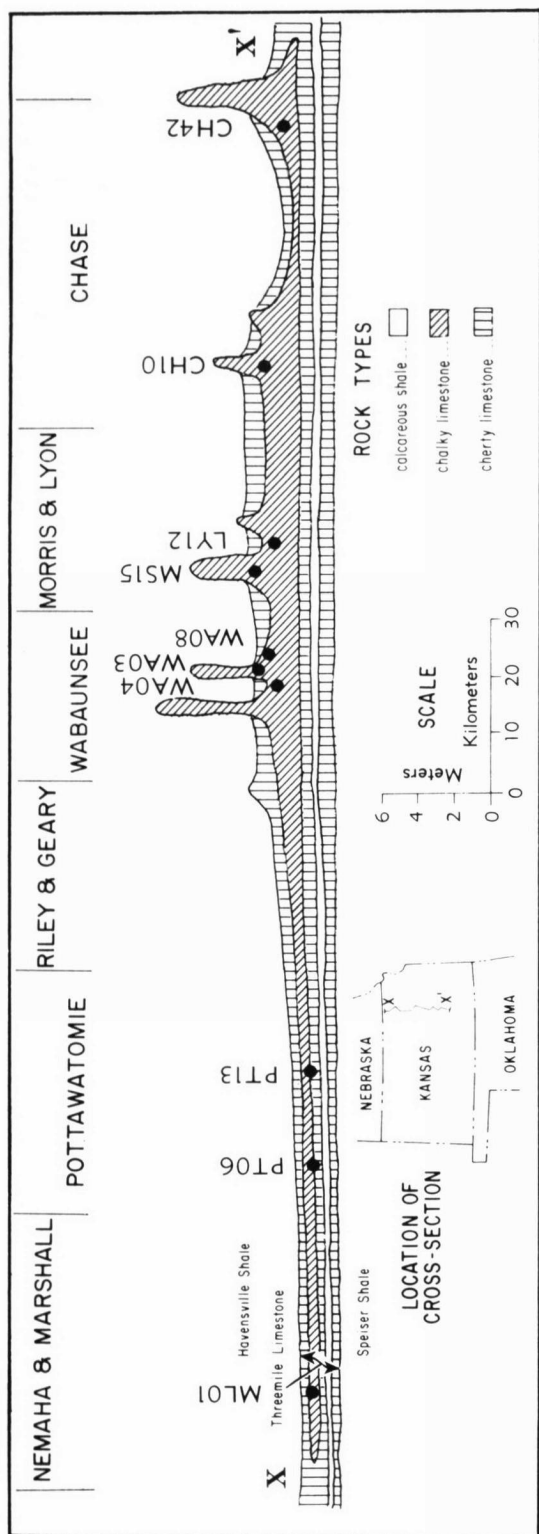
Exozone variably thick (0.02-0.36 mm, TP, ex of Karklins, 1969; Pl. 1, fig. 2; Pl. 2, fig. 8), noticeably thinner near branch growing tips (Pl. 1, fig. 4,6,9). In thin section (Pl. 1, fig. 2,4,5,9; Pl. 2, fig. 3,7,8), exozone or stereom solid, dense, vaguely fibrous, with fibers elongate and oriented approximately normal to mesotheca in longitudinal sections and perpendicularly to zoarial surface in transverse sections. In some shallow tangential sections through exozone, zooecial apertures immediately surrounded by thin lighter-colored rim (zooecial wall) embedded within dense, solid, darker, interapertural or frontal-wall material. Distinct lunaria not evident in sections examined. Interapertural tissue in many specimens mottled, with darker spots arranged parallel to zooecial ranges (and occasionally reminiscent of very indistinct acanthorods). In transverse sections, zooecial wall elements visible within exozone as darker-colored lines radiating outward toward zoarial surface along range boundaries (Pl. 2, fig. 3); similar structures are termed "valves" in Russian bifoliate (Astrova, 1960, translated by Sarycheva, 1972, p. 137).

Mesotheca (Pl. 2, fig. 6) imperforate (Ross, 1964, p. 934), similar to endozonal zooecial walls in microstructure, relatively thin (0.01-0.02 mm, MST, m of Karklins, 1969).

tangential sections (Pl. 1, fig. 3,5,8).

All zooecia of similar size and shape (no heterozooecia such as mesopores or gonozooecia apparent). Zooecia arranged in 3-7 (RN) adjacent longitudinal rows or ranges (Karklins, 1969), each parallel to growth direction of branch (Pl. 1, fig. 1,7; Pl. 2, fig. 4). Range boundaries or trabeculae evident in deep (and some shallow)

Zooecial apertures in tangential sections also obviously arranged in longitudinal sequence in ranges. Apertures comparatively widely spaced, with most commonly 3 to 4 along a 2-mm line (Z2; 2-5/3.6, 0.5; 115, 195) and 8 within a 1-square-mm area (Z1; 3-12/7.9, 1.8; 114, 114). Apertures in tangential section ovoid or egg- or pear-shaped ("pyriform," with narrower end usually distal; Pl. 1, fig. 3,5,8), 0.11-0.35 mm longi-



tudinally by 0.07-0.22 mm transversely (*LZAD*/0.187, 0.039; 118, 579; by *TZAD*/0.127, 0.024; 118, 572; *mj* by *mn* of Karklins, 1969). Interzooecial spacing 0.20-0.70 mm longitudinally (*ZSL*/0.387, 0.082; 111, 443; *lng* of Karklins, 1969) and 0.02-0.42 mm transversely (*ZST*/0.112, 0.056; 111, 149; *lat* of Karklins, 1969).

Zooecia sharply bent in passing outward from endozone to exozone (Pl. 1, fig. 4,9), nearly parallel to mesotheca in endozone (*ENA*), and nearly perpendicular to mesotheca in exozone (*EXA*; *az* of Karklins, 1969). In longitudinal section, intrazooecial cavities averaging about 0.3 mm deep by 0.5 mm high along the mesotheca (*ZD* by *ZHM*; *z* by *h* of Karklins, 1969). Internal diaphragms absent; terminal diaphragms thin, closing some zooecia distally (Pl. 1, fig. 4,6,9).

Endozonal zooecial walls relatively thin (0.01-0.02 mm, *IWT*). Details of wall microstructure preserved in relatively few specimens. Zooecial walls in endozone thin, nonlaminated, finely granular (Pl. 2, fig. 6); composed of central or inner dark-colored layer, flanked on each side by lighter-colored material. Dark layer generally continuous, interrupted in a few places (possible communication pores?); lighter layers contain numerous dark mottlings in some specimens. No cingulum.

Cystopores located above or frontal to proximal portion of endozonal zooecial wall and below inner basal surface of the solid exozone stereom; cystopores filling up those zooecial-wall- and exozonal-base-bounded cavities (Pl. 1, fig. 4,9; Pl. 2, fig. 7,8). Cystopores similar in shape in tangential, transverse, and longitudinal sections; cystopores in this species generally like those in Wreford fistuliporoids (Warner & Cuffey, 1973) except that deep tangential sections here show rounded (rather than polygonal, as in fistuliporoids) cystopores (Pl. 1, fig. 8). Cystopore dimensions quite variable in thin section, ranging up to 0.37 mm (*CHL-LO*, *CHL-TR*, *NCD*, *XCD*, *XCDL-LO*, *XCDL-TR*; Fig. 1). Cysto-

FIG. 2. Generalized north-south cross section of Threemile Limestone Member of Wreford Megacyclothem in Kansas, showing occurrences of *Filiramoporina kretaphilia*; each dot represents one locality yielding that species (modified from Cuffey, 1967, p. 14-15; Newton, 1971, p. 8-9; Garihan, 1973, pocket; Garihan & Cuffey, in press).

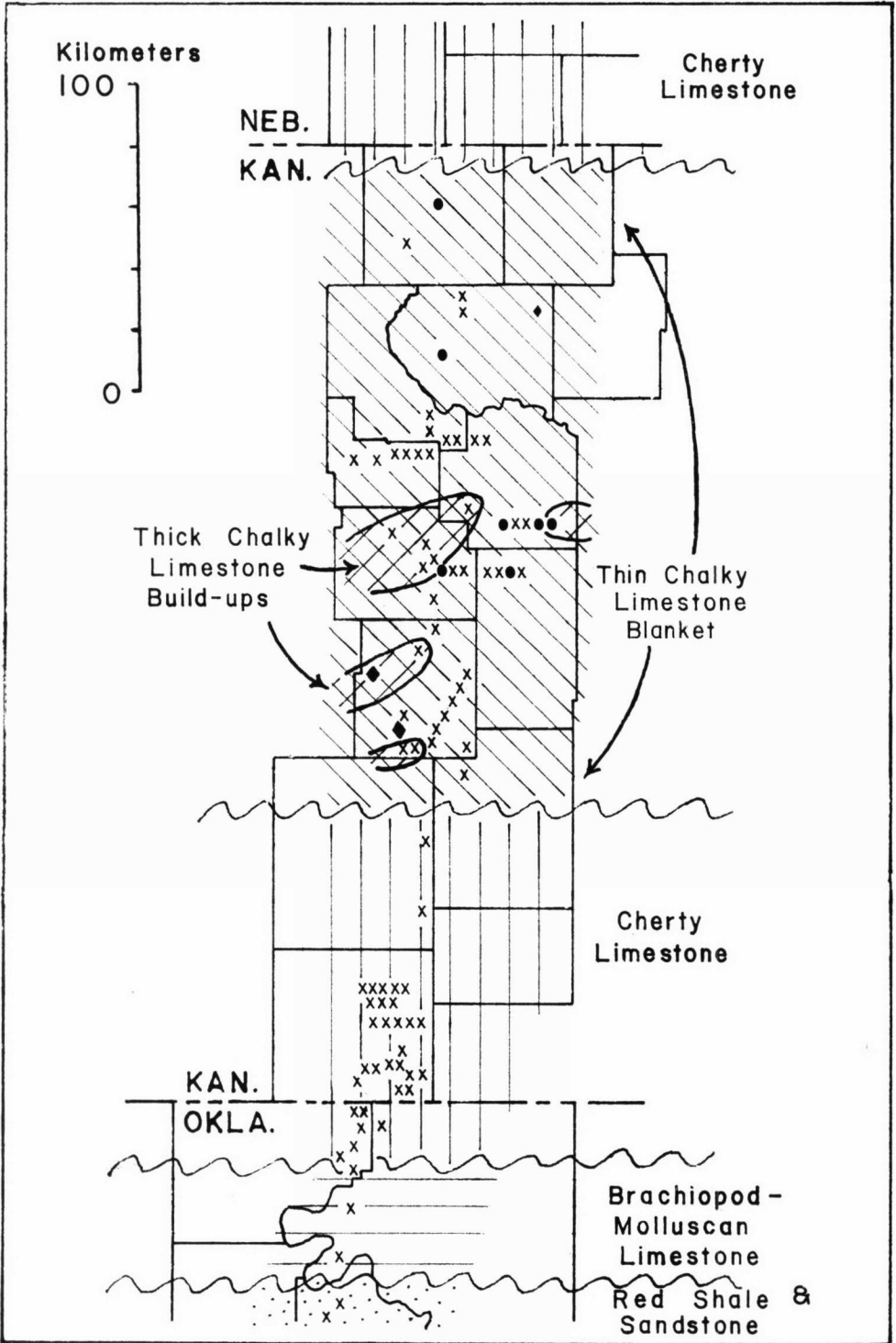


FIG. 3. (Explanation on facing page.)

pore roofs comparatively thin (0.01-0.02 mm, *CRTL*), and microstructurally similar to endozonal zoecial walls.

**Morphologic variability.**—Wreford specimens of *Filiramoporina kretaphilia* exhibit considerable skeletal variability. Nevertheless, this suite apparently represents only one paleobiologic species, as indicated especially by the presence of many morphological intermediates between extreme variants, as well as by the unimodal normal frequency curves obtained from each morphological measurement (Fry, 1975, p. 91-118) and by the specimens' highly restricted paleoecologic distribution.

The high intraspecific variability found among the Wreford bifoliate is comparable to that found within large populations of other tubulobryozoan species studied (Cuffey, 1967, p. 56-66; Horowitz, 1968; Foerster, 1970; Newton, 1971, p. 39-43; Warner & Cuffey, 1973, p. 4-8). Additionally, intracolony variability in *Filiramoporina kretaphilia* may be so great in some cases as to approach the intercolony variability shown by suites of specimens drawn from either single collecting localities or the total Wreford collection (Fry, 1975, p. 79-90).

The relative amount of variability in this species varies considerably among the different morphological parameters measured. Coefficients of variability calculated for each morphological measurement range from 13 to 64 in the total Wreford population (Fry, 1975, p. 13). Parameters displaying the lower variabilities are likely to be of greater taxonomic usefulness, as understanding of Paleozoic bryozoans expands. Moreover, some parameters may be interrelated (Fry, 1975, p. 120-121); zoarial branches with greater diameters and thicker exozones seemingly possess smaller zoecial apertures, which could reasonably reflect astogenetically greater age.

Unlike some species which display well-marked morphologic clines, morphologic variability in *Filiramoporina kretaphilia* does not correlate significantly with geographic location along the north-south Wreford outcrop belt (Fry, 1975, p. 52-78).

**Taxonomic discussion.**—The new species represented by the diminutive Wreford bifoliate is quite distinctive; it can not be assigned to presently known genera, let alone to previously described species, and therefore is herein made the type species of the new genus *Filiramoporina*.

Species of the genus *Timanodictya* seem the most similar to the new Wreford species. However, in contrast to *Timanodictya*, *Filiramoporina kretaphilia* has cystopores, much smaller branches, zoecial apertures not arranged in diagonally intersecting or obliquely transverse rows, no maculae, and no acanthorods. The Wreford species shows some similarities to the genera *Sulcoretepora*, *Ptilocella*, *Taeniopora*, and *Ramipora*, but differs substantially from them by having much more delicate zoarial form, smooth rather than longitudinally ridged or keeled branch surfaces, zoecia along the lateral margins of the branches, fewer cystopores, and no lunaria.

The trivial name of the new Wreford species, from *kreta* (chalk) and *philia* (love), alludes to its restrictedly "chalk-loving" paleoecologic distribution.

**Type specimens.**—Holotype specimen numbered CH10Ab-p-7043; figured paratypes specimens numbered CH10Ab-p-7001b, CH10Ab-p-7029, CH10Ab-p-7105, PT06Aa-p-7009, PT06Aa-p-7010, PT06Aa-p-7012, PT06Aa-p-7016, PT06Aa-p-7019, PT06Aa-p-7035, PT06Aa-p-7212, PT06Aa-p-7220; unfigured paratypes specimens numbered CH10Ab-p-7023, CH10Ab-p-7033, CH10Ab-p-7039, CH10Ab-p-7041, CH10Ab-p-7051, CH10Ab-p-7103, CH42Ckt9-p-7073, PT06Aa-p-7019c, PT06Aa-p-7027; all in Paleobryozoological Research Collection within Department of Geosciences at Pennsylvania State University.

**Occurrence.**—*Filiramoporina kretaphilia* is sparingly distributed in Permian chalky limestones of the middle upper Threemile Limestone Member of the Wreford Limestone; this new species is presently known from Kansas Wreford localities in the following counties: Chase (CH10, CH42), Lyon (LY12), Marshall (ML01), Morris (MS15), Pottawatomie (PT06, PT13), and Wabunsee (WA03, WA04, WA08) (details of these localities may be found in Cuffey, 1967, p. 18-20, 89-94).

beds of upper part of the Threemile Limestone. Diamonds indicate localities which yielded over 30 specimens of the species, circles 1-29, and crosses 0; facies boundaries are highly generalized.

FIG. 3. Distribution of *Filiramoporina kretaphilia* in middle beds of upper part of the Threemile Limestone. Diamonds indicate localities which yielded over 30 specimens of the species, circles 1-29, and crosses 0; facies boundaries are highly generalized.

## PALEOECOLOGY OF WREFORD FILIRAMOPORINA KRETAPHILIA

The paleoecology of *Filiramoporina kretaphilia* is highly distinctive in that this species has an extremely limited distribution within the Wreford Megacyclothem. This is in sharp contrast to other Wreford bryozoans studied thus far, especially to the very wide-ranging *Rhombopora* (Newton, 1971, p. 43-47), but even to the somewhat more restricted *Tabulipora* (Cuffey, 1967, p. 71-85), *Syringoclemis* (Newton, 1971, p. 45-47), and *Fistulipora* and *Meekepora* (Warner & Cuffey, 1973, p. 19-23).

Within the collections available to us, all specimens positively identifiable as *Filiramoporina kretaphilia* come from the middle beds of the upper part of the Threemile Limestone Member,

in northern and central Kansas (Fig. 2). In addition, these specimens occur only within the chalky limestone facies, particularly in its thicker developments (interpreted previously as shallow-marine carbonate mud banks; Cuffey, 1967, p. 12) in central Kansas (Fig. 2, 3). Moreover, as is evident from maps (Fig. 3), only a few of the many localities exposing this facies and horizon yield *Filiramoporina kretaphilia* specimens.

Many zoaria of *Filiramoporina kretaphilia*, particularly from northern Kansas localities, are partially silicified, especially in their exozones. This condition is reminiscent of that previously observed in Wreford *Meekepora* (Warner & Cuffey, 1973, p. 23).

## SUMMARY AND CONCLUSIONS

1) Study of a population-sized sample of very small bifoliate tubulobryozoans from the Wreford Megacyclothem (Lower Permian; Kansas) indicates that these forms represent a single paleobiologic species, hitherto undescribed but sufficiently distinctive to justify definition of both a new genus and a new species—*Filiramoporina kretaphilia*, n. gen., n. sp., tentatively referred to the cystoporates.

2) The skeletal morphology and variability of this new species are thoroughly described herein, as a basis for future comparative studies.

3) Distribution of this new species is extremely restricted. At present, it is known to occur only in the chalky limestone facies (representing carbonate mud banks) of the middle part of the upper Threemile Limestone Member in northern and central Kansas.

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## EXPLANATION OF PLATES

### PLATE 1

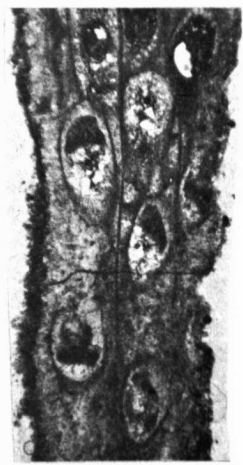
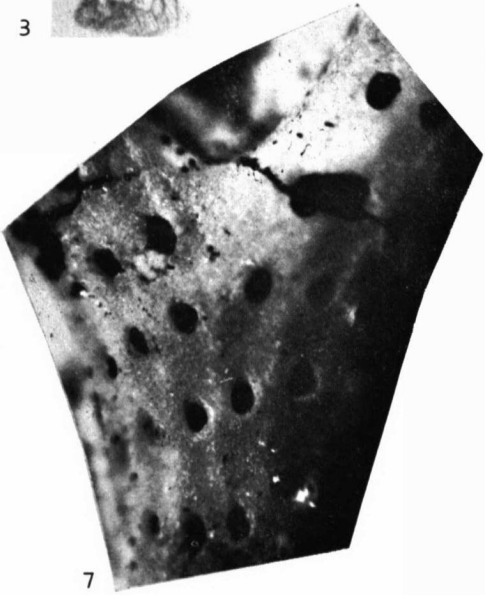
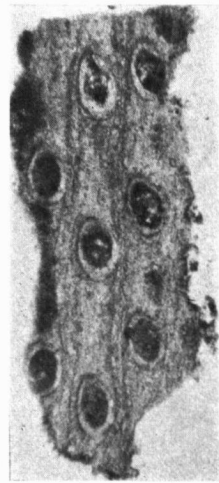
#### FIGURE

- 1-9. *Filiramoporina kretaphilia* Fry & Cuffey, n. sp.—1. External view of specimen, PT06Aa-p-7212,  $\times 3.5$ .—2. Transverse section of holotype, CH10Ab-p-7043,  $\times 60$ .—3. Tangential section of PT06Aa-p-7016 showing (lower part) deeply cut zooecia,  $\times 21$ .—4. Longitudinal section of PT06Aa-p-7012 showing cystopores,  $\times 21$ .—5. Tangential section of CH10Ab-p-7105, showing peristomes and range boundaries,  $\times 35$ .—6. Longitudinal section of CH10Ab-p-7029, showing growth tip, very thin exozone, and terminal diaphragms,  $\times 35$ .—7. Exterior view of PT06Aa-p-7010, showing slightly raised expression of range boundary,  $\times 23$ .—8. Tangential section of holotype, CH10Ab-p-7043, showing cystopores in deep portion of section,  $\times 40$ .—9. Longitudinal section of holotype, CH10Ab-p-7043, showing slightly raised peristomes and cystopores between zooecia and exozonal stereom,  $\times 40$ .

### PLATE 2

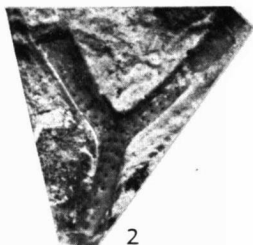
#### FIGURE

- 1-8. *Filiramoporina kretaphilia* Fry & Cuffey, n. sp.—1. External view of PT06Aa-p-7010,  $\times 3.5$ .—2. External view of PT06Aa-p-7035, showing peristomes,  $\times 3.5$ .—3. Transverse section of CH10Ab-p-7001b, showing branching (within the exozone) of dark laminae of interzooecial wall,  $\times 60$ .—4. External view of PT06Aa-p-7009, showing range boundaries,  $\times 3.5$ .—5. External view of PT06Aa-p-7220, showing peristomes,  $\times 3.5$ .—6. Transverse section of PT06Aa-p-7012, showing structure of mesotheca, interzooecial walls, and cystopores,  $\times 200$ .—7. Transverse section of PT06Aa-p-7019 with silicified exozone,  $\times 60$ .—8. Transverse section of PT06Aa-p-7012, showing cystopores and silicified exozone,  $\times 60$ .

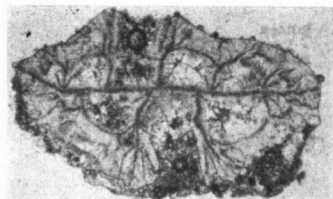




1



2



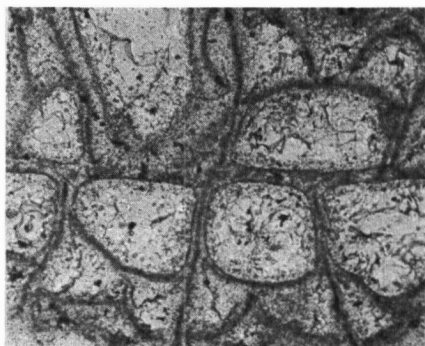
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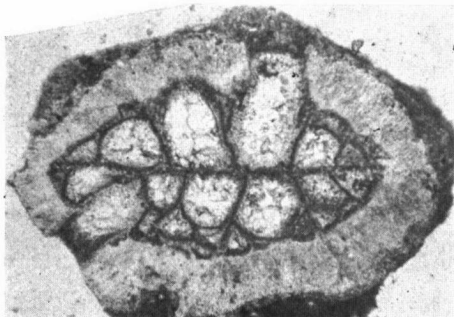
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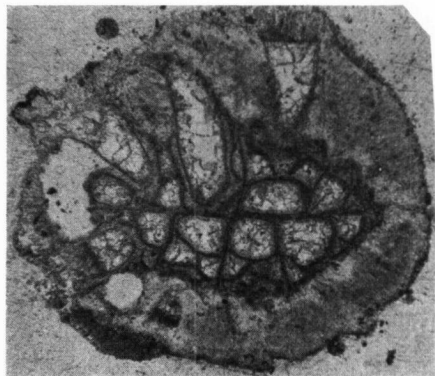
5



6



7



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