

UPPERMOST ORDOVICIAN AND LOWERMOST SILURIAN
STRATIGRAPHY AND SOLITARY RUGOSE CORALS
OF THE EAST-CENTRAL UNITED STATES

Robert J. McAuley

A thesis
presented to the University of Manitoba
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By

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ABSTRACT

A succession of three solitary rugosan assemblages is recognized within the uppermost Ordovician-lowermost Silurian sequence in the east-central United States. The lowest is a Late Ordovician assemblage in the upper Maquoketa Group (Richmondian). Salvadorea randi (Elias, 1981) occurs in southern Illinois, northwestern Illinois and eastern Iowa. Grewingkia canadensis (Billings, 1862) is present in eastern Wisconsin. These species represent the Red River-Stony Mountain and Richmond solitary coral provinces, respectively. They became extinct when the epicontinental sea withdrew at the end of Richmondian time, possibly due to a glacioeustatic sea-level drop.

This study is focused on the middle (Edgewood) assemblage. The strata containing these corals are thin, dominantly carbonate units. They were deposited during a transgression from the south, possibly due to a glacioeustatic sea-level rise. Normal, open marine environments were introduced to the region. The Edgewood corals were derived from taxa previously restricted to the continental margin. The Keel Formation of south-central Oklahoma contains Streptelasma subregulare

(Savage, 1913b), S. amsdeni n. sp., S. leemonense Elias, 1982, S. sp. cf. S. leemonense, Grewingkia sp. A, and Keelophyllum oklahomense n. gen., n. sp. In southern Illinois-southeastern Missouri, species within the Leemon Formation are S. subregulare, S. leemonense, Streptelasma sp. of Elias, 1982, and Bodophyllum shorti Elias, 1982. Streptelasma sp. A. is present in the Noix Limestone of northeastern Missouri. The overlying Bryant Knob Formation yields S. subregulare from the unnamed member and S. subregulare, S. leemonense, plus Grewingkia sp. A from the Kissenger Limestone Member. The Cyrene Formation, which is laterally equivalent to the Noix and Bryant Knob, contains S. subregulare. In northeastern Illinois, S. subregulare is present in the Schweizer and Birds members of the Wilhelmi Formation. This species has been reported from the base of the Mosalem Formation in northwestern Illinois. These rugosans comprise the Edgewood Solitary Coral Province. S. subregulare, the dominant species, exhibits a wide range of intraspecific variability.

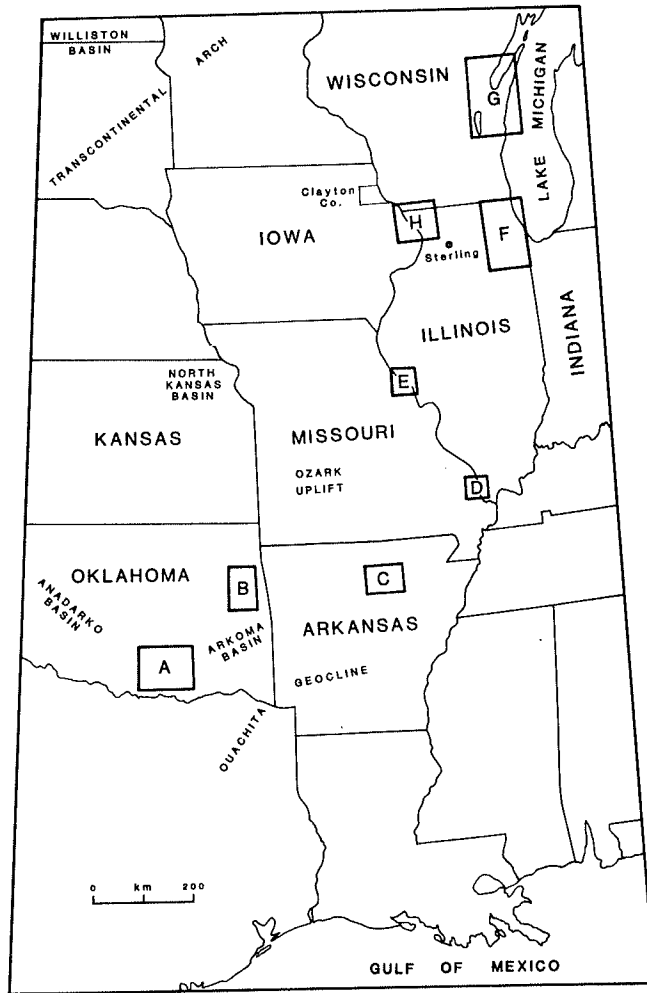
The Keel Formation, Leemon Formation, Noix Limestone, and lower Cyrene Formation are considered to be Late Ordovician (Gamachian) in age. The lower part of the Schweizer Member, Wilhelmi Formation, and lower part of the Mosalem Formation may also be Gamachian. The upper part of the Schweizer Member plus the Birds Member of the Wilhelmi Formation, the middle portion of the Mosalem Formation, the Bryant Knob Formation, and upper Cyrene Formation are Early Silurian (early early Llandovery). Thus, the Edgewood assemblage spans the time interval from Gamachian to early early Llandovery, and solitary Rugosa cannot be used to delineate the position of the Ordovician-Silurian boundary in the east-central United States.

The upper assemblage is characterized by genera typical of the Early through Middle Silurian. Dalmanophyllum and Phaulactis are found within the upper part of the Mosalem Formation (late early Llandovery) in northwestern Illinois. In the upper Elwood Formation (late early to middle Llandovery) of northeastern Illinois, Dinophyllum and Dalmanophyllum occur. Rhegmaphyllum, Dinophyllum, and Dalmanophyllum are present in the Bowling Green Dolomite (late early Llandovery) of northeastern Missouri. The Sexton Creek Limestone (middle Llandovery) of southeastern Missouri yields Dalmanophyllum. The Cochrane Formation (late Llandovery) of south-central Oklahoma contains Phaulactis. These Silurian corals were not derived from Edgewood taxa or any known North American Ordovician solitary rugosans.

INTRODUCTION

The uppermost Ordovician-lowermost Silurian sequence in the east-central United States is exposed in eight separate areas (Text-fig. 1). It comprises Late Ordovician (Richmondian) strata that are primarily shales (Sylvan Shale and Maquoketa Group), succeeded by dominantly carbonate units which are typically thin and of limited areal extent. The latter units were included in the Silurian and assigned to the Alexandrian Series by Savage (1908a, 1908b, 1909, 1910, 1912, 1913a, 1913b, 1914, 1916, 1917, 1926) and Reeds (1911). More recently, Satterfield (1971) studied conodonts in the Girardeau Limestone of southeastern Missouri and southern Illinois, and considered them to be very late Ordovician in age. Amsden (1971b, 1974, 1980) has worked on the brachiopod faunas, and suggested that the Keel Formation of south-central Oklahoma, the Pettit Formation of northeastern Oklahoma, an oolite bed in the Cason Shale of north-central Arkansas, the Leemon Formation of southern Illinois-southeastern Missouri, and the Noix Limestone of northeastern Missouri-west-central Illinois are Late Ordovician (Ashgill; Hirnantian) in age. Overlying units, including the Cochrane Formation of south-central Oklahoma, the Triplesia alata beds in the Cason Shale of north-central Arkansas, the Sexton Creek Limestone of southern Illinois-southeastern Missouri, and the Bryant Knob Formation and Bowling Green Dolomite of northeastern Missouri were assigned to the Early Silurian (Llandovery). Thompson and Satterfield (1975) investigated the conodont faunas within the strata contiguous to the systemic boundary in eastern Missouri and southwestern Illinois. The Leemon Formation of southern Illinois-southeastern Missouri, and the Noix Limestone and Cyrene Formation of northeastern Missouri were

Text-figure 1.—Map of the east-central United States showing outcrop areas of uppermost Ordovician and lowermost Silurian strata (A-H), several structural features of the region, and localities mentioned in the text. Details of areas A, B, D-H are shown in Text-figs. 3, 6, 8, 10, and 12.



considered to be Late Ordovician. The overlying Sexton Creek Limestone of southern Illinois-southeastern Missouri plus the Bryant Knob Formation and Bowling Green Dolomite of northeastern Missouri were included within the Early Silurian. Elias (1982) suggested that the Wilhelmi Formation of northeastern Illinois could be latest Ordovician (?Gamachian), after examining solitary rugose corals from that unit plus the Leemon Formation of southeastern Missouri and the Cyrene Formation of northeastern Missouri.

Although there has been a renewal of interest in these units and faunas during the past 15 years, precise correlations and ages, plus facies relationships, remain uncertain to varying degrees within individual areas and on a regional scale. This stratigraphic sequence is of particular significance because it was deposited at a time when transgressions and regressions related to glacial activity have been reported from other regions, including Anticosti Island, Québec (Petryk, 1981a, 1981b; Johnson, Cocks, and Copper, 1981), and Scandinavia (Brenchley and Newall, 1980; Stridsberg, 1980; Brenchley and Cocks, 1982).

Solitary rugose corals are a common faunal constituent in many uppermost Ordovician and lowermost Silurian units in the east-central United States. The purpose of this study is to precisely document their stratigraphic and geographic distributions in order to permit more precise correlations and age determinations, as well as the interpretation of facies relationships (preliminary work was done by Mattison, 1983, and McAuley, 1983). The global changeover from Ordovician to Silurian coral faunas is poorly understood because those of earliest Silurian age are inadequately known (Hill, 1981, pp. 51,

53). The present study will contribute to a better knowledge of geologic history in the east-central United States, plus the paleobiogeographic and evolutionary history of solitary Rugosa during latest Ordovician and earliest Silurian time.

ABBREVIATIONS AND REPOSITORIES

- A coll.: T.W. Amsden collection.
- E coll.: R.J. Elias collection.
- EM coll.: R.J. Elias and R.J. McAuley collection.
- EMM coll.: R.J. Elias, B.W. Mattison, and R.J. McAuley collection.
- S coll.: T.E. Savage collection.
- OGS: Oklahoma Geological Survey, Norman, Oklahoma, U.S.A.
- UCGM: University of Cincinnati Geological Museum, Cincinnati,
Ohio, U.S.A.
- UI: University of Illinois at Urbana-Champaign, Urbana,
Illinois, U.S.A.
- USNM: National Museum of Natural History, Smithsonian
Institution, Washington, D.C., U.S.A.

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STRATIGRAPHIC SECTIONS AND COLLECTIONS

Outcrops of uppermost Ordovician and lowermost Silurian strata were examined in seven areas during this study (Text-fig. 1, areas A, B, D-H). To ensure stratigraphic and paleontologic control, all sections that were selected had been described in previous literature, and fossils had been listed from most (see references cited below). The 27 localities provide representative geographic coverage within each area. Every section was thoroughly examined for solitary rugose corals, which were found at 18 of them. All specimens seen were collected, except from a few intervals in which they were so numerous that this was impractical (R.J. Elias, B.W. Mattison, and R.J. McAuley collection, 1982; Elias and McAuley collection, 1983). The relative abundance of corals was estimated qualitatively. Additional specimens from these sections were incorporated into this study from collections made by T.W. Amsden in south-central Oklahoma and R.J. Elias in southeastern and northeastern Missouri. Data were obtained from other localities in southern Illinois, northeastern Missouri, and northeastern Illinois using the collection of T.E. Savage. A total of 638 solitary rugose corals from the combined collections are identified herein. Locations and stratigraphic-paleontologic data are shown in Text-figs. 3, 6, 8, 10, and 12.

The locations of stratigraphic sections examined in this study are listed below. They are designated using U.S. Geological Survey topographic quadrangle maps (1:24,000 scale). Precise coordinates are measured first east and then north from the southwest corner of the map.

Eastern Wisconsin

1 (Katell Falls).—Bellevue, Wis., Quadrangle: 100 mm E, 224 mm N; SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T23N, R21E. Waterfall and stream valley, just north of State Route G, 0.5 km west of junction with State Route V, Brown County, Wisconsin (Savage and Ross, 1916, pp. 189, 190, fig. 2; Willman, 1973, p. 13; Mikulic and Kluessendorf, 1983, pp. 26, 28-30, figs. 18-20).

2 (High Cliff).—Sherwood, Wis., Quadrangle: 269 mm E, 153 mm N; SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 36, T20N, R18E. Abandoned quarry at top of High Cliff, along west side of road through High Cliff State Park, Calumet County, Wisconsin (Willman 1973, p. 13; Mikulic and Kluessendorf, 1983, pp. 23, 25, fig. 16).

Northeastern Illinois

3 (Garden Prairie).—Riley, Ill., Quadrangle: 179 mm E, 566 mm N; NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 31, T44N, R5E. Abandoned quarry, 0.5 km south of U.S. Route 20, McHenry County, Illinois (Savage, 1926, p. 518; Willman, 1973, p. 12).

4 (Schweizer West).—Channahon, Ill., Quadrangle: 302 mm E,

418 mm N; SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 35, T35N, R9E. Cuts on both sides of lower (western) railroad, southeast side of Des Plaines River valley, Will County, Illinois. Collecting intervals 4-1, 4-1a, 4-1c on west side of tracks. Type section of Wilhelmi Formation, and its Schweizer and Birds (lower part) members (Ross, 1962, fig. 1; Willman, 1962, p. 84, stop 4; Willman, 1973, pp. 50, 51, sec. 17; Liebe and Rexroad, 1977, p. 854, loc. 8, fig. 1; Elias, 1982, fig. 21, Will Co. sec.).

5 (Schweizer North).—Channahon, Ill., Quadrangle: 354 mm E, 449 mm N; SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T35N, R9E. Cut on southeast side of lower (western) railroad, and ravine from there to southeast side of upper (eastern) railroad, at new concrete culvert, southeast side of Des Plaines River valley, Will County, Illinois. Type section of Birds Member (upper part) of Wilhelmi Formation, and Elwood Formation (Ross, 1962, fig. 1; Willman, 1973, p. 50, sec. 16; Liebe and Rexroad, 1977, p. 854, loc. 7, fig. 1; Elias, 1982, fig. 21, Will Co. sec.).

6 (Plaines West).—Channahon Ill., Quadrangle: 405 mm E, 491 mm N; NW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 30, T35N, R10E. Cut on southeast side of lower (western) railroad, southeast side of Des Plaines River valley, Will County, Illinois. Type section of Drummond, Offerman, and Troutman (lower part) members, Kankakee Formation (Ross, 1962, fig. 1; Willman, 1973, pp. 49, 50, sec. 14; Liebe and Rexroad, 1977, p. 854, loc. 6, fig. 1; Elias, 1982, fig. 21, Will Co. sec.).

7 (Kankakee River).—Bonfield, Ill., Quadrangle: 340 mm E, 401 mm N; NE $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 36, T32N, R10E. Exposure on north bank of Kankakee River, just southwest of loop road in Kankakee River State Park campground, 0.3 km south of State Route 102 (Willman, 1962, pp. 82, 83, stop 2; Willman, 1973, p. 48, sec. 8).

Eastern Iowa

8 (King).—Menominee, Ill.—Iowa, Quadrangle: 120 mm E, 105 mm N, to 113 mm E, 133 mm N; E $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 27, T88N, R3E. Cut on east side of U.S. Route 52, just south of King, Dubuque County, Iowa. Type section of Mosalem and Tete des Morts formations (Willman, 1973, p. 52, sec. 22).

26 (Bellevue).—Springbrook, Iowa-Ill., Quadrangle: 288 mm E, 559 mm N, to 262 mm E, 572 mm N; NE $\frac{1}{4}$ sec. 19, T86N, R5E. Exposure along west side of U.S. Route 52 and south side of road in Bellevue State Park, Jackson County, Iowa (Whitlow and Brown, 1963, p. 13; Ross, 1964, p. 1107, fig. 1; Rose, 1967, pp. 44, 45, figs. 20, 21; Anderson, 1983, fig. 5.6).

Northwestern Illinois

9 (Winston).—Hanover, Ill., Quadrangle: 41 mm E, 461 mm N; SE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T27N, R1E. Quarry on east side of road, 1.8 km north of eastern end of Winston railroad tunnel, Jo Daviess County, Illinois (Willman, 1973, p. 55, sec. 34).

10 (Lost Mound).—Green Island, Iowa-Ill., Quadrangle: 288 mm E, 412 mm N; SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 28, T26N, R2E. East side of quarry in east bluff of Mississippi River valley, 1.3 km northwest of Lost Mound, Jo Daviess County, Illinois (Willman, 1973, pp. 52, 53, sec. 24).

11 (Schapville).—Elizabeth, Ill., Quadrangle: 92 mm E, 558 mm N; NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T27N, R2E. Cut on east side of road, 3.2 km southwest of Schapville, Jo Daviess County, Illinois (Willman, 1973, p. 54, sec. 30)

12 (Stockton).—Kent, Ill., Quadrangle: 148 mm E, 359 mm N; SE $\frac{1}{4}$

SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 17, T27N, R5E. Abandoned quarry at north edge of ridge, just south of road, 4 km southeast of Stockton, Jo Daviess County, Illinois (Willman, 1973, p. 54, sec. 32).

Northeastern Missouri

13 (Bowling Green).—Bowling Green, Mo., Quadrangle: 197 mm E, 497 mm N; NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T53N, R3W. Cut on north side of U.S. Route 54, 1.5 km northeast of junction with U.S. Route 61, Pike County, Missouri. Reference section of Cyrene Formation and Bowling Green Dolomite (Koenig, Martin, and Collinson, 1961, fig. 15; Amsden, 1974, p. 84, loc. D, figs. 4, 7; Thompson and Satterfield, 1975, pp. 96, 99, fig. 11, sec. 8; Elias, 1982, fig. 21).

14 (Higginbotham Farm).—Cyrene, Mo., Quadrangle: 391 mm E, 418 mm N, and 392 mm E, 424 mm N; W $\frac{1}{2}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 28, T53N, R1W. Exposures south (collecting interval 14-2) and north (collecting interval 14-1) of abandoned house, just east of State Route D, Pike County, Missouri (Laswell, 1957, p. 20, sec. 5; Amsden, 1974, p. 83, loc. A, fig. 4; Thompson and Satterfield, 1975, p. 93, fig. 16).

15 (Calumet).—Cyrene, Mo., Quadrangle: 415 mm E, 432 mm N, to 404 mm E, 434 mm N; S $\frac{1}{2}$ SE $\frac{1}{4}$ sec. 21, T53N, R1W. Abandoned quarry east of Stark Cemetery, 0.5 km east of State Route D, Pike County, Missouri (Thompson and Satterfield, 1975, p. 93, sec. 5, figs. 15, 16). Collecting interval 15-0 in loose blocks, 15-1 in in situ strata.

16 (Clinton Spring).—Louisiana, Mo.-Ill., Quadrangle: 312 mm E, 312 mm N; SW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 20, T54N, R1W. Exposure just west of Clinton Spring on west side of State Route 79, southern edge of Louisiana, Pike County, Missouri. Type section of Noix Limestone

(Laswell, 1957, pp. 18, 19, sec. 4; Koenig, Martin, and Collinson, 1961, p. 34, stop 8, figs. 21, 22; Birkhead, 1967, loc. I, fig. 4; Amsden, 1974, p. 83, loc. B, fig. 4; Thompson and Satterfield, 1975, p. 89, sec. 7, fig. 12; Elias, 1982, p. 40, fig. 21, loc. 21b).

17 (Clarksville).—Clarksville, Mo.-Ill., and Pleasant Hill West, Ill.-Mo., quadrangles: 333 mm E, 564 mm N (Clarksville) to 313 mm E, 1 mm N (Pleasant Hill West); SW $\frac{1}{4}$ sec. 9, T53N, R1E. Cut on west side of State Route 79, northern edge of Clarksville, Pike County, Missouri (Amsden, 1974, p. 84, loc. E, figs. 4-6; Thompson and Satterfield, 1975, pp. 99, 100, sec. 6, fig. 13; Elias, 1982, p. 40, loc. 21a; McCracken and Barnes, 1982, fig. 2). Collecting interval 17-0 at southern end of exposure, 17-2a from southern end to central portion, 17-1, 1a, 2 from central portion, 17-2b, 3 from north end.

18 (Kissenger).—Annada, Mo.-Ill., Quadrangle: 15 mm E, 312 mm N; SW $\frac{1}{4}$ sec. 35 (projected), T53N, R1E. Cut on west side of State Route 79, just west of Kissenger Hill and south of spring. Type section of Bryant Knob Formation and its Kissenger Limestone Member (Amsden, 1974, pp. 84, 85, loc. F, fig. 4; Thompson and Satterfield, 1975, pp. 97-100, sec. 11, fig. 14).

Southeastern Missouri

19 (New Wells).—Neelys Landing, Mo.-Ill., Quadrangle: 24 mm E, 254 mm N; NW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 9, T33N, R13E. Exposure along channel and east bank of Blue Shawnee Creek, 0.5 km east of New Wells, Cape Girardeau County, Missouri (Amsden, 1974, pp. 21, 22, 87, loc. U, fig. 17; Thompson and Satterfield, 1975, p. 79, sec. 4, fig. 9; Elias, 1982, p. 39, fig. 21, loc. 20b) (note: coordinates of this section

are incorrect in previous publications). Collecting interval 19-1 in northern part of exposure, 19-2 in southern part, 19-3 in loose blocks.

20 (Short Farm).—Cape Girardeau NE, Mo., Quadrangle: 44 mm E, 276 mm N; SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 21, T32N, R13E. Exposure along creek channel just east of barn, 0.25 km east of State Route W, Cape Girardeau County, Missouri. Collecting interval 20-1 in in situ strata, 20-2 to 5 in loose blocks. Type section of Leemon Formation (Amsden, 1974, pp. 19, 85, 86, loc. K, fig. 16; Thompson and Satterfield, 1975, sec. 3, fig. 7; Elias, 1982, p. 39, fig. 21, loc. 20a).

Northeastern Oklahoma

28 (Qualls).—Qualls, Okla., Quadrangle: 283 mm E, 441 mm N; NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 2, T14N, R21E. Exposure on west bank, White Oak Branch of Greenleaf Creek, 1.5 km west of Qualls, Cherokee County, Oklahoma (Amsden and Rowland, 1965, pp. 24, 95, 96, sec. Ch4, fig. 7, pl. B).

South-central Oklahoma

21 (Rock Crossing).—Overbrook, Okla., Quadrangle: 310 mm E, 348 mm N; SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 35, T5S, R1E. Exposure on west bank of Hickory Creek, east side of road, 0.15 km south of bridge, Carter County, Oklahoma (Amsden, 1960, pp. 208-210, sec. Call, panel 1). Collecting intervals 21-1, 1a to 1c in different lenses of bioclastic limestone.

22 (Cedar Village).—Turner Falls, Okla., Quadrangle: 437 mm E,

326 mm N; SE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T1S, R2E. Cut on west side of U.S. Route 77, 0.5 km south of junction with Interstate Route 35, just north of Cedar Village, Murray County, Oklahoma (section enlarged and improved since described by Amsden, 1960, pp. 256-258, sec. M17, panel 1).

23 (Lawrence Quarry).—Ahloso, Okla., Quadrangle: 93 mm E, 302 mm N to 98 mm E, 296 mm N; NW $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36 (northern site), and 92 mm E, 282 mm N; NW $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 36 (southern site), T3N, R5E. East side of Ideal Cement Company quarry at Lawrence, Pontotoc County, Oklahoma. Collecting intervals 23-1, 2, 2a, 3, 4 at northern site, 23a-1 at southern site. Type section of Keel Formation and its Ideal Quarry Member (Amsden, 1960, pl. 1, figs. 1, 2, panel 2, pl. A; 1974, p. 87, loc. P22).

24 (Coal Creek).—Harden City, Okla., Quadrangle: 253 mm E, 208 mm N; NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T1N, R7E. Exposure on north bank of Coal Creek, 0.4 km east of Gobbler Knob, Pontotoc County, Oklahoma (Amsden, 1957, fig. 5; 1960, pp. 279-282, sec. P9, panel 1; 1961, fig. 25).

25 (Hunton).—Wapanucka North, Okla., Quadrangle: 14 mm E, 519 mm N; NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T1S, R8E. Exposure 0.5 km south of northeast corner of section, Coal County, Oklahoma. Base of type section of Hunton Group (Amsden, 1960, pp. 182, 184-188, sec. C1, panel 2, pl. B).

STRATIGRAPHY AND SOLITARY RUGOSE CORALS

South-central Oklahoma

Lithostratigraphy.—The history of stratigraphic nomenclature of uppermost Ordovician and lowermost Silurian units in the Arbuckle Mountains - Criner Hills region of Oklahoma is summarized in Text-fig. 2. The lithostratigraphic terminology of Amsden (1967, 1974) is followed herein (Text-fig. 3). The areal distribution of the Keel Formation was shown by Amsden (1960, fig. 12; 1974, fig. 19). This unit is also present in the subsurface within the Anadarko Basin to the west (Amsden, 1975, p. 19) and Arkoma Basin to the east (Amsden, 1980, p. 30). An equivalent dolomitic oölite zone occurs in the North Kansas Basin (Lee, 1956, pp. 48-50; Goebel, 1968, pp. 15, 16). The type section of the Keel Formation and Ideal Quarry Member is at Section 23 (Lawrence Quarry) (Maxwell, 1936, p. 50; Amsden, 1957, pp. 9, 11). The formation is commonly about 1.5 m thick, but can be as much as 4.5 m thick (Amsden, 1960, p. 44, fig. 12).

The Keel comprises three main lithologies. Most of the formation is light gray oölite, and is commonly silicified (Amsden, 1960, pl. 10, figs. 4-6, pl. 11, figs. 1-6). Some pisolitic beds are present at Section 23 (Lawrence Quarry). The second lithology is the yellowish brown bioclastic calcarenite of the Ideal Quarry Member (Amsden, 1960, pl. 10, figs. 1-3). Its stratigraphic position ranges from the base to near the middle of the Keel, and this member is present at most outcrops (Amsden, 1960, pp. 33, 35). The third Keel lithology is a yellow-brown, laminated calcilutite unit situated between oörites of the Keel at a few outcrops in the eastern Arbuckle region, including Section 24 (Coal Creek) (Amsden, 1960, p. 40).

Text-figure 2.—History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in south-central Oklahoma. E. = early, L. = late, LLAND. = Llandovery.

		TAFF, 1904		REEDS, 1911, 1926		MAXWELL, 1936		AMSDEN, 1957, 1960, 1967		AMSDEN, 1974		ELIAS, 1982, PRESENT STUDY	
MEDINA		CLINTON		ALEXANDRIAN		SILURIAN		E. LLAND.		ORDOVICIAN		RICHMONDIAN	
SYLVAN SH.		LOWER HUNTON LST.		HUNTON GP.		ALEXANDRIAN		L. LLAND.		ASHGILL		GAMACHIAN	
SYLVAN SH.		CHIMNEYHILL LST.		CHIMNEYHILL LST.		CHIMNEYHILL LST.		CHIMNEYHILL SUBGP.		L. LLAND.		L. LLAND.	
SYLVAN SH.		GLAUCONITIC MBR.		OOLITIC MBR.		COCHRANE LST.		COCHRANE FM.		L. LLAND.		L. LLAND.	
SYLVAN SH.		HAWKINS LST.		KEEL LST.		HAWKINS LST.		KEEL FM.		L. LLAND.		L. LLAND.	
SYLVAN SH.		IDEAL QUARRY MBR.		COCHRANE LST.		COCHRANE FM.		COCHRANE FM.		L. LLAND.		L. LLAND.	

Text-figure 3.—Stratigraphic sections (to scale) and locality maps in south-central (A) and northeastern (B) Oklahoma. For legend, see Text-fig. 10. I.Q. = Ideal Quarry. For precise locations of sections plus references, see "Northeastern Oklahoma" and "South-central Oklahoma" under STRATIGRAPHIC SECTIONS AND COLLECTIONS.

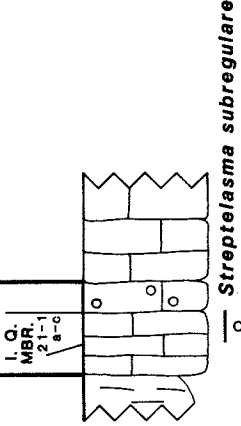
UPPER ORDOVICIAN | LOWER SILURIAN

RICHMONDIAN
SYLVAN SH.

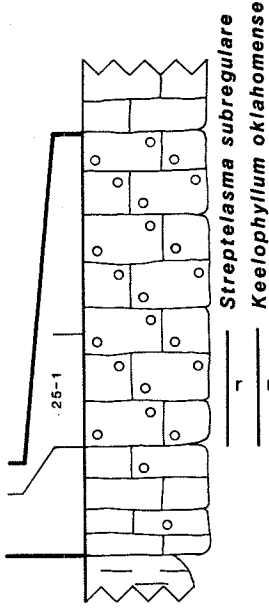
GAMACHIAN
KEEL FM.

UPPER LLANDOVERY
COCHRANE LST.

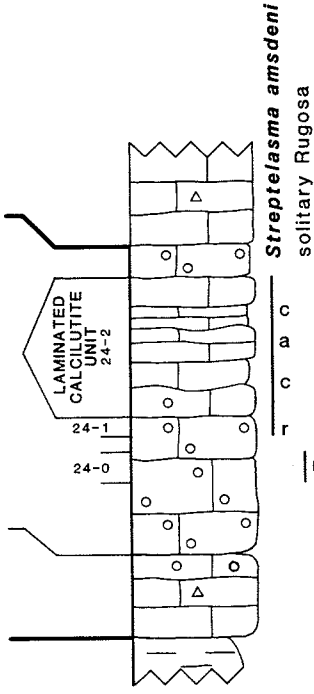
SECTION 21
(ROCK CROSSING)



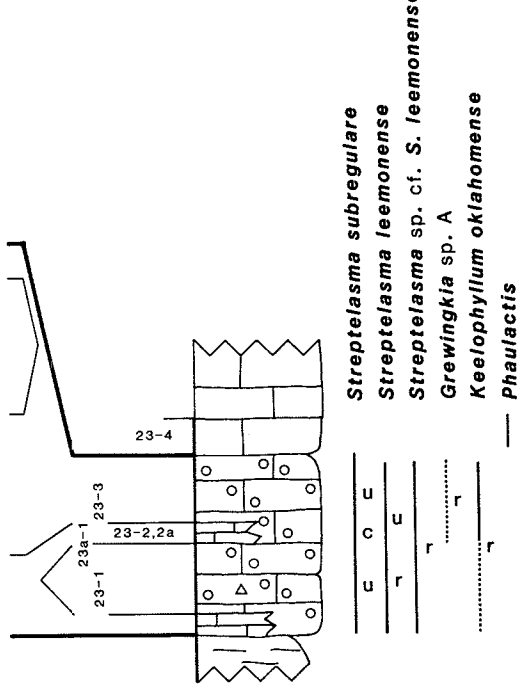
SECTION 25
(HUNTON)



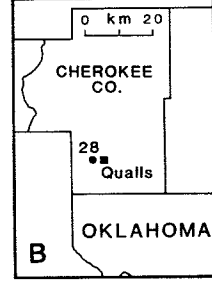
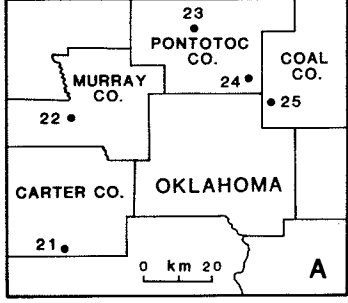
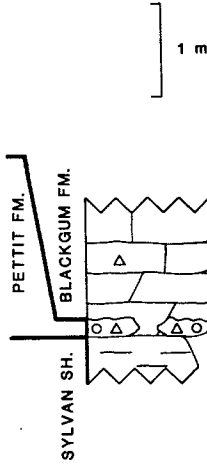
SECTION 24
(COAL CREEK)



SECTION 23
(LAWRENCE QUARRY)



SECTION 28
(QUALLS)



- *Streptelasma subregulare*
- *Streptelasma leemonense*
- *Streptelasma* sp. cf. *S. leemonense*
- *Grewingkia* sp. A
- *Keelophyllum oklahomense*
- *Phaulactis*

Streptelasma amsdeni
solitary Rugosa

Streptelasma subregulare
Keelophyllum oklahomense

The Keel overlies the green Sylvan Shale with apparent conformity (Amsden, 1980, p. 10), and is unconformably overlain by glauconitic bioclastic calcarenite to light-colored calcilutite of the Cochrane Formation or by younger Silurian strata.

Biota.—Reeds (1911, pp. 259, 261, 267; 1926, p. 470) reported crinoidal fragments, and listed nine species of brachiopods, three gastropods, two trilobites, one tabulate coral, and two solitary rugose corals identified as Streptelasma cf. bilateralis and Enterolasma waynense from the Keel Formation (his oölitic member of the Chimneyhill Limestone). Maxwell (1936, table 1) recorded two species of brachiopods, one gastropod, two bivalves, one bryozoan, two tabulate corals, and one solitary coral identified as Zaphrentis subregularis from the Ideal Quarry Member of the Keel Formation (his Hawkins Limestone). He also listed two brachiopods, two gastropods, four tabulate corals, and the solitary coral Streptelasma sp. from the oölitic portion of the Keel (Maxwell, 1936, table 2). Amsden (1957, p. 10, 11; 1960, p. 35) noted pelmatozoan plates and snails, and identified two species of brachiopods and one bivalve in the Ideal Quarry Member. He also mentioned pelmatozoan fragments, five species of brachiopods, one gastropod, two bivalves, and one tabulate coral from the Keel oölite (Amsden, 1957, pp. 12, 15; 1960, p. 44). Amsden (1971b, p. 22) later listed ten species of brachiopods from the Keel Formation. He subsequently reported algal-coated grains, crinoids, gastropods, bivalves, and tabulate plus rugose corals, and described the ten brachiopod species in the Keel, including its Ideal Quarry Member (Amsden, 1974, pp. 25, 26). One of these brachiopods has been

identified from a core through the Keel Formation in the Anadarko Basin of western Oklahoma (Amsden, 1975, p. 19). The same species is known from a core of this unit in the Arkoma Basin, eastern Oklahoma (Amsden, 1980, p. 30).

In addition to previously reported fossils, ostracodes, stromatoporoids, and colonial rugose corals were observed in the Keel during this study. Cornulitids are present in the laminated calcilutite unit. The solitary rugose corals Streptelasma subregulare (Savage, 1913b), S. amsdeni n. sp., S. leemonense Elias, 1982, S. sp. cf. S. leemonense, Grewingkia sp. A, and Keelophyllum oklahomense n. gen., n. sp. are described herein from the Keel Formation. Phaulactis sp. occurs at the base of the overlying Cochrane Formation (Pl. 8, fig. 19). Their stratigraphic and geographic distributions are shown in Text-fig. 3. Solitary corals were not observed in the Keel Formation at Section 22 (Cedar Village).

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 2. Amsden (1971b, p. 22; 1974, p. 26; 1980, pp. 10, 16) considered brachiopods of the Keel Formation to be Late Ordovician (late Ashgill; Hirnantian). The underlying Sylvan Shale contains late Late Ordovician graptolites of the Dicellograptus complanatus Zone (Decker, 1935, p. 698), and Late Ordovician chitinozoans (Jenkins, 1970, pp. 284, 285). Sweet (1983) reported Late Ordovician (late Edenian to early Maysvillian) conodonts beneath the Sylvan in the Welling Formation. The Cochrane Formation, which overlies the Keel, contains the brachiopod Triplesia alata, which Amsden (1971a, p. 145; 1980, p.

17) has considered to be Early Silurian (early late Llandovery). Conodonts considered to be late late Llandovery in age were identified in the uppermost Cochrane by Barrick and Klapper (1976, p. 66).

Depositional environments.—Amsden (1960, pp. 41, 42, 160) considered the Keel oölite to have formed in warm, shallow, agitated but not strongly turbulent water within the zone of effective light penetration. The gradational contact between the Ideal Quarry calcarenite and Keel oölite probably indicates shoaling (Amsden, 1960, p. 43). The lithology and bedding of the laminated calcilutite unit suggest that it may have been deposited in lower energy conditions than other facies of the Keel Formation.

Northeastern Oklahoma

Lithostratigraphy.—The history of stratigraphic nomenclature of uppermost Ordovician and lowermost Silurian units in the Marble City region of Oklahoma is summarized in Text-fig. 4. The lithostratigraphic terminology of Amsden (1980) is followed herein (Text-fig. 3). The Pettit Formation is locally present within a 1300 sq. km area in the vicinity of Lake Tenkiller (Amsden and Rowland, 1965, p. 22, fig. 8). The type section is located about 100 m south of Section 28 (Qualls) (Amsden and Rowland, 1965, p. 22, pl. 3, fig. 2). The Pettit is less than 0.6 m thick. It is an oölite that is commonly partially or completely silicified (Amsden and Rowland, 1965, pl. 6, figs. 1-6).

The Pettit Formation overlies the Sylvan Shale with apparent conformity (Amsden, 1980, p. 10), and is unconformably overlain by the tan dolomite member of the Blackgum Formation. At Section 28 (Qualls), the Sylvan is generally in contact with the Blackgum, and the Pettit oölite occurs as brecciated blocks at the base of the latter unit (Amsden and Rowland, 1965, p. 24).

Biota.—Fossil debris including pelmatozoan plates is present in the formation, but megafossils have not been found (Amsden and Rowland, 1965, pp. 26, 27). This unit was carefully examined for solitary corals at Section 28 (Qualls), but none were found (Text-fig. 3).

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 4. Amsden (1980, p. 24) tentatively considered the Pettit Formation to be Late Ordovician (Ashgill; Hirnantian) on the basis of its lithology, plus stratigraphic relations and position. From the underlying Sylvan

Text-figure 4.—History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in northeastern Oklahoma. L. = late.

HUFFMAN, 1953, 1958		AMSDEN AND ROWLAND, 1965		AMSDEN, 1980	
SILURIAN	ST. CLAIR FM.	LLANDOVERY BLACKGUM FM.	UPPER LIMESTONE MBR.	SILURIAN L.LLANDOVERY BLACKGUM FM.	UPPER LIMESTONE MBR.
			TAN DOLOMITE MBR.		TAN DOLOMITE MBR.
			PETTIT OOLITE MBR.		PETTIT FM.
ORDOVICIAN	SYLVAN SH.	SYLVAN SH.	ORDOVICIAN ASHGILL	SYLVAN SH.	

Shale, Huffman (1953, p. 450) and Decker and Huffman (1953) reported the late Late Ordovician graptolite Dicellograptus complanatus. The Blackgum Formation, which overlies the Pettit, contains the brachiopods Triplesia alata and Microcardinalia protriplesiana, indicating an Early Silurian (early late Llandovery) age (Amsden, 1971a, p. 145; 1980, p. 24).

Depositional environments.—The Pettit Formation was deposited in high energy conditions, as indicated by the numerous broken oöids (Amsden and Rowland, 1965, pp. 22-24).

Southern Illinois and Southeastern Missouri

Lithostratigraphy.—The history of stratigraphic nomenclature of uppermost Ordovician and lowermost Silurian units in Alexander County, Illinois, and Cape Girardeau County, Missouri, is summarized in Text-fig. 5. The lithostratigraphic terminology of Thompson and Satterfield (1975) is followed herein (Text-fig. 6).

The type section of the Leemon Formation is at Section 20 (Short Farm) (Thompson and Satterfield, 1975, p. 77). The formation has a maximum exposed thickness of 3.8 m (Thebes North Section), but is locally absent. Willman and Atherton (1975, p. 99) reported that this unit (their Edgewood) thickens eastward in the subsurface to as much as 18.3 m. Lithologies within the Leemon include oölite, oölitic bioclastic calcarenite, and calcareous shale. Small biohermal mounds up to 0.5 m high occur at the base at Section 19 (New Wells). They were described by Amsden (1974, pp. 21, 22). Quartz sand grains are most common in the Illinois sections (Amsden, 1974, p. 24), and clasts of the Girardeau Limestone are generally present near the base. The Leemon Formation unconformably overlies the Orchard Creek Shale or, where present, the Girardeau. The latter unit consists of irregularly bedded limestone with shale partings. The Leemon is unconformably overlain by the Sexton Creek Limestone, which contains bands of chert nodules.

Biota.—Worthen (1866, p. 127) reported one trilobite species, two brachiopods, and a tabulate coral from the Leemon Formation in Alexander County, Illinois (basal part of his Clear Creek Limestone). He later identified a solitary rugose coral as Zaphrentis (Worthen,

Text-figure 5.—History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in southern Illinois and southeastern Missouri. E. = Early, L. = late, Lland. = Llandovery, GAMACH. = Gamachian.

SWALLOW, 1855; SHUMARD, 1855, 1873		WORTHEN, 1866, 1866, 1871		SAVAGE, 1908a, 1908b		SAVAGE, 1909, 1910		SAVAGE, 1913a, 1913b, 1917		SAVAGE, 1926; WELER AND EKBLAW, 1940 *		PRYOR AND ROSS, 1962		SATTEFIELD, 1971		THOMPSON AND SATTEFIELD, 1976		ANSDEN, 1974		ELIAS, 1982; PRESENT STUDY	
SILURIAN	(NIAGARA GP.)	CLEAR CREEK LST.	LOWER HELDERBERG LST.	CLINTON FM.	SEXTON CREEK FM.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	SEXTON CREEK LST.	L. LLAND.	L. LLAND.	SEXTON CREEK LST.	SEXTON CREEK LST.
	CAPE GIRARDEAU LST.																				
	HUDSON RIVER GP.	CININNATI GP.	CAPE GIRARDEAU LST.	CAPE GIRARDEAU LST. (MBR. 3a)	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	GIRARDEAU LST.	ASHGILL	RICHMONDIAN	GIRARDEAU LST.	GIRARDEAU LST.
	THEBES SH.			SHALE (MBR. 2b)	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.	ORCHARD CREEK SH.			ORCHARD CREEK SH.	ORCHARD CREEK SH.	

* Should be zig-zag line for Savage, 1926.

Text-figure 6.—Stratigraphic sections (to scale) and locality map in southern Illinois and southeastern Missouri. For legend, see Text-figure 10. M.-U. = middle to upper. For precise locations of sections plus references, see "Southeastern Missouri" under STRATIGRAPHIC SECTIONS AND COLLECTIONS.

Thebes North Section.—Thebes, Ill.-Mo., Quadrangle (1:24,000): SE $\frac{1}{4}$ sec. 5, T15S, R3W. Exposure on east bank of Mississippi River, 1.5 km southwest of Gale and 1.8 km north of Thebes, Alexander County, Illinois (Savage, 1910, pp. 331, 332, pl. 36, fig. a; 1913b, pp. 20, 21; 1917, pp. 77-79) (see also Weller and Ekblaw, 1940, pp. 8-10; Pryor and Ross, 1962, pp. 7-10, fig. 3; Satterfield, 1971, p. 266, fig. 1; Amsden, 1974, pp. 23, 24, 86, loc. M; Thompson and Satterfield, 1975, pp. 77, 78, sec. 1, fig. 8; Kolata and Guensburg, 1979, p. 1121, loc. 1, fig. 1).

Gale Section.—Thebes, Ill.-Mo., Quadrangle (1:24,000): NE $\frac{1}{4}$ sec. 4, T15S, R3W. Abandoned quarry 0.4 km southeast of Gale, Alexander County, Illinois (Savage, 1910, pp. 332, 333, pl. 37, fig. a; 1913b, pp. 21, 22; 1917, p. 79) (for cut along State Route 3 in same vicinity, see Weller and Ekblaw, 1940, pp. 8-10; Pryor and Ross, 1962, pp. 7-10, fig. 3; Cote, Reinertsen, and Killey, 1968, pp. 7-10, stop 1, figs. 6, 7; Amsden, 1974, pp. 23, 24, 86, loc. L).

UPPER ORDOVICIAN

RICHMONDIAN

GAMACHIAN

LOWER SILURIAN

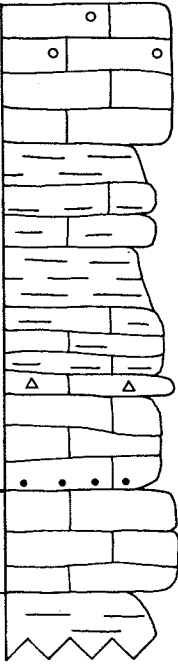
M. - U. LLANDOVERY

ORCHARD
CREEK
SH.

GIRAR-
DEAU
LST.

LEEMON FM.

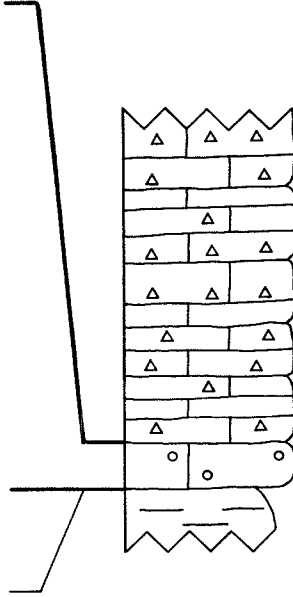
SEXTON CREEK FM.



THEBES NORTH

Streptelasma subregulare

Salvadorea randi

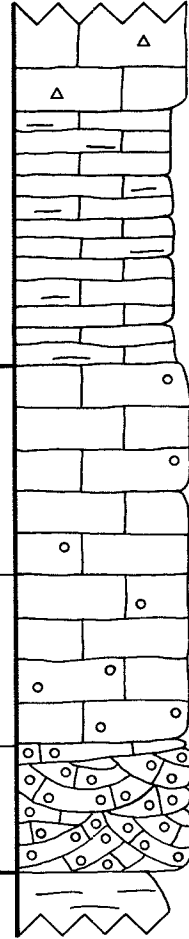


GALE

Streptelasma leemonense

20-2, 3, 4, 5

20-1



SECTION 20
(SHORT FARM)

Streptelasma subregulare

Streptelasma leemonense

Streptelasma sp.

Bodophyllum shorti

Dalmanophyllum



19-1,
2, 3

SECTION 19
(NEW WELLS)

Streptelasma subregulare

1 m

1868a, p. 25; basal part of his Lower Helderberg Limestone). Meek and Worthen (1868, pl. 6, figs. 1-6) described and illustrated the same trilobite and one of the brachiopods listed previously, plus two additional brachiopods, a gastropod, and a bivalve (their Niagara Group). In the synthesis of his work, Savage (1913b, pp. 24, 25; 1917, pp. 82, 83) described twenty brachiopods, six gastropods, one bivalve, four trilobites, one stromatoporoid, four tabulate corals, plus the solitary corals Zaphrentis cf. ambigua, Z. subregularis, and Z. cf. stokesi from the Leemon Formation (his Cyrene Member of the Edgewood Formation).

Amsden (1971b, p. 21) listed and illustrated brachiopods from the Leemon Formation (included in his basal Edgewood zone). He reported the presence of pelmatozoan plates, gastropods, bryozoans, and colonial plus solitary corals within the Leemon Formation in Cape Girardeau County, Missouri (Amsden, 1974, pp. 19, 21, 22, 85). From those localities and others in Alexander County, Illinois, 17 brachiopod species were also described (Amsden, 1974, fig. 20). Thompson and Satterfield (1975, figs. 7-9) identified a total of 12 conodont taxa within the Leemon in this region.

Elias (1982, fig. 21) reported the solitary corals Streptelasma leemonense Elias, 1982, Streptelasma sp., and Bodophyllum shorti Elias, 1982 from the Leemon Formation at Section 20 (Short Farm), and S. subregulare (Savage, 1913b) at Section 19 (New Wells). During the present study, the latter species was also found at Section 20 (Short Farm), and was identified in Savage's collection from the Thebes North Section. S. leemonense is represented in Savage's

collection from the Gale Section. Dalmanophyllum sp. occurs at the base of the Sexton Creek Formation, which overlies the Leemon (Pl. 8, fig. 12). Salvadorea randi (Elias, 1981) was described from the Orchard Creek Shale at the Thebes North Section by Elias (1982, pp. 61, 62, pl. 6, fig. 9; Elias, 1985, p. 45). The stratigraphic and geographic distributions of these corals are shown in Text-fig. 6.

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 5. Amsden (1971b, p. 21; 1974, pp. 19, 22, 24) considered the Leemon Formation to be Late Ordovician (Ashgill) in age on the basis of brachiopods. Thompson and Satterfield (1975, p. 79) also considered the unit to be Late Ordovician, based on the abundance of the conodont Amorphognathus ordovicicus. Satterfield (1971) and Thompson and Satterfield (1974, pp. 73, 74, fig. 6) assigned the underlying Girardeau Limestone to the very late Ordovician on the basis of stratigraphic relations and conodonts representing their Prioniodus ferrarius fauna. Crinoids in the Girardeau suggested a Richmondian or younger Ordovician (Gamachian) age to Brower (1973, p. 265). Kolata and Guensburg (1979, p. 1122) considered crinoids in the underlying Orchard Creek Shale to be Richmondian.

From the Sexton Creek Limestone, which overlies the Leemon, Amsden (1974, p. 24) identified the Early Silurian (early late Llandovery) brachiopod Microcardinalia sp. cf. M. protriplesiana at a section in Alexander County, Illinois. Within the lower Sexton Creek in Cape Girardeau County, Missouri, Thompson and Satterfield (1975, figs. 6, 7, 9) reported conodonts of their Early Silurian Paltodus dyscritus fauna, which corresponds to the Icriodina irregularis

Assemblage Zone of Nicoll and Rexroad (1968).

Depositional environments.—Savage (1910, p. 331; 1913b, pp. 20, 21; 1917, pp. 77, 79) interpreted the Leemon Formation of Illinois as having been deposited in a channel that was cut into the Girardeau Limestone during an earlier period of exposure. Amsden (1974, p. 24) noted that the presence of quartz sand and silt in the Leemon of Illinois and Missouri indicates deposition near a source area. He observed that brachiopods show little fragmentation and are commonly articulated, and inferred moderate energy environments. The development of small bioherms at Section 19 (New Wells) suggests open, normal marine conditions.

Northeastern Missouri and West-central Illinois

Lithostratigraphy.—The history of stratigraphic nomenclature and age assignments of uppermost Ordovician and lowermost Silurian strata in Pike County, Missouri, is summarized in Text-fig. 7. The lithostratigraphic terminology of Thompson and Satterfield (1975) is followed herein (Text-fig. 8). The Maquoketa Shale, Noix Limestone, Bowling Green Dolomite, and Sexton Creek Limestone also occur across the Mississippi River in Calhoun and other counties, Illinois. There, however, the Bryant Knob Formation is apparently absent (Savage, 1914, p. 29; Trapp, 1950, p. 32; Rubey, 1952, pp. 25, 27; Amsden, 1974, p. 18).

The Noix Limestone of the Edgewood Group occurs in a northwest-trending outcrop belt that is about 75 km long and at least 11 km wide (Thompson and Satterfield, 1975, p. 89), and extends a short distance to the east in the subsurface of west-central Illinois (Trapp, 1950, p. 32). The type section of the Noix is Section 16 (Clinton Spring). This unit is up to about 2 m thick, and is thickest along the west bank of the Mississippi River. It is typically a light gray oölite (Amsden, 1974, pl. 28, figs. 5, 6), and is cross-bedded in places. At a few localities, it is in part argillaceous, phosphatic, and conglomeratic (Thompson and Satterfield, 1975, fig. 10). The Noix unconformably overlies the Maquoketa Shale, and is overlain by the Bryant Knob Formation or Bowling Green Dolomite. It is a lateral equivalent of part of the Cyrene Formation, which is located to the west (Thompson and Satterfield, 1975, pp. 85, 103).

Geographically, the distribution of the Bryant Knob Formation approximately coincides with that of the Noix (Thompson and

Text-figure 7.—History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in northeastern Missouri and west-central Illinois. E. = Early, L. = Late, B. K. = Bryant Knob, LL. = Llandovery, GAM. = Gamachian, M.-L. = middle to late.

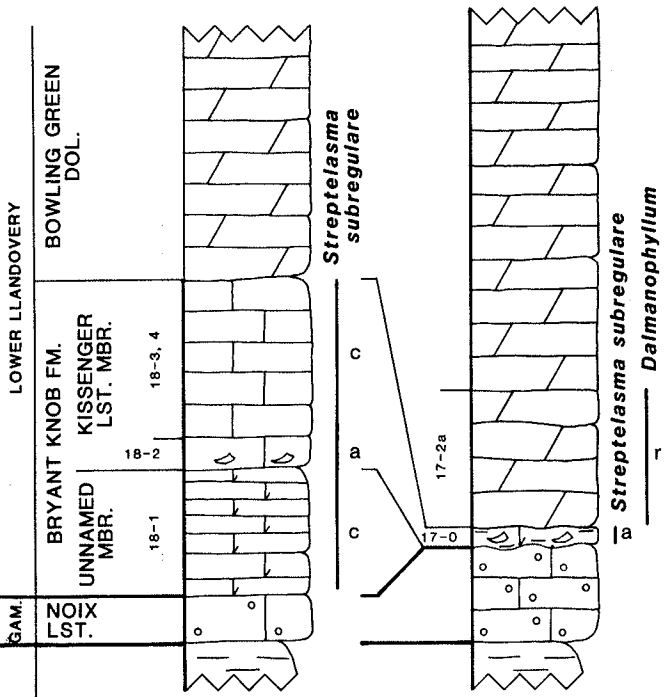
Text-figure 8.—Stratigraphic sections (to scale) and locality map in northeastern Missouri. For legend, see Text-figure 10. GAM. = Gamachian, B. K. = Bryant Knob, KIS. = Kissenger. For precise locations of sections plus references, see "Northeastern Missouri" under STRATIGRAPHIC SECTIONS AND COLLECTIONS.

LOWER SILURIAN

UPPER ORDOVICIAN

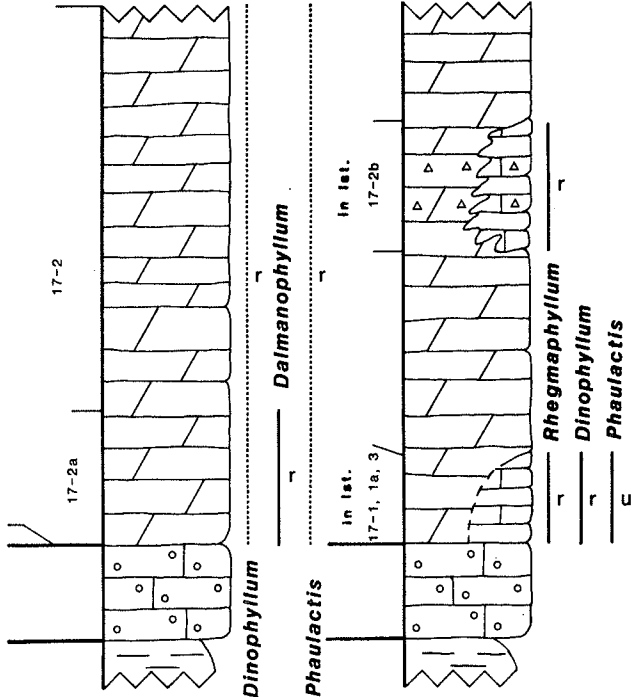
LOWER SILURIAN

UPPER ORDOVICIAN



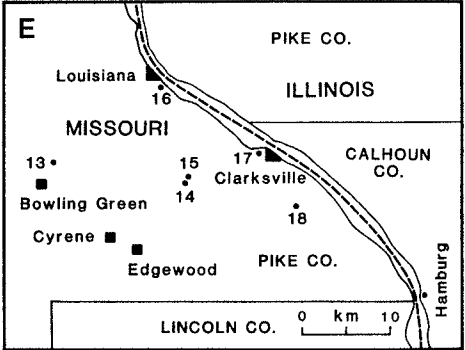
SECTION 18 (KISSENGER)

SECTION 17 (CLARKSVILLE SOUTH)



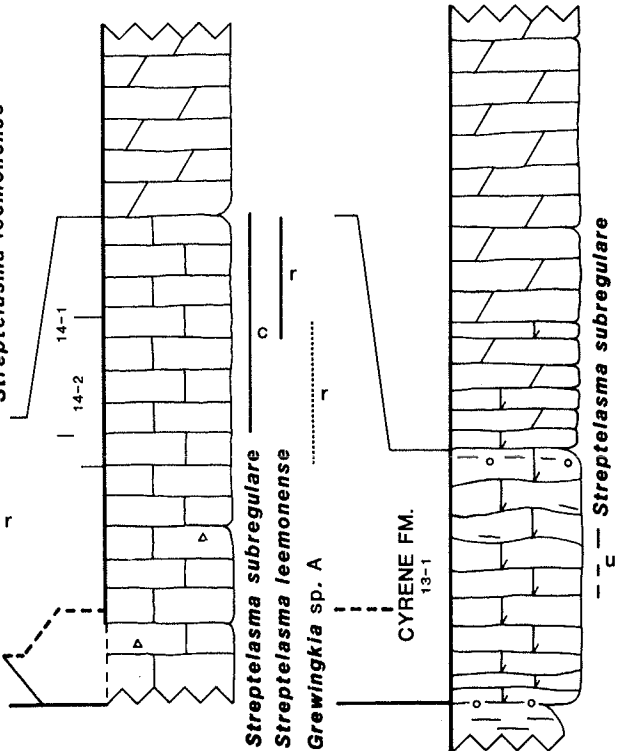
SECTION 17 (CLARKSVILLE CENTRAL)

SECTION 17 (CLARKSVILLE CENTRAL TO NORTH)



SECTION 16 (CLINTON SPRING)

SECTION 15 (CALUMET)



SECTION 14 (HIGGINBOTHAM FARM)

SECTION 13 (BOWLING GREEN)

1 m

Streptelasma sp. A

Streptelasma subregulare
Streptelasma leemonense

Streptelasma subregulare
Streptelasma leemonense
Grewingia sp. A

Streptelasma subregulare

GAM.
LOWER LLANDOVERY
BOWLING GREEN DOL.
BRYANT KNOB FM.
KISSENGER LST. MBR.
UNNAMED MBR.
NOIX LST.

RICHMONDIAN
MAQUOKETA SH.

GAMACHIAN
NOIX LST.
B. K. FM.
KIS. LST. MBR.
BOWLING GREEN DOL.

RICHMONDIAN
MAQUOKETA SH.

F

LOUISIANA
MISSOURI
CALHOUN CO.
PIKE CO.
LINCOLN CO.
HAMBURG

18-1
18-2
18-3, 4

17-0
17-2a

17-2a
17-2

in 1st.
17-1, 18, 3
17-2b

r
r
u

Streptelasma sp. A

Streptelasma subregulare
Streptelasma leemonense

Streptelasma subregulare
Streptelasma leemonense
Grewingia sp. A

Streptelasma subregulare

GAM.
LOWER LLANDOVERY
BOWLING GREEN DOL.
BRYANT KNOB FM.
KISSENGER LST. MBR.
UNNAMED MBR.
NOIX LST.

RICHMONDIAN
MAQUOKETA SH.

GAMACHIAN
NOIX LST.
B. K. FM.
KIS. LST. MBR.
BOWLING GREEN DOL.

RICHMONDIAN
MAQUOKETA SH.

F

LOUISIANA
MISSOURI
CALHOUN CO.
PIKE CO.
LINCOLN CO.
HAMBURG

18-1
18-2
18-3, 4

17-0
17-2a

17-2a
17-2

in 1st.
17-1, 18, 3
17-2b

r
r
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Streptelasma sp. A

Streptelasma subregulare
Streptelasma leemonense

Streptelasma subregulare
Streptelasma leemonense
Grewingia sp. A

Streptelasma subregulare

Satterfield, 1975, p. 85). The type section of this formation and its Kissenger Limestone Member is Section 18 (Kissenger) (Thompson and Satterfield, 1975, p. 98). An unnamed member that occurs at the base of the Bryant Knob at the latter section, and locally elsewhere, overlies the Noix with apparent conformity (Thompson and Satterfield, 1975, p. 103). This member consists of up to 2 m of dolomitic limestone and/or shale. The Kissenger Limestone Member is the upper portion of the Bryant Knob Formation where the unnamed member is present, and the only portion of the formation that occurs elsewhere. This unit is up to perhaps 5 m thick. It is a light gray, medium- to coarse-grained, massively bedded bioclastic calcarenite (Amsden, 1974, pl. 28, figs. 3, 4) that overlies the unnamed member with apparent conformity, or unconformably overlies the Noix. The Bryant Knob Formation is overlain unconformably by the Bowling Green Dolomite.

The Cyrene Formation occurs immediately west of the Noix-Bryant Knob. The type section, about 4 km northeast of Edgewood, Missouri, was located by Thompson and Satterfield (1975, pp. 82, 96). They described Section 13 (Bowling Green) as an excellent reference section. This unit is about 2 m thick. It is a brown to bluish gray, fine- to medium-grained, dolomitic limestone (Amsden, 1974, pl. 27, figs. 1a, b, 2a, b). The Cyrene overlies the Maquoketa Shale, and is overlain by the Bowling Green Dolomite. The latter contact is inconspicuous in the vicinity of Section 13 (Savage, 1913b, p. 23; 1914, p. 29; 1917, p. 80; Rowley, 1916, p. 317; Amsden, 1974, p. 11).

The Bowling Green Dolomite is the upper unit of the Edgewood Group. The type section is located about 1 km east-northeast of

Section 13 (Bowling Green), which Thompson and Satterfield (1975, p. 99) designated as a principal reference section. This unit has an average thickness of 6 to 9 m in Pike County (Krey, 1924, p. 27). It consists of buff, earthy, massive dolomite (Amsden, 1974, pl. 27, figs. 3a, b, pl. 28, figs. 1, 2), locally with beds of chert nodules in the upper two thirds. In the eastern part of this area, the Bowling Green unconformably overlies the Noix Limestone or Bryant Knob Formation. To the west, it overlies the Cyrene Formation. The Bowling Green Dolomite is overlain unconformably by the Sexton Creek Limestone or younger strata.

Biota.—Swallow (1855, p. 107) reported the solitary rugose coral Zaphrentis cornicula and a tabulate coral from his Onondaga oölitic beds (Noix and Bryant Knob) at Louisiana, Missouri. Other fossils listed from his Onondaga Limestone (Swallow, 1855, p. 219) are not from the Edgewood Group of present usage.

From the Noix Limestone plus Bryant Knob Formation (his oölitic limestone), Rowley (1908, p. 23) recognized one species of stromatoporoid, seven brachiopods, one tentaculitid, two gastropods, one cephalopod, two bivalves, one trilobite, two tabulate corals, and solitary corals identified as Zaphrentis sp. and Cyathophyllum sp. From the Bowling Green Dolomite (his brown, earthy limestone), he listed two species of stromatoporoids, three crinoids, eleven brachiopods, one conularid, ten gastropods, one cephalopod, one bivalve, two cornulitids, four trilobites, six tabulate corals, and the solitary corals Cyathophyllum sp. and Cystiphyllum sp. Rowley found 12 out of his 50 species in both stratigraphic units.

From the Noix Limestone plus Bryant Knob Formation (his Noix oölite) in the vicinity of Section 16 (Clinton Spring), Savage (1913b, pp. 24, 25; 1917, pp. 82, 83) identified one species of stromatoporoid, 24 brachiopods, eight gastropods, three bivalves, three or four trilobites, four tabulate corals, plus the solitary corals Zaphrentis cf. ambigua, Z. subregularis, and Z. cf. stokesi. From the Edgewood Group near Edgewood, he recorded one stromatoporoid, twenty brachiopods, nine gastropods, three bivalves, one cephalopod, five trilobites, three tabulate corals, plus the same solitary corals listed above. A total of 32 or 33 of the 59 species described by Savage were recognized in both collections.

Rubey (1952, p. 170) tabulated five species of brachiopods and Zaphrentis sp. from the Noix Limestone in Calhoun County, Illinois. One cornulitid, 16 brachiopods, unidentified bryozoans, one bivalve, two gastropods, one tentaculitid, four trilobites, one tabulate coral, plus Zaphrentis sp. and Z. sp. "small" were listed from the Bowling Green Dolomite.

Birkhead (1967, table 3) described two species of stromatoporoids associated with solitary corals in the basal bed of the Kissenger Limestone Member, Bryant Knob Formation (his Cyrene Member), at Section 16 (Clinton Spring).

Amsden (1971b, pp. 21, 22) listed the brachiopod fauna of the Edgewood Group in Pike County, Missouri, and Calhoun County, Illinois. Amsden (1974, figs. 10, 11, 20) described a total of 23 brachiopod species from these strata. Of these, 17 are known from the Noix Limestone, 14 from the Bryant Knob Formation (including Cyrene

Formation at Section 13), and five from the basal Bowling Green Dolomite at a locality 1.5 km north-northwest of Section 13 (strata equivalent to the Cyrene Formation). Amsden (1974, p. 12, fig. 9) demonstrated that, except for pelmatozoan plates, brachiopods overwhelmingly dominate the fauna in the above units. Bryozoans, trilobites, gastropods, bivalves, tabulate corals, and tentaculitids are minor constituents.

Thompson and Satterfield (1975, figs. 10-15) listed 49 conodont species within the Edgewood Group in Pike County, Missouri. Of these, they found 16 in the Noix Limestone, three in an unnamed unit beneath the Bryant Knob Formation but above the Noix at Section 15 (Calumet), eight in the unnamed member and 12 in the Kissenger Limestone Member of the Bryant Knob, 18 in the Cyrene Formation, 11 in their unnamed unit at the base of the Bowling Green Dolomite, and 26 in the Bowling Green. Thompson and Satterfield (1975, pp. 87, 96, 97, fig. 14) concluded that some conodonts in the Noix, Bryant Knob, and Bowling Green are reworked. At Section 17 (Clarksville), McCracken and Barnes (1982, table 1) identified 16 conodont species, of which eight occur in the Noix and nine in the Bowling Green. They described some of these taxa. Thompson and Satterfield (1975, pp. 97, 98) reported two graptolite taxa from the unnamed member of the Bryant Knob.

Elias (1982) described the holotype of Streptelasma subregulare (Savage, 1913b) from the Cyrene Formation near Edgewood, Missouri. In this study, S. subregulare was found in the Cyrene, plus the unnamed member and Kissenger Limestone Member of the Bryant Knob Formation. Streptelasma sp. A occurs in the Noix Limestone, and S. leemonense

Elias, 1982 and Grewingkia sp. A are present in the Kissenger Limestone. Representatives of Dinophyllum (Pl. 8, fig. 6), Dalmanophyllum (Pl. 8, figs. 13, 14), and Phaulactis (Pl. 8, figs. 20-22) are identified from the Bowling Green Dolomite, and Rhegmaphyllum (Pl. 8 figs. 1-5), Dinophyllum (Pl. 8, figs. 7-10), and Dalmanophyllum (Pl. 8, figs. 15, 16) are recognized in limestone patches within the Bowling Green. The stratigraphic and geographic distributions of these solitary corals are shown in Text-fig. 8.

Intraregional correlations.—Early workers reported that the upper part of their "oölite" (= Bryant Knob Formation of current terminology) at eastern exposures in Pike County, Missouri, contains abundant solitary and colonial corals, as does the upper portion of the Cyrene at western sections in the vicinity of Edgewood (Rowley, 1908, p. 20; 1916, pp. 319, 320; Savage, 1913b, p. 22; 1917, p. 80). Savage (1913b, p. 25; 1917, p. 83) considered the "oölite" to correspond to the upper half or two thirds of the Cyrene, and Rowley (1916, p. 319) noted that the coral horizon in the Cyrene is equivalent to his Watson Limestone. However, Thompson and Satterfield (1975, pp. 83, 85, 87, 96, 99, 103) interpreted the Noix Limestone of current usage (which underlies the Bryant Knob) as a facies of the upper part of the Cyrene Formation. The conodont faunas that they identified from the Cyrene at Section 13 (Bowling Green) also occur in the Bryant Knob (Thompson and Satterfield, 1975, figs. 10, 11). On the basis of brachiopods and lithologic similarity, Amsden (1974, pp. 9, 11, 14, 15) considered the upper half of Thompson and Satterfield's Cyrene at Section 13, plus Rowley's Watson Limestone, to be Bryant Knob. The interpretation that the Cyrene Formation is a facies equivalent of the Noix Limestone plus

Bryant Knob Formation is followed herein (Text-fig. 7). Streptelasma subregulare occurs in the Cyrene and Bryant Knob.

Strata overlying the Maquoketa Shale in a quarry located 1.5 km north-northwest of Section 13 (Bowling Green) were assigned to the Bowling Green Dolomite by Amsden (1974, p. 8). He identified five brachiopod species from the lower 3 m of that unit, which was tentatively correlated with the Noix Limestone (Amsden, 1974, pp. 15, 18). Three of the brachiopods occur in both the Noix and Bryant Knob Formation, one is known from the Bryant Knob, and one is unique. It is suggested herein that these beds, now covered by water, correspond to the Cyrene Formation.

Amsden (1974, pp. 16-18, figs. 12, 13) considered two hypotheses for the relationship between the Bryant Knob Formation and overlying Bowling Green Dolomite. On the basis of lithostratigraphic data, he favored the interpretation that these units are laterally and vertically intergrading facies, rather than discrete units having separate depositional histories. Amsden inferred that basal strata of the Bowling Green at Section 17 (Clarksville) are equivalent to the unnamed dolomitic member comprising the lower portion of the Bryant Knob at Section 18 (Kissenger) (see Text-fig. 8). At the latter locality, a thin bed containing abundant solitary corals is present at the base of the Kissenger Limestone Member, which comprises the upper portion of the Bryant Knob. This bed is also situated at the base of the Kissenger at Section 16 (Clinton Spring), where the unnamed member is absent (Elias, 1982, p. 40, fig. 21; Birkhead, 1967, fig. 7), and has been reported in the same stratigraphic position at a

locality about 2 km southeast (Rowley, 1908, p. 20). During the present study, this solitary coral bed was also found at the extreme southern end of Section 17, where it is bounded by shale interbeds, overlies the Noix Limestone along an irregular contact, is overlain by the Bowling Green along an undulatory surface, and pinches out northward along the exposure. The coral bed, containing abraded and algal- and/or stromatoporoid-coated solitary rugosans, is interpreted as a lag deposit and is considered to be a synchronous marker. Streptelasma subregulare, the only solitary rugosan species in the coral bed, occurs in the unnamed member plus other strata included in the Kissenger Limestone Member of the Bryant Knob Formation. The solitary coral assemblage in the basal Bowling Green Dolomite at Section 17, both above and lateral to the coral bed, is entirely different. It is inferred that the unnamed member of the Bryant Knob is older than the Kissenger Limestone Member, which in turn is older than the Bowling Green Dolomite.

The above interpretation, based on the distribution of solitary Rugosa, is consistent with the nature of contacts between the various units in this sequence. Where the unnamed member of the Bryant Knob Formation is present (e.g., Section 18), it overlies the Noix Limestone with apparent conformity (Thompson and Satterfield, 1975, p. 103). Where the solitary coral marker bed at the base of the Kissenger Limestone Member of the Bryant Knob overlies the Noix, the contact is unconformable (e.g., Sections 17, 16; see previous paragraph and Elias, 1982, p. 40). The contact between the Bryant Knob and Bowling Green is unconformable at some sections (e.g., Sections 17, 18; see previous paragraph and Thompson and Satterfield, 1975, pp. 98, 103). It is

concluded that the unnamed member and Kissenger Limestone Member of the Bryant Knob Formation, and the Bowling Green Dolomite, are discrete units, as recognized by Thompson and Satterfield, (1975, p. 103).

Thompson and Satterfield (1975, pp. 89, 100, figs. 13, 14) reported an unnamed unit composed of soft, white limestone locally present at the base of the Bowling Green Dolomite. It was described as thin "lenses" on the Bryant Knob Formation at Section 18 (Kissenger), and as two low "mounds" on the Noix Limestone at Section 17 (Clarksville). Thompson and Satterfield noted that the "mound" at the north end of the latter section is associated with an irregularity along the upper surface of the Noix, and is enclosed by a thin shale seam. During the present study, this unit was not exposed at Section 18, but two "mounds" were observed on weathered faces of the exposure at Section 17. One was at the north end, and the other was located toward the south. It is uncertain whether these are the same "mounds" reported by Thompson and Satterfield. In 1983, slumping along parts of Section 17 exposed fresh surfaces. Two irregular patches composed of soft, white limestone that is indistinguishable from the "mounds" were observed within the Bowling Green Dolomite about 3 m above the Noix. One was situated above, and separated from, the southern "mound." The other was found farther north, along part of an inclined joint or fracture. It contained chert nodules at the same stratigraphic positions as the surrounding dolomite. These observations suggest that areas of limestone at the base of, and within, the Bowling Green represent undolomitized remnants of this unit, rather than a discrete stratigraphic interval. Dalmanophyllum and Dinophyllum have been found in both lithologies. Although Rhegmaphyllum is recognized

only in the limestone and Phaulactis is known only from the dolomite, these apparent differences may be related to the overall rarity of solitary corals in the Bowling Green, and the relatively poor preservation of fossils in the dolomite.

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 7. Brachiopods of the Noix Limestone were considered to be Late Ordovician by Amsden (1971b, p. 22; 1974, pp. 13, 14). Amorphognathus ordovicicus and other conodonts in the Noix indicate a Late Ordovician age (Thompson and Satterfield, 1975, p. 87). McCracken and Barnes (1982, p. 1477) noted that the Noix conodont fauna has characteristics of a slightly modified Fauna 12 (late Richmondian) rather than Fauna 13 (Gamachian). Thompson and Satterfield (1975, p. 93) reported the Late Ordovician Prioniodus ferrarius conodont fauna from coquina (their bioherm) situated beneath the Bryant Knob Formation at Section 14 (Higginbotham Farm).

Amsden (1971b, pp. 21, 22; 1974, p. 14) tentatively assigned the Bryant Knob Formation to the Early Silurian (early Llandovery), primarily on the basis of stratigraphic position and the absence of certain characteristic Noix brachiopods. Conodonts in the unnamed member at the base of the Bryant Knob Formation include representatives of A. ordovicicus, Icriodella? sp., and the Paltodus dyscritus fauna (Thompson and Satterfield, 1975, p. 97, figs. 10, 14). The conodonts, plus graptolites (Berry in Thompson and Satterfield, 1975, pp. 97, 98) were considered to indicate an Early Silurian age (Thompson and Satterfield, 1975, p. 101). The overlying Kissenger Limestone Member of the Bryant Knob contains A. ordovicicus plus the Prioniodus

ferrarius and Paltodus dyscritus faunas, and was also referred to the Early Silurian (Thompson and Satterfield, 1975, p. 101, figs. 10, 12, 14, 15). Nowlan (in Bolton and Nowlan, 1979, pp. 5, 21) suggested that this mixed fauna including A. ordovicicus plus Paltodus dyscritus might be Late Ordovician, based on an occurrence elsewhere in undoubtedly Ordovician strata.

Brachiopods in the Cyrene Formation as recognized herein were tentatively assigned Late Ordovician and early Llandovery ages by Amsden (1974, pp. 14, 15). Thompson and Satterfield (1975, p. 96, fig. 11) reported A. ordovicicus plus the Prioniodus ferrarius and Paltodus dyscritus faunas in the Cyrene. They considered this unit to be Late Ordovician, but it is herein equated with the Noix plus Bryant Knob, as discussed previously.

Thompson and Satterfield (1975, pp. 96, 97, 101, 102) identified the Paltodus dyscritus fauna in the Bowling Green Dolomite (including their unnamed unit), and concluded that this formation is Early Silurian. They considered conodonts in eastern exposures to be younger than those in western sections on the basis of three specimens identified as Neospathognathodus celloni. McCracken and Barnes (1982, p. 1475) suggested that the latter conodonts represent Oulodus? cf. O.? nathani, of which they found one specimen in the Bowling Green. On the basis of the latter individual, they inferred that this unit may be earliest Llandovery in age (McCracken and Barnes, 1982, p. 1477).

The Bryant Knob Formation, Bowling Green Dolomite, and Sexton Creek Formation were assigned to the Icriodina irregularis Assemblage Zone of Nicoll and Rexroad (1968) based on the presence of the P. dyscritus fauna (Thompson and Satterfield, 1975, p. 70).

Savage (1913b, p. 30; 1917, p. 88), Willman (1973, p. 16), and Willman and Atherton (1975, p. 97) reported the brachiopod Platymerella manniensis at the base of the Sexton Creek Limestone (Kankakee) in northeastern Missouri and adjacent Illinois. This zone was placed in the middle Llandovery by Berry and Boucot (1970, pl. 2). Specimens of Microcardinalia sp., also from the Sexton Creek, were considered to be late Llandovery by Amsden (1974, pp. 18, 24).

Depositional environments.—Savage (1914, p. 30) concluded from the lithostratigraphic record that the sea in which the lower Edgewood Group was deposited was deepest in the west, where the Cyrene Formation accumulated, and became progressively shallower toward the east, where the Noix Limestone was formed. The shoreline gradually receded westward during Bryant Knob time. Deposition of the Bowling Green Dolomite was initiated by a slight uplift (but not emergence) to the west and subsidence to the east, resulting in an eastward onlap.

Thompson and Satterfield (1975, pp. 93, 103, fig. 16) interpreted a coarse, bioclastic limestone situated beneath the Bryant Knob Formation at Section 14 (Higginbotham Farm) as a bioherm. This unit is herein considered to be a coquina within the Bryant Knob Formation. They suggested that it was a source of nuclei for ooids that formed to the east, and acted as a barrier that separated Noix and Cyrene deposition. McCracken and Barnes (1982, p. 1477) considered conodont assemblages to indicate that the Noix Limestone formed in relatively shallow water, and the Bowling Green Dolomite was deposited during a transgression. On the basis of conodont data, Thompson and Satterfield (1975, p. 97) concluded that deposition of the Bowling Green began earlier at Section 13 (Bowling Green) in the west than at Section 17

(Clarksville) in the east. However, McCracken and Barnes (1982, pp. 1475, 1477) interpreted conodonts from the latter section as representing an earlier zone than that indicated by Thompson and Satterfield. The latter authors suggested that local structural movements contributed to the complex facies relations and unconformities in the Edgewood sequence (Thompson and Satterfield, 1975, p. 103).

Northeastern Illinois and Eastern Wisconsin

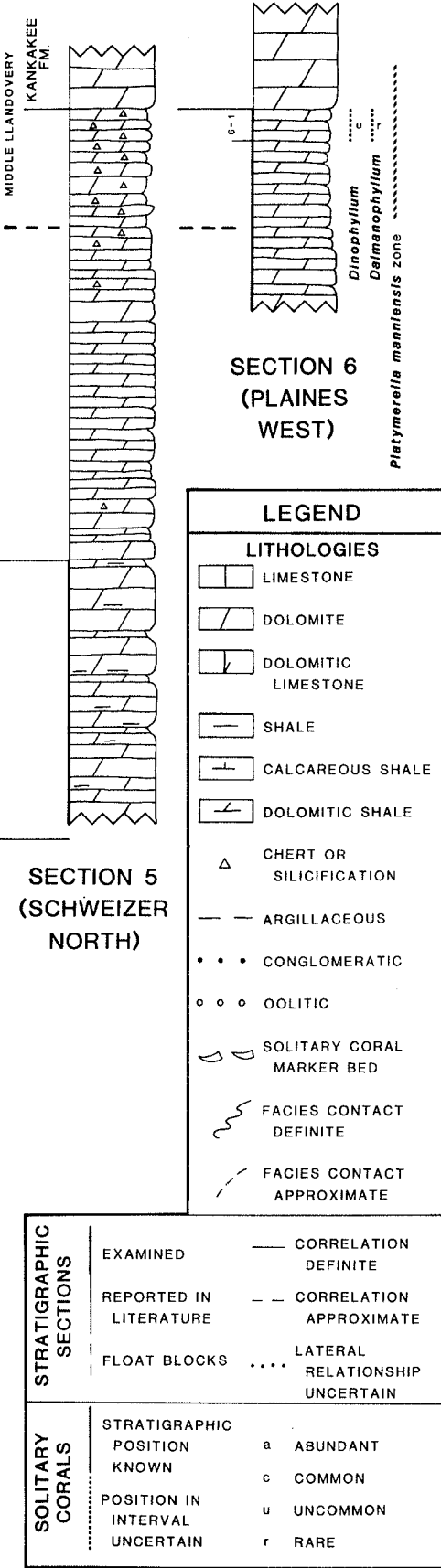
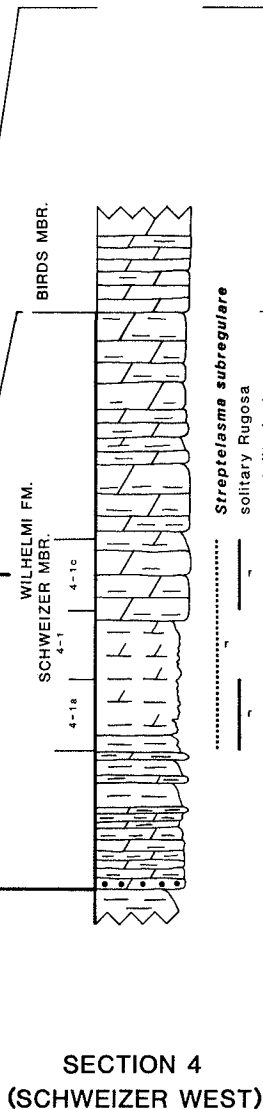
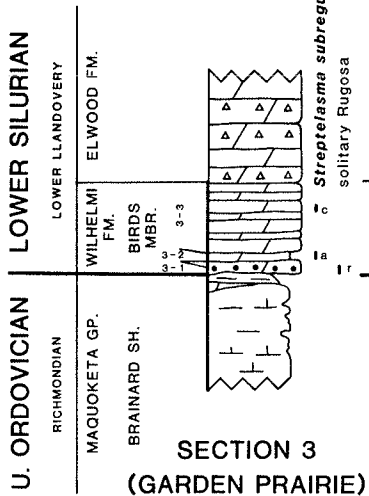
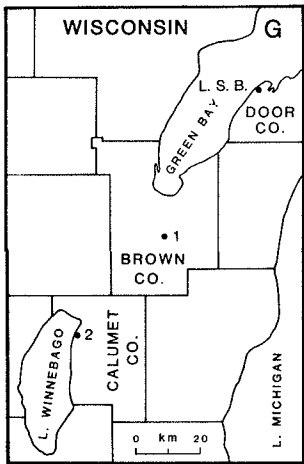
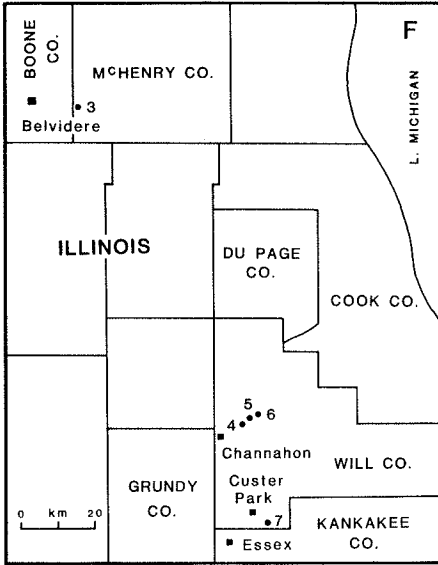
Lithostratigraphy.—The history of stratigraphic nomenclature of uppermost Ordovician and lowermost Silurian strata in Will County and vicinity, Illinois, is summarized in Text-fig. 9. The lithostratigraphic terminology of Willman (1973) is followed herein (Text-fig. 10).

The areal distribution and thickness of the Alexandrian Series was shown by Willman and Atherton (1975, fig. S-14). The Wilhelmi Formation is exposed at only a few localities. The type section of this formation plus its Schweizer Member is at Section 4 (Schweizer West), and the type section of the Birds Member is at Section 4 plus Section 5 (Schweizer North) (Willman, 1973, pp. 12-14). The Wilhelmi is up to 30 m thick where it fills or nearly fills channels eroded into the underlying Maquoketa Group, but is thin or absent elsewhere in the area. The Schweizer Member, which is up to 24 m thick, is generally present only where the formation is relatively thick. The lower portion consists primarily of gray, dolomitic shale, whereas the upper part is very argillaceous, silty, thinly bedded dolomite. This unit is overlain conformably by the Birds Member, which is up to 6 m thick. The Birds is a gray, slightly argillaceous, flaggy dolomite. The Wilhelmi Formation unconformably overlies strata of the Maquoketa Group, ranging from the uppermost unit, the Neda Formation, down to the top of the Fort Atkinson Limestone, which underlies the Brainard Shale. The Wilhelmi is overlain conformably by slightly argillaceous to pure dolomite of the Elwood Formation, which contains numerous layers of chert (Willman, 1973, p. 14). The type section of the

Text-figure 9. History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in northeastern Illinois. E. = Early, L. = Late, SIL. = Silurian, ALEX. = Alexandrian, NIAG. = Niagaran, GAM. = Gamachian.

PERCIVAL, 1856	WORTHEN, 1866, 1871; BRADLEY, 1870	BANNISTER, 1870; SHAW, 1873b	SAVAGE, 1910	SAVAGE, 1912	SAVAGE, 1913a, 1913b, 1917	SAVAGE, 1914	SAVAGE, 1916	SAVAGE, 1926; WILLMAN, 1962; ROSS, 1962	WILLMAN, 1973; LIEBE AND REXRoad, 1977	PRESENT STUDY					
NIAGARAN	L. SILURIAN	L. SIL. NIAGARA GP.	NIAGARAN	LST.	SEXTON CREEK (BRASS- FIELD) LST.	SEXTON CREEK (BRASS- FIELD) LST.	KANKAKEE LST.	KANKAKEE LST.	KANKAKEE FM.	PRESENT STUDY					
				ESSEX LST.							ESSEX LST.	BOWLING GREEN LST. MBR.	EDGEWOOD LST.	EDGEWOOD (CHAN- NAHON) LST.	ELWOOD FM.
BLUE SH.	E. SILURIAN	E. SILURIAN CINCINNATI GP.	ALEX. NIAGARAN	CHAN- NAHON LST.	ALEXANDRIAN	EDGE- WOOD FM.	CHAN- NAHON LST. MBR.	EDGEWOOD FM.	CHAN- NAHON LST. MBR.	EDGEWOOD LST.	EDGEWOOD (CHAN- NAHON) LST.	WILHELM FM.			
			ORDOVICIAN	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA SH.	MAQUOKETA GP.	NEDA FM.	BRAINARD FM.	RICHMONDIAN	

Text-figure 10.—Stratigraphic sections (to scale) and locality maps in northeastern Illinois (F) and eastern Wisconsin (G). L. S. B. = Little Sturgeon Bay, U. = Upper. For precise locations of sections plus references, see "Eastern Wisconsin" and "Northeastern Illinois" under STRATIGRAPHIC SECTIONS AND COLLECTIONS.



Elwood is Section 5 (Schweizer North).

To the north, in eastern Wisconsin, the lower portion of the Mayville Dolomite is equivalent to the Wilhelmi-Elwood sequence (Savage, 1916, pp. 310, 311; Willman, 1973, p. 13; Mikulic and Kluessendorf, 1983, fig. 2). The Schweizer Member is traceable eastward in the subsurface into northwestern Indiana, where it is included within the Sexton Creek Limestone (Rexroad and Droste, 1982, pp. 4, 5, fig. 3). The Birds Member and Elwood Formation may also be present in this region, but are not differentiated (Rexroad and Droste, 1982, p. 12).

Intraregional correlations.—Savage (1910, pp. 334, 335) proposed the name Channahon Limestone for Alexandrian strata in the vicinity of Channahon in Will County, Illinois. On the basis of an exposure near Essex in Kankakee County, Savage (1912, pp. 100, 102) established the term Essex Limestone for Alexandrian strata above the position of the Channahon, up to and including a zone containing the brachiopod Platyerella manniensis. He subsequently lowered the upper contact to the top of a fossiliferous limestone unit (Savage, 1913b, p. 28; 1917, p. 86). Using data from additional exposures, Savage (1914, pp. 31-33) considered the Channahon and Essex to represent the lower, "more fossiliferous portion of the Edgewood Formation," and assigned the "almost barren magnesian limestone" between the Essex and P. manniensis zone to the Bowling Green Limestone. He later included the P. manniensis zone at the top of the Edgewood (Savage, 1916, p. 315), but finally included that zone at the base of the Kankakee Limestone (Savage, 1926, p. 518).

It is suggested herein that the Schweizer Member of the Wilhelmi

Formation in Willman's (1973) stratigraphic revision corresponds to the "more fossiliferous portion of the Edgewood," or Channahon and Essex, of Savage (1913b, 1914, 1917). The Birds Member of the Wilhelmi is considered equivalent to his "almost barren magnesian limestone," or Bowling Green. The Edgewood (Channahon) stratigraphic sequence described by Savage (1926, p. 518) near Belvidere in Boone County is very similar to that at Section 3 (Garden Prairie). At the latter locality, the basal bed above the Maquoketa Shale, plus the almost barren flaggy dolomite above it, was identified as the Wilhelmi Formation by Willman (1973, p. 12) and is herein assigned to the Birds Member. The overlying dolomite containing chert layers represents the Elwood Formation (Willman, 1973, p. 14).

Along the Du Page River about 7 to 9 km north of Channahon, D.J. Fisher (1925, pp. 26, 27) described a unit of gray, flaggy dolomite and an overlying interval of dolomite containing chert layers, situated beneath the P. manniensis zone at the base of the Kankakee. Those strata probably represent the Birds Member of the Wilhelmi Formation and the Elwood Formation, respectively. Willman (1973, p. 14) noted that the contact between the Elwood and Kankakee formations is situated within the P. manniensis zone, which is 2.6 m thick in the vicinity of the type Elwood (Ross, 1962, fig. 1). He also stated that beds containing P. manniensis at the top of the Wilhelmi Formation near Essex may be equivalent to the Elwood.

Along the Kankakee River near Custer Park in Will County, Savage (1913b, p. 26; 1917, p. 84) reported "a bed of iron-stained oolite ... which is thought to be the equivalent of the Noix oolite in Missouri and western Illinois," situated above the Maquoketa Shale

and beneath a unit resembling his Bowling Green Limestone. He considered the oölite to be the youngest member of the Maquoketa (Savage, 1916, p. 306). Athy (1928, pp. 33-35) identified this unit as the Noix Oölite Member of the Edgewood Formation. It is the Neda Formation of the Maquoketa Group in current nomenclature (Willman and Buschbach, 1975, p. 86).

At Section 2 (High Cliff) in eastern Wisconsin, Willman (1973, p. 13) noted that the lower 3 m of the Mayville Dolomite, which overlies the Maquoketa Shale, resembles the Wilhelmi Formation, and the overlying 6 m of Mayville is like the Elwood Formation. Willman (1973, p. 13) stated that the Mayville at Section 1 (Katell Falls) consists largely of Kankakee lithology, but that approximately the lower meter overlying the Neda Formation is similar to the Wilhelmi.

Biota.—Savage (1913b, p. 27; 1917, p. 85) described eleven species of brachiopods, three gastropods, one bivalve, one cephalopod, three trilobites, one ostracode, plus solitary rugose corals identified as Zaphrentis ambigua, Z. subregularis, and Z. stokesi from the lower part of the Schweizer Member, Wilhelmi Formation (his Channahon), along the Des Plaines River about 1.6 km southeast of Channahon. He noted that corals were restricted to his bed 2 (Savage, 1913b, p. 26; 1917, p. 84). Along the Des Plaines River, 3.2 km south of Channahon, Savage (1914, p. 31) reported that strata corresponding to his bed 2 overlie the Maquoketa Group. From a zone 1.5 to 2.1 m above those strata, and from an equivalent zone exposed 2.4 km farther along the river from Channahon, he identified seven species of brachiopods, one gastropod, one trilobite, and one tabulate coral. Savage (1914, p. 33)

considered the beds containing these fossils to correspond to his Essex. They probably represent the upper part of the Schweizer Member. At the latter locality, overlying strata up to a position that would be 5.8 to 6.4 m above bed 2 contain two brachiopod species (Savage, 1914, p. 31). Savage (1914, pp. 32, 33) indicated that those strata are equivalent to his Bowling Green. They probably belong to the Birds Member of the Wilhelmi Formation. From the Wilhelmi (his Essex) along Horse Creek about 2.4 km east of Essex in Kankakee County, Savage (1913b, p. 29; 1917, p. 87) listed 17 species of brachiopods, five gastropods, one cornulitid, two bivalves, two tabulate corals, plus Zaphrentis sp. Savage (1926, p. 518) reported Z. subregularis from the Birds Member of the Wilhelmi (his Edgewood), and three species of brachiopods from the Elwood Formation (also his Edgewood), about 5.5 km south of Belvidere.

D.J. Fisher (1925, pp. 26, 27) listed four species of brachiopods and a trilobite from his Edgewood along the Du Page River about 7 km north of Channahon. Those strata possibly represent the Birds Member of the Wilhelmi Formation.

From the Wilhelmi (his Essex) at Savage's locality near Essex, Athy (1928, pp. 40, 41) reported two species of cornulitids, one tentaculitid, 29 brachiopods, seven gastropods, 11 bivalves, one conularid, algae?, two tabulate corals, and solitary corals identified as Z. stokesi and Z. subregularis. He also listed one species of tentaculitid, seven brachiopods, one trilobite, and algae? from the same unit exposed along Horse Creek 0.4 km west of Custer Park in Will County.

Ross (1962) described three species of graptolites from the argillaceous dolomite in the upper part of the Schweizer Member, Wilhelmi Formation (his Edgewood), at Section 4 (Schweizer West). His collection was subsequently reexamined, and four species were recognized (Berry and Boucot, 1970, p. 145). Buschbach (1964, p. 59) reported scolecodont fragments in the Wilhelmi-Elwood sequence (his Edgewood) in northeastern Illinois. Liebe and Rexroad (1977, figs. 2, 4) reported 12 species of conodonts from the Schweizer Member of the Wilhelmi Formation in Will County, 29 species from the Birds Member, and 29 from the Elwood Formation. Collections were made at Sections 4, 5 and 6. Mikulic, et al. (1985, p. 10) reported lingulid brachiopods, trilobites, and trace fossils in the basal shaly strata, and gastropods, trilobites, brachiopods, bryozoans, pelmatozoan debris, plus orthoconic cephalopods in the upper dolomitic part of the Wilhelmi.

Elias (1982, pp. 40, 57, fig. 21) studied two of Savage's collections of solitary corals from the Channahon Limestone. These include specimens that Savage had identified and illustrated as Z. ambigua and Z. subregularis. Elias concluded that they represent one species, Streptelasma subregulare (Savage, 1913b). He assumed they came from the upper part of the Wilhelmi Formation, based on statements in Ross (1962, p. 1385) and Willman (1973, pp. 12, 13). However, from information presented by Savage (1914, p. 31; 1916, p. 306), and collections made during this study at Section 4 (Schweizer West), it is apparent that the species also occurs in the lower portion of the Schweizer Member. Brachiopods, bryozoans, trilobites, gastropods, cornulitids, and colonial corals were observed at the

latter locality.

During the present study, additional solitary corals obtained by Savage in the vicinity of Channahon were examined. S. subregulare is the only taxon that is represented. The same species occurs in his collection from near Belvidere, and has been found in the Birds Member of the Wilhelmi Formation at Section 3 (Garden Prairie). Solitary corals were not observed in the Birds Member at Section 5 (Schweizer North). The genera Dinophyllum (Pl. 8, fig. 11) and Dalmanophyllum (Pl. 8, fig. 17) appear in the upper portion of the Elwood Formation at Section 6 (Plaines West). The distribution of these corals is shown in Text-fig. 10. At Section 7 (Kankakee River), solitary corals were not found in the 0.3-m-thick Wilhelmi Formation, or in the underlying Neda Formation of the Maquoketa Group. The Kankakee Formation overlies the Wilhelmi at this location.

In eastern Wisconsin, solitary corals were not observed in the basal 3-m-thick unit, or in immediately overlying strata, of the Mayville Dolomite at Section 2 (High Cliff). Solitary Rugosa were not found in the lower meter of the Mayville, or in the underlying Neda Formation, at Section 1 (Katell Falls). This is the only locality at which the Neda is known to contain fossils. Savage and Ross (1916, p. 191) identified one species of asteroid, one bryozoan, three brachiopods, three bivalves, and one gastropod. In addition to the above groups, J. Emerick has found conularids and trilobites (Mikulic and Kluessendorf, 1983, p. 29). In the vicinity of Little Sturgeon Bay, E.O. Ulrich observed a coral-rich dolomite up to 2 m thick, and in places overlain by a thin interval of the Neda, locally preserved

between the Maquoketa Shale and Mayville Dolomite (Mikulic and Kluessendorf, 1983, p. 36, figs. 27, 28). Elias (1982 pp. 29, 67, fig. 18, pl. 10, fig. 8) identified the solitary rugosan Grewingkia canadensis (Billings, 1862) in Ulrich's collection from the coral-rich unit.

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 9. Ross (1962) considered graptolites from a bed in the upper part of the Schweizer Member, Wilhelmi Formation, to be Early Silurian (early Llandovery) in age. This was confirmed by Berry (in Berry and Boucot, 1970, p. 145). Liebe and Rexroad (1977, pp. 848, 849, fig. 5) and Rexroad and Droste (1982, fig. 6) assigned conodonts of the Schweizer to the Panderodus simplex Zone, inferred to be early Llandovery. However, correlation and age assignments on the basis of these conodonts are unreliable because diagnostic, biostratigraphically important taxa are not present (Liebe and Rexroad, 1977, p. 848; Mikulic, et al., 1985, p. 16). Conodonts in the Birds Member of the Wilhelmi and the overlying Elwood Formation were assigned to the Ozarkodina (or Spathognathodus) hassi subzone of the Distomodus (or Icriodina) irregularis Zone (= Paltodus dyscritus fauna of Thompson and Satterfield, 1975). Mikulic, et al. (1985, p. 10) noted that O. hassi suggests a middle to early late Llandovery age.

Savage and Ross (1916, p. 191) and Savage (1916, p. 309) assigned a Late Ordovician (Richmondian) age to the Neda Formation, which is the uppermost unit of the Maquoketa Group. This seems reasonable on the basis of lithostratigraphic data (Mikulic and Kluessendorf, 1983, p. 3; Kolata and Graese, 1983, p. 31). The underlying Brainard

Formation is Richmondian also (Mikulic, et al., 1985, p. 8).

Savage (1913b, p. 30; 1917, p. 88), Willman (1973, pp. 14, 15), plus Willman and Atherton (1975, p. 97) reported the brachiopod Platymerella manniensis from the upper Elwood Formation and basal Kankakee Formation. This zone was placed in the middle Llandovery by Berry and Boucot (1970, pl. 2).

Depositional environments.—Savage (1913b, pp. 34, 35; 1916, p. 314; 1917, p. 92) considered the Wilhelmi Formation (his Edgewood) to have been deposited during a transgression that followed a period of erosion. Willman (1973, p. 12) noted that this unit occupies channels that had been cut into the Maquoketa Group. The basal bed of the Wilhelmi is conglomeratic at Section 4 (Schweizer West), and contains clasts of Maquoketa shale at Section 3 (Garden Prairie). The Schweizer Member, which is very argillaceous and silty, occurs only in the deeper parts of major channels (Willman, 1973, p. 13). As the surface of the Maquoketa became covered, the amount of argillaceous material in the overlying deposits decreased. Liebe and Rexroad (1977, p. 844) reported that reworked Ordovician conodonts decreased in abundance upward in the Schweizer Member, and occur sporadically above it. This is the same distribution as argillaceous material derived from the Maquoketa. The Birds Member of the Wilhelmi is slightly argillaceous and the overlying Elwood Formation contains little or no clastic material. The lithologies and bedding in this sequence suggest deposition in relatively low energy conditions.

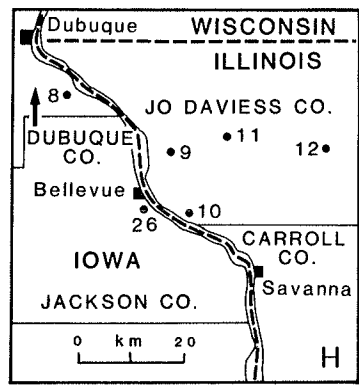
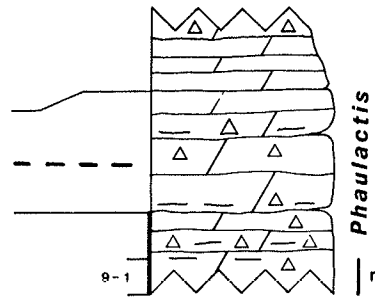
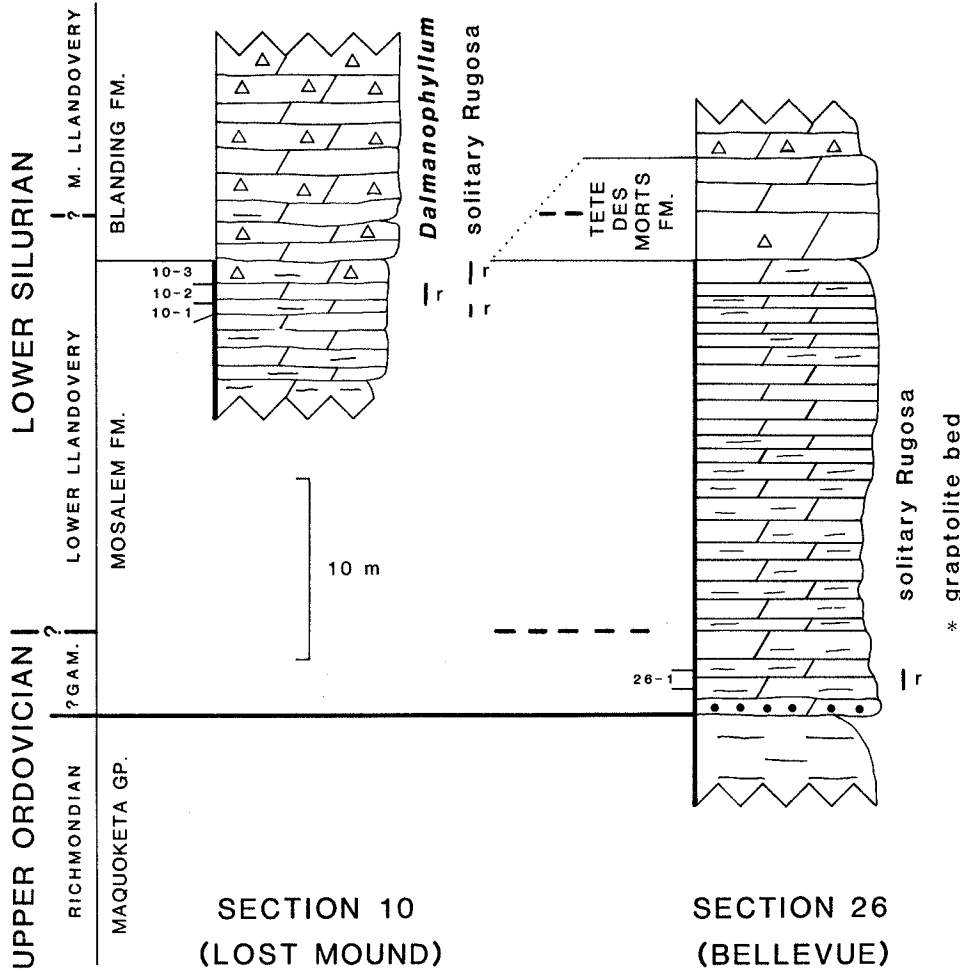
Northwestern Illinois and Eastern Iowa

Lithostratigraphy.—The history of stratigraphic nomenclature and age assignments of uppermost Ordovician and lowermost Silurian strata in the vicinity of Jo Daviess County, Illinois, and Jackson County, Iowa, is summarized in Text-fig. 11. The lithostratigraphic terminology of Willman (1973) is followed herein (Text-fig. 12).

The type section of the Mosalem Formation is Section 8 (King) (Willman, 1973, p. 32). The Mosalem is up to 30 m thick where it fills channels eroded into the underlying Maquoketa Group, but thins almost to absence above paleotopographic highs (Brown and Whitlow, 1960, pp. 34, 36-39, figs. 9, 10; Whitlow and Brown, 1963, pp. 11, 13, fig. 62.2; Willman, 1973, pp. 31-33). Where the Mosalem is relatively thick, the lower part is composed of gray, dolomitic shale and very argillaceous dolomite. The clastic content decreases upward. The upper portion of the unit consists of slightly argillaceous dolomite with a few bands of chert. Where the Mosalem is comparatively thin, only the upper dolomitic portion is present. This formation unconformably overlies strata of the Maquoketa Group ranging from the Neda Formation, preserved on paleotopographic highs, down into the underlying Brainard Shale. Within channels, the base of the Mosalem is characterized by a thin, persistent conglomerate containing clasts derived from the Maquoketa. The Mosalem Formation is overlain with apparent conformity by the massive, vuggy, pure dolomite of the Tete des Morts Formation in the northern part of this area, and by relatively pure, cherty dolomite of the Blanding Formation in the south.

Text-figure 11.—History of stratigraphic nomenclature and age assignments for uppermost Ordovician and lowermost Silurian units in northwestern Illinois and eastern Iowa. E. = Early, L. = Late, GAM. = Gamachian.

Text-figure 12.—Stratigraphic sections (to scale) and locality map in northwestern Illinois and eastern Iowa. For legend, see Text-fig. 10. GAM. = Gamachian, M. = middle. For precise locations of sections plus references, see "Eastern Iowa" and "Northwestern Illinois" under STRATIGRAPHIC SECTIONS AND COLLECTIONS.



Biota.—Calvin and Bain (1900, p. 445) identified a species of brachiopod from the lower part of the Mosalem Formation (their "transition beds") at Rockville, Iowa. Savage (1906, pp. 601, 602) reported three species of brachiopods and one trilobite from the Mosalem (his transition beds) near Bellevue, and one of the brachiopod species from those beds in Prairie Spring Township. From a section in Jo Daviess County, Illinois, Savage (1914, p. 34) listed three species of inarticulate brachiopods, five articulate brachiopods, and three trilobites within the Mosalem (his Winston). Savage (1926, pp. 527, 528) also reported fossils from the Mosalem (his Edgewood) at two sections in Carroll County, Illinois. At one of these, where the formation is 18 m thick, he mentioned two species of brachiopods, one trilobite, plus solitary rugose corals identified as Zaphrentis subregularis from near the base, and a different species of brachiopod from the upper part. At the other locality, he identified five species of brachiopods, one bivalve, one trilobite, and Zaphrentis sp.

From the Mosalem and Tete des Morts formations (his Edgewood) in Iowa, Scobey (1938, table 2) listed one species of stromatoporoid, two bryozoans, one inarticulate brachiopod, 16 articulate brachiopods, four gastropods, three cephalopods, one ostracode, seven trilobites, six tabulate corals, plus Z. subregularis and Zaphrentis sp. Many of these are probably from the Tete des Morts. Brown and Whitlow (1960, pp. 37-39) stated that brachiopods, bryozoans, and trilobites are the dominant fossils in the Mosalem of Dubuque County, Iowa. They noted the presence of probable conodonts, especially in the basal 1.5 m where burrow mottling is common. At localities where the Mosalem is thin,

possible algal stromatolites were reported at the base. In the lowermost bed of the formation at one section, small phosphatic fossils resembling the "depauperate fauna" at the base of the Maquoketa Group were observed. Comminuted fossil fragments from the Cornulites zone in the upper Brainard Shale were noted within the basal conglomerate of the Mosalem.

Ross (1964) described one species of graptolite and reported a specimen representing a different genus from a horizon situated about 3.4 m above the base of the Mosalem Formation as currently recognized at Section 26 (Bellevue) (see Rose, 1967, fig. 21). He reported typical Maquoketa fossils from the basal 0.6 m thick conglomeratic, silty, dolomitic calcarenite of the Mosalem at this locality (Ross, 1964, p. 1107), but it is not known if they are reworked. Whitlow and Brown (1963, p. 13) found phosphatic fossil fragments in this bed.

During the present study, three solitary corals were collected from an interval 1.8 to 2.4 m above the base of the Mosalem Formation at Section 26 (Bellevue). They are too poorly preserved for identification. However, the specimens from Carroll County, Illinois, that were identified as Z. subregularis by Savage (1926) are tentatively considered to be Streptelasma subregulare (Savage, 1913b). All of his other reports of this species, in northeastern Illinois, northeastern Missouri, and southern Illinois, have been confirmed in this study. Dalmanophyllum (Pl. 8, fig. 18) and Phaulactis (Pl. 8, fig. 23) occur near the top of the Mosalem at Section 9 (Winston North) and Section 10 (Lost Mound), respectively. The stratigraphic distribution of these corals is shown in Text-fig. 12. One

unidentifiable specimen was also found in the upper 2 m of the Mosalem at Section 11 (Schapville). Solitary Rugosa were not observed in this formation at Sections 8 (King) and 12 (Stockton). Salvadorea randi (Elias, 1981) was described from the Brainard Shale of the Maquoketa Group at Sterling, Illinois, and Clayton County, Iowa, by Elias (1982, pp. 61, 62, pl. 6, figs. 1-7; see also Elias, 1985, p. 45).

Age of units.—The history of age assignments for lithostratigraphic units in this area is summarized in Text-fig. 11. Ross (1964) noted that graptolites from a bed about 3.4 m above the base of the Mosalem Formation represent an Early Silurian (early Llandovery) zone.

Faunal and lithostratigraphic correlation of the upper Brainard Shale and its uppermost Cornulites zone (Maquoketa Group) in Iowa and Illinois with the Late Ordovician (latest Richmondian) "Elkhorn" strata in the Cincinnati Arch region was considered highly probable by Ladd (1929, pp. 369, 370) and Templeton and Willman (1963, pp. 132, 133). The upper portion of the Maquoketa in northern Illinois was considered to be late Maysvillian and Richmondian on the basis of preliminary work indicating conodonts of Fauna 12 (Votaw and Kolata, 1981). Glenister (1957, pp. 720, 721) plus Kolata and Graese (1983, pp. 5, 6) assigned the Maquoketa Group of eastern Iowa and northwestern Illinois to the Maysvillian through Richmondian.

The age of units overlying the Mosalem is imprecisely known, because important biostratigraphic marker zones are absent.

Depositional environments.—Savage (1914, p. 34; 1926, p. 528) recognized that the Mosalem Formation was deposited during a

transgression. Brown and Whitlow (1960, p. 36) interpreted the Mosalem as having been deposited in a shallow marine environment as a sea advanced over the eroded Maquoketa surface. As sediments accumulated in low areas, topographic highs continued to be eroded, either above or below sea level. The detrital content of the Mosalem decreased as the summits became covered with marine deposits. Erosional relief on the Maquoketa is 41 m in Dubuque County, south of Dubuque, Iowa (Brown and Whitlow, 1960, p. 23; Whitlow and Brown, 1963, p. 11).

SOLITARY RUGOSE CORAL ASSEMBLAGES

A succession of three solitary rugosan assemblages is recognized within the uppermost Ordovician-lowermost Silurian sequence in the east-central United States (Text-fig. 13, Table 1). The lowest is a Late Ordovician assemblage in the Maquoketa Group. Salvadorea randi, a Maysvillian-Richmondian species (Elias, 1985, p. 45), is present in the Orchard Creek and Brainard shales (Elias, 1982, pp. 35, 36). Grewingkia canadensis occurs immediately below the Neda Formation in eastern Wisconsin (Elias, 1982, p. 29). It is a Richmondian species (Elias, 1982, p. 67).

The upper assemblage is Silurian in age, and includes representatives of Rhegmaphyllum, Dinophyllum, Dalmanophyllum, and Phaulactis. These genera are typical of the Early through Middle Silurian (Hill, 1981, pp. 159, 160, 163, 252), and occur in the late early to late(?) Llandovery Brassfield Formation of the Cincinnati Arch region in Kentucky-Indiana-Ohio (Laub, 1979). Collections made from the strata containing this assemblage are not extensive, and most of the specimens were not identified because of poor preservation. No attempt was made to differentiate species within these genera.

This study is focused on the middle assemblage, here termed the Edgewood. Streptelasma subregulare is the most widely distributed species, followed by S. leemonense. Seven other species are also recognized (Table 1). Their stratigraphic position between Late Ordovician (Richmondian) and Early to Middle Silurian assemblages suggests a latest Ordovician to earliest Silurian age range. Solitary Rugosa of the Edgewood assemblage are comparable primarily to species in the following units (refer to discussions of taxa in SYSTEMATIC

Text-figure 13.—Composite stratigraphic sections showing age and correlation of uppermost Ordovician and lowermost Silurian units and distribution of solitary rugose corals in the east-central United States. Strata containing the Edgewood solitary coral assemblage (Gamachian to early early Llandovery in age) are stippled. Hachures indicate Platymerella manniensis zone. GAM. = Gamachian, E. = early, LLAND. = Llandovery.

LATE ORDOVICIAN | EARLY SILURIAN
RICHMONDIAN | GAM. | LATE LLANDOVERY



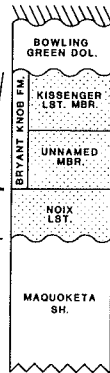
Streptelasma subregulare
Streptelasma emsdeni
Streptelasma leemonense
S. sp. cf. S. leemonense
Grewingkia sp. A
Keelophyllum oklahomense
Phaulactis

SOUTH-CENTRAL OKLAHOMA



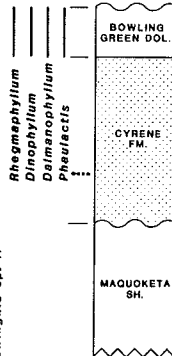
Salvadorea randi
Streptelasma subregulare
Streptelasma leemonense
Streptelasma sp.
Bodophyllum shorti
Dalmanophyllum

SOUTHERN ILLINOIS AND SOUTHEASTERN MISSOURI



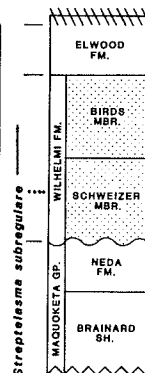
Streptelasma sp. A
Streptelasma subregulare
Streptelasma leemonense
Grewingkia sp. A

NORTHEASTERN MISSOURI (EAST)



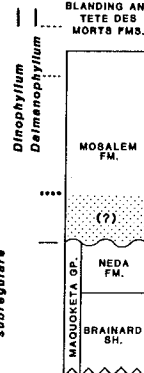
Rhegmaphyllum
Dinophyllum
Dalmanophyllum
Phaulactis

NORTHEASTERN MISSOURI (WEST)



Streptelasma subregulare

NORTHEASTERN ILLINOIS



Streptelasma subregulare
Dinophyllum
Dalmanophyllum
Salvadorea randi
(?) Streptelasma subregulare
Dalmanophyllum
Phaulactis

NORTHWESTERN ILLINOIS AND EASTERN IOWA

RICHMONDIAN | GAM. | E. LLANDOVERY | MIDDLE LLAND. | EARLY SILURIAN

Table 1.—Latest Ordovician and earliest Silurian solitary rugose corals in the east-central United States.

Silurian Assemblage

Suborder Streptelasmatina

Family Streptelasmataidae

Subfamily Streptelasmatinae

Rhegmaphyllum

Subfamily Dinophyllinae

Dinophyllum

Subfamily Dalmanophyllinae

Dalmanophyllum

Suborder Lycophyllina

Family Lykophyllidae

Phaulactis

Edgewood Assemblage [Edgewood Province]

Suborder Streptelasmatina

Family Streptelasmataidae

Subfamily Streptelasmatinae

Streptelasma subregulare (Savage, 1913b)

Streptelasma amsdeni n. sp.

Streptelasma leemonense Elias, 1982

S. sp. cf. S. leemonense Elias, 1982

Streptelasma sp. A

Streptelasma sp. of Elias, 1982

Grewingkia sp. A

Subfamily Dalmanophyllinae

Bodophyllum shorti Elias, 1982

Suborder Monacanthina

Family Lambelasmataidae

Subfamily Coelostylinae

Keelophyllum oklahomense n. gen., n. sp.

Late Ordovician Assemblage

Suborder Streptelasmatina

Family Streptelasmataidae

Subfamily Streptelasmatinae

Salvadorea randi (Elias, 1981) [Red River-Stony
Mountain Province]

Grewingkia canadensis (Billings, 1862)
[Richmond Province]

PALEONTOLOGY): Vauréal and Ellis Bay formations (Richmondian, Gamachian), Anticosti Island, Québec, Canada; unnamed units (Ashgill) in the eastern Klamath Mountains, California, and Penobscot County, Maine, U.S.A.; Stages 5a plus 5b (Ashgill) and Stage 6a (early Llandovery), Norway; Boda Limestone plus Dalmanitina Beds (Ashgill) and possibly younger strata (earliest Llandovery), Sweden; and Pirgu Stage (Ashgill), Estonian S.S.R. Neuman (1982, p. 34) noted that several species in Norway range from the Ashgill into the early Llandovery. On Anticosti Island, one species ranges from the Richmondian through Gamachian and into the early Llandovery (Elias, unpublished data).

The three solitary rugosan assemblages in the east-central United States have no species in common, and the overall generic compositions are also distinct. Diversity at all taxonomic levels increases from the Late Ordovician to Edgewood assemblages and, at least at the subfamily level, from the Edgewood to Silurian assemblages (Table 1).

AGE OF UNITS AND INTERREGIONAL CORRELATION

Amsden (1971b, pp. 21,22; 1974, p. 26) considered the Keel-Edgewood brachiopod assemblage in south-central Oklahoma, southern Illinois and southeastern Missouri, and northeastern Missouri and west-central Illinois to be fairly characteristic of the latest Ordovician (late Ashgill) to earliest Silurian (early Llandovery). Brachiopods in the Keel Formation, Leemon Formation, and Noix Limestone most closely resemble the latest Ordovician Hirnantia fauna, but the species are different. This may be due, at least in part, to ecologic factors. Amsden concluded that the Ordovician aspect of brachiopods in the Keel, Leemon, and Noix indicated a latest Ordovician age. The brachiopod assemblage in the Bryant Knob Formation, which overlies the Noix in northeastern Missouri, is different in some respects, and was tentatively assigned to the early Llandovery (Amsden, 1971b, p. 22; 1974, p. 26).

Brachiopods of the lower Edgewood assemblage were provisionally considered to be post-Hirnantian by Lespérance (1974, p. 22). Lespérance and Sheehan (1976, pp. 719, 720) noted that these brachiopods could represent a latest Ordovician endemic North American fauna, with species derived from the Hirnantia community and other North European Province species. However, they suggested that it was most likely a Silurian fauna with a few holdovers from the Late Ordovician North American Province. A Hirnantian age was accepted by Jaanusson (1979, p. 154), based on a trilobite and other indications from beds in Illinois.

In view of the presence of Ordovician conodonts in the Leemon

Formation and Noix Limestone, the Ordovician aspect of the brachiopods in the Keel Formation, Leemon, and Noix, plus the position of these units above Late Ordovician (Richmondian) strata, a latest Ordovician (Gamachian) age is accepted herein, as suggested and discussed by Elias (1982, pp. 38, 39) (Text-fig. 13). Streptelasma subregulare, S. leemonense, Grewingkia sp. A, and other solitary corals in the Keel, Leemon, and Noix, are considered to have first appeared in the east-central United States during Gamachian time.

In northeastern Illinois, Streptelasma subregulare is present in the Schweizer and Birds members of the Wilhelmi Formation. It occurs both below and above a bed in the upper Schweizer that contains early Llandovery graptolites (Ross, 1962, p. 1383; Berry in Berry and Boucot, 1970, p. 145) and conodonts (Liebe and Rexroad, 1977, fig. 5; Rexroad and Droste, 1982, figs. 5, 6). Therefore, the range of S. subregulare extends into the Silurian. Lower Schweizer strata infilling the deepest channels in the eroded Maquoketa, below the position of the graptolite bed, may be Gamachian in age, as suggested by Elias (1982, p. 40, fig. 21) (Text-fig. 13).

Ross (1964, p. 1107) and Willman (1973, pp. 13, 31, fig. 2) correlated the lower part of the Wilhelmi Formation with the lower portion of the Mosalem Formation in northwestern Illinois and eastern Iowa on the basis of graptolites and lithology, respectively. Graptolites near the base of the Mosalem are similar to those in the Wilhelmi, and are early Llandovery in age (Ross, 1964). Solitary corals tentatively considered to be Streptelasma subregulare occur in the basal Mosalem. It is suggested herein that lower Mosalem strata infilling the deepest channels eroded into the Maquoketa, below the position of the graptolite bed, may be Gamachian in age (Text-fig. 13).

In northeastern Illinois, corals of the Silurian assemblage occur with the brachiopod Platymerella manniensis in the upper Elwood Formation. These strata are considered to be middle Llandovery in age by Berry and Boucot (1970, pl. 2). In northwestern Illinois, this coral assemblage appears in the upper part of the Mosalem Formation. The upper Mosalem is considered younger than the upper part of the Wilhelmi Formation because Streptelasma subregulare occurs in the Birds Member of the Wilhelmi, whereas the Silurian assemblage is present in the upper Mosalem. The Edgewood and Silurian assemblages are not known to co-occur. Although Willman (1973, pp. 15-17, 35, 36) tentatively correlated the Elwood with the Blanding Formation of northwestern Illinois on the basis of lithology, he noted that the Tete des Morts Formation plus the Blanding could correlate with the lower Kankakee Formation, which overlies the Elwood. From the coral evidence, it is inferred that the upper Mosalem must be equivalent to at least the lower part of the Elwood (Text-fig. 13).

In northeastern Missouri, the Silurian coral assemblage occurs in the Bowling Green Dolomite at an eastern exposure. The middle Llandovery Platymerella manniensis zone is present at the base of the Sexton Creek Limestone, which overlies the Bowling Green. Therefore, the Bowling Green is correlated with the lower Elwood and upper Mosalem and is considered late early Llandovery in age (Text-fig. 13).

Corals of the Edgewood assemblage in the Bryant Knob Formation, which overlies the Noix Limestone and underlies the Bowling Green Dolomite in northeastern Missouri, could be Gamachian or early early Llandovery in age. Streptelasma subregulare, S. leemonense, and Grewingkia sp. A are also known from the Keel Formation (Gamachian),

and S. subregulare plus S. leemonense occur in the Leemon Formation (Gamachian). However, S. subregulare is known to extend into early early Llandovery strata of the Wilhelmi Formation, in which the other species are not represented. Interpretations of brachiopods (Amsden, 1971b, 1974; Lespérance, 1974; Lespérance and Sheehan, 1976), conodonts (Thompson and Satterfield, 1975), and graptolites (Berry in Thompson and Satterfield, 1975) in the Bryant Knob Formation suggest a Silurian age, and the unit is herein considered to be early early Llandovery on the basis of its position beneath the Bowling Green. (Text-fig. 13).

The lower and upper portions of the Cyrene Formation are equated with the Noix Limestone (Gamachian) and Bryant Knob Formation (early early Llandovery), respectively, which occur immediately to the east. The evidence for these correlations, based on conodonts, brachiopods, and lithologic similarity, was discussed in a previous section. Streptelasma subregulare occurs in the middle of the Cyrene and in the Bryant Knob. A hiatus has never been recognized between the Cyrene Formation and the overlying Bowling Green Dolomite (late early Llandovery). Therefore, the Cyrene is herein considered to be Gamachian through early early Llandovery in age (Text-fig. 13).

The lower part of the Sexton Creek Limestone in southeastern Missouri and southern Illinois could be as old as the Bowling Green Dolomite (late early Llandovery). Both units contain conodonts representing the Paltodus dyscritus fauna (Thompson and Satterfield, 1975, figs. 6, 7, 9, 11-15), plus solitary corals of the Silurian assemblage. Early late Llandovery brachiopods are also present in

the Sexton Creek (Amsden, 1974, p. 24).

The Silurian solitary coral assemblage is represented in basal beds of the Cochrane Formation in south-central Oklahoma. The Cochrane contains early late Llandovery brachiopods (Amsden, 1971a, p. 145; 1980, p. 17).

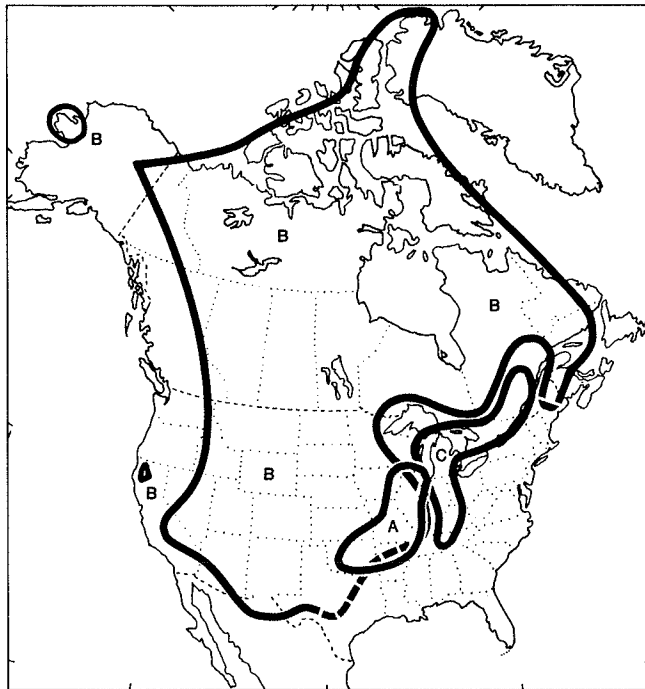
The Edgewood solitary coral assemblage is latest Ordovician (Gamachian) to earliest Silurian (early early Llandovery) in age, and therefore these rugosans cannot be used to delineate the position of the Ordovician-Silurian boundary in the east-central United States. In Illinois and Missouri, they occur in strata that were included within the Alexandrian Series by Savage (see Text-figs. 5, 7, 9). Reeds (1911) extended the use of that term for correlative strata in Oklahoma. This series was proposed by Savage (1908a, pp. 434, 442, 443; 1908b, pp. 110, 111) to include strata, thought to be earliest Silurian in age, situated between the Richmondian Stage of the Cincinnati Series (Ordovician) and the Niagaran Series (Silurian). It has been recommended that the term Alexandrian be discontinued as a series because of a proliferation of synonymous names (D.W. Fisher, 1954, p. 1984), and because outcrops in the type area are meager, the units are not especially fossiliferous, and unconformities are present within the sequence (Amsden, 1974, p. 5).

PALEOBIOGEOGRAPHY

Two paleobiogeographic provinces are represented by solitary rugose corals of the Late Ordovician assemblage in the Maquoketa Group. Salvadorea randi in Iowa and Illinois is also known from middle Maysvillian strata in the Selkirk Member (Elias, 1981, pp. 20, 21) and the Richmondian Fort Garry Member of the Red River Formation in southern Manitoba (Elias, unpublished data). It belongs to the Red River-Stony Mountain Solitary Coral Province (Text-fig. 14). The distribution of this species indicates dispersion across the Transcontinental Arch between the Williston Basin and the area of Maquoketa deposition. Grewinkia canadensis, which is present in the Maquoketa Group of eastern Wisconsin, is a characteristic species of the Richmond Solitary Coral Province (Text-fig. 14). Elias (1982, p. 29) suggested that this occurrence may represent a westward shift in the geographic range of the species associated with a regression during the late Richmondian. S. randi and G. canadensis, plus other solitary rugosan taxa, disappeared from the east-central United States during the final regression of the epicontinental sea at the end of Richmondian time, possibly due to a glacioeustatic sea-level drop (Elias, 1982, pp. 48, 51).

The solitary Rugosa of the Edgewood assemblage represent the Edgewood Solitary Coral Province (Text-fig. 14). The inclusion of south-central Oklahoma in this province is confirmed herein, and the boundary is tentatively extended to include northwestern Illinois and eastern Iowa. The Edgewood Province corresponds to a predominantly carbonate sequence deposited during a transgression that probably

Text-figure 14.—Paleobiogeography of Late Ordovician and earliest Silurian solitary Rugosa in North America. A, Edgewood Province of Gamachian to early early Llandovery age coincided with transgression that introduced open, high energy environments to continental interior (Elias, 1982, pp. 51, 52). B, Red River-Stony Mountain Province of Edenian to Gamachian and possibly early early Llandovery age included vast interior region characterized by carbonate sedimentation in somewhat restricted seas, plus continental margin with open, normal marine environments (Elias, 1981, pp. 2, 8, 10; 1982, pp. 48, 49; 1983, pp. 927-931; 1985, pp. 16-20; Elias and Potter, 1984, pp. 1205, 1206); isolated areas to west are Cordilleran terranes with possible Red River-Stony Mountain assemblages. C, Richmond Province of Richmondian age corresponded to carbonate platform bordering epicontinental sea that received clastic sediments from deltaic complex to east (Elias, 1982, pp. 49-51).



proceeded from the south (Savage, 1913a, pp. 373, 374; 1913b, pp. 34, 35; 1916, pp. 314-316; 1917, pp. 91, 92), possibly due to a rise in sea-level related to deglaciation (Elias, 1982, p. 39). This event introduced open, normal marine environments to the east-central United States. The Edgewood species were not derived from corals of the Late Ordovician assemblage in this region. Their resemblance to taxa previously restricted to the continental margin of North America suggests that they originated from such forms. Within the Edgewood Province, diversity at all taxonomic levels decreases from south to north (Text-fig. 13, Table 1). This apparently corresponds to an environmental gradient from continental margin to epicontinental conditions. Solitary corals of the Edgewood Province became extinct during early Llandovery time. Genera recognized in the succeeding Silurian assemblage were not derived from Edgewood taxa or other known North American Ordovician solitary Rugosa. They must have originated elsewhere and been introduced to this region. Laub (1975, p. 280; 1979, p. 45) noted that rugosan species in the late early to late(?) Llandovery Brassfield Formation of the Cincinnati Arch region are not known in pre-Brassfield strata of North America, but some occur in the Baltic area, the Siberian platform, and possibly Venezuela.

EVOLUTION

The only recognizable evolutionary event, within the Edgewood Province involves the derivation of Streptelasma amsdemi from S. subregulare, apparently by geographic speciation. The morphological similarities and differences between these two species are discussed in SYSTEMATIC PALEONTOLOGY, under S. amsdeni (see also Table 6). The

high degree of intraspecific variability in S. subregulare apparently allowed small populations of atypical individuals to survive in atypical environments. S. amsdeni likely arose as a result of the founder effect. The high degree of variability is probably what enabled S. subregulare to dominate the Edgewood solitary rugosan assemblage. Over 80 percent of all specimens are S. subregulare.

SYSTEMATIC PALEONTOLOGY

Subclass RUGOSA Milne-Edwards and Haime, 1850

Order STAURIIDA Verrill, 1865

Suborder STREPTELASMATINA Wedekind, 1927

Family STREPTELASMATIDAE Nicholson in

Nicholson and Lydekker, 1889

Subfamily STREPTELASMATINAE Nicholson in

Nicholson and Lydekker, 1889

Genus Streptelasma Hall, 1847

Streptelasma Hall, 1847, p. 17 (as Streptoplasma), and page facing p. 338 (see Laub, 1979, p. 60); Neuman, 1969, pp. 8-10; McLean, 1974, pp. 38-41; Laub, 1979, pp. 59-61; Elias, 1982, p. 52.

Type species.—Designated by Roemer (1861, p. 19): Streptelasma corniculum Hall, 1847, lower Trenton Limestone (upper Middle Ordovician), Middleville, New York.

Diagnosis.—Solitary or with few offsets. Septa nondilated to completely dilated in early stage, dilation usually decreases during ontogeny. Major septa straight or wavy, generally extend to axis in early stage and become shorter during intermediate to late stages. Septal lobes and rarely lamellae can form a typically simple axial structure in intermediate and/or late stages. Cardinal septum and fossula inconspicuous to prominent.

Discussion.—Neuman's (1969, pp. 8-11) study of the lectotype of

Streptelasma corniculum has formed a basis for the generally accepted concept of Streptelasma. This genus is considered to include streptelasmatids with major septa that are long, thin to moderately thick, and usually joined to form a simple axial structure during early to intermediate stages. These septa become shorter and thinner in late stages, when an axial structure is seldom present. However, because intraspecific variability of the type species is unknown, Streptelasma remains poorly understood. Furthermore, most species presently included in the genus are based on small collections.

McLean (1974, pp. 38-41) stated that Streptelasma, Dinophyllum Lindström, 1882, and Porfirieviella Ivanovskiy, 1963 may prove to be synonymous. He also noted that many species resembling Streptelasma in late stages are not well enough known in earlier stages to be included in the genus with certainty. Elias (1982, p. 52) indicated that further study may demonstrate that Streptelasma, Helicelasma Neuman, 1969, Borelasma Neuman, 1969, and Grewingkia Dybowski, 1873 are synonyms. He showed that in S. divaricans (Nicholson, 1875) there is complete gradation from corals with open axial regions to those with axial structures similar to Grewingkia (Elias, 1982, pp. 52, 55, 56, pl. 1, figs. 1-19).

S. subregulare (Savage, 1913b), described in this study on the basis of a large collection, is important in establishing the range of variability in Streptelasma. In this highly variable species there is continuous gradation from coralla that closely resemble S. corniculum, to those that are similar to Helicelasma, Borelasma, and Ullernelasma Neuman, 1975. Within some individuals,

different ontogenetic stages would be assigned to different genera if they were considered independently. The diagnosis of Streptelasma is herein broadened to include all representatives of S. subregulare.

Streptelasma subregularare (Savage, 1913b)

Plate 1, figures 1-28; Plate 2, figures 1-22;

Plate 3, figures 1-10

Zaphrentis subregularis Savage, 1913b, p. 62, pl. 3, fig. 5, pl. 7,

fig. 1; 1917, p. 113, pl. 5, fig. 5, pl. 9, fig. 1.

Zaphrentis ambigua Savage, 1913b, pp. 109, 110, pl. 7, fig. 2;

1917, p. 149, pl. 9, fig. 2.

Streptelasma subregularare (Savage, 1913b). Elias, 1982, pp. 57, 58,

pl. 4, figs. 7-22.

Holotype.—By original designation: UI X-851 (Savage, 1913b, pl. 3, fig. 5; 1917, pl. 5, fig. 5; Elias, 1982, pl. 4, figs. 7, 8), S coll., Cyrene Formation, near Edgewood, Pike County, Missouri.

Additional material.—UI C1619 (6 specimens labelled Zaphrentis subregularis), S coll., Birds Member, Wilhelmi Formation (labelled Channahon), near Belvidere, Boone County, Illinois; USNM 3-2-2, 8, 11, 12, interval 3-2, EMM coll., USNM 3-3-13, 15, 16, 24, 27, 29, 30, interval 3-3, EM coll., Birds Member, Wilhelmi Formation, Section 3 (Garden Prairie), McHenry County, Illinois; UI C1560 (7 specimens labelled Zaphrentis channahonensis), UI C1563 (2 slabs and 1 specimen labelled Zaphrentis ambigua), S coll., Schweizer Member, Wilhelmi Formation (labelled Edgewood and Channahon Limestone, respectively), Channahon, Will County, Illinois; UI C1581 (5 specimens labelled Z. subregularis), S coll., Schweizer Member, Wilhelmi Formation (labelled Channahon Limestone), southeast of Channahon, Will County, Illinois; UI C1547 (slab with 2 specimens labelled Z. channahonensis), UI C1561 (10 specimens labelled Z. subregularis), UI X-947 (type specimens of

Z. ambigua, 1 specimen plus slab with 5 specimens, one figured by Savage, 1913b, pl. 7, fig. 2; 1917, pl. 9, fig. 2), S coll., Schweizer Member, Wilhelmi Formation (labelled Edgewood), near Channahon, Will County, Illinois; UI X-926 (2 specimens labelled Z. subregularis, one figured by Savage, 1913b, pl. 7, fig. 1; 1917, pl. 9, fig. 1), S coll., Schweizer Member, Wilhelmi Formation (labelled Edgewood, Channahon Limestone), Will County, Illinois; USNM 4-1-1-4-1-6, interval 4-1, EMM coll., Schweizer Member, Wilhelmi Formation, Section 4 (Schweizer West), Will County, Illinois; UI C864 (labelled Zaphrentis), S coll., Cyrene Formation (labelled Edgewood Limestone), Edgewood, Pike County, Missouri; USNM 13-1-1-13-1-5, interval 13-1, EMM coll., Cyrene Formation, Section 13 (Bowling Green), Pike County, Missouri; USNM 14-1-2-4, 6-20, 22-28, 30, 32, 33, interval 14-1, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 14 (Higginbotham Farm), Pike County, Missouri; USNM 15-1-1-15-1-7, interval 15-1, EMM coll., USNM 15-1-9, 11, 13-20, 40, interval 15-1, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 15 (Calumet), Pike County, Missouri; UCGM 45643-45645, USNM 21b-2-3, 4, 8, interval 16-1, E coll., USNM 16-1-1-8a, 8b-14, 16-47, interval 16-1, EMM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 16 (Clinton Spring), Pike County, Missouri; USNM 17-0-1-34, 36, 37, 39, interval 17-0, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 17 (Clarksville), Pike County, Missouri; USNM 18-1-1-18-1-20, interval 18-1, EMM coll., USNM 18-1-25-18-1-29, interval 18-1, EM coll., unnamed member, Bryant Knob Formation, USNM 18-2-1-16, 18, 19, interval 18-2, USNM 18-3-1-18-3-11, interval 18-3, EMM coll.,

USNM 18-3-15-18-3-22, interval 18-3, USNM 18-4-1, interval 18-4, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 18 (Kissenger), Pike County, Missouri; UCGM 45618-45634, E coll., USNM 365918, 19-1-1-5, 7-15, interval 19-1, USNM 19-2-1-19-2-23, interval 19-2, USNM 19-3-1-12, 12a-21, 23-42, interval 19-3, EMM coll., Leemon Formation, Section 19 (New Wells), Cape Girardeau County, Missouri; USNM 365919, 20-1-1-5, 7-9, 11-14, interval 20-1, EMM coll., USNM 20-1-16-20-1-18, interval 20-1, EM coll., USNM 20-2-1, 20-2-2, interval 20-2, EMM coll., USNM 20-3-2-20-3-10, interval 20-3, USNM 20-4-1, 20-4-3, interval 20-4, USNM 20-5-1-8, 10, 11, interval 20-5, EM coll., Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, Missouri; UI ENT-1, ENT-2, S coll., Leemon Formation (labelled Edgewood), Thebes North Section (labelled near Thebes), Alexander County, Illinois; USNM 21-1-1, 21-1-3, interval 21-1, EMM coll., USNM 21-1a-1-21-1a-4, interval 21-1a, USNM 21-1b-1-4, 8, 9, interval 21-1b, USNM 21-1c-1-4, 6-8, 10, 13, 17, interval 21-1c, EM coll., Ideal Quarry Member, Keel Formation, Section 21 (Rock Crossing), Carter County, Oklahoma; USNM 23-1-1, interval 23-1, USNM 23-2-1-31, 33, 34, 37-41a, 41b, 42-45, 47, 49-56, interval 23-2, EMM coll., Ideal Quarry Member, Keel Formation, USNM 23-2a-1, 3, 5, interval 23-2a, EM coll., USNM 23-3-6, 23-3-9, interval 23-3, EMM coll., USNM 23-3-14-18, 24, 25, 27-29, 31, 32, 35-40, interval 23-3, USNM 23a-1-4, 5, 8, interval 23a-1, EM coll., Keel Formation, Section 23 (Lawrence Quarry), Pontotoc County, Oklahoma; USNM 25-1-1, 3-5, interval 25-1, EMM coll., Keel Formation, Section 25 (Hunton), Coal County, Oklahoma.

Occurrences.—Uppermost Ordovician (Gamachian): Leemon Formation, southeastern Missouri and southern Illinois; Keel Formation including

Ideal Quarry Member, south-central Oklahoma. Uppermost Ordovician (Gamachian) to lowermost Silurian (lower lower Llandovery): Schweizer Member, Wilhelmi Formation, northeastern Illinois; Cyrene Formation, northeastern Missouri. Lowermost Silurian (lower lower Llandovery): Birds Member, Wilhelmi Formation, northeastern Illinois; Bryant Knob Formation including unnamed member and Kissenger Limestone Member, northeastern Missouri.

Diagnosis.—Solitary, generally ceratoid. In early stages, major septa generally moderately to greatly dilated and extend to axis, where distal ends join. During intermediate to late stages, septal length and dilation decrease, axial region opens. Cardinal septum commonly conspicuous in late stages. Cardinal fossula usually inconspicuous, but can be very broad or distinctively shaped. Minor septa typically extend a short distance beyond relatively narrow stereozone. Tabulae generally moderately to widely spaced, commonly depressed in cardinal fossula.

Description of corals.—The largest specimen is 102 mm long and 44 mm in diameter at the calice rim (USNM 18-4-1). Growth form is trochoid (Pl. 1, fig. 5) to ceratoid (Pl. 1, fig. 1) to rarely subcylindrical, and coralla vary from straight to moderately curved (Pl. 1, fig. 13) to gradually curved through 90 degrees (Table 2). Several corals have slight to moderate bends in two different directions. A few individuals have single right angle bends (Pl. 2, fig. 13), but none have more than one such bend. Corallum shape in cross section is generally circular, but a few are elliptical. Well-preserved specimens show prominent septal grooves and interseptal ridges, plus growth lines. Coarse rugae are present on some

Table 2.—Growth form and curvature for specimens of Streptelasma subregulare, S. amsdeni, S. leemonense (including S. sp. cf. S. leemonense), and Keelophyllum oklahomense. Data from Appendix 1.

Section	Growth form			Curvature		
	Trochoid	Ceratoid	Cylindrical	Non-curved ¹	Moderately curved ²	Greatly curved ³
<u>Streptelasma subregulare</u>						
3 + Belvidere	8 (100%)	0 (0%)	0 (0%)	3 (38%)	5 (63%)	0 (0%)
4 + Channahon	15 (56%)	12 (44%)	0 (0%)	6 (22%)	20 (74%)	1 (4%)
13 + Cyrene						
+ Edgewood	4(100%)	0 (0%)	0 (0%)	3 (75%)	1 (25%)	0 (0%)
14	4 (18%)	18 (82%)	0 (0%)	3 (17%)	14 (78%)	1 (6%)
15	9 (75%)	3 (25%)	0 (0%)	7 (58%)	5 (42%)	0 (0%)
16	8 (20%)	33 (80%)	0 (0%)	20 (50%)	17 (43%)	3 (8%)
17	6 (18%)	26 (79%)	1 (3%)	13 (43%)	14 (47%)	3 (10%)
18-1, 2	4 (36%)	7 (64%)	0 (0%)	3 (27%)	7 (64%)	1 (9%)
18-3, 4	6 (50%)	6 (50%)	0 (0%)	5 (42%)	7 (58%)	0 (0%)
19	26 (29%)	60 (67%)	3 (3%)	42 (48%)	41 (47%)	5 (6%)
20	19 (76%)	6 (24%)	0 (0%)	6 (26%)	15 (65%)	2 (9%)
21	4 (80%)	1 (20%)	0 (0%)	2 (40%)	3 (60%)	0 (0%)
23	44 (80%)	11 (20%)	0 (0%)	26 (47%)	26 (47%)	3 (5%)
25	3 (100%)	0 (0%)	0 (0%)	2 (67%)	1 (33%)	0 (0%)
<u>Streptelasma amsdeni</u>						
24	0 (0%)	25 (53%)	22 (47%)	22 (48%)	23 (50%)	1 (2%)
<u>Streptelasma leemonense</u>						
14 + 15 + 20						
+ 23 + Gale	9 (43%)	10 (48%)	2 (10%)	8 (38%)	13 (62%)	0 (0%)
<u>Keelophyllum oklahomense</u>						
23 + 25	1 (20%)	4 (80%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)

¹Non-curved = 0° to 10° curvature of growth axis.

²Moderately curved = 11° to 70° curvature of growth axis.

³Greatly curved = >70° curvature of growth axis.

individuals. Rejuvenations, if present on a coral, are few in number and not pronounced. On the convex cardinal side at the apex, two specimens have small grooves (USNM 23a-1-8, 23-2a-1). These are interpreted as attachment structures. Depth of the calice is commonly about 50 percent of the coral length, but varies from 30 percent to perhaps as much as 90 percent in several individuals that have unusually short major septa throughout ontogeny (USNM 19-1-2, 19-1-5, 19-2-7, 19-2-16, 19-3-34).

Ontogeny and internal structures.—The relationship between number of septa and coral diameter is shown in Text-fig. 15 and Table 3. During early ontogenetic stages (Pl. 1, figs. 2, 9, 14, 20, 23, Pl. 2, figs. 3, 10, 19, Pl. 3, fig. 1) major septa generally extend to or near the axis, where their distal ends meet in small groups. Septa are shorter in some specimens, but only rarely extend less than half the coral radius. During intermediate (Pl. 1, figs. 3, 4, 6, 7, 10, 11, 15, 21, 24, Pl. 2, figs. 4, 5, 11, 14, 16, 20, 21, Pl. 3, figs. 2, 4-9) and late stages (Pl. 1, figs. 8, 12, 16, 17, 22, 25, Pl. 2, figs. 6, 12, 15, 17, 18, 22, Pl. 3, figs. 3, 10), the septa usually decrease in length gradually (Text-fig. 16, Table 3). However, they remain long in some corals, and rapidly decrease in length in others. Septa are relatively straight to wavy in cross sections. A few septal lobes are present in some individuals (Pl. 2, figs. 12, 21), but paliform septal lamellae are rare (Pl. 3, fig. 8).

Major septa can be nondilated to completely dilated in any ontogenetic stage. Typically, the degree of dilation is moderate to

Text-figure 15.—Relationship between number of major septa and coral diameter in Streptelasma subregulare. Numbers beside data points indicate frequencies greater than one. Arbitrary line was used to derive proportions shown in part of Table 3. Data from Appendix 2.

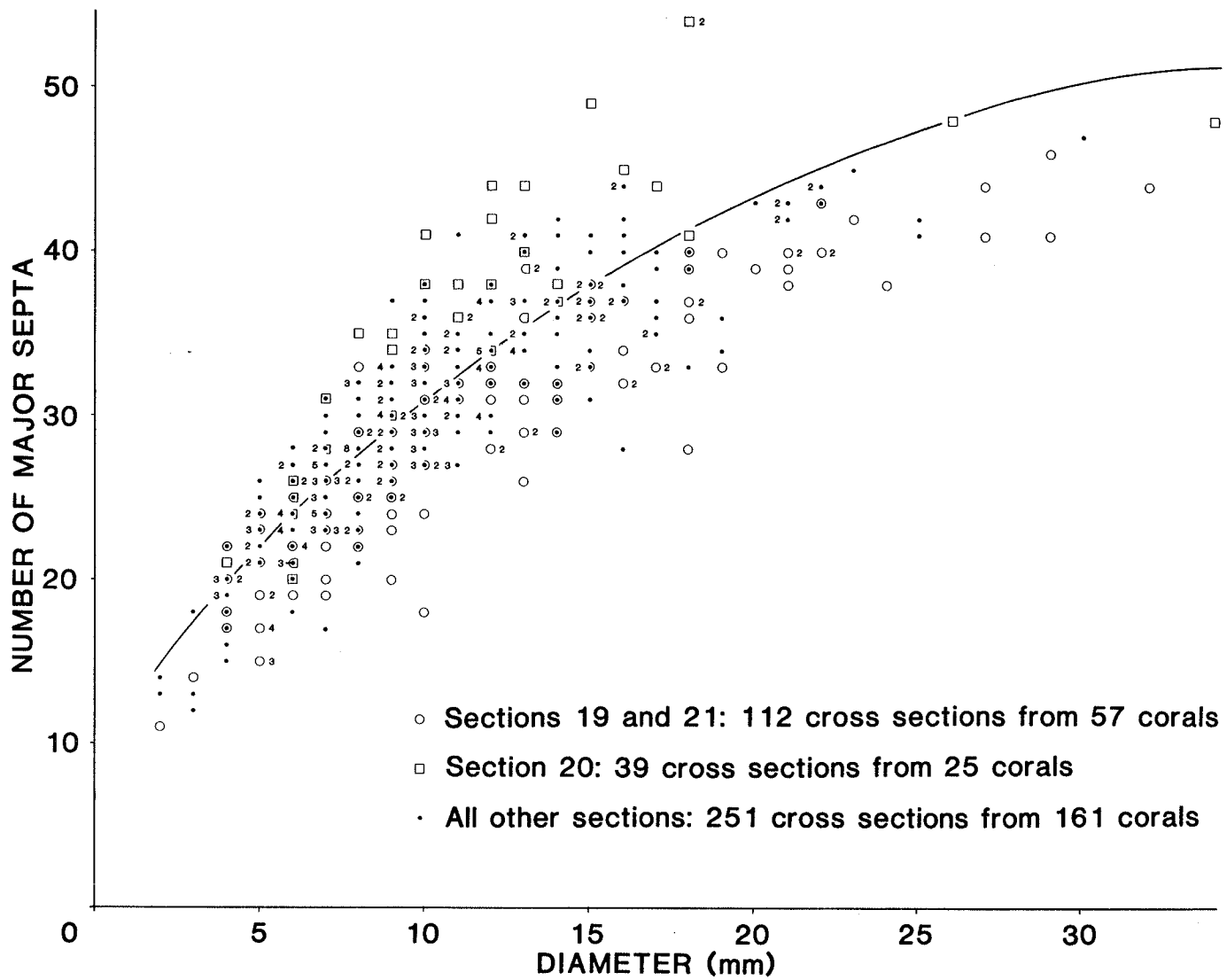
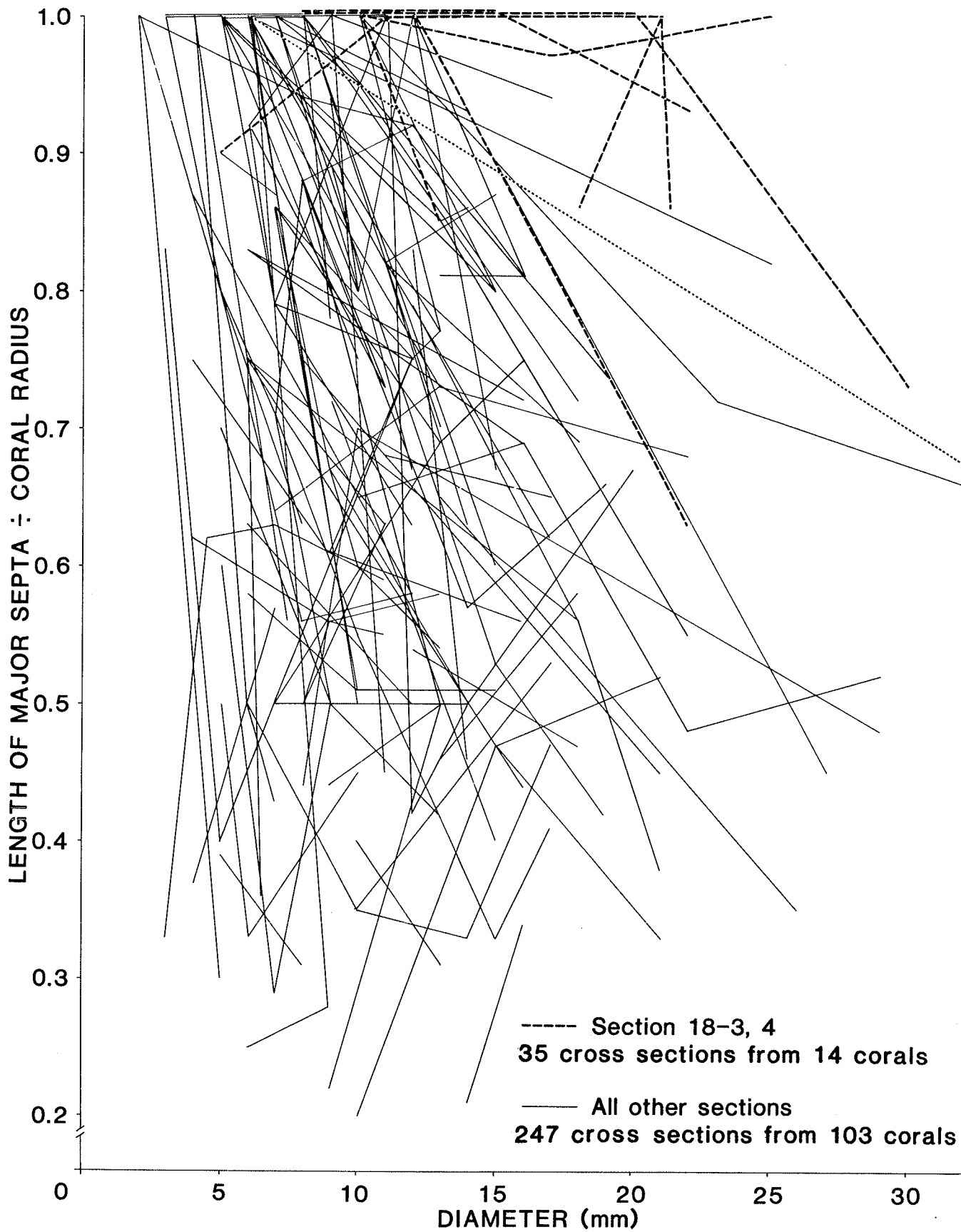


Table 3.—Proportions of data points above (A), or on and below (B), arbitrary lines drawn in Text-figures 15-18, 20-23, for characteristics of major septa and cardinal fossula in *Streptelasma subregulare* and *S. amsdeni*.

Section	Number of septa		Length of septa		Thickness of septa		Width of fossula	
	A	B	A	B	A	B	A	B
<u><i>Streptelasma subregulare</i></u>								
3	3 (43%)	4 (57%)	1 (11%)	8 (89%)	4 (44%)	5 (56%)	0 (0%)	5 (100%)
4	5 (45%)	6 (55%)	1 (14%)	6 (86%)	3 (33%)	6 (67%)	1 (11%)	8 (89%)
13	3 (43%)	4 (57%)	0 (0%)	7 (100%)	2 (29%)	5 (71%)	0 (0%)	6 (100%)
14	7 (29%)	17 (71%)	5 (27%)	25 (83%)	21 (72%)	8 (28%)	2 (8%)	23 (92%)
15	3 (23%)	10 (77%)	3 (23%)	10 (77%)	6 (46%)	7 (54%)	0 (0%)	13 (100%)
16	12 (33%)	24 (67%)	9 (20%)	36 (80%)	27 (61%)	17 (39%)	2 (5%)	38 (95%)
17	29 (59%)	20 (41%)	6 (11%)	47 (89%)	27 (51%)	26 (49%)	2 (4%)	52 (96%)
18-1	5 (36%)	9 (64%)	1 (7%)	13 (93%)	10 (71%)	4 (29%)	9 (69%)	4 (31%)
18-2	6 (38%)	10 (63%)	1 (6%)	15 (94%)	10 (63%)	6 (38%)	5 (36%)	9 (64%)
18-3, 4	9 (32%)	19 (68%)	20 (69%)	9 (31%)	20 (69%)	9 (31%)	7 (26%)	20 (74%)
19	8 (9%)	79 (91%)	5 (5%)	89 (95%)	11 (12%)	81 (88%)	31 (38%)	51 (62%)
20	30 (77%)	9 (23%)	8 (20%)	33 (80%)	9 (22%)	32 (78%)	1 (3%)	34 (97%)
21	3 (12%)	22 (88%)	1 (4%)	24 (96%)	12 (48%)	13 (52%)	0 (0%)	25 (100%)
23	8 (29%)	35 (81%)	13 (25%)	40 (75%)	23 (45%)	28 (55%)	1 (2%)	40 (98%)
25	0 (0%)	3 (100%)	0 (0%)	2 (100%)	1 (50%)	1 (50%)	0 (0%)	1 (100%)
<u><i>Streptelasma amsdeni</i></u>								
24	2 (4%)	51 (96%)	4 (8%)	48 (92%)	0 (0%)	51 (100%)	8 (18%)	37 (82%)

Text-figure 16.—Relationship between length of major septa and coral diameter in Streptelasma subregulare, for specimens yielding more than one transverse thin section. The length of a typical septum was measured and divided by the coral radius, yielding a ration between 0.0 and 1.0. Arbitrary line (dotted) was used to derive proportions shown in part of Table 3. Data from Appendix 2.



great in early stages and decreases during ontogeny. The actual thickness of septa generally increases in early to intermediate stages, and then decreases (Text-fig. 17, Table 3). However, in some corals the septa decrease in thickness throughout ontogeny, and in others their thickness remains about the same.

The cardinal septum is most commonly inconspicuous, being the same length and thickness as other major septa (Table 4). However, it can be distinct if it is relatively short or long, and thin or thick. Prominence of this septum varies among corals, and can vary in different stages within individuals. In many specimens, the cardinal septum becomes relatively short and thin in late stages near the base of the calice. In early to intermediate stages of a few individuals, the cardinal and counter septa are longer than other major septa (Pl. 1, fig. 7). The cardinal fossula is usually inconspicuous, having the same width and shape as other pairs of interseptal spaces. However, it becomes very broad in some corals (Text-fig. 18, Table 3). Five basic intergradational shapes are recognized in cross sections, as follows: (1) width decreases from periphery toward coral axis, (2) width constant, (3) width increases toward axis, (4) biconvex with maximum width midway between periphery and axial end, (5) hourglass-shaped with constriction midway between periphery and axial end (Table 5). Shapes (3) to (5) can be especially distinctive.

In ontogenetic stages where major septa are nondilated to slightly dilated, minor septa extend a short distance beyond the stereozone. In a few individuals, the minor septa immediately adjacent to the counter septum are anomalous in being longer than the

Text-figure 17.—Relationship between thickness of major septa and coral diameter in Streptelasma subregulare, for specimens yielding more than one transverse thin section. Septal thickness was measured in transverse thin sections halfway between the axial and peripheral ends of a typical septum on the counter side (usually the counter septum). Arbitrary line (dotted) was used to derive proportions shown in part of Table 3. Data from Appendix 2.

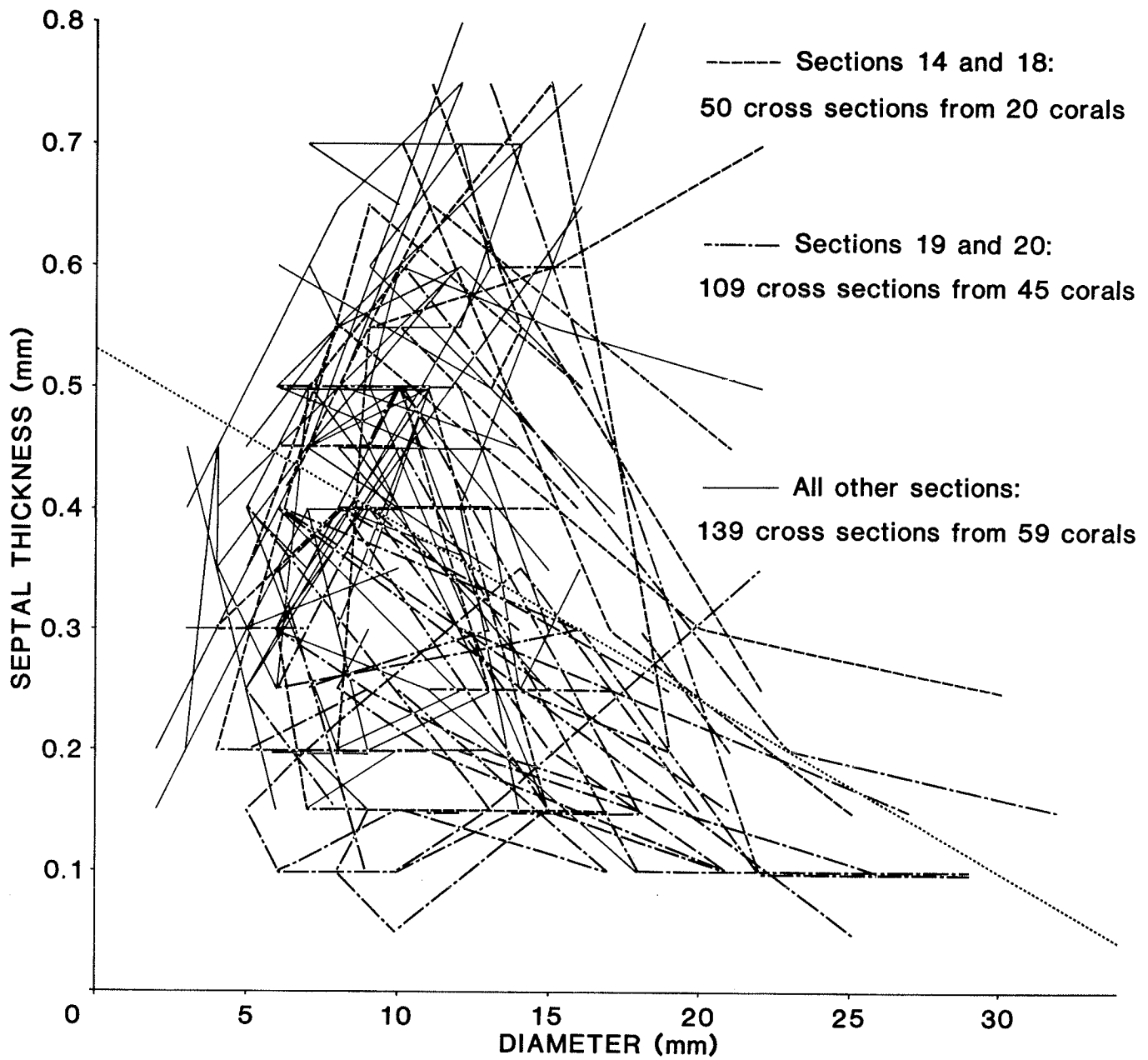


Table 4.—Length and thickness of cardinal septum, compared with other typical major septa, for transverse thin sections of Streptelasma subregulare and S. amsdeni (Section 24). Data from Appendix 2.

Section	<u>Length of cardinal septum</u>			<u>Thickness of cardinal septum</u>		
	Shorter	Same	Longer	Thinner	Same	Thicker
<u>Streptelasma subregulare</u>						
3	0 (0%)	6 (100%)	0 (0%)	1 (17%)	3 (50%)	2 (33%)
4	1 (11%)	3 (33%)	5 (56%)	3 (33%)	5 (56%)	1 (11%)
13	2 (40%)	2 (40%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)
14	3 (12%)	19 (73%)	4 (15%)	6 (23%)	17 (65%)	3 (12%)
15	1 (10%)	8 (80%)	1 (10%)	2 (20%)	7 (70%)	1 (10%)
16	5 (15%)	27 (79%)	2 (6%)	7 (21%)	24 (71%)	3 (9%)
17	8 (16%)	31 (63%)	10 (20%)	18 (37%)	25 (51%)	6 (12%)
18-1, 2	5 (20%)	11 (44%)	9 (36%)	10 (37%)	15 (56%)	2 (7%)
18-3, 4	5 (17%)	19 (66%)	5 (17%)	6 (21%)	20 (69%)	3 (10%)
19	19 (22%)	34 (40%)	32 (38%)	23 (27%)	57 (68%)	4 (5%)
20	4 (10%)	16 (41%)	19 (49%)	9 (23%)	28 (72%)	2 (5%)
21	1 (4%)	8 (35%)	14 (61%)	7 (29%)	10 (42%)	7 (29%)
23	5 (12%)	20 (48%)	17 (40%)	16 (33%)	26 (54%)	6 (13%)
<u>Streptelasma amsdeni</u>						
24	0 (0%)	26 (53%)	23 (47%)	0 (0%)	48 (98%)	1 (2%)

Text-figure 18.—Relationship between width of cardinal fossula and coral diameter in Streptelasma subregulare. Width of cardinal fossula was measured between median lines of septa immediately adjacent to the fossula, midway between axial and peripheral ends of septa bounding the fossula. Numbers beside data points indicate frequencies greater than one. Arbitrary line was used to derive proportions shown in part of Table 3. Data from Appendix 3.

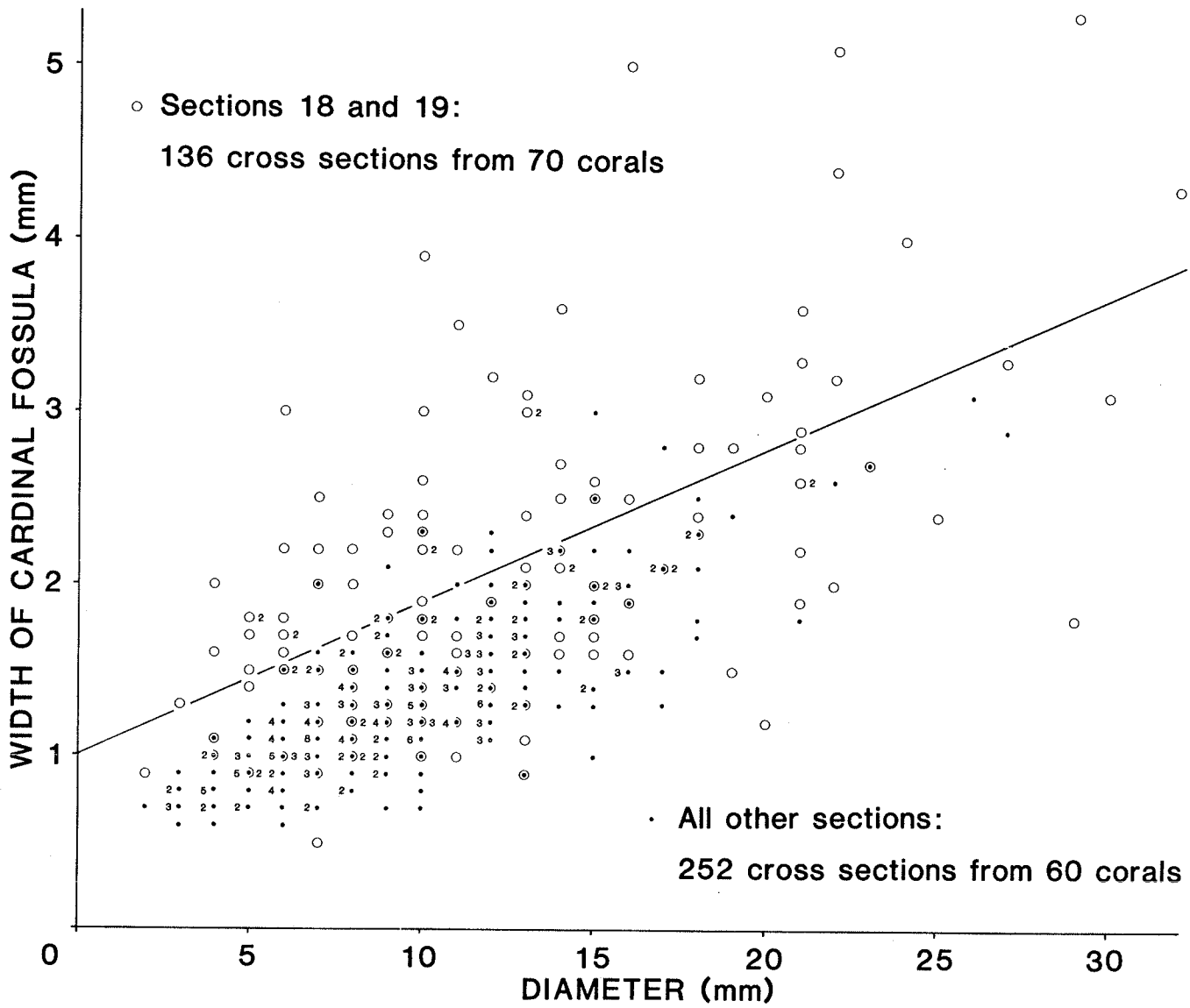


Table 5.—Proportions of each type of cardinal fossula shape for transverse thin sections of Streptelasma subregulare and S. amsdeni. In cases where the shape on either side of a fossula is different, each side was counted as one half. Fossula types are described in SYSTEMATIC PALEONTOLOGY under S. subregulare. Data from Appendix 3.

Section	Fossula shape									
	1		2		3		4		5	
	<u>Streptelasma subregulare</u>									
3	1	(20%)	1	(20%)	3	(60%)	0	(0%)	0	(0%)
4	0	(0%)	1	(11%)	2.5	(28%)	2	(22%)	3.5	(39%)
13	0	(0%)	0.5	(8%)	3	(50%)	1	(17%)	1.5	(8%)
14	6	(24%)	4	(16%)	6.5	(26%)	3	(12%)	5.5	(22%)
15	0	(0%)	4	(31%)	4	(31%)	1	(8%)	4	(31%)
16	24	(56%)	7.5	(17%)	8.5	(20%)	1	(2%)	2	(5%)
17	16	(31%)	20.5	(39%)	7.5	(14%)	5	(10%)	3	(6%)
18-1, 2	2.5	(9%)	7.5	(28%)	6	(22%)	3.5	(13%)	7.5	(28%)
18-3, 4	1.5	(6%)	12	(44%)	7	(26%)	1	(4%)	5.5	(20%)
19	17	(21%)	17.5	(21%)	15.5	(19%)	18.5	(23%)	13.5	(16%)
20	0.5	(1%)	10	(28%)	6	(17%)	12.5	(35%)	7	(19%)
21	1	(4%)	11.5	(46%)	3.5	(14%)	7	(28%)	2	(8%)
23	6	(15%)	15	(37%)	8.5	(21%)	8.5	(21%)	3	(7%)
	<u>Streptelasma amsdeni</u>									
24	19	(42%)	4.5	(10%)	1	(2%)	7.5	(17%)	13	(29%)

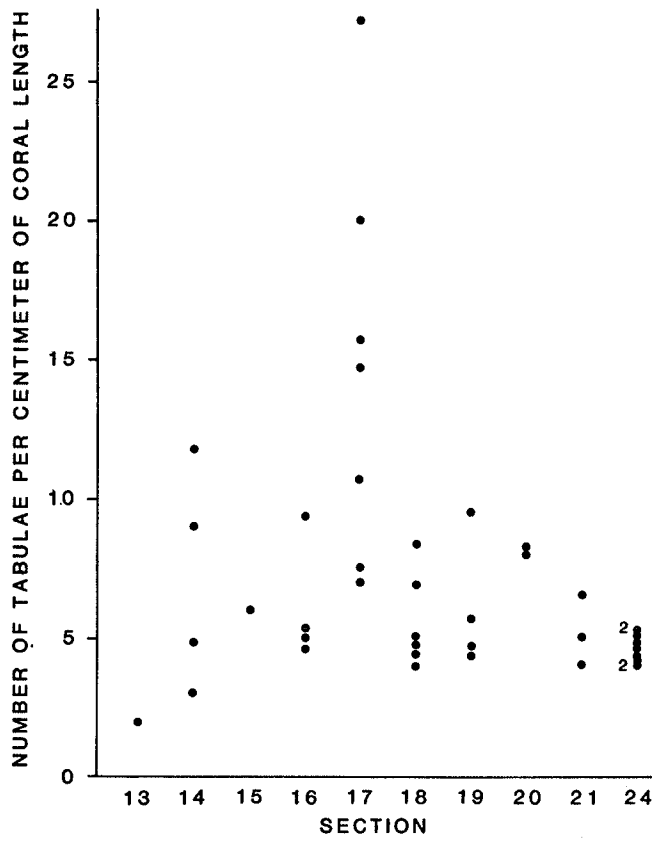
other minor septa, and can be almost as long as the major septa (Pl. 2, figs. 12, 17, 18; Elias, 1982, pl. 4, fig. 13). Thickness of the stereozone ranges from 5 to 15 percent of the coral radius. Specimens with thick septa tend to have thick stereozones.

Tabulae are commonly complete and thin (Pl. 1, figs. 18, 19, 26-28, Pl. 2, figs. 1, 2, 7-9). They are usually convex upward in the septal region, but can be flat or rarely concave upward. In the axial region, they are concave or flat. They are generally moderately to widely spaced, but can be very closely spaced (Text-fig. 19). Tabulae are usually depressed in the cardinal fossula (Pl. 2, figs. 8, 9; Elias, 1982, pl. 4, fig. 7).

Microstructure.—In transverse thin sections, the major septa are fibrous in all ontogenetic stages. However, fibers are difficult to discern if septa are thin. The fibers originate at the median line within the septum, and curve outward in the direction of the coral axis so that their convex sides face axially. Where the major septa are greatly to completely dilated, minor septa appear as triangular wedges between them (e.g., Elias, 1985, fig. 17). Where major septa are nondilated to slightly dilated, U-shaped lamellae with concave sides facing the coral axis form the stereozone between adjacent major and minor septa (e.g., Elias, 1982, pl. 2, fig. 10). A contorted suture extends through the lamellae in a medial position between adjacent septa. The epitheca is composed of short fibers oriented approximately perpendicular to the outer surface of the coral. In longitudinal thin sections, septal fibres are inclined from the periphery of the coral toward the axis at an angle of about 40 degrees.

Discussion.—Savage (1913a) mentioned Zaphrentis subregularis

Text-figure 19.—Number of tabulae (counted along coral axis) per centimeter of coral length in longitudinal thin sections of Streptelasma subregulare (Sections 13 to 21) and S. amsdeni (Section 24). Numbers beside data points indicate frequencies greater than one. Data from Appendix 4.



n. sp. and Z. ambigua n. sp. in his text and tables, but descriptions and illustrations of these species were published later (Savage, 1913b, 1917). Elias (1982, p. 57) established that Z. ambigua is a synonym of Z. subregularis, and assigned the species to Streptelasma.

Zaphrentis channahonensis n. sp. was listed in a table by Savage (1912, pp. 98, 99), but he did not provide a description or illustrations, and the species was not mentioned in subsequent literature. Therefore, this is a nomen nudum. Specimens labelled Z. channahonensis by Savage were examined in this study. They are from the same unit and location as others which he identified as Z. subregularis and Z. ambigua. Thin sections of one prove that it is Streptelasma subregulare (Pl. 1, figs. 2-4).

The continuous spectrum of values for the numerous features measured and compared in this study demonstrates that there are no morphologic discontinuities among specimens in the large collection described above. Those characteristics exhibiting anomalous trends at some localities or in particular stratigraphic intervals always fall within or overlap the range of values for corals from elsewhere. There are no apparent geographic or stratigraphic patterns, or interrelationships among these anomalies (Table 6). It is concluded that S. subregulare is a highly variable species. An important confirmation of this intraspecific variability is the great range of characteristics seen within some individuals.

Solitary corals from the Keel Formation at Section 24 (Coal Creek) generally lie within the range of variability for this taxon, but most of the individual characteristics are atypical (Table 6).

Table 6.—Morphologic characteristics of Streptelasma subregulare (Sections 14-21, 23) and the closely related species S. amsdeni (Section 24) for sections with relatively large sample sizes, based on inspection of coral lengths and data in Tables 2-4 plus Text-figure 19. H = unusually high frequency; T = typical frequency; L = unusually low frequency; - = insufficient data (fewer than 10 data points for comparison, except for "Closely spaced tabulae" where all points were used).

Characteristics	Sections											
	14	15	16	17	18-1,	18-3,	2 and 4	19	20	21	23	24
Long corals	T	T	T	T	T	H	H	H	T	T	H	
Trochoid	L	H	L	L	T	T	T	H	-	H	L	
Cylindrical	T	T	T	T	T	T	T	T	-	T	H	
Straight	L	H	T	T	L	T	T	L	-	T	T	
Greatly curved	T	L	H	H	H	L	T	H	-	T	L	
Numerous septa	T	T	T	T	T	T	L	H	L	T	L	
Long major septa	T	T	T	T	T	H	T	T	T	T	T	
Thin major septa	L	T	T	T	L	L	H	H	T	T	H	
Long cardinal septum	T	T	T	T	T	T	T	H	H	T	H	
Thick cardinal septum	T	T	T	T	T	T	T	T	H	T	T	
Wide cardinal fossula	T	T	T	T	H	H	H	T	T	T	T	
Closely spaced tabulae	T	T	T	H	T	T	T	T	T	-	L	

They comprise a population that is considered to represent a different species, S. amsdeni n. sp.

Some specimens of S. subregulare with moderately dilated septa closely resemble the lectotype of S. corniculum Hall, 1847, from the Trenton Limestone (upper Middle Ordovician) of New York (Neuman, 1969, pp. 10, 11, figs. 5, 6). The number of septa, width of the cardinal fossula, and spacing of tabulae in the latter specimen are about average for S. subregulare. However, the major septa are slightly longer than usual, and the degree of septal dilation is greater on the cardinal side than on the counter side. Further comparison is not possible at this time because the range of variability in S. corniculum is unknown.

Some representatives of S. subregulare with thin, wavy septa are similar to S. affine (Billings, 1865) from the Vauréal Formation (Richmondian) and Ellis Bay Formation (Gamachian) on Anticosti Island, Québec (Bolton, 1981, pl. 3, figs. 3-8; Elias, 1982, pp. 59, 60, pl. 5, figs. 4-18), S. primum (Wedekind, 1927), an Ashgill species found in Stage 5a of Norway, the Boda Limestone of Sweden, and the Pirgu Stage of the Estonian S.S.R. (Neuman, 1969, pp. 11-17, figs. 7a-c, e-h, 8-10; see also Neuman, 1975, pp. 357, 358), and S. unicum Neuman, 1975 from the Dalmanitina Beds (uppermost Ashgill; Hirnantian) or lowermost Llandovery of Sweden (Neuman, 1975, pp. 353, 356-358, figs. 15, 16). However, in S. affine and S. primum the cardinal septum is always indistinct, and a cardinal fossula is never developed. In S. unicum, the cardinal septum becomes short and the fossula is conspicuous in late stages, but early ontogenetic stages and intraspecific variability are unknown. Minor septa are longer in S. affine than

in the other three species.

A few individuals of S. subregulare resemble Helicelasma simplex Neuman, 1969, from the Dalmanitina Beds (uppermost Ordovician; Hirnantian) of Sweden (Neuman, 1969, pp. 29-33, figs. 23-26). In the latter species, major septa are greatly to completely dilated in early stages, and gradually become thinner during ontogeny. A simple axial structure of fused septal tips is formed during the intermediate and late stages. The cardinal septum and fossula are inconspicuous in H. simplex, but are most commonly conspicuous in comparable corals belonging to S. subregulare.

Like some specimens of S. subregulare, Borelasma crassitangens Neuman, 1969 from the Dalmanitina Beds (uppermost Ashgill; Hirnantian) of Sweden has thick major septa that are greatly to completely dilated in early stages and decrease in length during ontogeny (Neuman, 1969, pp. 66-69, figs. 57-59). A diagnostic characteristic of this taxon is the long cardinal and counter septa in early stages, a feature that is rare in S. subregulare. The cardinal septum and fossula are inconspicuous in late stages. Borelasma spp. a and b were reported from Stages 6b and 6c (lower Llandovery; Rhuddanian-Idwian) and Stage 6c (Idwian), respectively, of Norway (Neuman, 1982, pl. 1, figs. 14-19). They are similar to B. crassitangens, but the cardinal septum becomes short and a fossula is developed in late stages.

Specimens of S. subregulare with thick septa that are greatly to completely dilated in early stages, and a few distantly spaced tabulae, resemble Ullernelasma svartoeensis Neuman, 1975 from Stage 5b (uppermost Ashgill; Hirnantian) and Stage 6a (lowermost Llandovery;

Rhuddanian) of Norway (Neuman, 1975, pp. 348, 350-353, figs. 10-13). In the latter species, the cardinal septum is distinct and becomes short in late stages, and the cardinal fossula is conspicuous. Those features are less common in similar individuals of S. subregulare. Neuman noted that a few incomplete tabulae seem to be present in U. svartoeyensis. Tabulae in S. subregulare are complete, but their presence is not always revealed in cross sections because they can be widely spaced and approximately horizontal.

Streptelasma amsdeni n. sp.

Plate 3, figures 11-28; Plate 4, figure 1

Derivation of name.—The specific name honors Thomas W. Amsden of the Oklahoma Geological Survey, who collected some of the specimens described herein.

Holotype.—USNM 24-2-36, interval 24-2, EMM coll.

Paratypes.—USNM 24-1-1, interval 24-1, EMM coll., USNM 365920, OGS-5, 10, 13, interval 24-2, A coll., USNM 24-2-11, 17, 24, 27, 29, interval 24-2, EMM coll.

Additional material.—USNM OGS-1 (slab with 3 specimens), 2, 4, 6-9, 11, 12, 14, interval 24-2, A coll., USNM 24-2-1-10, 12-16, 18-23, 26, 28, 30-35, 37-55, interval 24-2, EMM coll.

Occurrence.—Uppermost Ordovician (Gamachian): lower oölitic and middle laminated calcilitite units (intervals 24-1 and 24-2, respectively) of the Keel Formation, Section 24 (Coal Creek), Pontotoc County, south-central Oklahoma.

Diagnosis.—Solitary, slender ceratoid to cylindrical. Major septa thin, nondilated to slightly dilated and extend to axis in early stages, gradually withdraw from axis during ontogeny. Cardinal septum indistinct to relatively long and conspicuous. Cardinal fossula usually inconspicuous, but can be distinctively shaped. Minor septa typically extend a short distance beyond very narrow stereozone. Tabulae widely spaced.

Description of corals.—The greatest observed length and diameter are 155 mm (USNM OGS-1b, incomplete at both ends; Pl. 4, fig. 1b) and 23 mm (USNM 24-2-55, incomplete calice), respectively. In early ontogenetic stages, the majority of corals are

slender ceratoid in form, with moderate or slight curvature (Pl. 3, fig. 16). The typical adult form is long and cylindrical, but some remain slender ceratoid (Table 2). Specimens are generally relatively straight, but have slight to moderate bends plus several constrictions and rejuvenations (Pl. 4, fig. 1). A few have right angle bends. Periodicity of growth has been observed only in the straight portion of one individual, where six successive constrictions are spaced 6 to 7 mm apart (average 6.8 mm; Pl. 3, fig. 28). Septal grooves and interseptal ridges, plus growth lines, are preserved on all specimens. Attachment structures are not present. Depth of the calice is estimated to be about 20 percent of the coral length in small individuals, and is probably less than 10 percent in adults.

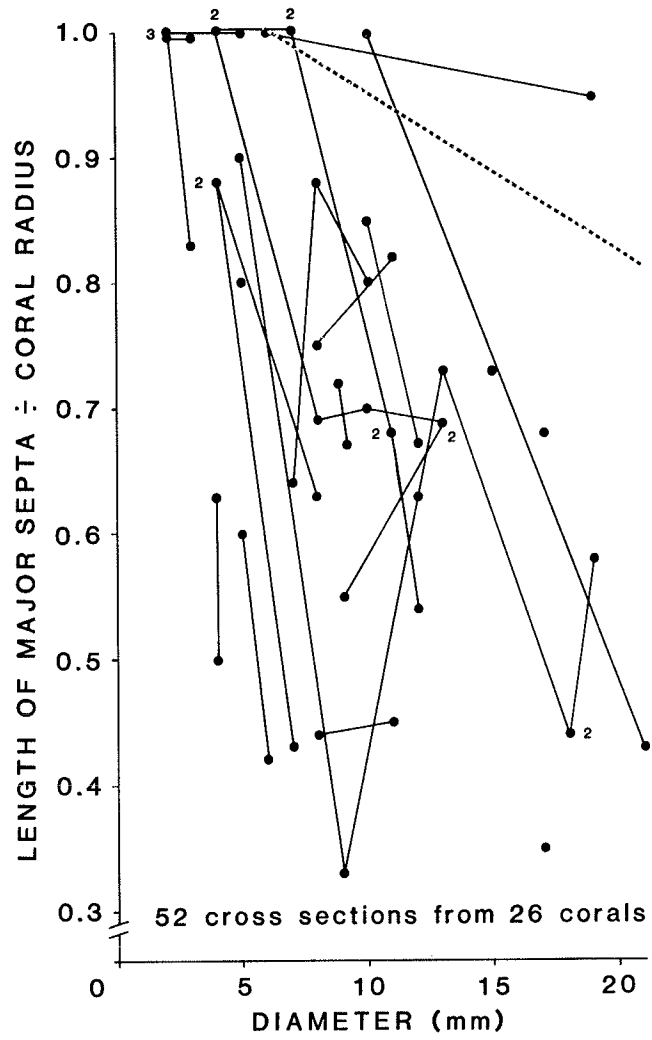
Ontogeny and internal structures.—The relationship between number of septa and coral diameter is shown in Text-fig. 20. In early ontogenetic stages (Pl. 3, figs. 12-15, 20), the major septa extend to or almost to the axis, where they meet. During intermediate stages (Pl. 3, figs. 21, 22, 24, 26, 27), the septa withdraw from the axis, leaving an open axial region. They shorten to half the coral radius or less in late stages (Pl. 3, figs. 23, 25; Text-fig. 21). Major septa are generally straight to slightly curved in early stages, and become wavy by late stages in many individuals. They are thin throughout ontogeny (Text-fig. 22; Pl. 3, fig. 11), but can be slightly dilated in early stages.

Compared with other major septa, the cardinal septum is the same length or longer, and virtually always the same thickness, during all stages (Table 4). The cardinal fossula is about the same width as other pairs of interseptal chambers in most specimens, but is somewhat

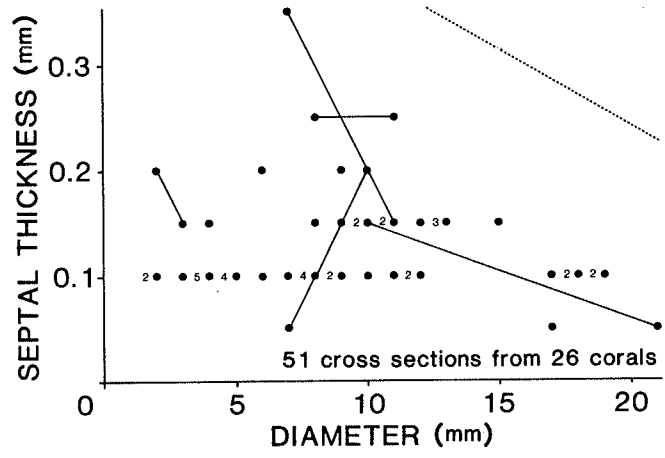
Text-figure 20.—Relationship between number of major septa and coral diameter in Streptelasma amsdeni. Numbers beside data points indicate frequencies greater than one. Arbitrary line (in same position as that for S. subregulare in Text-figure 15) was used to derive proportions shown in part of Table 3. Data from Appendix 2.



Text-figure 21.—Relationship between length of major septa and coral diameter in Streptelasma amsdeni. The length of a typical septum was measured and divided by the coral radius, yielding a ratio between 0.0 and 1.0. Arbitrary line (dotted, in same position as that for S. subregulare in Text-figure 16) was used to derive proportions shown in Table 3. Data from Appendix 2.



Text-figure 22.—Relationship between thickness of major septa and coral diameter in Streptelasma amsdeni. Septal thickness was measured in transverse thin sections halfway between the axial and peripheral ends of a typical septum on the counter side (usually the counter septum). Lines join data points from individual specimens. Numbers beside data points indicate frequencies greater than one. Arbitrary line (dotted, in same position as that for S. subregulare in Text-figure 17) was used to derive proportions shown in part of Table 3. Data from Appendix 2.



wider in intermediate and late stages of a few (Text-fig. 23). Shapes of the fossula are as described for S. subregulare (Table 5). Minor septa generally project a short distance beyond the very narrow stereozone.

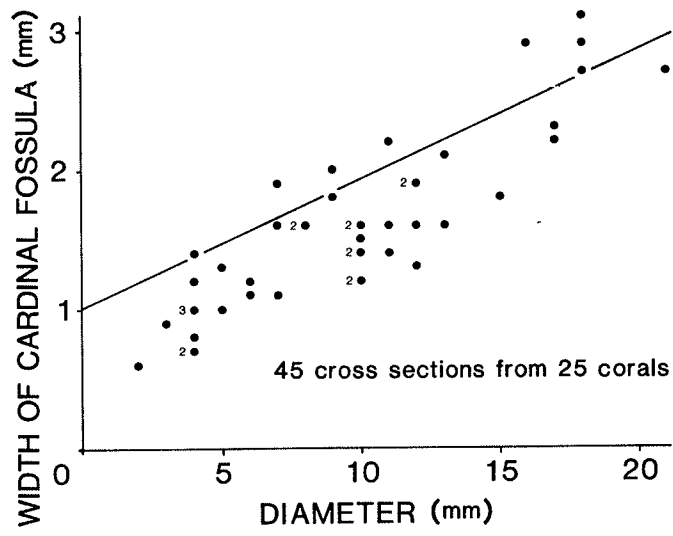
Throughout ontogeny, the tabulae are usually complete, very thin, and relatively widely spaced (Pl. 3, figs. 17-19; Text-fig. 19). They are most commonly convex upward in the septal region, but can be flat. In the axial region, they are flat to concave upward.

Microstructure.—The microstructure in transverse and longitudinal thin sections is the same as described for specimens of S. subregulare having nondilated to slightly dilated septa.

Discussion.—There is relatively little variation among corals in the collection described above. The morphologic characteristics generally lie within the range of variability in S. subregulare (Savage, 1913b), but are not typical of that species (Table 6). The most striking features are the long, cylindrical growth form and thin septa. The corals are considered to comprise a population representing a distinct taxon, Streptelasma amsdeni n. sp., because of these consistent differences. This species was referred to as Streptelasma sp. in previous paleobiologic studies (Elias, 1984a, tables 1, 3-5; 1984b, pp. 535, 536).

S. amsdeni resembles S. primum (Wedekind, 1927) and S. unicum Neuman, 1975, which were discussed under S. subregulare. However, the new species is distinct in having more widely spaced tabulae. The cardinal septum does not become short, as in S. unicum.

Text-figure 23.—Relationship between width of cardinal fossula and coral diameter in Streptelasma amsdeni. Width of cardinal fossula was measured between median lines of septa immediately adjacent to the fossula, midway between axial and peripheral ends of septa bounding the fossula. Numbers beside data points indicate frequencies greater than one. Arbitrary line (in same position as that for S. subregulare in Text-figure 18) was used to derive proportions shown in part of Table 3. Data from Appendix 3.



Streptelasma leemonense Elias, 1982

Plate 4, figures 2-12; Plate 5, figures 1-4

Streptelasma leemonense Elias, 1982, p. 56, pl. 4, figs. 1-3.

Holotype.—UCGM 45614 (Elias, 1982, pl. 4, figs. 1, 2), same interval as 20-3, 20-4, 20-5, E coll., Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, Missouri.

Paratype.—UCGM 45615 (Elias, 1982, pl. 4, fig. 3), same interval as 20-3, 20-4, 20-5, E coll., Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, Missouri.

Additional material.—USNM 14-1-5, 31, 34, interval 14-1, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 14 (Higginbotham Farm), Pike County, Missouri; USNM 15-1-8, 15-1-12, interval 15-1, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 15 (Calumet), Pike County, Missouri; USNM 20-1-10, 20-1-15, interval 20-1, EMM coll., USNM 20-1-19, 20-1-20, interval 20-1, USNM 20-3-1, interval 20-3, USNM 20-4-2, interval 20-4, EM coll., Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, Missouri; UI C1448, S coll., Leemon Formation (labelled Edgewood), Gale Section, Alexander County, Illinois; USNM 23-2-32, 23-2-36, interval 23-2, EMM coll., Ideal Quarry Member, Keel Formation, USNM 23-2a-2, interval 23-2a, EM coll., USNM 23-3-1, 3, 4, 5, 8, 10-13, interval 23-3, EMM coll., USNM 23-3-20, 23, interval 23-3, USNM 23a-1-2, 3, interval 23a-1, EM coll., Keel Formation, Section 23 (Lawrence Quarry), Pontotoc County, Oklahoma.

Occurrences.—Uppermost Ordovician (Gamachian): Leemon Formation, southeastern Missouri and southern Illinois; Keel Formation including

Ideal Quarry Member, south-central Oklahoma. Lowermost Silurian (lower lower Llandovery): Kissenger Limestone Member, Bryant Knob Formation, northeastern Missouri.

Diagnosis.—Solitary or with peripheral offsets, generally ceratoid. Major septa typically thin, extend to or almost to axis throughout ontogeny. Cardinal septum indistinct to relatively long, cardinal fossula usually inconspicuous. Minor septa at least half the length of major septa, commonly contraclined to contratingent, extend beyond narrow to very broad stereozone. Tabulae moderately to closely spaced.

Description of corals.—The greatest observed length and diameter are 55 mm (USNM 23-3-11, incomplete at both ends) and 20 mm (USNM 20-3-1, at base of calice), respectively. Of 12 individuals, six are ceratoid, three are trochoid, and three are cylindrical (Pl. 4, fig. 10). Ten are slightly to moderately curved, and two are straight. Corallum shape in cross section is generally circular, but can be irregular (Pl. 5, fig. 4). The presence of septal grooves and interseptal ridges has been verified in transverse thin sections of specimens enclosed in matrix. The measured depth of the calice is approximately 10 percent of the coral length, but calice rims in those individuals are poorly preserved and may be incomplete.

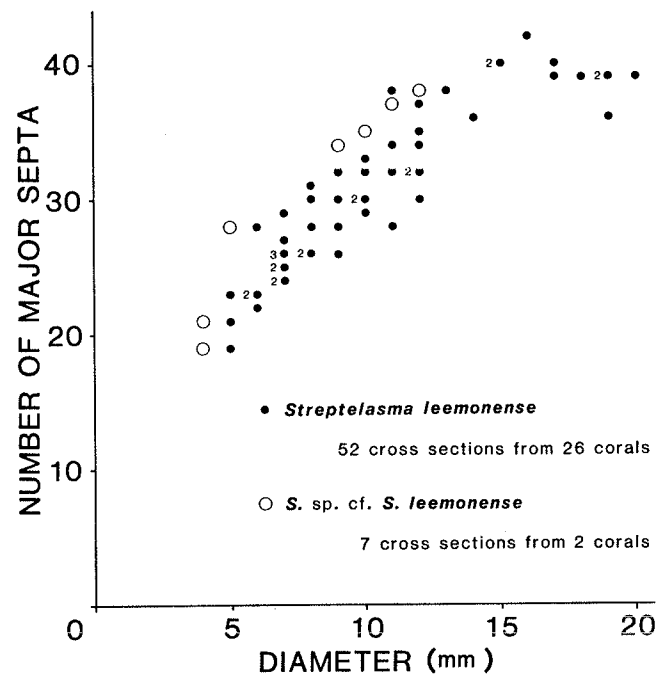
Clusters of up to about 20 individuals were collected at Sections 15, 20, and 23 (USNM 15-1-8, 20-3-1, 23-3-23). Smaller clusters were also found, consisting of at least six coralla at Section 14 and five at Section 20 (USNM 14-1-5, 20-1-20). Enclosure in matrix or poor preservation makes it difficult to establish whether they represent true colonies or pseudocolonies. Evidence from one large cluster and

several other coralla indicates that budding did occur (USNM 20-3-1, 23-2-32, 23-3-3; Pl. 5, figs. 1-4). Definite peripheral offsets are located between the older and younger walls at constrictions, and are initially oriented approximately parallel to the protocorallite. Some diverge outward in later stages. Offsets are found on alar, counter, and cardinal quadrants of the parents with about equal frequency. One specimen has at least seven at the same height, and they are distributed over about 75 percent of the circumference (USNM 23-3-3). The offsets can become quite large. In one cluster, several of the big individuals with numerous offsets began as buds themselves (Pl. 5, figs. 1-4).

Other specimens could represent budding or a gregarious, epizoic habit. In two clusters, several relatively small corals located on only one side of a larger individual are oriented approximately perpendicular to it (USNM 15-1-8, 20-1-20). They may have used an exposed side as a substrate for attachment. In other cases, small corals occur on the exterior of a large individual that lacks constrictions at those sites (e.g., USNM 23-3-5). They are usually oriented at high angles to the growth axis of the host or protocorallite. Peripheral offsets and/or epizoic individuals are present in approximately 25 percent of the specimens studied herein.

Ontogeny and internal structures.—The relationship between number of septa and coral diameter is shown in Text-fig. 24. In early (Pl. 4, figs. 2, 3, Pl. 5, figs. 1, 2), intermediate (Pl. 4, figs. 4, 7, 12, Pl. 5, fig. 3), and late ontogenetic stages (Pl. 4, figs. 5, 8, 9, Pl. 5, fig. 4), the major septa extend to or almost to the axis, where they commonly meet in small groups. A counterclockwise

Text-figure 24.—Relationship between number of major septa and coral diameter in Streptelasma leemonense and S. sp. cf. S. leemonense. Numbers beside data points indicate frequencies greater than one. Data from Appendix 2.



axial whorl is present in some specimens. The septa are usually slightly curved to wavy. They are generally thin, but can be slightly to rarely greatly dilated in early stages.

The cardinal septum is as long as or longer, and in some cases slightly thicker, than the other major septa. The cardinal fossula is usually inconspicuous, having the same width and shape as other pairs of interseptal chambers, but it can be slightly wider or biconvex in cross section. The length of minor septa is generally about 50 percent of the coral radius, but varies from 30 to 70 percent. Minor septa are commonly contraclined to contratingent. They extend beyond the stereozone. The thickness of the stereozone is typically 10 to 20 percent of the coral radius, but can be as great as 40 percent. The stereozone is very thick at sites of rejuvenescence.

Tabulae are generally complete (Pl. 4, figs. 6, 11). In the septal region, they can be relatively flat and approximately horizontal to steeply inclined upward toward the axis, or convex upward. They are flat to concave upward in the axial region. Spacing of tabulae varies from 9.3 (USNM 20-1-10) to 20 per centimeter of coral length (USNM 23-3-11).

Microstructure.—In transverse thin sections, the major septa are fibrous. The fibers are visible in or near the stereozone within thin septa, and along the entire length of relatively thick septa. Fibers originate at the median line within the septum, and extend outward in the direction of the coral axis. They are generally slightly curved, with convex sides facing the axis. In the stereozone, major and minor septa are expanded into lateral contact along a

contorted suture. The epitheca consists of fibers oriented approximately perpendicular to the outer surface of the coral. In longitudinal thin sections, septal fibers are inclined from the periphery of the coral toward the axis at an angle of about 45 degrees.

Discussion.—Streptelasma leemonense Elias, 1982 was previously known only from the holotype and paratype, which are small, incomplete, and lack offsets. The new material documented above provides data on all ontogenetic stages, microstructure, and blastogeny. This species is easily identified by its long, contraclined to contratingent minor septa. The presence of offsets and occurrence in clusters is unique among the taxa described herein. Specimens from Oklahoma that were referred to as S. sp. cf. S. leemonense in a previous paleobiologic study (Elias, 1984b, p. 536) are S. leemonense. Three individuals from the Keel Formation at Section 23 (Lawrence Quarry) resemble S. leemonense, but are anomalous in having very long counter as well as cardinal septa. They are described as S. sp. cf. S. leemonense in this paper.

S. leemonense resembles S. etnaense Elias in Elias and Potter, 1984 from an Upper Ordovician (Ashgill) limestone in the Horseshoe Gulch unit, eastern Klamath Mountains, California (Elias and Potter, 1984, pp. 1207, 1209, fig. 2a-g), S. eccentricum Neuman, 1969 from Stage 5a (Ashgill) of Norway (Neuman, 1969, pp. 25-28, figs. 20, 21), and S. ostrogothicum Neuman, 1969 from the Dalmanitina Beds (uppermost Ashgill; Hirnantian) of Sweden (Neuman, 1969, pp. 21-23, figs. 13, 14). All have relatively long minor septa, thin major septa that commonly meet in groups axially and can form an axial whorl, a cardinal septum that is indistinct to long, and a typically inconspicuous cardinal

fossula. However, tabulae are convex upward in S. etnaense and S. eccentricum, offsets are intracalicular in S. etnaense and S. ostrogothicum and lacking in S. eccentricum, septal lobes form a very small axial structure in S. etnaense, and in S. eccentricum the axis is displaced toward the counter side during late stages and the stereozone is very thin. The minor septa can be longer in S. leemonense than in the other three species.

Streptelasma sp. cf. S. leemonense Elias, 1982

Plate 4, figures 13-17

[cf.] Streptelasma leemonense Elias, 1982, p. 56, pl. 4, figs. 1-3.

Material.—USNM 23-2a-4, interval 23-2a, USNM 23-3-22, interval 23-3, USNM 23a-1-7, interval 23a-1, EM coll.

Occurrence.—Uppermost Ordovician (Gamachian): Keel Formation, Section 23 (Lawrence Quarry), Pontotoc County, south-central Oklahoma.

Description of corals.—The greatest length and diameter are estimated to be 30 mm and 22 mm, respectively (USNM 23a-1-7, incomplete apex and calice rim). The growth form is slender ceratoid and slightly curved (USNM 23-3-22), to questionably trochoid (USNM 23a-1-7). Septal grooves and interseptal ridges are present (USNM 23-2a-4).

Ontogeny and internal structures.—The relationship between number of septa and coral diameter is shown in Text-fig. 24. The major septa extend to or near the axis in early (Pl. 4, fig. 13) to intermediate stages (Pl. 4, fig. 15), where some of them meet in pairs or small groups. All except the cardinal and counter septa withdraw from the axis during late stages (Pl. 4, figs. 16, 17). The major septa are straight to usually slightly curved. They are nondilated to slightly dilated during early to intermediate stages, and thin in late stages.

The cardinal and counter septa are longer than the other major septa throughout ontogeny. They are joined to form a median lamella during early to intermediate stages, and become disconnected and gradually withdraw from the axis in late stages. Their axial ends

are dilated. The cardinal fossula is inconspicuous. Minor septa are long, but their length is less than half the coral radius. They are seldom contraclined or contratingent. The minor septa extend beyond the stereozone, which has a thickness that is about 10 to 30 percent of the coral radius.

Tabulae are convex upward in the septal region, and flat to concave upward in the axial region (Pl. 4, fig. 14).

Microstructure.—The microstructure in transverse and longitudinal thin sections is the same as described for S. leemonense.

Discussion.—The specimens described above are distinguished by their cardinal and counter septa, which form a median lamella during early to intermediate stages and remain longer than other major septa in late stages. Other characteristics lie within the range of variability in Streptelasma leemonense Elias, 1982, although the number of septa is comparatively high (Text-fig. 24) and the minor septa are relatively short. These three incomplete specimens were found together with S. leemonense, but it is uncertain whether they are atypical corals of that species, or represent a closely related new species that is rare in the Keel Formation at Section 23 (Lawrence Quarry). They are therefore identified as S. sp. cf. S. leemonense.

Streptelasma sp. A

Plate 5, figures 5, 6; Plate 6, figures 1-5

Material.—USNM 15-0-1, 1A, 1C, interval 15-0, EM coll.

Occurrence.—Uppermost Ordovician (Gamachian): Noix Limestone, Section 15 (Calumet), Pike County, northeastern Missouri.

Description of corals.—All three individuals are epizoic, less than 3 mm in diameter, and probably less than 5 mm in length. They are located on what is probably the upper side of a single, horizontally oriented bryozoan (Pl. 5, figs. 5, 6, Pl. 6, figs. 1-5). Two are spaced about 11 mm apart, and the third is situated approximately 20 mm from the others on what is likely the same colony. The corals grew subparallel and then perpendicular to the surface of the bryozoan. They are probably attached by their cardinal sides. The apical part of the attached side is flattened and conforms to the shape of the host, whereas unattached portions are round, with septal grooves and interseptal ridges. The bryozoan colony eventually grew around the sides of the epizoic corals.

Ontogeny and internal structures.—From 12 to 17 major septa are present at diameters of 2 to 3 mm. In early stages they can be as little as 50 percent of the coral radius in length (Pl. 6, fig. 3), or can extend to the axis (Pl. 6, fig. 1). During intermediate to late stages, they meet at the axis in one individual (Pl. 6, figs. 4, 5). In another, a few fine septal lobes at the axis occupy less than 10 percent of the coral diameter (Pl. 5, figs. 5, 6). The third has several coarse septal lobes occupying almost 20 percent of the coral diameter (Pl. 6, fig. 2). The major septa vary from relatively

straight to wavy, and are thin throughout ontogeny.

In one specimen, what may be the cardinal septum is longer than other major septa (USNM 15-0-1A). The cardinal fossula is indistinct. Minor septa, where present, are very short. The thickness of the stereozone varies from less than 5 percent to about 8 percent of the coral radius.

Tabulae are possibly present in the late stage of one individual (Pl. 6, fig. 5), but longitudinal sections could not be prepared for confirmation.

Microstructure.—The microstructure could not be distinguished in transverse thin sections of these small corals having very thin septa and stereozones.

Discussion.—The epizoic habit and morphology of the specimens described above are similar to Streptelasma divaricans (Nicholson, 1875). The latter, highly variable species is known from the Upham Dolomite Member of the Second Value Dolomite (middle Edenian to lowermost Maysvillian), Montoya Group, New Mexico and Texas (Elias, 1985, pp. 37, 38, 40, figs. 14.1-14.12), and the following Richmondian units: Dillsboro Formation, Whitewater Formation, and Rowland, Bardstown, Saluda Dolomite, and Preachersville members of the Drakes Formation, Cincinnati Arch region, Kentucky-Indiana-Ohio; Bay de Noc Member, Stonington Formation, Michigan; Meaford and Kagawong beds, upper member, Georgian Bay Formation, Ontario (Elias, 1982, pp. 53-56, pl. 1, figs. 1-41, pl. 2, figs. 1-16, pl. 3, figs. 1-23; 1983, pp. 9, 10, pl. 2, figs. 16-33). Although corals of S. divaricans are small (Elias, 1982, fig. 14), the individuals from the Noix Limestone are even

smaller. However, it is uncertain whether they are mature because only three are known, and all are probably attached to the same host. S. (?) parasiticum Ulrich in Winchell and Schuchert, 1895, from the upper Middle Ordovician "Trenton limestone" (= Platteville Limestone; Blackriveran) and "Trenton shales" (= Decorah Shale; Rocklandian) of Minnesota, forms pseudocolonies or colonies attached to bryozoans (Winchell and Schuchert, 1895, pp. 89, 90, fig. 6; see Bassler, 1950, pp. 14, 15). The coralla are only several millimeters long, but internal structures are unknown. The specimens described herein are identified as Streptelasma sp. A because of these uncertainties.

Streptelasma sp. of Elias, 1982

Streptelasma sp. Elias, 1982, pp. 56, 57, pl. 4, figs. 4-6.

Material.—UCGM 45616, same interval as 20-3, 20-4, 20-5, E coll.

Occurrence.—Uppermost Ordovician (Gamachian): Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, southeastern Missouri.

Discussion.—Additional material was not found during the present study. This specimen may be Streptelasma subregulare (Savage, 1913b), but cannot be positively identified as that species because it is small and incomplete.

Genus Grewingkia Dybowski, 1873Grewingkia sp. A

Plate 6, figures 6-10

Material.—USNM 14-2-7, interval 14-2, EM coll., Kissenger Limestone Member, Bryant Knob Formation, Section 14 (Higginbotham Farm), Pike County, Missouri; USNM 23-3-34, interval 23-3, EM coll., Keel Formation, Section 23 (Lawrence Quarry), Pontotoc County, Oklahoma.

Occurrences.—Uppermost Ordovician (Gamachian): Keel Formation, south-central Oklahoma. Lowermost Silurian (lower lower Llandovery); Kissenger Limestone Member, Bryant Knob Formation, northeastern Missouri.

Description of corals.—The largest specimen is 25 mm long and 14 mm in diameter (USNM 14-2-7, apex and calice incomplete). Its growth form is trochoid and curved. An attachment structure is located on what is almost certainly a cardinal-alar quadrant (Pl. 6, fig. 7).

Ontogeny and internal structures.—The numbers of major septa at diameters of 5 mm, 7 mm, and 11 mm are 20, 22, and 32, respectively (USNM 14-2-7). In early ontogenetic stages, a few septal lobes are present at the axis (Pl. 6, fig. 6). An axial structure of septal lobes and lamellae develops during intermediate stages (Pl. 6, figs. 7, 8). In late stages, the major septa become relatively short, and the moderately complex axial structure comprising long, curved to contorted septal lobes and lamellae has a radius that is 40 to 50 percent of the coral radius (Pl. 6, figs. 9, 10). The septa are straight to slightly curved and thin to moderately thick in all known

stages.

The cardinal septum and fossula are inconspicuous. In late stages, the length of minor septa is 40 percent of the coral radius. Minor septa extend beyond the stereozone, which has a thickness of 10 to 20 percent of the coral radius.

Several tabulae are apparent in one transverse section (Pl. 6, fig. 10).

Microstructure.—Microstructure is preserved in portions of these silicified specimens. In transverse thin sections, fibers appear to originate at medial positions within major septa, and curve slightly outward in the direction of the coral axis. In the stereozone, major and minor septa are expanded into lateral contact.

Discussion.—Although the specimens documented above are poorly preserved, they clearly differ from the other streptelasmatids described herein in having axial structures of septal lobes and lamellae. In that respect, and in the nature plus arrangement of major septa and length of minor septa, they resemble the single representative of Bodophyllum shorti Elias, 1982, described previously from the Leemon Formation (uppermost Ordovician; Gamachian) at Section 20 (Short Farm) in southeastern Missouri (Elias, 1982, pp. 77, 78, pl. 13, figs. 10-14). However, in the latter taxon the axial structure is solid in early stages, includes a median lamella in intermediate stages and is comparatively small in late stages, and more tabulae are present in transverse sections. In view of these differences and the limited amount of data, the two specimens described herein are identified as Grewingkia sp. A.

The nature plus arrangement of major septa and length of minor

septa in Grewingkia sp. A are similar to the following species: G. penobscotensis Elias, 1982 from Upper Ordovician (Ashgill) strata within an unnamed formation in Penobscot County, Maine (Elias, 1982, pp. 72, 73, pl. 12, figs. 1-6), and within the Horseshoe Gulch unit in the eastern Klamath Mountains of California (Elias and Potter, 1984, pp. 1209, 1210, fig. 2h-1); G. anguinea (Scheffen, 1933) from Stage 5a (Ashgill) in Norway (Neuman, 1969, pp. 48-50, figs. 39-41); G. contexta Neuman, 1969 from the Boda Limestone (Ashgill) of Sweden (Neuman, 1969, pp. 43, 45-48, figs. 34-38); and G. cuneata McLean, 1977 from the Cape Schuchert Formation (upper Llandovery) of northwestern Greenland (McLean, 1977, pp. 11, 12, pl. 1, figs. 8, 10, 12). However, in late stages the axial structure is simpler with fewer lamellae in G. penobscotensis, septal lamellae are typically shorter in G. anguinea, lamellae are more numerous and the axial structure is more complex in G. contexta, and in G. cuneata many fine lamellae are concentrated at the periphery of the axial structure, and only a few coarse lamellae are present at the axis.

Subfamily DALMANOPHYLLINAE Lecompte, 1952

Genus Bodophyllum Neuman, 1969

Bodophyllum shorti Elias, 1982

Bodophyllum shorti Elias, 1982, pp. 77, 78, pl. 13, figs. 10-14.

Holotype.—UCGM 45613, same interval as 20-3, 20-4, 20-5, E coll.

Occurrence.—Uppermost Ordovician (Gamachian): Leemon Formation, Section 20 (Short Farm), Cape Girardeau County, southeastern Missouri.

Discussion.—Additional material was not found during the present study. This specimen was originally assigned to Bodophyllum because it has a solid axial structure in early stages, and a prominent dilated median septal lamella in intermediate stages (Elias, 1982, p. 78). However, it was noted that, unlike B. shorti, other species of the genus have a dense to solid axial structure in late stages as well. It is possible that this coral represents a genus in the Subfamily Streptelasmatinae. The similarity to Grewingkia sp. A was discussed under the latter taxon.

Suborder MONACANTHINA Neuman, 1984

Family LAMBELASMATIDAE Weyer, 1973

Subfamily COELOSTYLINAE Weyer, 1973

Genus Keelophyllum n. gen.

Derivation of name.—The generic name refers to the landowner after whom the Keel Formation was named by Maxwell (1936, p. 50).

Type and only species.—Keelophyllum oklahomense n. sp., Keel Formation (uppermost Ordovician; Gamachian), south-central Oklahoma.

Diagnosis.—Solitary, ceratoid to trochoid, cardinal side convex. Septa monacanthine, imperforate, radially arranged. Minor septa very long. Axial structure of moderate size and complexity. Tabulae numerous.

Discussion.—Keelophyllum n. gen. is included in the Suborder Monacanthina Neuman, 1984 because of its monacanthine microstructure. Placement within the Family Lambelasmataidae Weyer, 1973 is justified by the ceratoid to trochoid growth form, and lack of dissepiments (refer to Neuman, 1984, p. 125; Elias, in press). This family was originally intended to include corals with porous septa (Weyer, 1973, p. 33). However, the presence of perforations requires verification in most of the included genera (see Hill, 1981, pp. 183-185).

Keelophyllum may be related to the Neotryplasmataidae Elias, in press. Its septal arrangement, axial structure, and long minor septa are similar to Neotryplasma Kaljo, 1957, but it differs in having imperforate septa and lacking dissepiments. Neotryplasma is known from the upper Middle and Upper Ordovician of the U.S.S.R., and the Upper Ordovician of the Estonian S.S.R. and Texas.

The subfamilies of Lambelasmataidae were reviewed by Neuman (1984, p. 125). Keelophyllum is placed within the Coelostylinae Weyer, 1973 because of its long, radially arranged septa, convex cardinal side, and tabulae. The very long minor septa in Keelophyllum distinguish it from all other members of the subfamily. The only other coelostylins with axial structures are Coelostylis Lindström in Angelin and Lindström, 1880 from the Middle Ordovician of Scandinavia, and Rectigrewingkia Kaljo, 1961 from the Upper Ordovician of the Estonian S.S.R. Keelophyllum differs from them in having well developed tabulae.

Keelophyllum oklahomense n. sp.

Plate 7, figures 1-16

Derivation of name.—The specific name refers to the state in which the specimens were found.

Holotype.—USNM 23-3-33, interval 23-3, EM coll., Section 23 (Lawrence Quarry), Pontotoc County, Oklahoma.

Paratypes.—USNM 23-3-2, interval 23-3, EMM coll., USNM 23-3-19, 23-3-30, interval 23-3, USNM 23a-1-1, EM coll., Section 23 (Lawrence Quarry), Pontotoc County, Oklahoma; USNM 25-1-2, interval 25-1, EMM coll., Section 25 (Hunton), Coal County, Oklahoma.

Occurrence.—Uppermost Ordovician (Gamachian): Keel Formation, south-central Oklahoma.

Diagnosis.—Septa nondilated, taper axially, some with small, irregular carinae; in lateral contact at periphery to form moderately thick stereozone. Cardinal septum and fossula inconspicuous. Minor septa more than two-thirds the length of major septa. Axial structure in late stages consists of septal lobes plus numerous paliform to long and contorted septal lamellae that can be thickened by sclerenchyme; occupies about one third of coral radius. Tabulae convex upward in septal region, generally with upturned peripheral edges; slightly concave to greatly convex upward in axial region.

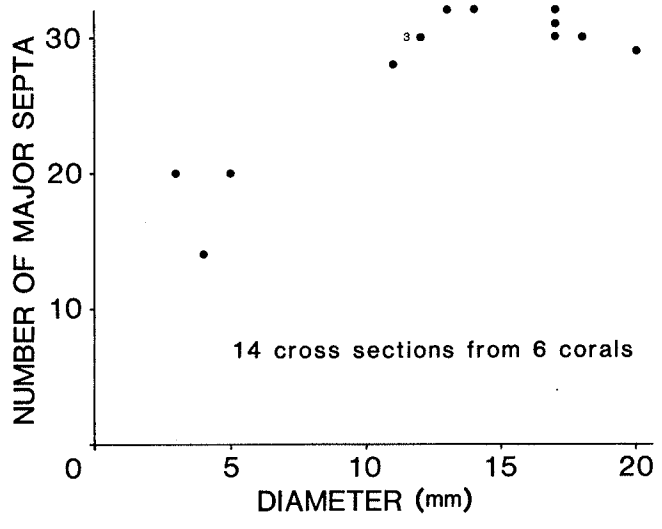
Description of corals.—The greatest observed length and diameter are 50 mm and 21 mm, respectively (USNM 23-3-2, apex and calice incomplete). The corals are generally trochoid (USNM 23-3-33, 33-3-30, 2 individuals in 23a-1-1; Pl. 7, fig. 7) and curved (USNM 23-3-2, 23a-1-1), but can be ceratoid (USNM 23-3-2, 23-3-19, 25-1-2;

Pl. 7, fig. 4) and possibly straight (USNM 25-1-2). Septal grooves, interseptal ridges, and rugae are preserved on most specimens. One corallum that is epizoic on a halysitid colonial coral has two small individuals attached to itself (Pl. 7, figs. 1-3). They are probably also epizoans, because there is no evidence to suggest an origin as offsets. Attachment by the cardinal side can be confirmed in the large coral and in the uppermost epizoan. Another specimen has a sharp bend and possibly an attachment structure at the apex (Pl. 7, fig. 7). Depth of the calice could not be established accurately, but is likely less than 30 percent of the coral length. A low calicular boss is formed by elements comprising the axial structure.

Ontogeny and internal structures.—The relationship between number of septa and coral diameter is shown in Text-fig. 25. In early (Pl. 7, figs. 1, 11) to early intermediate ontogenetic stages (Pl. 7, figs. 2, 12), the major septa extend to or almost to the axis, where they meet in groups that are commonly enclosed in sclerenchyme. During late intermediate (Pl. 7, figs. 5, 14) to late stages (Pl. 7, figs. 3, 6, 13, 15), the major septa withdraw from the axis, and an axial structure develops. It comprises septal lobes plus numerous paliform to long and contorted septal lamellae that can be thickened by sclerenchyme, and occupies about 30 percent of the coral radius in late stages. The major septa are curved and somewhat irregularly oriented in early stages, but become straight and radially arranged in later stages. They are nondilated throughout ontogeny, but are thick in the stereozone and taper axially. Small, irregular carinae can be present.

The cardinal septum is indistinct, but is slightly thicker than

Text-figure 25.—Relationship between number of major septa and coral diameter in Keelophyllum oklahomense. Numbers beside data points indicate frequencies greater than one. Data from Appendix 2.



the other major septa in one individual (USNM 25-1-2). The cardinal fossula is inconspicuous. Minor septa are about two-thirds as long as the major septa in early stages, and can be contraclined to contratingent. By late stages, they can extend to 95 percent of the length of major septa; very few are contraclined, and none are contratingent. The minor septa extend beyond the stereozone. Thickness of the stereozone decreases during ontogeny, from 25 percent of the coral radius in early stages to 15 percent in late stages.

The complete and incomplete tabulae are convex upward in the septal region, and commonly have upturned peripheral edges (Pl. 7, figs. 4, 8-10). In the axial region, they are slightly concave upward to greatly convex upward. The close spacing of tabulae within the cardinal fossula in one transverse section suggests that they are depressed within that structure (Pl. 7, fig. 14).

Microstructure.—It is established from transverse and longitudinal thin sections that the septa are monacanthine and imperforate. Monacanthi are inclined from the periphery of the coral toward the axis at an angle of about 40 degrees, and the edges of septa can be acanthine (Pl. 7, fig. 4). In the stereozone, adjacent septa are expanded into lateral contact along a contorted suture (Pl. 7, fig. 16).

Discussion.—The monacanthine, radially arranged septa of Keelophyllum oklahomense n. sp. are unique among the species described herein. The relationship to other taxa was discussed under the genus.

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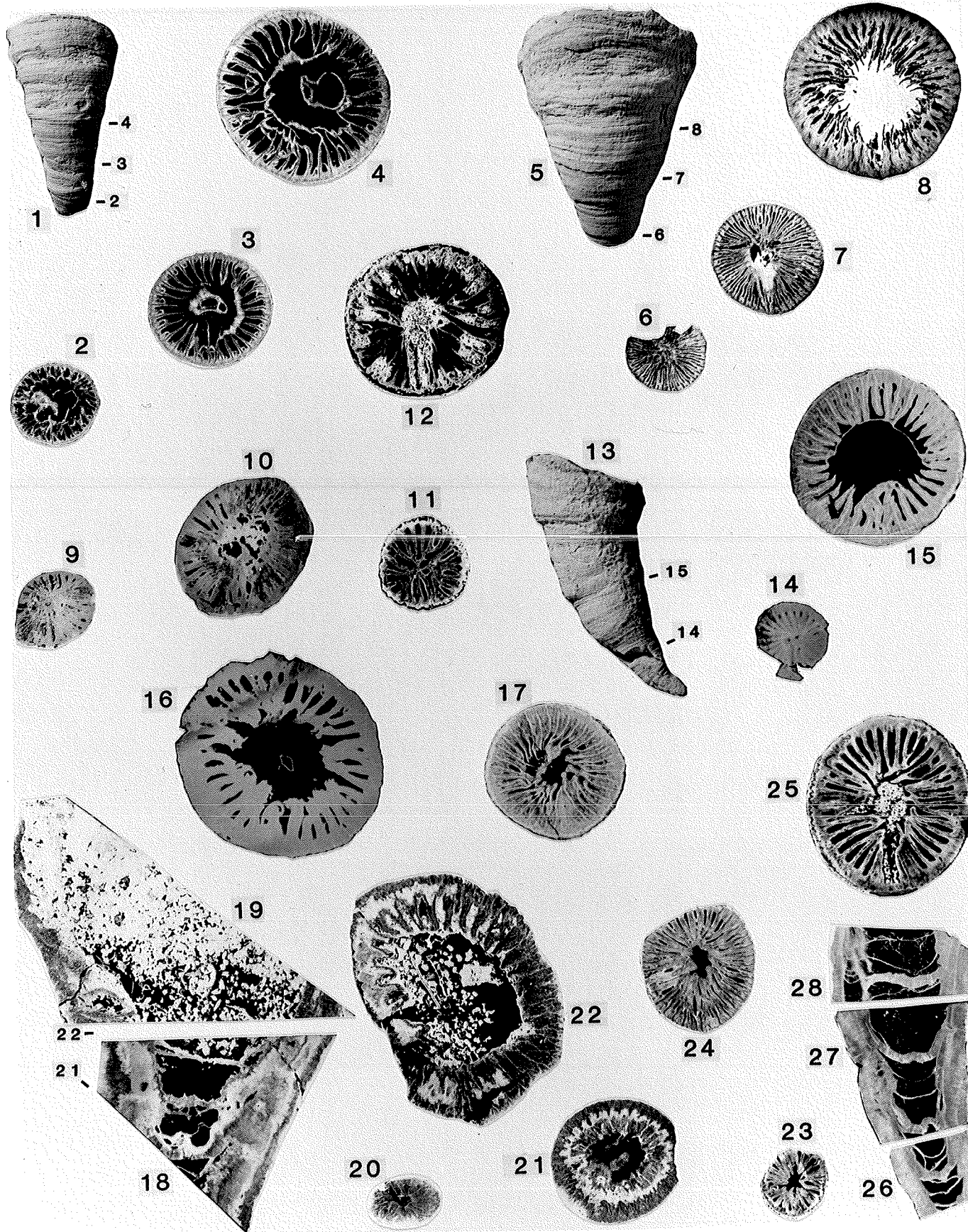
PLATES

Exterior views are of specimens coated with ammonium chloride. Transverse and longitudinal sections (except photomicrograph) were prepared using thin sections as negatives in a photographic enlarger. Transverse sections are oriented as they appear looking down from the calice towards the apex of the coral, with the cardinal side facing the bottom of the page, unless otherwise noted. Longitudinal sections are oriented with the calical end facing the top of the page. Dashes with figure numbers beside exterior views and longitudinal sections indicate position of transverse sections.

EXPLANATION OF PLATE 1

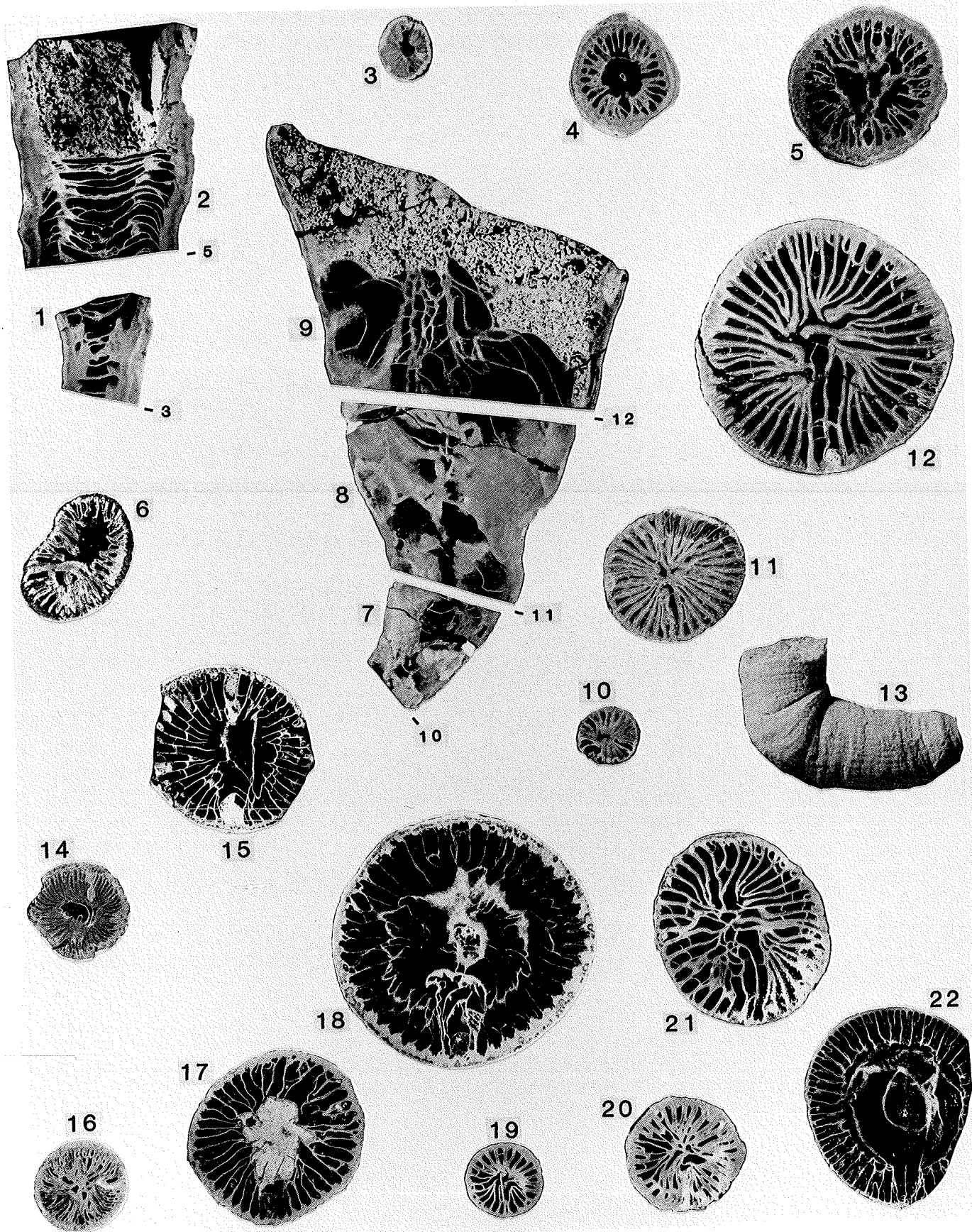
Figure	Page
1-28. <u>Streptelasma subregulare</u> (Savage, 1913b)	96
<p>(1-4, Schweizer Mbr., Wilhelmi Fm., Channahon, Will Co., Illinois; 5-8, Schweizer Mbr., Wilhelmi Fm., southeast of Channahon, Will Co., Illinois; 9, 10, Birds Mbr., Wilhelmi Fm., Section 3 (Garden Prairie), McHenry Co., Illinois; 11, 12, Cyrene Fm., Section 13 (Bowling Green), Pike Co., Missouri; 13-16, Kissenger Limestone Mbr., Bryant Knob Fm., Section 14 (Higginbotham Farm), Pike Co., Missouri; 17, Kissenger Limestone Mbr., Bryant Knob Fm., Section 15 (Calumet), Pike Co., Missouri; 18-25, Kissenger Limestone Mbr., Bryant Knob Fm., Section 16 (Clinton Spring), Pike Co., Missouri; 26-28, Kissenger Limestone Mbr., Bryant Knob Fm., Section 17 (Clarksville), Pike Co., Missouri).</p>	
1-4.	UI C1560a; <u>1</u> , exterior cardinal view, x 1; <u>2-4</u> , transverse sections, x 2.5.
5-8.	UI C1581a; <u>5</u> , exterior cardinal view, x 1; <u>6-8</u> , transverse sections, x 1.5.
9, 10.	USNM <u>3-3-30</u> ; interval 3-3; transverse sections, x 2.
11, 12.	USNM <u>13-1-2</u> ; interval 13-1; transverse sections, x 2.
13-15.	USNM <u>14-1-2</u> ; interval 14-1; <u>13</u> , exterior alar view, cardinal side to right, x 1; <u>14</u> , <u>15</u> , transverse sections, x 2.25.

16. USNM 14-1-13; interval 14-1; transverse section,
x 2.25.
17. USNM 15-1-15; interval 15-1; transverse section,
x 1.5.
- 18-22. USNM 16-1-5; interval 16-1; 18, 19, longitudinal
sections, cardinal side unknown, x 3; 20-22,
transverse sections, cardinal side unknown, x 3.
- 23-25. USNM 16-1-29; interval 16-1; transverse sections,
x 2.
- 26-28. USNM 17-0-10; interval 17-0; longitudinal sections,
cardinal side to left, x 2.5.



EXPLANATION OF PLATE 2

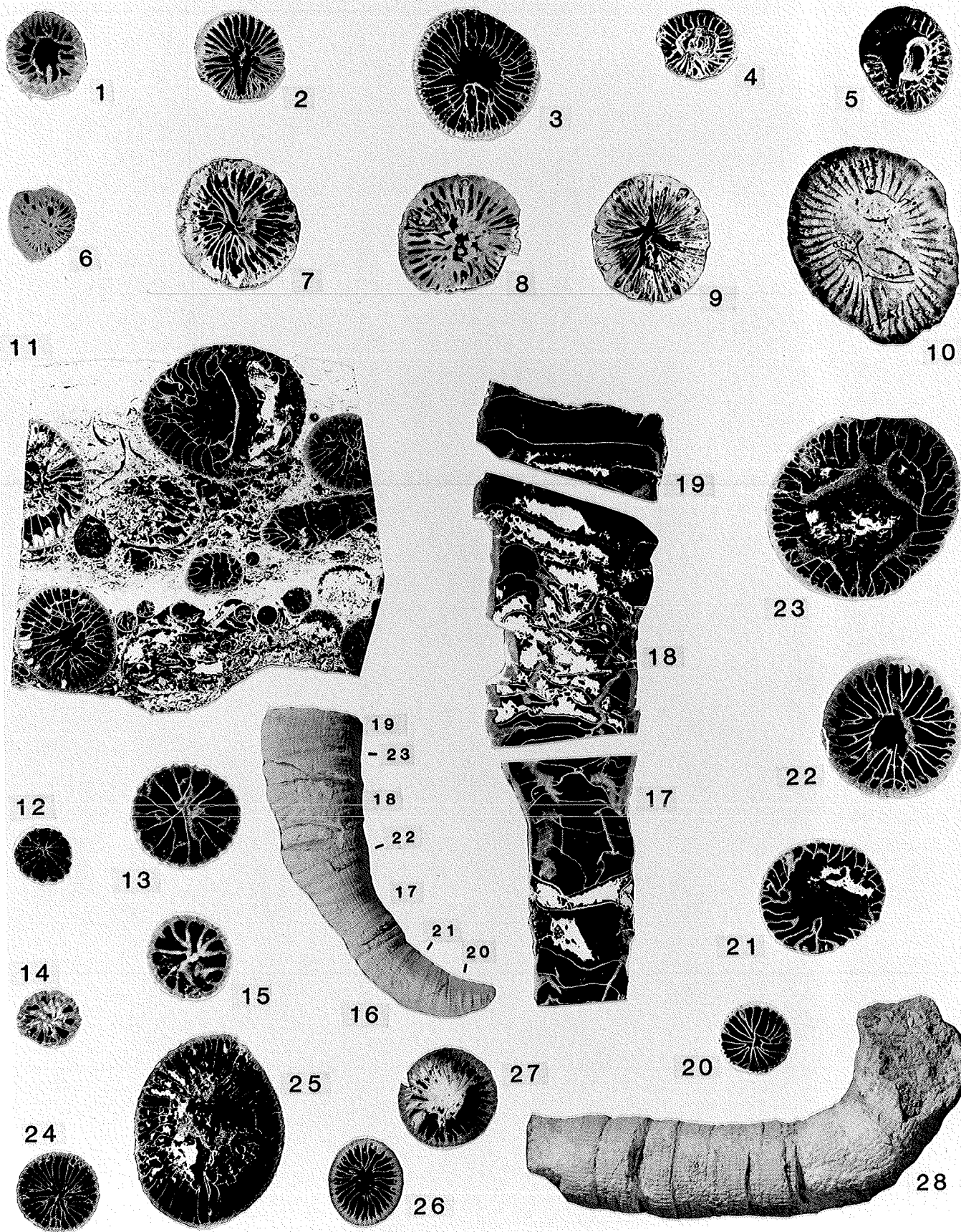
Figure	Page
1-22. <u>Streptelasma subregulare</u> (Savage, 1913b)	96
<p>(1-5, Kissenger Limestone Mbr., Bryant Knob Fm., Section 17 (Clarksville), Pike Co., Missouri; 6-12, Kissenger Limestone Mbr., Bryant Knob Fm., Section 18 (Kissenger), Pike Co., Missouri; 13-18, Leemon Formation, Section 19 (New Wells), Cape Girardeau Co., Missouri; 19-22, Leemon Formation, Section 20 (Short Farm), Cape Girardeau Co., Missouri).</p>	
1-5.	USNM <u>17-0-6</u> ; interval 17-0; <u>1</u> , <u>2</u> , longitudinal sections, cardinal side to left, x 2.5; <u>3-5</u> , transverse sections, x 2.5.
6.	USNM <u>18-2-15</u> ; interval 18-2; transverse section, x 1.5.
7-12.	USNM <u>18-3-17</u> ; interval 18-3; <u>7-9</u> , longitudinal sections, cardinal side to right, x 2.25; <u>10-12</u> , transverse sections, x 2.25.
13.	USNM <u>19-3-12a</u> ; interval 19-3; exterior view, cardinal side unknown, x 2.5.
14, 15.	USNM <u>19-1-4</u> ; interval 19-1; transverse sections, x 1.5.
16-18.	USNM <u>19-1-15</u> ; interval 19-1; transverse sections, x 1.5.
19-21.	USNM <u>20-1-3</u> ; interval 20-1; transverse sections, x 2.5.
22.	USNM <u>20-4-1</u> ; interval 20-4; transverse section, x 1.5.



EXPLANATION OF PLATE 3

Figure	Page
1-10. <u>Streptelasma subregulare</u> (Savage, 1913b)	96
<p>(1-3, Ideal Quarry Mbr., Keel Fm., Section 21 (Rock Crossing), Carter Co., Oklahoma; 4-7, Ideal Quarry Mbr., Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma; 8, Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma; 9, 10, Keel Fm., Section 25 (Hunton), Coal Co., Oklahoma).</p>	
1.	USNM <u>21-1-3</u> ; interval 21-1; transverse section, x 2.5.
2, 3.	USNM <u>21-1a-1</u> ; interval 21-1a; transverse sections, x 1.5.
4, 5.	USNM <u>23-2-28</u> ; interval 23-2; transverse sections, x 1.5.
6, 7.	USNM <u>23-2-45</u> ; interval 23-2; transverse sections, x 1.5.
8.	USNM <u>23-3-25</u> ; interval 23-3; transverse section, x 2.
9, 10.	USNM <u>25-1-4</u> ; interval 25-1; transverse sections, x 1.5
11-28. <u>Streptelasma amsdeni</u> n. sp.	122
<p>(11-25, 28, middle laminated calcilutite unit, Keel Fm., Section 24 (Coal Creek), Pontotoc Co., Oklahoma; 26, 27, lower oölitic unit, Section 24 (Coal Creek), Pontotoc Co., Oklahoma).</p>	
11.	USNM <u>24-2-55</u> ; interval 24-2; transverse section, top of bed faces top of page, x 1.5.

- 12, 13. USNM OGS-5; interval 24-2; transverse sections, x 4.5 (paratype).
- 14, 15. USNM 24-2-24; interval 24-2; transverse sections, x 6 (paratype).
- 16-23. USNM 24-2-36; interval 24-2; 16, exterior counter view, x 1; 17-19, longitudinal sections, cardinal side to right, x 2; 20-23, transverse sections, x 2.5, x 2.5, x 2, x 2 (holotype).
- 24, 25. USNM 24-2-17; interval 24-2; transverse sections, x 1.5 (paratype).
- 26, 27. USNM 24-1-1; interval 24-1, transverse sections, x 1.5 (paratype).
28. USNM OGS-2; interval 24-2; exterior view, cardinal side unknown, x 1 (paratype).



EXPLANATION OF PLATE 4

Figure	Page
1. <u>Streptelasma amsdeni</u> n. sp.	122
(middle laminated calcilutite unit, Keel Fm., Section 24 (Coal Creek), Pontotoc Co., Oklahoma).	
1. USNM <u>OGS-1a, b, c</u> ; interval 24-2; exterior view, on bedding plane, x 1.	
2-12. <u>Streptelasma leemonense</u> Elias, 1982	133
(2, Kissenger Limestone Mbr., Bryant Knob Fm., Section 14 (Higginbotham Farm), Pike Co., Missouri; 3-8, Leemon Fm., Section 20 (Short Farm), Cape Girardeau Co., Missouri; 9-12, Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma).	
2. USNM <u>14-1-5c</u> ; interval 14-1; transverse section, x 2.5.	
3-5. USNM <u>20-1-19</u> ; interval 20-1; transverse sections, x 2.5.	
6-8. USNM <u>20-1-10</u> ; interval 20-1; <u>6</u> , longitudinal section, cardinal side to left, x 2.5; <u>7</u> , <u>8</u> , transverse sections, x 2.5.	
9. USNM <u>23-3-3</u> ; interval 23-3; transverse section, x 2.5.	
10-12. USNM <u>23-3-11</u> ; interval 23-3; <u>10</u> , exterior cardinal view, x 1; <u>11</u> , longitudinal section, cardinal side to right, x 2.5; <u>12</u> , transverse section, x 2.5.	

13-17. Streptelasma sp. cf. S. leemonense Elias, 1982 141

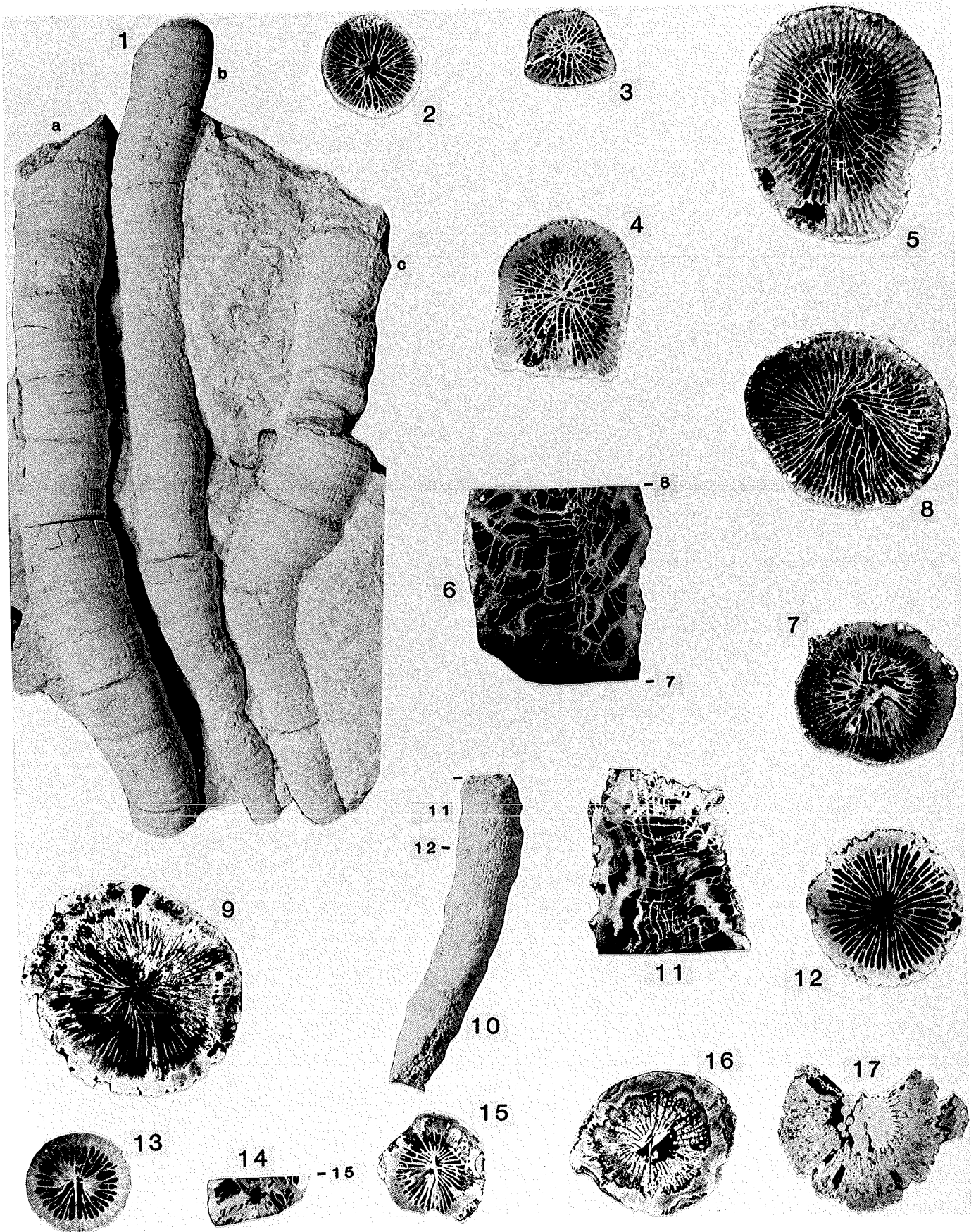
(Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co.,
Oklahoma).

13. USNM 23-3-22; interval 23-3; transverse
section, x 5.

14-16. USNM 23-2a-4; interval 23-2a; 14, longitudinal
section, cardinal side unknown, x 2.5; 15, 16,
transverse sections, x 2.5.

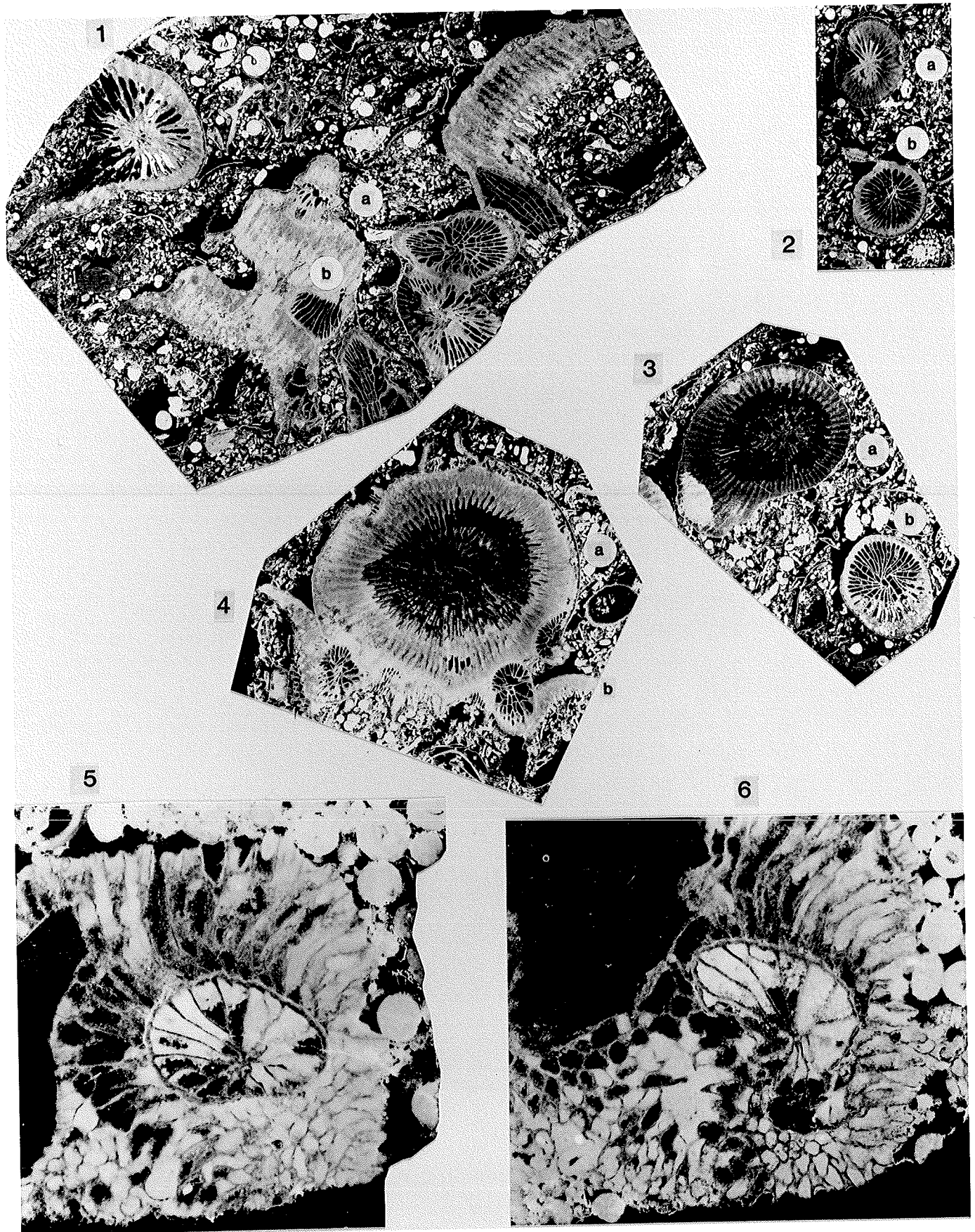
17. USNM 23a-1-7; interval 23a-1; transverse
section, x 2.5.

Pl. 4



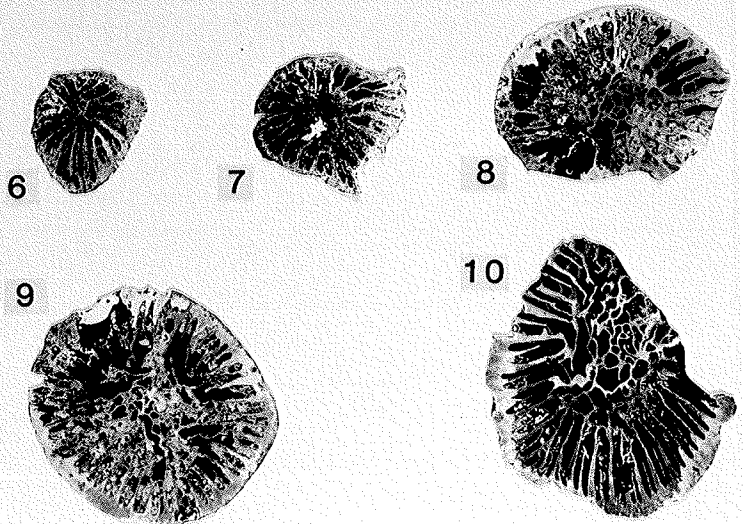
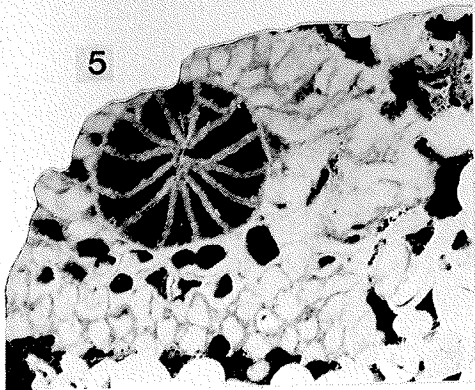
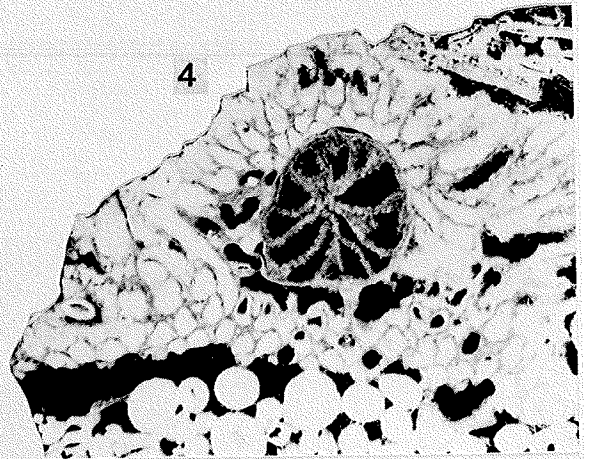
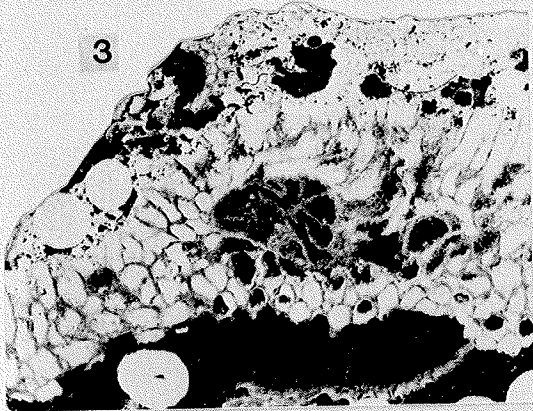
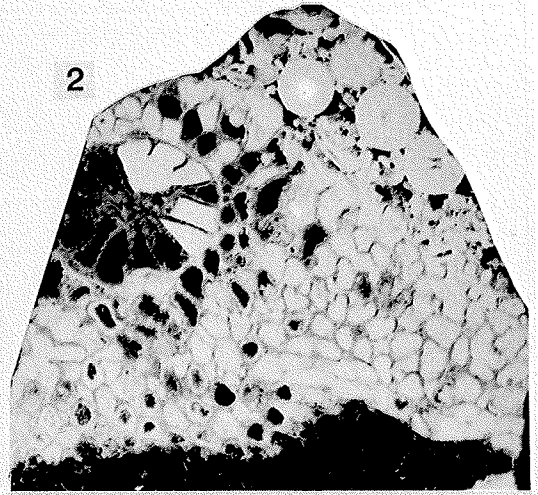
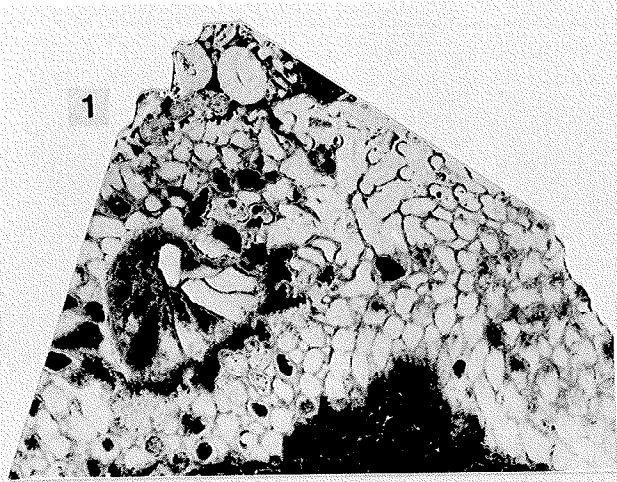
EXPLANATION OF PLATE 5

Figure	Page
1-4. <u>Streptelasma leemonense</u> Elias, 1982	133
(Leemon Fm., Section 20 (Short Farm), Cape Girardeau Co., Missouri).	
1-4. USNM <u>20-3-1a</u> ; interval 20-3; two offsets (a and b), transverse sections, x 2.5.	
5, 6. <u>Streptelasma</u> sp. A	143
(Noix Limestone, Section 15 (Calumet), Pike Co., Missouri).	
5, 6. USNM <u>15-0-1</u> ; interval 15-0; transverse sections, cardinal side unknown, x 10.	



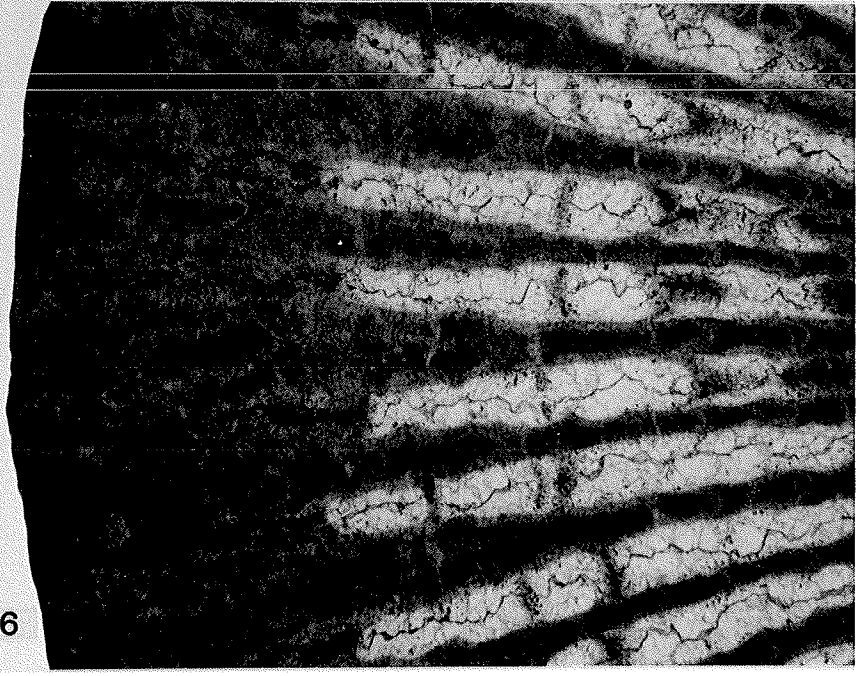
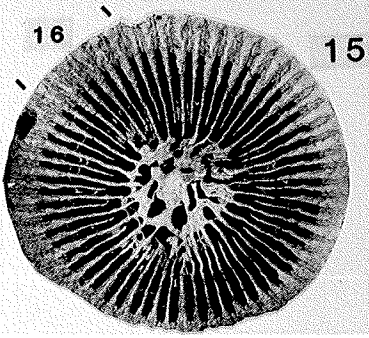
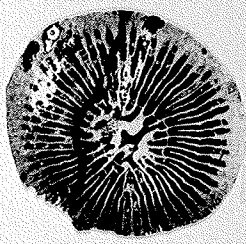
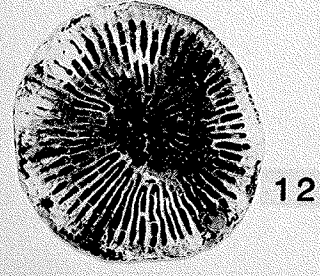
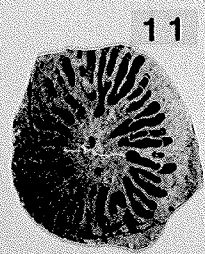
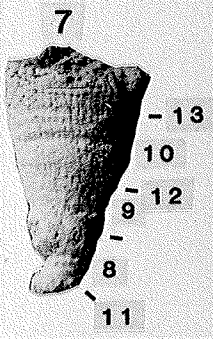
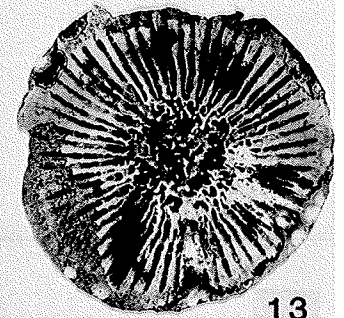
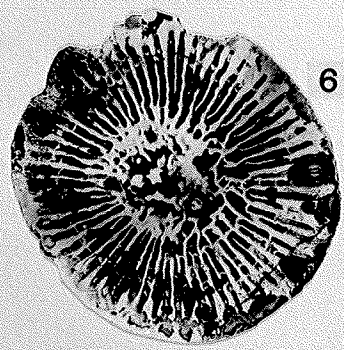
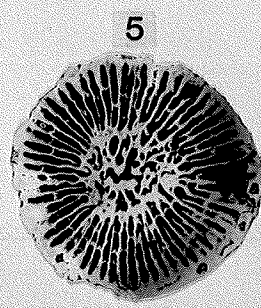
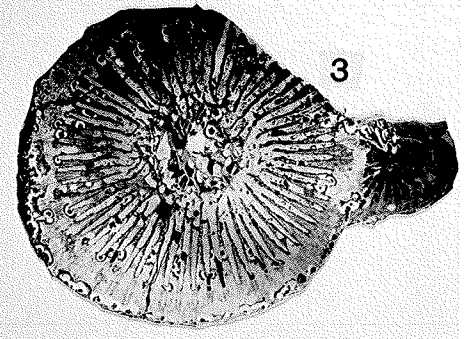
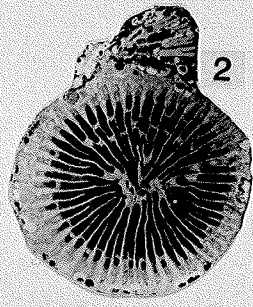
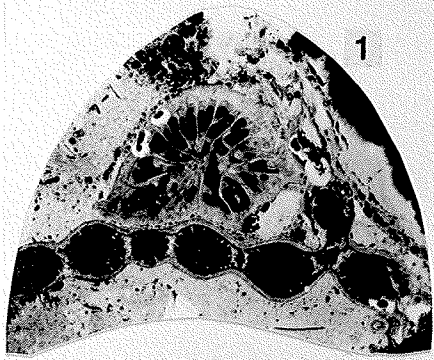
EXPLANATION OF PLATE 6

Figure	Page
1-5. <u>Streptelasma</u> sp. A	143
(Noix Limestone, Section 15 (Calumet), Pike Co., Missouri).	
1, 2. USNM <u>15-0-1A</u> ; interval 15-0; transverse sections, cardinal side unknown, x 10.	
3-5. USNM <u>15-0-1C</u> ; interval 15-0; transverse sections, cardinal side unknown, x 10.	
6-10. <u>Grewingkia</u> sp. A	147
(6-9, Kissenger Limestone Mbr., Bryant Knob Fm., Section 14 (Higginbotham Farm), Pike Co., Missouri; 10, Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma).	
6-9. USNM <u>14-2-7</u> ; interval 14-2; transverse sections, x 3.	
10. USNM <u>23-3-34</u> ; interval 23-3; transverse section, x 3.	



EXPLANATION OF PLATE 7

Figure	Page
1-16. <u>Keelophyllum oklahomense</u> n. gen., n. sp.	153
(1-13, Keel Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma; 14-16, Keel Fm., Section 25 (Hunton), Coal Co., Oklahoma).	
1-3. USNM <u>23a-1-1</u> ; interval 23a-1; transverse sections, x 5, x 3, x 2.5 (paratype).	
4. USNM <u>23-3-2</u> ; interval 23-3; longitudinal section, cardinal side unknown, x 2 (paratype).	
5, 6. USNM <u>23-3-19</u> ; interval 23-3; transverse sections, x 2.5 (paratype).	
7-13. USNM <u>23-3-33</u> ; interval 23-3; <u>7</u> , exterior cardinal view, x 1; <u>8-10</u> ; longitudinal sections, cardinal side not shown, x 2.5; <u>11-13</u> , transverse sections, x 5, x 3, x 2.5 (holotype).	
14-16. USNM <u>25-1-2</u> ; interval 25-1; <u>14</u> , <u>15</u> , transverse sections, x 2.5; <u>16</u> , positive photomicrograph (for position see fig. 15), x 20 (paratype).	



EXPLANATION OF PLATE 8

Figure	Page
1-5. <u>Rhegmaphyllum</u>	47
(1-4, limestone facies at base of Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 5, limestone facies within Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri).	
1, 2. USNM <u>17-1a-4</u> ; interval 17-1; transverse sections, x 5.	
3, 4. USNM <u>17-3-5</u> ; interval 17-3; transverse sections, x 5.	
5. USNM <u>17-2b-5</u> ; interval 17-2b; transverse section, x 5.	
6-11. <u>Dinophyllum</u>	47, 65
(6, limestone facies within Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 7-10, limestone facies at base of Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 11, Elwood Fm., Section 6 (Plaines West), Will Co., Illinois).	
6. USNM <u>17-2b-3</u> ; interval 17-2b; transverse section, x 3.	
7-10. USNM <u>17-3-1</u> ; interval 17-3; <u>7</u> , <u>8</u> , longitudinal sections, cardinal side to right, x 2; <u>9</u> , <u>10</u> , transverse sections, x 2.	
11. USNM <u>6-1-9</u> ; interval 6-1, transverse section, x 2.	
12-18. <u>Dalmanophyllum</u>	36, 47, 65, 74
(12, Sexton Creek Limestone, Section 20 (Short Farm),	

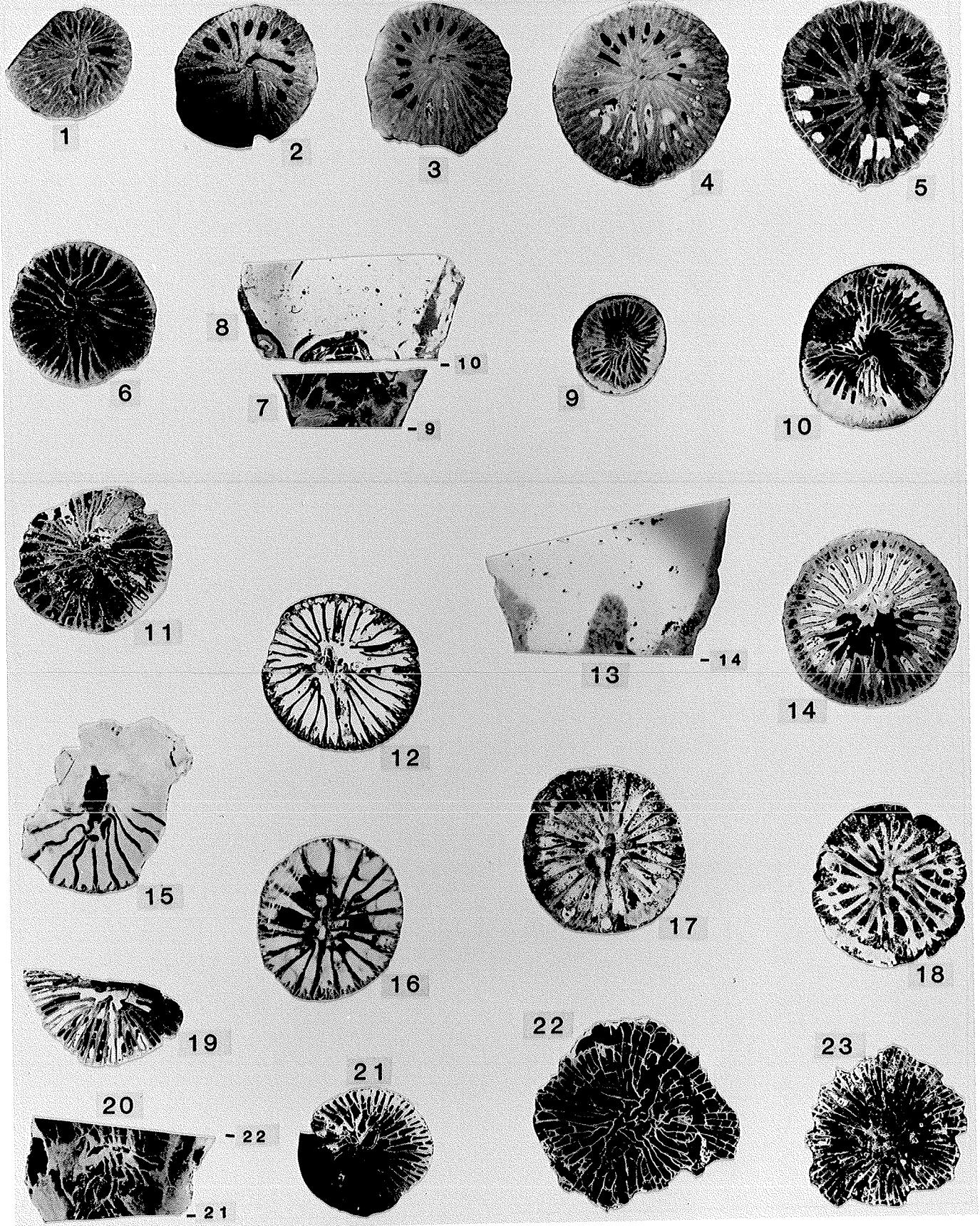
Cape Girardeau Co., Missouri; 13, 14, Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 15, 16, limestone facies at base of Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 17, Elwood Fm., Section 6 (Plaines West), Will Co., Illinois; 18, Mosalem Fm., Section 10 (Lost Mound), Jo Daviess Co., Illinois).

12. UCGM 45639; transverse section, x 2.5.
- 13, 14. USNM 17-2a-2; interval 17-2a; 13, longitudinal section, cardinal side to right, x 3; 14, transverse section, x 3.
- 15, 16. USNM 17-1-10; interval 17-1; transverse sections, x 5.
17. USNM 6-1-5; interval 6-1; transverse section, x 4.
18. USNM 10-2-5; interval 10-2; transverse section, x 4.

19-23. Phaulactis 24, 47, 74

(19, Cochrane Fm., Section 23 (Lawrence Quarry), Pontotoc Co., Oklahoma; 20-22, Bowling Green Dolomite, Section 17 (Clarksville), Pike Co., Missouri; 23, Mosalem Fm., Section 9 (Winston), Jo Daviess Co., Illinois).

19. USNM 23-4-1; interval 23-4; transverse section, x 2.
- 20-22. USNM 17-2-1; interval 17-2; 20, longitudinal section, cardinal side to left, x 2; 21, 22, transverse sections, x 2.
23. USNM 9-1-6; interval 9-1; transverse section, x 2.5.



APPENDIX 1: GROWTH FORM AND CURVATURE

tr (trochoid) = ratio of length to diameter $\leq 2:1$.

cer (ceratoid) = ratio of length to diameter $> 2:1$.

cyl (cylindrical) = diameter approximately constant for at least half the coral length.

non (noncurved) = 0° to 10° curvature of growth axis.

mod (moderately curved) = 11° to 70° curvature of growth axis.

great (greatly curved) = $> 70^{\circ}$ curvature of growth axis.

Note: sharp bends are not considered the same as smooth curvature of the growth axis, and are ignored.

Identical specimen numbers in Appendix 1 represent different individuals catalogued under the same number.

SPECIMEN	GROWTH		SPECIMEN	GROWTH	
	FORM	CURVATURE		FORM	CURVATURE
<u>Streptelasma subregulare</u>					
UI X-851	tr	non	UI C1619	tr	non
UI C1619	tr	non	UI C1619	tr	mod
UI C1619	tr	mod	UI C1619	tr	mod
3-3-13	tr	mod	3-3-27	tr	non
3-3-30	tr	mod	UI C1560a	cer	mod
UI C1560	cer	mod	UI C1560	tr	mod
UI C1560	cer	mod	UI C1560	tr	mod
UI C1560	cer	non	UI C1563	cer	mod
UI C1563	tr	mod	UI C1581a	tr	mod
UI C1581	tr	mod	UI C1547	cer	mod

UI C1547	cer	mod	UI C1561	tr	non
UI C1561	tr	non	UI C1561	tr	non
UI C1561	tr	mod	UI C1561	tr	mod
UI C1561	tr	non	UI X947	cer	mod
UI X947	cer	great	UI X947	cer	mod
UI X926a	tr	non	UI X926b	tr	mod
4-1-1	cer	mod	4-1-2	tr	mod
4-1-3	tr	mod	4-1-4	tr	mod
4-1-5	tr	non	4-1-6	cer	mod
UI C864	tr	non	13-1-2	tr	mod
13-1-3	tr	mod	14-1-2	cer	mod
14-1-3	cer	mod	14-1-4	cer	mod
14-1-7	cer	mod	14-1-8	cer	-
14-1-9	tr	great	14-1-10	cer	mod
14-1-11	tr	-	14-1-12	cer	-
14-1-13	cer	mod	14-1-14	cer	mod
14-1-15	cer	mod	14-1-16	cer	-
14-1-17	cer	mod	14-1-19	cer	mod
14-1-20	tr	non	14-1-22	cer	non
14-1-24	cer	mod	14-1-26	cer	mod
14-1-27	cer	mod	14-1-28	tr	non
14-1-30	cer	mod	15-1-1	cer	non
15-1-2	cer	mod	15-1-3	tr	mod
15-1-4	tr	non	15-1-5	tr	non
15-1-11	tr	non	15-1-13	cer	mod
15-1-14	tr	mod	15-1-15	tr	non

15-1-16	tr	non	15-1-19	tr	non
15-1-20	tr	mod			
21b-2-3	cer	non	21b-2-4	cer	non
21b-2-8	tr	mod	16-1-1	cer	non
16-1-2	tr	mod	16-1-3	cer	mod
16-1-4	cer	non	16-1-5	cer	non
16-1-6	cer	non	16-1-7	cer	non
16-1-8a	cer	non	16-1-8b	cer	mod
16-1-9	cer	mod	16-1-10	cer	non
16-1-11	tr	mod	16-1-12	cer	-
16-1-13	cer	non	16-1-14	cer	mod
16-1-17	tr	non	16-1-19	cer	non
16-1-20	cer	non	16-1-21	cer	non
16-1-22	tr	non	16-1-23	cer	non
16-1-25	cer	great	16-1-26	cer	mod
16-1-27	cer	mod	16-1-28	cer	mod
16-1-29	tr	mod	16-1-30	cer	mod
16-1-31	cer	non	16-1-33	cer	mod
16-1-35	cer	mod	16-1-36	cer	mod
16-1-37	cer	non	16-1-38	tr	mod
16-1-40	cer	non	16-1-41	cer	mod
16-1-45	tr	non	16-1-46	cer	great
16-1-47	cer	great			
17-0-1	cer	mod	17-0-2	tr	non
17-0-3	cer	non	17-0-4	cer	great
17-0-5	cer	mod	17-0-6	cer	mod
17-0-7	cer	mod	17-0-8	tr	great

17-0-9	cer	mod	17-0-10	cer	mod
17-0-11	cer	non	17-0-12	cer	great
17-0-13	cer	=	17-0-14	tr	mod
17-0-15	cer	non	17-0-16	cer	mod
17-0-17	cer	non	17-0-18	cer	mod
17-0-19	tr	non	17-0-20	cer	non
17-0-21	cer	non	17-0-22	cer	mod
17-0-23	cer	mod	17-0-25	cer	non
17-0-27	cer	-	17-0-29	tr	mod
17-0-31	tr	non	17-0-32	cer	mod
17-0-33	cer	mod	17-0-34	cer	-
17-0-36	cer	non	17-0-37	cer	non
17-0-39	cyl	non	18-1-14	cer	great
18-1-19	cer	non	18-1-28	cer	mod
18-2-3	cer	mod	18-2-5	cer	non
18-2-7	cer	non	18-2-10	cer	mod
18-2-11	tr	mod	18-2-13	tr	mod
18-2-16	tr	mod	18-2-19	tr	mod
18-3-1	tr	non	18-3-2	tr	non
18-3-4	cer	mod	18-3-9	cer	mod
18-3-10	tr	non	18-3-15	cer	non
18-3-16	tr	mod	18-3-17	cer	mod
18-3-19	cer	mod	18-3-21	tr	mod
18-3-22	tr	mod	18-4-1	cer	non
UCGM 45618	tr	non	UCGM 45619	tr	non
UCGM 45620	cer	non	UCGM 45621	cer	mod

UCGM 45622	tr	non	UCGM 45623	cer	non
UCGM 45624	tr	mod	UCGM 45625	tr	mod
UCGM 45626	cer	non	UCGM 45627	tr	mod
UCGM 45628	tr	non	UCGM 45629	tr	mod
UCGM 45630	cer	mod	UCGM 45633	cer	non
UCGM 45634	cyl	non			
USNM 365918	cer	non	19-1-2	cer	non
19-1-3	cer	non	19-1-4	tr	mod
19-1-5	cer	mod	19-1-6	cer	non
19-1-7	cer	non	19-1-8	cer	non
19-1-9	tr	mod	19-1-10	tr	non
19-1-11	tr	great	19-1-12	tr	mod
19-1-13	tr	mod	19-1-14	cer	non
19-1-15	tr	non	19-2-1	cer	mod
19-2-2	tr	great	19-2-3	cer	non
19-2-4	cer	mod	19-2-5	cer	mod
19-2-6	cer	non	19-2-7	cer	mod
19-2-9	cer	mod	19-2-10	tr	mod
19-2-11	cer	non	19-2-12	cer	mod
19-2-13	tr	non	19-2-14	cer	non
19-2-15	cer	mod	19-2-16	cer	non
19-2-17	cer	non	19-2-18	tr	non
19-2-19	cer	non	19-2-20	cer	mod
19-2-22	cer	non	19-2-23	cer	non
19-3-1	tr	great	19-3-2	tr	mod
19-3-3	cer	mod	19-3-4	tr	non
19-3-5	cyl	mod	19-3-6	cer	mod

19-3-7	cer	non	19-3-8	cer	non
19-3-9	cer	mod	19-3-10	cer	great
19-3-11	cer	mod	19-3-12	cer	non
19-3-13	cer	-	19-3-14	cer	mod
19-3-15	cer	mod	19-3-16	cer	mod
19-3-17	cer	non	19-3-18	cyl	great
19-3-19	cer	mod	19-3-20	cer	mod
19-3-21	cer	non	19-3-23	cer	non
19-3-24	tr	non	19-3-25	cer	mod
19-3-26	cer	non	19-3-27	cer	mod
19-3-28	cer	non	19-3-29	cer	mod
19-3-30	cer	mod	19-3-32	cer	mod
19-3-33	cer	non	19-3-34	cer	non
19-3-35	cer	mod	19-3-36	cer	mod
19-3-39	tr	mod	19-3-40	tr	mod
19-3-41	tr	non	19-3-42	cer	mod
			20-1-1	cer	mod
20-1-2	tr	great	20-1-3	tr	great
20-1-4	cer	mod	20-1-5	tr	non
20-1-7	tr	non	20-1-8	cer	mod
20-1-9	cer	-	20-1-11	cer	non
20-1-12	tr	mod	20-1-14	tr	mod
20-1-18	tr	non	20-3-2	tr	mod
20-3-3	tr	mod	20-3-4	tr	mod
20-3-6	tr	mod	20-3-7	tr	mod
20-3-8	tr	mod	20-4-1	tr	mod

20-5-2	tr	mod	20-5-3	tr	non
20-5-5	tr	mod	20-5-8	cer	mod
UI ENT-1	tr	non	UI ENT-2	tr	-
21-1a-1	tr	non	21-1a-4	tr	mod
21-1b-1	tr	non	21-1b-8	cer	mod
21-1c-3	tr	mod	23-1-1	cer	mod
23-2-1	cer	non	23-2-2	tr	non
23-2-3	tr	non	23-2-4	tr	mod
23-2-5	tr	mod	23-2-6	tr	mod
23-2-7	tr	non	23-2-8	tr	great
23-2-9	cer	mod	23-2-10	tr	great
23-2-11	tr	mod	23-2-13	tr	non
23-2-14	tr	non	23-2-15	cer	mod
23-2-16	tr	non	23-2-17	tr	mod
23-2-20	tr	mod	23-2-21	tr	non
23-2-22	tr	mod	23-2-23	cer	mod
23-2-24	tr	non	23-2-26	cer	non
23-2-31	cer	non	23-2-33	tr	non
23-2-38	tr	non	23-2-39	tr	mod
23-2-40	tr	non	23-2-41a	tr	non
23-2-41b	tr	mod	23-2-42	cer	mod
23-2-43	cer	mod	23-2-45	tr	mod
23-2-47	tr	non	23-2-48	cer	non
23-2-49	tr	non	23-2-55	tr	non
23-2a-1	tr	non	23-2a-3	tr	mod
23-2a-5	tr	mod	23-3-9	tr	mod

23-3-14	tr	mod	23-3-15	tr	non
23-3-16	cer	mod	23-3-17	tr	non
23-3-18	tr	mod	23-3-21	tr	non
23-3-24	tr	mod	23-3-25	tr	non
23-3-27	tr	mod	23-3-28	tr	non
23-3-31	tr	mod	23-3-35	tr	non
23-3-37	tr	great	23a-1-8	tr	mod
25-1-1	tr	mod	25-1-3	tr	non
25-1-4	tr	non			

Streptelasma amsdeni

OGS-1a	cyl	non	OGS-1b	cyl	non
OGS-1c	cyl	mod	OGS-2	cyl	non
OGS-3	cer	non	OGS-6	cyl	non
OGS-7	cyl	-	OGS-8	cer	mod
OGS-9	cer	-	OGS-10	cer	mod
OGS-13	cyl	non	24-1-1	cyl	mod
24-2-1	cer	mod	24-2-3	cyl	non
24-2-4	cyl	mod	24-2-5	cer	non
24-2-6	cer	non	24-2-7	cer	non
24-2-8	cyl	non	24-2-9	cyl	mod
24-2-10	cer	non	24-2-11	cyl	mod
24-2-12	cer	non	24-2-13	cer	mod
24-2-14	cer	mod	24-2-15	cer	mod
24-2-16	cyl	non	24-2-17	cyl	non
24-2-18	cer	mod	24-2-19	cer	mod
24-2-22	cer	mod	24-2-23	cyl	non

24-2-24	cer	mod	24-2-26	cyl	mod
24-2-27	cer	mod	24-2-28	cyl	mod
24-2-29	cer	mod	24-2-30	cyl	non
24-2-31	cer	non	24-2-33	cyl	non
24-2-34	cer	mod	24-2-35	cyl	non
24-2-36	cer	great	24-2-38	cer	mod
24-2-40	cer	mod	24-2-42	cyl	non
24-2-44	cer	non			

Streptelasma leemonense

14-1-5	tr	mod	15-1-8	tr	mod
20-1-10	cer	non	20-1-19	tr	mod
20-3-1	tr	mod	UI C1448	tr	non
23-2-32	tr	mod	23-2-36	tr	mod
23-2a-2	cer	non	23-3-1	cer	non
23-3-3	cyl	non	23-3-4	cer	non
23-3-8	tr	mod	23-3-11	cyl	mod
23-3-12	cer	mod	23-3-13	cer	mod
23-3-20	cer	non	23a-1-2	cer	mod
23a-1-3	cer	mod			

Streptelasma sp. cf. S. leemonense

23-3-22	cer	mod	23a-1-7	tr	non
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Keelophyllum oklahomense

23-3-2	cer	non	23-3-19	cer	non
23-3-33	cer	great	23a-1-1	tr	mod
25-1-2	cer	non			

APPENDIX 2: BIOMETRIC DATA

n = number of major septa.

d = coral diameter, in mm.

l = length of major septa, as a fraction of the coral radius.

w = width of major septa at midpoint of length, in mm.

cl = length of cardinal septum, as below.

cw = width of cardinal septum, as below.

Note: l = less than other major septa.

s = same as other major septa.

g = greater than other major septa.

SPECIMEN	n	d	l	w	cl	cw
<u>Streptelasma subregulare</u>						
3-2-11	21	6	.63	.30	-	-
3-2-12	27	9	.89	.35	-	-
3-3-13	34	12	.50	.20	s	s
3-3-15	27	7	.93	.30	-	-
3-3-16	-	10	.60	.25	s	s
3-3-24	37	12	.54	.45	s	s
3-3-27	-	14	.79	.35	s	l
3-3-30	28	8	1.00	.45	s	g
	39	13	.69	.45	s	g
UI C1560a	28	7	.50	.15	g	s
	30	10	.60	.20	g	l
	37	13	.54	.20	s	s

UI C1581a	34	10	1.00	.60	g	s
	41	15	.80	.55	g	g
	44	22	-	.50	l	l
4-1-2	26	7	.71	.20	g	s
	30	9	.61	.15	s	s
4-1-3	35	17	-	-	-	-
4-1-4	24	7	-	-	-	-
4-1-5	39	18	.67	.30	s	l
13-1-1	27	7	.79	.40	g	s
13-1-2	22	8	.94	.45	s	s
	33	15	.80	.25	l	l
13-1-3	23	5	1.00	.25	-	-
	35	13	.73	.60	l	l
13-1-4	24	5	.70	.40	-	-
13-1-5	18	4	1.00	.20	s	g
14-1-2	24	7	1.00	.50	g	s
	36	15	.53	.75	s	l
	36	19	.42	.20	l	l
14-1-3	32	14	.39	.80	l	l
14-1-4	32	10	.65	.55	s	s
	37	16	.69	.40	s	l
14-1-7	31	11	.73	.70	s	s
14-1-8	37	9	.89	.15	s	g
	38	12	.79	.15	g	s
	39	17	.62	.15	s	s

14-1-9	23	8	1.00	.40	s	s
	34	15	.80	.40	l	s
14-1-11	33	18	.50	.65	s	l
14-1-12	34	13	.85	.45	s	l
14-1-13	37	17	.62	.50	s	s
14-1-14	30	11	.50	.70	-	-
14-1-15	-	3	1.00	-	s	s
	-	5	.80	.35	s	s
	-	8	.63	.55	s	s
14-1-17	-	12	.71	.55	-	-
14-1-18	28	8	1.00	.50	s	g
14-1-19	33	10	.75	.50	s	s
14-1-20	-	7	.70	.50	-	-
14-1-22	32	8	.62	.50	s	s
14-1-23	31	14	.96	.60	-	-
14-1-26	27	11	.68	.35	s	s
14-1-28	-	8	1.00	.40	s	s
14-1-30	20	4	.75	.20	g	g
	33	9	.61	.65	s	s
	42	16	.56	.50	g	s
15-1-1	19	4	.87	.40	s	s
	30	12	.58	.60	-	-
15-1-3	28	9	.89	.40	s	s
15-1-4	25	6	1.00	.30	s	g
15-1-6	24	6	1.00	.30	s	s
15-1-7	34	11	-	-	-	-

15-1-9	37	12	1.00	.50	s	1
15-1-11	23	7	1.00	.50	-	-
15-1-14	29	9	1.00	.70	s	s
15-1-15	24	6	.83	.50	s	s
	38	16	.72	.75	1	1
15-1-18	-	7	.71	.50	-	-
15-1-19	24	6	.83	.40	g	s
15-1-40	20	4	.87	.35	s	s
UCGM 45644	36	15	.97	.40	s	1
21b-2-3	21	5	1.00	.45	s	s
	24	8	1.00	.55	1	1
21b-2-4	-	3	1.00	.45	-	-
	22	6	1.00	.15	s	s
	-	10	.50	-	1	s
21b-2-8	30	9	.89	.60	-	-
	34	12	.67	.70	-	-
16-1-1	20	6	.92	.50	s	s
	-	11	.73	.45	1	s
16-1-2	-	4	.50	.45	-	-
16-1-3	33	9	.94	.45	s	s
16-1-4	13	2	1.00	.20	s	s
	28	8	.94	.50	g	g
	37	12	.92	.75	s	s
16-1-5	13	3	.83	.40	-	-
	22	5	.40	.50	-	-
	32	8	.56	.65	-	-
	-	12	.75	.75	-	-

16-1-6	36	17	.41	.15	s	s
16-1-9	18	6	1.00	.40	s	s
	25	8	1.00	.35	g	1
16-1-10	44	16	.44	.50	s	s
16-1-11	-	9	1.00	.65	-	-
16-1-17	-	8	.88	.50	s	s
	34	13	.50	.25	s	1
16-1-19	27	8	1.00	.40	s	s
	30	12	1.00	.35	s	s
16-1-22	23	6	.75	.30	s	s
	-	16	.44	.65	s	1
16-1-25	37	12	.83	.55	s	s
	39	14	.46	.70	1	s
16-1-26	32	11	1.00	.50	-	-
	34	12	.42	.40	1	1
	-	14	.50	.15	s	s
16-1-27	22	5	1.00	.25	s	s
	27	10	.90	.45	s	s
16-1-29	24	7	.71	.60	s	s
	28	8	.88	.55	s	g
	34	12	.92	.60	s	s
	41	16	.81	.50	s	1
16-1-31	34	10	.90	.45	s	s
16-1-37	27	8	1.00	.25	-	-
	32	9	.78	.30	s	s
16-1-47	28	8	.62	.40	s	g

(17-0) 24-2-25	26	7	.86	.50	g	s
	33	10	.50	.40	g	1
17-0-1	38	10	.60	.40	s	s
	41	13	.69	.40	s	1
	42	14	.71	.25	1	1
	44	16	.75	.35	1	1
17-0-2	27	10	1.00	.65	-	-
17-0-3	37	15	.80	.25	s	g
17-0-4	36	10	1.00	.50	g	g
	41	13	.77	.30	g	s
17-0-5	32	8	.50	.30	s	s
	41	11	.63	.50	s	g
17-0-6	-	5	.80	.40	s	s
	29	8	.56	.20	1	s
	33	12	.58	.25	s	s
17-0-7	27	9	.67	.50	s	s
	31	10	.60	.60	s	s
17-0-8	24	7	.86	.45	g	s
	29	12	.75	.80	s	1
17-0-9	32	10	.65	.40	-	-
17-0-10	12	3	.33	.20	s	s
	16	4	.75	.45	s	1
	17	4	.62	.35	s	s
	27	7	.63	.45	s	1
	34	11	.59	.50	1	1
17-0-11	33	9	.39	.25	s	1

17-0-14	24	7	1.00	.50	g	s
17-0-16	30	12	1.00	.50	l	l
	31	15	.67	.30	l	l
17-0-17	28	6	.58	.30	s	l
	35	10	.50	.50	s	l
	38	15	.50	.35	s	l
17-0-18	32	9	.56	.25	g	s
17-0-19	30	9	.83	.45	s	l
17-0-20	27	10	.75	.30	-	-
17-0-23	24	5	1.00	.40	g	s
	27	7	.79	.35	s	s
	33	11	1.00	.50	g	g
17-0-24	-	8	.50	.30	s	s
17-0-25	23	8	1.00	.45	s	s
17-0-26	-	9	.61	.55	-	-
	-	12	.75	.55	s	s
17-0-27	28	10	.65	.35	l	l
17-0-28	28	10	.80	.20	s	s
17-0-29	28	7	.86	.45	s	s
	32	13	.69	.35	l	s
17-0-30	31	9	.44	.55	s	s
17-0-31	23	5	1.00	.30	s	g
17-0-32	18	3	1.00	.30	s	s
	26	5	1.00	.30	s	s
	36	10	.75	.35	g	g
17-0-37	27	6	.75	.30	s	l

17-0-39	23	5	.70	.35	s	1
18-1-1	29	10	.40	.50	-	-
18-1-2	25	7	.71	.35	g	g
18-1-5	-	8	.56	.55	s	s
18-1-6	37	10	.90	.55	-	-
18-1-7	26	8	1.00	.55	s	1
18-1-10	23	6	1.00	.50	-	s
18-1-12	37	14	.57	.20	1	s
18-1-18	26	8	.50	.25	1	1
18-1-19	28	10	-	-	-	-
18-1-25	31	11	.82	.50	s	1
	37	15	.87	.15	1	1
18-1-26	31	11	.82	.60	s	1
18-1-27	40	16	.66	.45	1	1
18-1-28	26	6	1.00	.45	s	1
	32	10	.80	.45	1	1
18-2-2	37	13	.85	.50	s	s
	41	14	.86	.55	s	s
18-2-4	34	19	.68	.40	s	s
18-2-5	21	6	.75	.50	s	s
	27	11	.63	.50	s	s
18-2-7	20	4	-	-	-	-
	30	7	.14	.20	g	s
18-2-8	29	14	.57	.65	-	s
18-2-9	21	6	.75	.30	g	g
	29	7	.36	.15	g	s

18-2-10	27	6	.50	.25	g	s
18-2-12	21	8	-	.50	-	-
18-2-15	32	11	.82	.75	s	s
	35	14	.63	.55	g	l
18-2-16	19	4	1.00	.30	g	s
	31	8	.56	.40	g	l
18-2-18	-	7	.43	-	-	-
18-2-19	-	10	1.00	.70	g	s
18-3-1	29	10	1.00	.70	g	s
	40	17	.97	.30	l	s
	42	25	1.00	.15	s	s
18-3-2	35	12	1.00	.65	s	g
	44	22	.63	.25	g	s
18-3-3	29	10	1.00	.50	s	s
	30	11	.95	.40	s	l
	34	13	.85	.25	s	l
18-3-5	35	11	1.00	.60	s	s
18-3-8	33	14	.50	.40	l	l
18-3-10	31	7	.86	.40	s	g
18-3-15	40	18	.86	.30	s	s
	42	21	1.00	.20	s	s
18-3-16	30	8	1.00	.20	s	g
	30	9	1.00	.55	s	s
	40	15	1.00	.60	s	l
	43	22	.93	.70	g	s
18-3-17	21	5	.90	.35	s	s

	35	11	1.00	.65	1	s
	42	21	1.00	.45	g	s
	43	21	.86	.45	s	s
18-3-18	41	25	.96	.20	1	1
18-3-19	32	10	.85	.55	s	s
18-3-20	26	9	.67	.25	g	s
18-3-21	-	9	.78	.40	s	s
18-3-22	27	11	.63	.20	s	s
18-4-1	28	8	1.00	.55	s	s
	43	20	1.00	.30	s	1
	47	30	.73	.25	1	s
UCGM 45618	29	10	.70	.45	s	s
	40	18	.61	.10	g	s
	46	29	.48	.10	1	1
UCGM 45619	36	15	.47	.20	s	1
	40	21	.52	.10	s	s
UCGM 45622	29	8	1.00	.40	s	s
	36	15	.60	.15	1	1
USNM 365918	32	16	.69	.30	g	s
	40	22	.48	.10	1	1
	41	29	.52	.10	1	s
19-1-2	20	7	.71	.15	g	s
	25	9	.50	.15	g	s
19-1-4	32	13	.73	.75	g	1
	40	22	.68	.10	1	1
19-1-7	29	10	.40	.10	s	s
	31	13	.31	.15	1	1

19-1-8	27	10	.35	.10	-	-
	-	14	.33	.15	-	-
	33	17	.47	.15	s	s
19-1-9	25	6	.83	.40	g	s
	37	16	.69	.30	s	s
19-1-10	31	10	.95	.50	1	1
	36	18	.72	.15	s	s
19-1-11	33	8	.75	.25	g	s
	-	11	.68	.20	1	s
	39	21	.45	.10	s	s
19-1-12	23	5	1.00	.40	g	s
	39	13	.85	.15	s	s
	43	22	.55	.35	1	s
19-1-13	38	24	.54	.35	1	s
19-1-14	15	5	-	-	-	-
	18	10	-	-	-	-
	28	18	.50	.10	s	s
19-1-15	34	10	1.00	.60	1	1
	42	23	.72	.20	s	1
	44	32	.66	.15	1	s
19-2-1	26	9	.22	.10	s	s
	-	13	.50	-	-	-
19-2-5	25	8	.50	.15	g	s
19-2-6	24	9	.72	.40	g	s
	33	15	.40	.20	-	-
19-2-7	-	6	.25	.35	g	g
	-	9	.28	.10	s	s

19-2-11	22	6	.50	.10	g	s
	27	10	.35	.15	g	l
	33	17	.53	.10	g	s
19-2-16	20	4	.62	.20	g	s
	27	9	.56	.20	s	l
	31	11	.55	.20	s	l
19-2-18	19	6	.83	.25	g	s
	32	16	.69	.30	g	s
19-3-1	23	7	.50	.20	s	s
	32	14	.50	.35	s	s
	39	20	.67	.15	l	s
19-3-2	31	12	1.00	.30	s	s
	41	27	.45	.15	s	s
	44	27	-	-	-	-
19-3-3	22	6	.75	.40	s	s
	37	18	.56	.20	l	l
	38	21	.38	.15	l	l
19-3-4	19	7	1.00	.35	-	-
	29	8	1.00	.40	s	s
	40	19	.74	.25	s	l
19-3-8	22	8	.50	.10	s	s
	23	9	.56	.15	g	g
	29	13	.58	.15	l	l
19-3-12	33	10	.20	.05	g	s
	38	15	.47	.15	g	s
	40	21	.33	.10	l	s

19-3-14	-	14	.21	.15	s	s
	34	16	.34	.15	g	s
19-3-15	-	10	.55	.25	s	1
	-	15	.33	.15	s	1
	-	17	.41	.10	-	-
19-3-16	15	5	.50	.15	g	s
	21	6	.33	.10	g	s
	29	10	.45	.10	g	s
19-3-17	15	5	.60	.15	s	s
	22	7	.29	.20	g	s
	25	9	.50	.20	s	s
19-3-19	18	4	.37	.30	g	g
	23	7	.57	.30	g	g
19-3-20	21	5	.30	.05	g	s
19-3-21	17	5	.70	.20	-	-
	20	9	.50	.25	s	-
	26	13	.42	.20	s	s
19-3-23	19	5	.40	.25	g	s
	25	8	.31	.15	1	s
19-3-24	29	14	.57	.25	1	1
	33	19	.66	.20	s	s
19-3-26	29	13	.46	.20	g	1
19-3-32	24	10	.50	.10	g	s
19-3-39	28	12	.42	.20	s	s
19-3-40	28	12	.75	.60	s	1
19-3-41	38	15	.67	.35	g	1

19-3-42	17	5	.30	.05	-	-
USNM 365919	48	27	.52	.10	1	s
20-1-1	44	13	.46	.15	s	s
	54	18	.58	.15	s	s
20-1-2	38	11	.77	.15	g	s
	38	12	.75	.15	s	s
20-1-3	24	6	.92	.25	g	s
	30	9	1.00	.40	1	1
	38	14	1.00	.30	s	1
20-1-5	49	15	.60	.25	g	1
20-1-7	36	11	.68	.25	g	s
	44	17	.65	.25	s	1
20-1-11	35	8	.44	.10	1	s
	41	10	.70	.05	g	s
20-1-13	26	6	1.00	.40	g	s
	-	25	.82	.05	-	-
20-1-16	-	25	.82	.05	-	-
20-2-1	34	9	.94	.45	g	g
	38	10	.80	.50	g	s
20-3-2	48	34	.69	.10	g	1
20-3-3	25	6	.92	.15	s	s
20-3-4	31	7	.64	.25	g	s
	40	13	.73	.30	g	s
20-3-5	20	6	.83	.10	g	1
20-3-6	39	13	.81	.60	g	s
	45	16	.81	.60	s	1

20-3-7	44	12	.54	.20	s	s
	54	18	.47	.15	s	s
20-3-8	36	11	1.00	.60	g	s
20-3-9	41	18	1.00	.10	s	s
20-3-10	37	14	1.00	.15	s	s
20-4-1	39	13	.65	.20	s	s
	48	26	.35	.10	s	s
20-5-2	34	12	.54	.30	g	s
20-5-3	35	9	.67	.20	g	g
20-5-5	26	6	.92	.50	s	s
	28	7	.79	.50	s	s
	42	12	.63	.50	g	l
20-5-6	21	6	1.00	.30	g	s
	30	9	.28	.25	l	s
20-5-7	21	4	1.00	.05	g	s
UI ENT-1	36	13	.88	.20	s	l
21-1-1	11	2	1.00	.15	-	-
	19	5	.80	.30	g	s
	24	7	.71	.40	g	s
21-1a-1	22	6	1.00	.30	s	s
	32	11	.82	.25	g	l
	37	18	.69	.10	g	s
21-1a-2	26	7	.79	.45	g	s
	32	12	.75	.60	s	l
21-1a-3	26	7	.43	.40	g	g
21-1a-4	22	6	.75	.45	g	l
21-1b-1	23	8	.88	.50	s	s

	31	14	.57	.45	g	1
21-1b-2	17	5	.40	.25	-	-
21-1b-4	24	5	.60	.45	g	g
21-1c-1	33	12	.79	.40	s	1
	39	18	.56	.80	l	1
21-1c-2	26	7	.71	.45	g	g
	31	10	.55	.50	s	s
21-1c-3	36	13	.92	.50	g	1
21-1c-4	20	4	1.00	.50	g	g
21-1c-7	17	5	.90	.40	s	s
	23	7	.86	.50	s	g
21-1c-8	14	3	1.00	.20	s	g
21-1c-10	22	4	.38	.10	g	s
21-1c-13	17	4	.75	.15	g	g
23-1-1	15	4	1.00	.40	g	s
23-2-4	33	9	.39	.25	g	s
23-2-8	28	9	.67	.50	g	1
	33	15	.47	.15	s	s
23-2-17	34	12	1.00	.65	s	s
	37	16	.81	.70	s	1
23-2-20	27	7	1.00	.70	s	g
	30	10	.95	.65	g	s
23-2-24	-	9	1.00	.35	l	1
	32	11	.45	.50	s	s
23-2-28	29	9	.44	.20	g	g
	35	13	.50	.25	s	s

23-2-29	-	4	1.00	.35	s	s
	-	6	.50	.25	g	s
23-2-31	-	9	1.00	.50	-	-
23-2-37	22	4	1.00	.30	g	s
23-2-39	-	6	.50	.25	g	s
	-	7	.43	.50	g	g
23-2-40	43	21	.76	.40	s	1
23-2-41a	23	6	.63	.40	s	1
	33	12	.50	.25	1	s
23-2-43	28	8	.50	.25	1	s
23-2-45	31	9	1.00	.60	g	g
	35	17	.94	.40	-	-
23-2-47	28	8	1.00	.35	1	s
23-2-50	14	2	1.00	.10	g	g
	25	5	.30	-	s	s
23-2-52	19	4	.75	.30	g	s
23-2-54	-	12	.71	.65	s	1
23-2-55	30	10	.90	.25	s	1
23-2a-1	26	7	.86	.20	g	s
23-2a-3	33	12	1.00	.50	s	s
23-2a-5	23	7	.86	.40	s	s
	26	9	.67	.20	s	s
23-3-6	32	12	.75	.70	s	1
	34	13	.77	.60	s	1
23-3-9	-	11	.82	.15	-	-
23-3-14	23	6	1.00	.50	s	1

	25	7	.93	.50	s	1
	29	11	.73	.50	s	1
23-3-17	17	7	1.00	.70	g	g
	36	14	.93	.70	s	1
23-3-18	37	14	.46	.10	s	1
23-3-25	24	6	1.00	.60	s	s
	37	13	.77	.50	s	s
23-3-29	-	7	1.00	.40	-	-
	-	10	.80	.40	s	s
	33	12	1.00	-	1	1
23-3-31	31	11	.59	.40	s	1
23-3-35	-	9	.89	.50	-	-
23-3-36	25	9	.72	.25	g	s
23-3-40	25	7	.71	.30	g	s
23a-1-4	38	16	-	-	-	-
23a-1-8	30	12	.83	.55	g	s
25-1-1	23	7	.86	.30	-	-
25-1-4	38	15	.80	.40	-	-
	45	23	-	-	-	-

Streptelasma amsdeni

OGS-3	16	4	1.00	.15	g	s
	26	8	.69	.15	-	-
	27	10	.70	.15	s	s
	29	13	.69	.15	s	s
OGS-4	9	2	1.00	.10	-	-
	12	3	.83	.10	-	-

OGS-5	12	2	1.00	.10	g	s
	16	5	1.00	.10	g	s
OGS-6	33	11	.68	.10	s	s
OGS-8	28	12	.63	.10	s	s
OGS-9	31	17	.68	.10	s	s
OGS-11	17	4	1.00	.10	s	s
	19	7	1.00	.10	s	s
OGS-13	31	18	.44	.10	g	s
	31	19	.58	.10	g	s
OGS-14	27	7	.64	.05	s	s
	27	8	.88	.10	s	s
	31	10	.80	.20	s	s
24-1-1	24	10	.85	.10	s	g
	25	12	.67	.15	g	s
24-2-1	23	6	1.00	.20	g	s
	34	19	.95	.10	-	-
24-2-5	23	8	.75	.25	g	s
	27	11	.82	.25	s	s
24-2-11	22	7	1.00	.35	s	s
	28	11	.68	.15	g	s
	31	12	.54	.10	s	s
24-2-17	29	10	1.00	.15	s	s
	36	21	.43	.05	g	s
24-2-18	17	4	.88	.10	s	s
	23	8	.63	.10	s	s
24-2-24	10	2	1.00	.20	s	s
	10	3	1.00	.15	s	s

24-2-27	35	17	.35	.05	g	s
24-2-29	28	9	.55	.10	g	s
	31	13	.69	.15	s	s
24-2-31	26	8	.44	.10	g	s
	28	11	.45	.15	g	s
24-2-34	32	15	.73	.15	s	s
	32	18	-	-	s	s
24-2-36	20	5	.90	.10	g	s
	25	9	.33	.10	g	s
	31	13	.73	.15	g	s
	34	18	.44	.10	g	s
24-2-38	27	9	.67	.15	s	s
	27	9	.72	.20	s	s
24-2-39	17	4	.88	.10	s	s
	23	7	.43	.10	g	s
24-2-40	18	5	.80	.10	s	s
24-2-47	16	5	.60	.10	g	s
	21	6	.42	.10	g	s
24-2-54	18	4	.63	.10	g	s
	19	4	.50	.10	g	s

Streptelasma leemonense

SPECIMEN ¹	n	d	SPECIMEN	n	d
UCGM 45614	32	9	UCGM 45615	24	7
14-1-5	31	8	14-1-31	30	8
15-1-12	36	19	20-1-10	38	13

¹Numbers in parentheses indicate continuation of data from the same individual.

(20-1-10)	40	15	20-1-15	26	8
20-1-19	28	6	(20-1-19)	38	11
(20-1-19)	40	17	20-3-1a	21	5
(20-3-1a)	23	6	(20-3-1a)	25	7
(20-3-1a)	26	9	(20-3-1a)	30	10
(20-3-1a)	32	12	(20-3-1a)	36	14
(20-3-1a)	39	17	(20-3-1a)	39	18
(20-3-1a)	39	19	(20-3-1a)	39	19
(20-3-1a)	39	20	20-3-1b	19	5
(20-3-1b)	22	6	(20-3-1b)	23	6
(20-3-1b)	24	7	(20-3-1b)	25	7
(20-3-1b)	26	7	(20-3-1b)	28	8
20-4-2	28	9	UI C1448	37	12
23-2-32	29	10	23-2-36	34	11
23-2a-2	29	7	23-3-1	26	8
(23-3-1)	30	10	23-3-3	40	15
(23-3-3)	42	16	23-3-4	32	10
23-3-8	26	7	23-3-10	23	5
(23-3-10)	27	7	23-3-11	28	11
(23-3-11)	30	12	23-3-12	26	7
(23-3-12)	35	12	23-3-13	32	12
23-3-20	32	11	23a-1-2	35	12
23a-1-3	30	9	(23a-1-3)	33	10

Streptelasma sp. cf. S. leemonense

23-2a-4	28	5	(23-2a-4)	34	9
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(23-2a-4)	35	10	(23-2a-4)	37	11
(23-2a-4)	38	12	23-3-22	19	4
(23-3-22)	21	4			

Streptelasma sp. A

15-0-1	16	2.5	(15-0-1)	17	3
15-0-1A	12	2	(15-0-1A)	14	2
15-0-1C	12	2	(15-0-1C)	13	2.5

Grewingia sp. A

14-2-7	22	7	(14-2-7)	31	10
(14-2-7)	32	11			

Keelophyllum oklahomense

23-3-2	29	20	23-3-19	32	13
(23-3-19)	32	14	(23-3-19)	32	17
23-3-30	31	17	23-3-33	20	3
(23-3-33)	30	12	23a-1-1	14	4
(23a-1-1)	20	5	(23a-1-1)	28	11
(23a-1-1)	30	18	25-1-2	30	12
(25-1-2)	30	12	(25-1-2)	30	17

Rhegmaphyllum

17-1a-4	18	4	(17-1a-4)	19	5
17-2b-5	21	7	(17-2b-5)	22	8
17-3-5	19	5	(17-3-5)	22	6

Dinophyllum

17-2-3	21	4	(17-2b-3a)	29	9
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17-3-1	23	5	(17-3-1)	36	9
(17-3-1)	41	15			

Dalmanophyllum

6-1-5	24	8	10-2-5	24	8
(10-2-5)	30	11	17-1-10	12	2
(17-1-10)	15	3	(17-1-10)	20	5
(17-1-10)	?20	?6	17-2a-2	28	11
UCGM 45639	30	12			

Phaulactis

9-1-6	30	13	(9-1-6)	?35	22
17-2-1	30	12	(17-2-1)	38	23

Unassigned specimens belonging to Silurian assemblage

17-1-2	20	5	(17-1-2)	23	7
17-1-3	15	4	(17-1-3)	24	7
17-1-4	17	3	(17-1-4)	20	5
17-1-8	12	3	17-1a-1	23	6
(17-1a-1)	29	10	17-1a-5	18	5
17-1a-6	22	5	17-1a-7	20	4
(17-1a-7)	25	8	(17-1a-7)	25	9
17-2-2	27	8	17-2-4	24	6
(17-2-4)	25	7	17-2-9	16	4
(17-2-9)	24	7	17-2-14	20	5
17-2-15	31	9	17-2-16	25	8
17-2a-3	26	6			

17-2a-4	27	7	17-2a-6	20	5
17-2a-7	21	5	17-0(2a)-38	24	6
17-2b-1	21	7	17-2b-2	19	6
17-2b-3	26	7	17-2b-4	14	3
(17-2b-4)	18	4	17-3-2	20	4
(17-3-2)	22	6	(17-3-2)	30	13
(17-3-2)	30	15	17-3-3	21	6
(17-3-3)	26	10	(17-3-3)	27	12
17-3-4	17	4	(17-3-4)	19	6
(17-3-4)	21	8	17-3-6	23	7
17-3-7	25	7	17-3-8	32	10
17-3-9	20	6	17-3-10	15	4
17-3-11	18	6	(17-3-11)	18	7
17-3-12	21	7	14-2-2	18	4
(14-2-2)	22	5	14-2-8	20	6
(14-2-8)	24	7			

APPENDIX 3: CARDINAL FOSSULA WIDTH AND SHAPE

Width of cardinal fossula (fw) was measured in mm between median lines of septa immediately adjacent to the fossula, midway between axial and peripheral ends of septa bounding the fossula. Shape (ft) is according to the types described in SYSTEMATIC PALEONTOLOGY under Streptelasma subregulare. Two numbers separated by a slash indicate the shapes on either side of a fossula. Coral diameter (d) was measured in mm on the transverse thin section. Specimen numbers in parentheses indicate continuation of data from the same individual.

SPECIMEN	fw	ft	d	SPECIMEN	fw	ft	d
<u>Streptelasma subregulare</u>							
3-3-13	1.7	1	12	3-3-16	1.8	4	10
3-3-24	1.5	2	12	3-3-30	1.4	4	8
(3-3-30)	1.8	4	13	UI C1560a	1.1	4/5	7
(UI C1560a)	1.6	3	10	(UI C1560a)	1.6	5	13
UI C1581a	1.5	2	10	(UI C1581a)	1.9	3	15
(UI C1581a)	2.6	5	22	4-1-2	1.1	4	6
(4-1-2)	.9	4/5	8	4-1-6	2.0	5/4	7
13-1-1	1.5	5/2	7	13-1-2	1.6	4	8
(13-1-2)	1.8	5	15	13-1-3	.7	4	5
(13-1-3)	1.7	3	13	13-1-5	.8	4	4
14-1-2	1.0	2	7	(14-1-2)	1.4	5/1	15
(14-1-2)	2.4	1/3	19	14-1-3	2.2	5	14

14-1-4	1.1	5/1	10	(14-1-4)	2.2	4	16
14-1-7	1.2	3/1	11	14-1-8	1.2	4/5	9
(14-1-8)	1.7	3	12	(14-1-8)	1.5	2	17
14-1-9	1.2	4	8	(14-1-9)	1.8	4	15
14-1-11	1.7	4	18	14-1-12	.9	5	13
14-1-13	2.8	3	17	14-1-15	.7	1	3
(14-1-15)	.9	1	5	(14-1-15)	1.3	1	8
14-1-18	1.1	2	8	14-1-19	1.3	4	10
14-1-22	1.4	2	8	14-1-26	2.0	1	11
14-1-30	.7	5	4	(14-1-30)	.7	5	9
(14-1-30)	1.9	4	16	15-1-1	.8	2/5	4
(15-1-1)	1.4	5/3	12	15-1-2	.9	4	3
15-1-3	1.3	5	9				
15-1-4	1.2	4/3	6	15-1-6	1.2	4	6
15-1-7	1.8	5	11	15-1-9	1.3	2	12
15-1-11	1.0	2	7	15-1-13	1.3	2/4	17
15-1-14	1.4	4	9	15-1-15	.8	5	6
15-1-16	1.0	2	6	UCGM 45644	1.4	1	15
21b-2-3	1.0	1	5	(21b-2-3)	.8	1	8
21b-2-4	1.1	4	7	(21b-2-4)	.8	1	10
21b-2-8	-	1	4	(21b-2-8)	-	1	9
(21b-2-8)	-	1	12	16-1-1	1.0	2/4	6
(16-1-1)	1.2	5/4	11	16-1-3	1.1	2	9
(16-1-3)	1.2	2	12	16-1-4	.7	4	2
(16-1-4)	1.5	1	8	(16-1-4)	1.2	2	12
16-1-5	.8	1	3	(16-1-5)	.7	1	5

(16-1-5)	1.3	1	8	(16-1-5)	1.2	1	10
(16-1-5)	1.3	1	12	16-1-6	2.1	4	17
16-1-9	1.2	1	6	(16-1-9)	1.1	1	8
16-1-10	2.0	1	16	16-1-11	1.8	4	9
(16-1-11)	2.1	1	9	16-1-19	1.4	4	8
(16-1-19)	2.2	1/4	12	16-1-22	.9	1	6
(16-1-22)	2.0	4	16	16-1-25	1.1	5	12
(16-1-25)	1.5	2	14	16-1-26	1.3	1	10
(16-1-26)	1.6	1/2	12	16-1-27	1.0	1	5
(16-1-27)	1.4	1	10	16-1-29	1.6	1	7
(16-1-29)	1.0	2	8	(16-1-29)	1.4	4	12
(16-1-29)	1.5	2/5	16	16-1-31	1.0	1	10
16-1-37	1.5	2	9	16-1-47	1.6	3	8
17-0-(24-2-25)	1.0	2	7	[17-0-(24-2-25)	1.1	2	10]
17-0-1	1.2	2/1	10	(17-0-1)	1.4	5	13
(17-0-1)	1.3	4/5	14	(17-0-1)	1.5	5/2	16
17-0-2	1.5	1	10	17-0-3	1.0	2/5	15
17-0-4	1.4	2	10	(17-0-4)	1.7	2	13
17-0-5	1.0	3	8	(17-0-5)	1.5	3	11
17-0-6	.8	1	5	(17-0-6)	1.3	4	8
(17-0-6)	1.5	2	12	17-0-7	1.1	1	9
(17-0-7)	1.1	1	10	17-0-8	1.1	2	7
(17-0-8)	1.1	2	12	17-0-9	.9	3	10
17-0-10	.7	1	3	(17-0-10)	.8	1	4
(17-0-10)	.9	2	7	(17-0-10)	1.2	2	11
17-0-11	1.3	1/3	9	17-0-13	1.7	1	9

17-0-14	1.2	4	7	17-0-16	1.8	1	12
(17-0-16)	2.2	4	15	17-0-17	1.1	2	6
(17-0-17)	2.3	3	10	(17-0-17)	2.5	1	15
17-0-18	1.8	2	9	17-0-19	1.2	4	9
17-0-20	1.3	1	10	17-0-23	.9	2	5
(17-0-23)	1.2	2	7	(17-0-23)	1.4	4	11
17-0-25	1.4	1	8	17-0-26	2.0	1/5	13
17-0-27	1.1	1	10	17-0-28	1.1	1	10
17-0-29	.9	2	7	(17-0-29)	1.3	2	12
17-0-30	1.0	4	9	17-0-31	1.0	2	5
17-0-32	.7	2	3	(17-0-32)	.9	2	5
(17-0-32)	1.4	2	10	17-0-34	1.0	1	6
17-0-36	1.3	3/1	7	17-0-37	.8	4	6
18-1-2	2.0	4	7	18-1-5	1.4	4/2	8
18-1-6	2.3	2	10	18-1-7	2.2	5	8
18-1-12	2.1	2	14	18-1-16	1.3	2	3
(18-1-16)	1.6	5	6	18-1-25	2.2	5	11
(18-1-25)	2.0	5	15	18-1-26	1.7	2	11
18-1-27	5.0	4	16	18-1-28	3.0	4	6
(18-1-28)	3.0	3	10	18-2-2	.9	1	13
(18-2-2)	1.6	1	14	18-2-7	.9	2	2
(18-2-7)	2.0	4	4	(18-2-7)	2.2	3	7
18-2-8	3.6	3/5	14	18-2-9	1.5	5	6
(18-2-9)	2.5	3	7	18-2-10	1.8	5	6
18-2-15	1.2	4/1	11	(18-2-15)	1.7	5	14
18-2-16	1.1	2	4	(18-2-16)	1.0	2	8

18-2-19	1.0	4	10	18-3-1	2.2	2	10
(18-3-1)	1.8	2/1	17	(18-3-1)	2.4	2	25
18-3-2	3.2	4/2	12	(18-3-2)	5.1	2	22
18-3-3	2.6	4	10	(18-3-3)	3.5	2	11
18-3-3	3.0	2/5	13	18-3-8	2.2	3	14
18-3-10	.9	2	7	18-3-11	1.5	4	5
18-3-15	2.3	5/2	18	(18-3-15)	1.9	5	21
18-3-16	1.2	4	8	(18-3-16)	1.2	4	9
(18-3-16)	1.6	5	15	(18-3-16)	2.0	5	22
18-3-17	.9	2	5	(18-3-17)	1.6	4	11
(18-3-17)	2.6	2	21	(18-3-17)	2.6	2/5	21
18-3-19	1.2	4/2	10	18-3-20	2.3	2/5	9
18-3-22	1.6	1	11	18-4-1	1.1	4	8
(18-4-1)	1.2	2	20	(18-4-1)	3.1	2/5	30
USNM 365918	1.9	3/5	16	(365918)	3.2	3	22
(365918)	5.3	3	29	UCGM 45618	3.9	3	10
(UCGM 45618)	3.2	2	18	(UCGM 45618)	1.8	3/2	29
UCGM 45619	1.7	1	15	(UCGM 45619)	2.2	2	21
19-1-2	1.4	5/1	5	(19-1-2)	2.2	2/5	6
(19-1-2)	1.5	4/2	8	(19-1-2)	1.5	2/4	11
19-1-4	1.3	5	13	(19-1-4)	3.6	3	21
19-1-7	1.8	5/4	10	(19-1-7)	3.0	3	13
19-1-8	1.8	1	10	(19-1-8)	2.4	1/5	13
19-1-9	1.0	4/2	6	(19-1-9)	1.6	5/4	16
19-1-10	1.4	4	10	(19-1-10)	2.4	2	18
19-1-11	1.0	1	8	(19-1-11)	1.0	1/4	11

(19-1-11)	2.9	3/1	21	19-1-12	.9	1/4	5
(19-1-12)	2.1	2/4	13	(19-1-12)	4.4	3	22
19-1-13	4.0	3	24	19-1-14	2.1	5/2	17
19-1-15	1.2	4	10	(19-1-15)	2.7	4/3	23
(19-1-15)	4.3	3	32	19-2-1	1.3	5	13
19-2-5	1.3	4	8	19-2-7	1.7	3	6
(19-2-7)	1.8	5/4	9	19-2-11	1.7	4/1	6
(19-2-11)	2.4	4	10	(19-2-11)	2.1	5	17
19-2-16	1.6	4/1	4	(19-2-16)	2.4	4/1	9
(19-2-16)	1.6	4/5	11	19-2-18	1.0	2	6
(19-2-18)	2.5	2/3	16				
19-3-1	1.5	3/2	7	(19-3-1)	2.5	4	14
(19-3-1)	3.1	2	20	19-3-2	1.4	1	12
(19-3-2)	3.3	3/1	27	19-3-3	1.0	4/1	6
(19-3-3)	2.8	3/1	18	(19-3-3)	2.8	3	21
19-3-4	.5	2	7	(19-3-4)	1.2	2	8
(19-3-4)	1.5	5/4	19	19-3-8	1.7	3	8
(19-3-8)	1.6	5/4	9	(19-3-8)	1.1	5	13
19-3-12	2.2	1	10	(19-3-12)	2.6	2	15
(19-3-12)	3.3	5/3	21	19-3-15	1.7	5	10
(19-3-15)	2.5	4	15	19-3-16	1.9	1	10
19-3-17	1.3	1	10	19-3-19	1.0	1	4
(19-3-19)	1.2	2/4	7	19-3-20	1.7	2	5
19-3-21	1.8	3	5	(19-3-21)	1.6	1	9
(19-3-21)	2.0	1	13	19-3-23	1.8	1	5
(19-3-23)	2.0	3	8	19-3-24	2.7	4/3	14

(19-3-24)	2.8	2	19	19-3-26	1.6	5	13
19-3-29	1.5	2	6	19-3-32	1.2	5/2	10
19-3-40	1.9	5	12	19-3-41	2.1	2	14
(19-3-41)	2.0	3/1	15	USNM 365919	1.3	5	13
(365919)	2.0	1	16	20-1-1	1.5	2	13
(20-1-1)	2.3	3	18	20-2-2	1.5	3/4	11
(20-2-2)	1.8	3	12	20-1-3	.6	5	6
(20-1-3)	.9	5	9	(20-1-3)	2.2	5/4	14
20-1-5	3.0	3	15	20-1-6	2.9	2	27
20-1-7	1.4	4/5	11	(29-1-7)	2.1	3	17
20-1-11	1.1	3	8	(20-1-11)	1.2	2	10
20-1-13	1.5	4	6	20-2-1	1.2	4	9
(20-2-1)	1.3	3	10	20-3-3	.8	5	6
20-3-4	1.5	3	7	(20-3-4)	1.6	3/5	13
20-3-5	1.3	5/3	6	20-3-7	1.5	3	12
(20-3-7)	1.8	2	18	20-3-8	1.5	2	11
20-3-9	2.1	2/5	18	20-3-10	1.8	2	14
20-4-1	2.0	2/4	13	(20-4-1)	3.1	3	26
20-5-2	1.6	2	12	30-5-3	1.0	5/2	9
20-5-5	1.0	3/4	6	(20-5-5)	1.3	3/1	7
(20-5-5)	2.0	3	12	20-5-10	2.5	4/2	-
UI ENT-1	1.7	2	13	21-1-3	1.1	2	5
(21-1-3)	1.1	3	7	21-1a-1	1.1	3/4	6
(21-1a-1)	1.6	3	11	(21-1a-1)	2.5	3	18
21-1a-2	1.1	3	7	(21-1a-2)	1.3	2	12
21-1a-3	1.2	2	7	21-1a-4	.8	2	6
21-1b-1	1.1	2/4	8	(21-1b-1)	1.9	2	14

21-1b-3	.7	1	4	21-1b-4	.9	2	5
21-1b-9	.7	2	4	21-1c-1	1.1	5	12
(21-1c-1)	2.3	3	18	21-1c-2	1.1	3	7
(21-1c-2)	1.1	5	10	21-1c-3	1.9	4/3	13
21-1c-4	1.1	2	4	21-1c-7	1.2	2	5
(21-1c-7)	1.2	4	7	21-1c-8	.6	4	3
21-1c-10	.9	2	4	21-1c-13	1.0	2	4
23-1-1	.6	1	4	23-2-8	1.5	4	9
(23-2-8)	1.3	3	15	23-2-17	2.3	2	12
(23-2-17)	1.5	4	16	23-2-24	1.9	4	12
23-2-28	1.3	3/1	9	(23-2-28)	1.3	3/5	13
23-2-29	.8	1	4	(23-2-29)	1.1	3/5	6
23-2-37	1.0	2	4	23-2-39	1.2	3	6
23-2-40	1.8	2	21	23-2-41a	1.0	3	6
(23-2-41a)	1.3	2	12	23-2-45	1.2	4	9
23-2-47	.8	5	8	23-2-50	.8	2	3
(23-2-50)	.9	2	5	23-2-52	.8	1/4	4
23-2-54	1.7	3/4	12				
23-2-55	1.3	2	10	23-2a-1	1.1	2	7
23-2a-3	1.3	4	12	23-2a-5	1.3	4/2	7
(23-2a-5)	1.6	2	9	23-3-6	1.2	4/3	12
23-3-14	.7	2	6	(23-3-14)	.7	2	7
(23-3-14)	1.2	2	11	23-3-17	2.0	4/2	15
23-3-18	2.2	3	14	23-3-24	1.5	1	10
23-3-25	.9	2	6	(23-3-25)	1.8	4	13
23-3-29	.9	1	7	(23-3-29)	.7	5	10

23-3-31	1.4	3	11	23-3-36	1.7	3	9
23-3-40	1.1	2	7	23a-1-8	1.6	1	12
25-1-4	2.7	3	23				

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OGS-3	1.0	1/5	4	(OGS-3)	1.4	1	10
(OGS-3)	1.3	5	12	OGS-5	1.0	5	4
OGS-6	1.6	2	11	OGS-8	2.2	5	11
OGS-9	2.2	5/2	17	OGS-11	.7	1/2	4
(OGS-11)	1.6	4	7	OGS-13	2.3	5	17
(OGS-13)	3.1	1	18	OGS-14	1.2	1/2	10
24-1-1	1.5	1	10	(24-1-1)	1.9	5	12
24-2-1	1.1	4	6	24-2-5	1.1	4/1	7
(24-2-5)	1.4	5	10	24-2-11	1.2	4	6
(24-2-11)	1.4	5	11	(24-2-11)	1.9	1	12
24-2-17	1.2	5	10	(24-2-17)	2.7	4	21
24-2-18	1.0	2/1	4	(24-2-18)	1.6	5/4	8
24-2-24	.6	1	2	(24-2-24)	.9	1	3
24-2-27	2.7	4	18	24-2-29	2.0	3	9
(24-2-29)	1.8	5/2	9	(24-2-29)	1.6	5/1	12
(24-2-29)	2.1	4/5	13	24-2-31	1.6	1	8
24-2-34	1.8	1/5	15	(24-2-34)	2.9	1	18
24-2-36	1.0	1	5	(24-2-36)	2.9	1	18
(24-2-36)	1.6	5/1	13	24-2-38	1.6	4/1	10
(24-2-38)	1.6	2/1	10	24-2-39	.8	2/1	4
(24-2-39)	1.9	1	7	24-2-40	1.3	2	5
24-2-47	1.4	5	4	24-2-54	.7	1/4	4
(24-2-54)	1.2	1	4				

APPENDIX 4: TABULAE PER UNIT LENGTH

Tabulae/cm was calculated by counting the number of tabulae at the coral axis in a longitudinal thin section, and dividing by the total length of the interval examined.

SPECIMEN	Tabulae/cm	SPECIMEN	Tabulae/cm
<u>Streptelasma subregulare</u>			
<u>13-1-2</u>	2.0	<u>14-1-3</u>	2.9
<u>14-1-8</u>	11.8	<u>14-1-13</u>	9.0
<u>14-1-30</u>	4.8	<u>15-1-15</u>	6.0
<u>16-1-1</u>	5.0	<u>16-1-3</u>	5.3
<u>16-1-5</u>	4.7	<u>16-1-6</u>	9.3
<u>17-0-3</u>	20.0	<u>17-0-6</u>	15.7
<u>17-0-10</u>	7.5	<u>17-0-11</u>	27.2
<u>17-0-16</u>	10.7	<u>17-0-17</u>	7.0
<u>17-0-20</u>	14.7	<u>18-2-15</u>	5.0
<u>18-3-1</u>	6.8	<u>18-3-15</u>	4.4
<u>18-3-17</u>	4.7	<u>18-3-18</u>	8.3
<u>18-4-1</u>	3.9	UCGM 45619	4.6
UCGM 45628	4.4	<u>19-1-12</u>	9.5
<u>19-3-4</u>	5.6	<u>20-3-7</u>	8.0
<u>20-3-9</u>	8.1	<u>21-1a-1</u>	6.5
<u>21-1c-3</u>	4.0	<u>21-1c-18</u>	5.0

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<u>OGS-7</u>	4.8	<u>OGS-10</u>	5.1
<u>OGS-12</u>	4.0	<u>OGS-13</u>	4.3
<u>24-2-7</u>	5.0	<u>24-2-10</u>	5.1
<u>24-2-11</u>	4.0	<u>24-2-12</u>	4.1
<u>24-2-36</u>	4.7		

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<u>20-1-10</u>	9.3	<u>23-3-1</u>	11.4
<u>23-3-11</u>	20.0		
