UNIVERSITY OF KANSAS PALEONTOLOGICAL CONTRIBUTIONS

COELENTERATA, ARTICLE 3, PAGES 1-12, PLATES 1, 2, FIGURES 1-3

MISSISSIPPIAN CORALS FROM NEW MEXICO AND A RELATED PENNSYLVANIAN SPECIES

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ABSTRACT

A varied assemblage of fossil corals characterizes the marine Mississippian rocks of New Mexico. This paper summarizes information concerning the occurrence and identification of some easily recognized species that are known also from the Mississippi Valley region. The corals include *Microcyclus blairi* MILLER, *Cleistopora typa gorbyi* (MILLER) JEFFORDS, n. comb., *Palaeacis bifida* WELLER, *P. enormis* (MEEK & WORTHEN), and an unnamed form referred questionably to *Cumminsia*. A related species, *Palaeacis kingi* JEFFORDS, n. sp., from Missourian (Canyon) rocks of Texas is described also.

INTRODUCTION

During studies on the stratigraphy of Mississippian strata in the Sacramento Mountains of south-central New Mexico, L. R. LAUDON and A. L. BOWSHER obtained excellent collections of the invertebrate fauna. Preliminary identification of the varied assemblage of corals, bryozoans, crinoids, and brachiopods have been tabulated (LAUDON & BOWSHER, 1941), and more comprehensive investigations, particularly on the crinoids, are in progress.

This paper describes a few of the more distinctive corals that occur in the Mississippian formations of south-central New Mexico, and one related Pennsylvanian species from Texas. The corals have especial value in that they may be recognized commonly without sectioning, and so are usable readily in field studies.

Lower and Middle Mississippian corals from North America are described in many papers including particularly those by EASTON (1944), GROVE (1934, 1935), HAYASAKA (1936), KEYES (1894), MILLER (1892), SLOSS (1945), STUMM (1948), WELLER (1909), WILLIAMS (1943), and WINCHELL (1863). A few reports (COPE, 1882; GORDON, 1907; LAUDON & BOWSHER, 1941; MILLER, 1881; and SPRINGER, 1884) list fossils, including a few corals, from the Mississippian formations of New Mexico, but none describes or illustrates critical data on the coral fauna. A single species of rugose coral, *Caninia arcuata* JEFFORDS (1943), has been described, but little information is available on other rugose species.

Studies on Lower Carboniferous corals carried on in western Europe (CARRUTHERS, 1910; HILL, 1938-40; VAUGHAN, 1905, 1909) and in Asia (CHI, 1931; YÜ, 1931) have demonstated the importance of these fossils in stratigraphic correlation for these areas. The narrowly defined faunal zones of the marine Lower Carboniferous strata in Europe and Asia either have rugose or tabulate corals as diagnostic index fossils or utilize them as important supplementary guide forms. In North America, however, corals of this age have been used less commonly than some other fossils such as the crinoids and brachiopods. Recognition and use of Mississippian corals seems to have been retarded in part by the indefinite description given by early workers at a time when the importance of many structural features was unknown. Also, the stratigraphic implication of some significant forms has been concealed by a very broad interpretation of specific characters. Recent papers by GROVE (1934, 1945), EASTON (1944), SLOSS (1945), and STUMM (1948) furnish much needed information on many species of Mississippian corals, but there remain many important types of corals that are known very incompletely.

The Mississippian rocks of south-central New Mexico have been divided into the Caballero formation (below) and the restricted Lake Valley formation (above) by LAUDON & BOWSHER (1941). This latter unit is divided, in ascending order, into the Alamogordo, Arcente, and Dona Ana members (Fig. 1). The fauna of the Caballero formation includes a predominance of Kinderhookian species together with a few typical Osagian forms. Accordingly, this formation is placed in the Kinderhookian Series, probably Chouteau in age, because of the relative abundance of species that occur typically in rocks of that age elsewhere. The possibility of an early Osagian age is recognized (LAUDON & BOWSHER, 1941, p. 2123-2125). The restricted Lake Valley formation is interpreted to range in age from earliest Osagian to the upper part of the lower Bur-

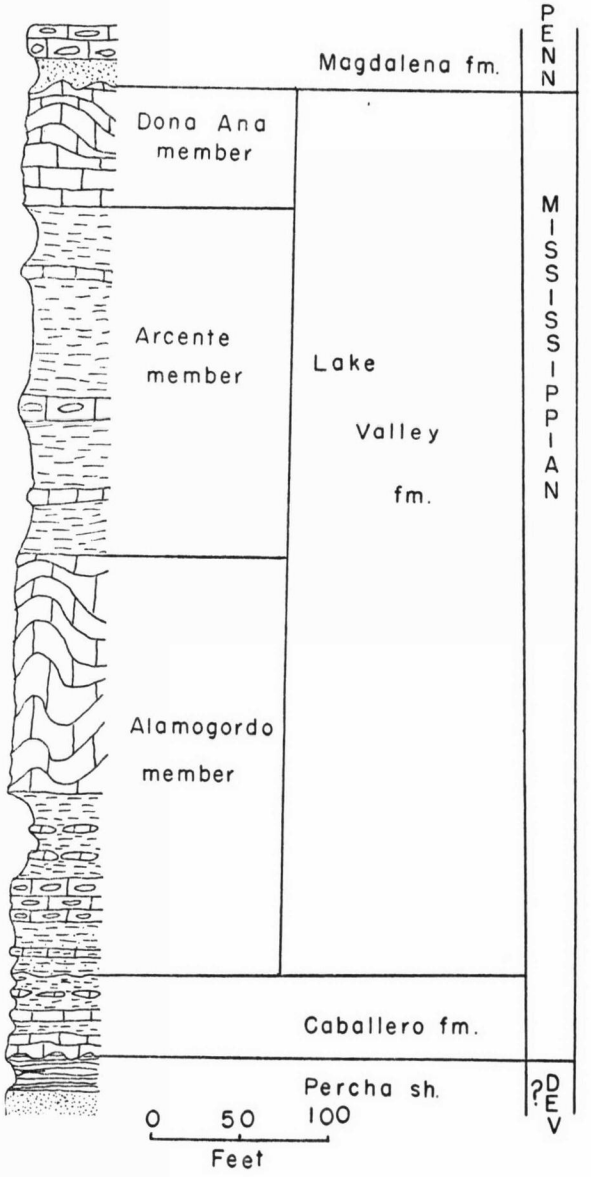


FIGURE 1.—Section showing relationships of Mississippian formations in the Sacramento Mountains of New Mexico (*after Laudon & Bowsher, 1941*).

lington limestone of the Mississippi Valley area (LAUDON & BOWSHER, 1941, p. 2138).

Of the corals recognized in the Mississippian rocks of New Mexico, *Palaeacis* occurs somewhat sparingly throughout the Mississippian in North America and has been identified also in equivalent rocks of Australia and Great Britain. This genus is known also in the Bendian and Missourian Series of the Pennsylvanian, and closely allied forms occur in the Permian of Timor. *Palaeacis bifida* WELLER (1909) from the Caballero and Lake Valley formations is known in the Mississippi Valley area from the Fern Glen formation and possibly may be represented in the younger Kinderhookian formations. *Palaeacis enormis* (MEEK & WORTHEN, 1860), which is identified from the Alamogordo member in the lower part of the Lake Valley formation, is reported also in the Rockford limestone of Indiana, the Hampton formation (of LAUDON) of Iowa, and the Saverton and Louisiana formations of Missouri.

Cleistopora typa gorbyi (MILLER) JEFFORDS, n. comb., which occurs in the Caballero formation, is essentially identical to specimens from the lower Chouteau limestone of Missouri. *Microcyclus blairi* MILLER is known both from the Caballero formation of New Mexico and the Chouteau, Sedalia, and Burlington formations of the Mississippi Valley area. A preliminary examination of the rugose corals of the Lake Valley formation, largely from the blue-gray marl facies of the Alamogordo member, indicates the abundant occurrence of *Cyathaxonia* and so-called zaphrenthid species. This fauna resembles that of the Fern Glen shale of Missouri, but the similarity is indicative probably of similar facies conditions rather than precise stratigraphic equivalence.

The corals here described do not definitely establish the accuracy of the correlations made by LAUDON & BOWSHER (1941), but insofar as these species and genera are known now in Mississippian rocks of other areas, they are in general accordance. The coral fauna suggests strongly that the Caballero formation is not later than Chouteau in age and probably is equivalent to the early Chouteau. The relative age of the Lake Valley formation is not closely defined by the data on the corals, but the Alamogordo member is tentatively considered to be the approximate equivalent or slightly older than the Fern Glen formation of Illinois and Missouri.

The specimens from New Mexico that are described in the present paper were loaned for study by L. R. LAUDON (University of Wisconsin) and A. L. BOWSHER (U. S. Geological Survey), formerly of the University of Kansas. They have aided this study, also, by furnishing pertinent information on the occurrence of the specimens and on the stratigraphic position of corals in Mississippian formations of the upper Mississippi Valley. R. H. KING, University of Kansas, furnished several specimens of the new species of *Palaeacis* from Texas, and H. J. PLUMMER (formerly, University of Texas) made available for study additional material from the type locality.

SYSTEMATIC PALEONTOLOGY

SUBCLASS **RUGOSA** EDWARDS & HAIME, 1850

FAMILY **PORPITIDAE** MOORE & JEFFORDS, 1945

Descriptions and information concerning this family are given in MOORE & JEFFORDS (1945, p. 164) and in the preceding article. Accordingly, these data do not need repetition here. Range, Silurian to Pennsylvanian.

GENUS **MICROCYCLUS** MEEK & WORTHEN, 1868

Small very thin discoidal solitary corals comprise this genus. The base is covered by a concentrically wrinkled theca having a small area of attachment located slightly on the counter side of the center. Septal markings are lacking on the base. The calyx, which rises slightly above the theca surrounding it, bears a shallow cardinal fossula and indistinct alar pseudofossulae. These features may be quite inconspicuous, however, on mature specimens of some species. The cardinal septum is shortened slightly and other major septa are subequal in radial length; the septal arrangement in youthful stages seems to be the cumminsioid type. Minor septa, where present, are short and commonly lean or incline toward adjacent major septa. The axial region is relatively broad and smooth. An axial column, tabulae, and dissepiments are lacking.

Genotype.—*Microcyclus discus* MEEK & WORTHEN (1868), Devonian (probably Hamilton), Illinois.

Discussion.—The relatively even distribution of the short septa and the thin discoidal form serve to separate *Microcyclus* from other genera of porpitid corals. Although the cumminsioid pattern of the septa in immature specimens resembles that of *Cumminsia* MOORE & JEFFORDS (1945, p. 164) and some species commonly referred to *Hadrophyllum* EDWARDS & HAIME (1850, p. lxvii), the general shape of the corallite permits separation readily.

Occurrence.—Devonian of North America and Europe; Mississippian of North America.

Microcyclus blairi MILLER

Plate 1, figures 2, 6-7; Plate 2, figure 5

Microcyclus blairi MILLER, *1891*, Indiana Dept. Geol. Nat. Res., 17th. Ann. Rept., p. 7, pl. 9, figs. 27-28, Adv. Sheets. ——— MILLER, *1892*, Indiana Dept. Geol. Nat. Res., 17th. Ann. Rept., p. 261, pl. 9, figs. 27-28. ——— BASS-

LER, *1937*, Jour. Paleontology, vol. 11, p. 196, pl. 31, fig. 17. ——— EASTON, *1944*, Illinois Geol. Survey, Rept. Invest. 97, p. 20, pl. 16, figs. 9-10.

This species is represented by relatively small thin to flat corallites that bear well defined concentric wrinkles on the basal theca. The specimens are mostly about 9 mm in diameter, but a large gerontic specimen reaches 18 mm. The cardinal septum lies in a large cardinal fossula on the small immature specimens and the septa of the cardinal quadrants shorten progressively from the alar to the cardinal septum. The septal pattern is typically cumminsioid, and the longer septa reach nearly to the axis. Major septa are gradually shortened as maturity is reached where they are represented by short peripheral structures. The cardinal fossula persists, but the alar pseudofossulae are inconspicuous. A few gerontic specimens are characterized by a large flat to rounded axial area and very short undifferentiated major septa along the periphery.

Discussion.—The specimens of *Microcyclus* from New Mexico include the immature stage in which the septa reach nearly to the axis and the cardinal fossula and alar pseudofossulae are well defined, and more mature specimens. The corallites correspond closely to illustrations of the type material given by EASTON (1944, pl. 16, figs. 9-10). A few of the specimens are slightly larger than described representatives of *Microcyclus blairi*, but these seem to comprise gerontic individuals in an extreme breviseptal stage.

Occurrence.—Caballero formation, Kinderhookian series, Lower Mississippian, New Mexico. The specimens were collected by L. R. LAUDON and A. L. BOWSHER in the Sacramento Mountains from midway between Alamo and Marble Canyons (3 feet above the base of the formation); Marble Canyon, SW sec. 23, T. 16 S., R. 10 E.; 1 mile south of Marble Canyon; and ¼ mile south of Marble Canyon. Specimens were collected also from Ash Canyon at SE NW sec. 28, T. 19 S., R. 4 E.; San Andres Canyon; and north side of Apache Hill, cen. sec. 28, T. 18 S., R. 17 W., near Lake Valley. Other corallites were collected from the north end of Cooks Range, SE sec. 14, T. 20 S., R. 9 E.

EASTON (1944, p. 29) reports this species from the Chouteau, Sedalia, and Burlington formations of the Mississippi Valley area.

Material studied.—About twenty specimens were available for examination. Most of the corallites were attached to the matrix by one side, but a few were free.

GENUS CUMMINSIA MOORE & JEFFORDS, 1945

This genus includes thick discoidal to top-shaped corallites which bear a concentrically wrinkled theca on the base. The septa typically rise above the thecate portion of the corallite. Major septa are grouped into well defined quadrants that are outlined by the very deep cardinal fossula, the slightly elongated and elevated counter septum, and the two alar pseudofossulae. The strong angle between the long alar septa and the shorter septa of the counter quadrants and similarly between the cardinal septum and the adjacent major septa of the cardinal quadrants is a prominent characteristic. Axial structures and vesicular tissue are lacking.

Genotype.—*Hadrophyllum aplatum* CUMMINS, Smithwick shale, Bendian series, Lower Pennsylvanian, Texas.

EXPLANATION OF PLATE 1

All figures are three times natural size except as indicated.

FIGURE — PAGE

1, 3, 10.—*Palaeacis kingi* JEFFORDS, n. sp., from the Brownwood? shale, Missourian (Canyon) Series, Pennsylvanian, at the clay pit in Bridgeport, Wise County, Texas 11

1a-b.—Type specimen (Univ. Kansas No. 7089-21a). *a*, View showing the interior of the calices. *b*, Side view

3.—Lateral view of a more elongate specimen (Univ. Kansas No. 7089-21b) showing the anastomosing ridges on the surface

10.—View (× 7.5) of fragment (Univ. Kansas No. 7089-21c) showing the anastomosing character of the surface

2, 6-7.—*Microcyclus blairi* MILLER, from the Caballero formation, Kinderhookian Series, Mississippian, New Mexico 3

2a-b.—Mature specimen (J306b) from the north side of Apache Hill, cen. sec. 28, T. 18 S., R. 7 W., near Lake Valley, New Mexico. *a*, View of base showing area of attachment. *b*, View of calyx showing short septa and smooth axial area

6.—View of calyx of large mature specimen (J308a) from San Andres Canyon, San Andres Mountains, New Mexico

7.—View of calyx of small specimen (J310a) from ¼ mile south of Marble Canyon, Sacramento Mountains

FIGURE — PAGE

4.—*Palaeacis enormis* (MEEK & WORTHEN), from the blue-gray marl facies, 18 feet above the top of the black cherty limestone, Alamogordo member, Lake Valley formation, Osagian Series, Mississippian, at NW sec. 28, T. 16 S., R. 10 E., Sacramento Mountains, New Mexico, 10

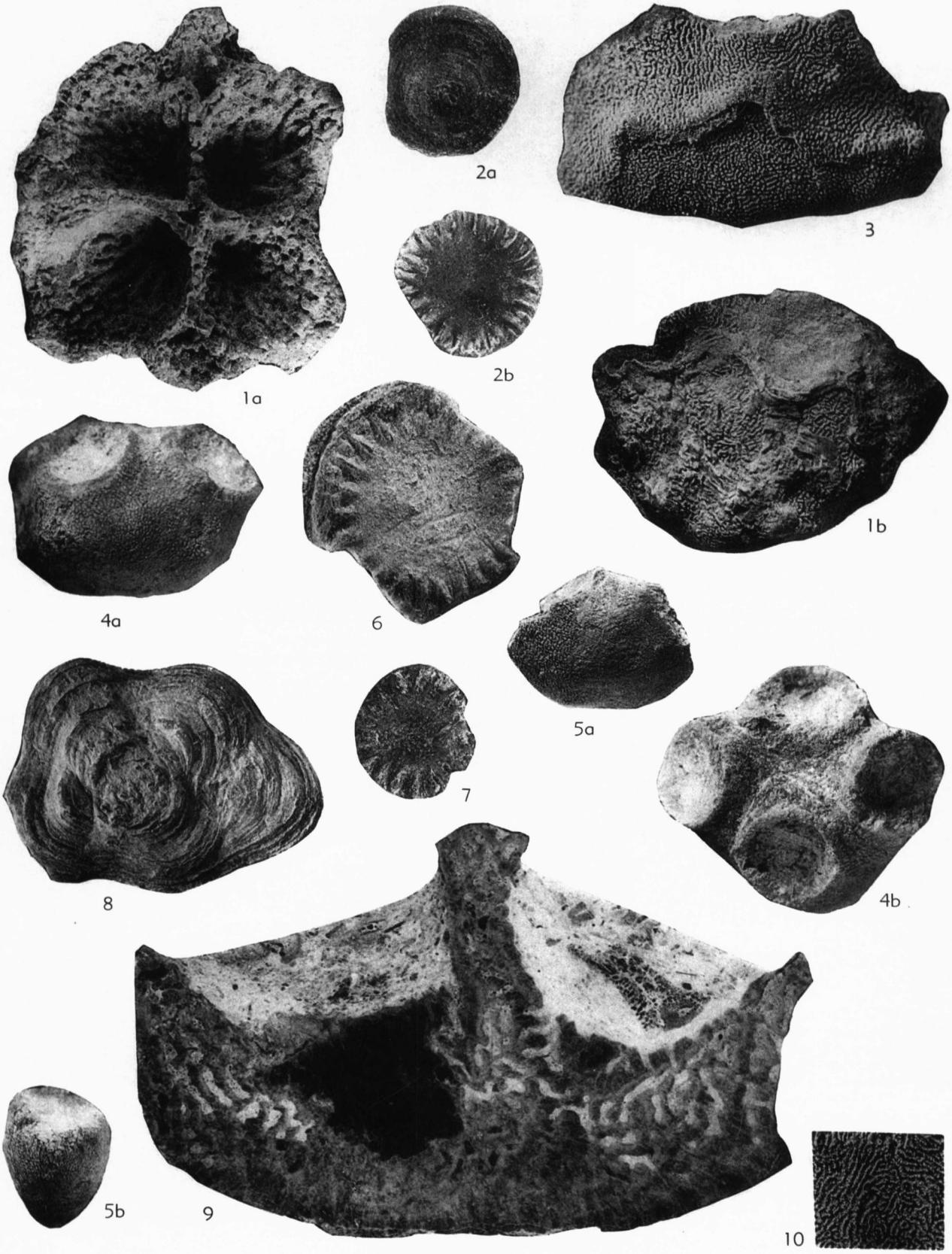
4a-b.—Specimen (J311a). *a*, Side view showing the anastomosing ridges on the surface. *b*, Dorsal view showing the four calices separated by ridged tissue

5, 9.—*Palaeacis bifida* WELLER, Mississippian 10

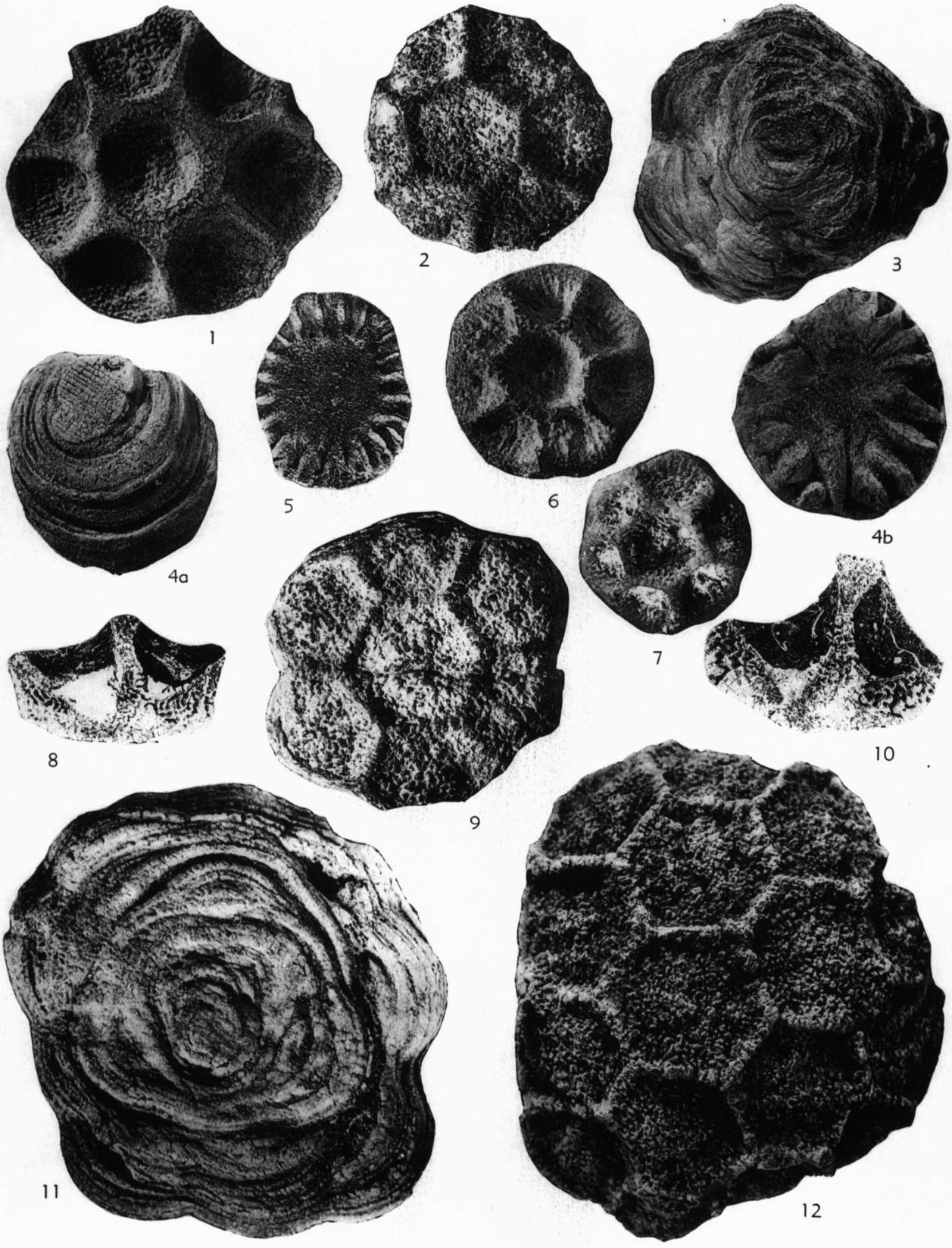
5a-b.—Specimen (J308a) from 10 feet above the base of the *Taonurus* facies, Alamogordo member, Lake Valley formation, midway between Alamo and Marble Canyons, Sacramento Mountains, New Mexico. *a*, Side view. *b*, End view

9.—Thin section (× 11.5) of specimen (J307a) from the Fern Glen shale, at Fern Glen Station, Missouri

8.—*Cleistopora typa gorbyi* (MILLER) JEFFORDS, n. comb., Caballero formation, Kinderhookian Series, Lower Mississippian, from Marble Canyon, Sacramento Mountains, New Mexico. View of the base of an elongate specimen (J302b) 6



JEFFORDS — Mississippian Corals



JEFFORDS — Mississippian Corals

Discussion.—Consideration of the relationship of the form described below to *Cumminsia* is given with discussion of that coral.

Cumminsia? species A

Plate 2, figures 4a-b

The corallum is flattened to discoidal in outline and bears sharp concentric wrinkles on the basal theca. A large flattened area of attachment occurs near the periphery directly below the counter septum. The counter-cardinal diameter is 12 mm and the alar diameter is 11.2 mm. The height is 4.4 mm.

The major septa extend upward in the calyx above the theca; minor septa seem to be lacking. The cardinal septum reaches nearly to the axis and other major septa are subequal in length. The septal formula, insofar as determined, is *K 5 A 3 C 3? A ? K*. Fossulae do not seem to be present along the counter-cardinal plane, and the alar pseudofossulae are inconspicuous.

Discussion.—This specimen resembles *Cumminsia* in the general pattern of the septa and in the elevation of the septa above the peripheral theca. The swollen and elongated cardinal septum, however, seem to be a character found only in the very immature specimens of the genotype. A basal view of this coral resembles rather closely that shown by BASSLER (1937, Pl. 31, Fig. 20) for *Xenocyathellus thedfordensis* (STEWART), but the calices are very dissimilar. This specimen seems distinct from previously described species of porpitid corals, but because of incomplete preservation and uncertainty as to the variation in growth form, no specific name is proposed at this time.

Several other specimens in the collection from the Dona Ana and Alamogordo members of the Lake Valley formation have a broad corallite somewhat like that of the porpitid corals, but their septal characters are not preserved.

Occurrence.—Caballero formation, Kinderhookian series, Lower Mississippian, from Marble Canyon, SW sec. 23, T. 16 S., R. 10 E., Sacramento Mountains, New Mexico.

SUBCLASS TABULATA EDWARDS & HAIME

FAMILY CLEISTOPORIDAE EASTON, 1944

Leptoporidae MILLER, *1892*, Indiana Dept. Geol Nat. Hist., 17th Ann. Rept. p. 616.

Flat to discoidal colonial tabulate corals that may be free or attached comprise this family. The base bears a sharply wrinkled holotheca, and a variable number of polygonal to subrounded corallites open normal to the surface. The calices lack axial structures and septa are rudimentary or absent. Corallites commonly contain reticulate vesicular to tabular tissue near the base. Pores connect adjacent corallites and permeate the walls.

Discussion.—This family seems to include *Cleistopora* NICHOLSON (1888), *Squameophyllum* SMYTH (1933a), *Ethmoplax* SMYTH (1939), and *Vaughania* GARWOOD (1912). *Palaeacis* HAIME (1857) and *Microcyathus* HINDE (1896) were referred to the Leptoporidae (= Cleistoporidae) by ROBINSON (1917) and WILLIAMS (1943), but the uncertainty regarding these forms makes their exclusion desirable. The Cleistoporidae differ from the Favositidae in the presence of reticulate structures within

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EXPLANATION OF PLATE 2

All figures are three times natural size.

the corallites and in the flattened and essentially encrusting form of the coralla.

Range, Silurian to Mississippian.

GENUS CLEISTOPORA NICHOLSON 1888

Leptopora WINCHELL, *1863*, Acad. Nat. Sci. Philadelphia, Proc., p. 2.———ROBINSON, *1917*, Connecticut Acad. Arts Sci., Trans., vol. 21, p. 163.

[not] *Leptopora* D'ORBIGNY, *1849*, Mag. Zoology Rev., no. 2, p. 504.

Cleistopora NICHOLSON, *1888*, Geol. Mag., dec. 3, n. s., vol. 5, p. 150.———EASTON, *1944*, Illinois Geol. Survey, Rept. Invest. 97, p. 57.

These coralla are small and discoidal in form, and may be free or attached. The basal holotheca is concentrically wrinkled. Corallites are short and prismatic in form, and contain reticulate calcareous tissue in the lower portions. Septa are rudimentary or lacking. The relatively thick walls of the corallites are interconnected by straight pores or canals.

Genotype.—Michelinia geometrica EDWARDS & HAIME (1851, p. 252), Lower Devonian, Viré and Loué, Sarthe, France.

Discussion.—The generic placement of these early Mississippian corals calls for discussion of the genera *Leptopora* WINCHELL (1863), *Cleistopora* NICHOLSON (1888), and *Vaughania* GARWOOD (1912). In North America these corals from Lower Mississippian rocks have been placed in *Leptopora*, although KEYES (1894) has used the name *Cleistopora*. EASTON (1944, p. 57) recognized that *Leptopora* WINCHELL is a junior homonym of *Leptopora* D'ORBIGNY (1849), and assigned the American species to *Cleistopora*.

Generally similar corals from about the same stratigraphic horizon in western Europe were described by VAUGHAN (1903, 1905) as *Cleistopora* aff. *geometrica* (EDWARDS & HAIME), and the lowermost part of the Avonian was named the *Cleistopora* or "K" zone. GARWOOD (1912) described a Lower Carboniferous coral which he considered to resemble *C.* aff. *geometrica* closely as *Vaughania cleistoporoides*, n. gen., n. sp. Subsequently, SMYTH (1927, 1933a) described the internal structures of both topotype material of *C. geometrica* from the Lower Devonian of France and the index coral of the "K" zone called *C.* aff. *geometrica*. The former corals were found to be characterized by loosely reticulate tissue in the lower part of the corallites whereas *Vaughania* and the Mississippian forms assigned to *C.* aff. *geometrica* seem to lack this tissue. In addition the Carboniferous corals have a distinctive system of covered or open ring canals that are not present in *Cleistopora*. Following SMYTH, these important corals of the "K" zone of Europe have been placed in *Vaughania* by HILL (1938, p. 6). On the basis of external features and stratigraphic occurrence, the corals from Europe and North America are quite similar as was suggested by LANG, SMITH, & THOMAS (1940, p. 76). EASTON (1944, p. 57-60) has indicated that the American corals, however, contain reticulate tissue like that found in the genotype of *Cleistopora*. Sections of specimens from the Chouteau and Sedalia formations of Missouri and the Caballero formation of New Mexico confirm the occurrence of these trabeculate structures in the lower parts of the corallites. The available material is not sufficiently well preserved to give positive indication regarding ring canals, although a few of the corallites seem to have this feature. Accordingly, these American corals are placed tentatively in *Cleistopora*. It is noted, however, that some very thin coralla and those appreciably altered by silicification do not show the reticulate structures. There seems need, therefore, for additional study of the internal structures of the European species assigned to *Vaughania* and of the possibility of ring canals in the American species. It is possible, also, that *Squameophyllum* SMYTH (1933a) or *Ethmoplax* SMYTH (1939), which are not well characterized now, may be more closely related to these Mississippian corals than to the genotype of *Cleistopora*.

A Lower Devonian coral, *Michelinia lenticularis* HALL (1874, p. 113), occurs commonly in the New Scotland shale of New York and Maryland, and in the Birdsong and Ross formations of Tennessee (Pl. 2, figs. 6-7). This coral generally resembles the genotype of *Cleistopora*, which occurs at a similar stratigraphic position in France, but sections of relatively well preserved specimens indicate the absence of any trabeculate tissue. Although this coral may belong with *Pleurodictyum* GOLDFUSS (1829, p. 113; = *Pleurodictyum* in part of some authors), it is here questionably assigned to *Cleistopora*.

Occurrence.—Lower Devonian and Lower Mississippian, Europe and North America.

Cleistopora typa gorbyi (MILLER) JEFFORDS, n. comb.

Plate 1, figure 8; Plate 2, figures 1-3, 9; text figure 2

Leptopora gorbyi MILLER, *1891*, Indiana Dept. Geol. Nat. Res., 17th. Ann. Rept., p. 6, pl. 1, figs. 1-4, Adv. Sheets. ——— MILLER, *1892*, Indiana Dept. Geol. Nat. Res., 17th. Ann. Rept., p. 616, pl. 1, figs. 1-4.

Leptopora typa WINCHELL [in part] EASTON, *1944*, Illinois Geol. Survey, Rept. Invest. 97, p. 59, pl. 16, figs. 1-4.

This subspecies comprises relatively thin coralla composed of a central hexagonal corallite surrounded by about seven peripheral corallites. A few corallites of the second series may be developed but this cycle is not complete. The undersurface is covered by a holotheca which is concentrically wrinkled. The calices are shallow and the floors are horizontal or domed. Walls between adjacent corallites are thick and granular in appearance. The lower parts of the corallites are irregularly reticulate in structure, and pores connect adjacent coralla directly.

Discussion.—The relatively flat disclike specimens of *Cleistopora* have been described in North America as *Leptopora typa* WINCHELL (1863), *Michilinia?* [sic] *placenta* WHITE (1880), *Leptopora gorbyi* MILLER (1891), and *Leptopora winchelli*

WHITE (1879). After study of abundant representative material including the types of *L. typa* and *L. gorbyi*, EASTON (1944) considered *M.? placenta* and *L. gorbyi* to be junior synonyms of *L. typa* as revised.

Examination of similar material from about a dozen localities in the Lower Mississippian of Missouri, Illinois, and Iowa tends to confirm the general intergradation of these forms. Insofar as indicated by published descriptions and illustrations and by the limited amount of correlative material, however, much of this intergradation seems to occur between formations rather than within a limited stratigraphic zone. For example, MILLER (1892, p. 616-617) studied more than 150 specimens of *Cleistopora* from the lower part of the Chouteau limestone near Sedalia, Missouri, and found that the typical coralla comprised a median corallite surrounded by seven lateral corallites. In no case was the second circlet of corallites complete. Coralla from the top of the Chouteau limestone at Sedalia and other localities in Missouri, which have been described as *Michilinia?* [sic] *placenta* by WHITE (1880), on the other hand, typically consist of a much larger number of corallites in a broader corallum (Pl. 2, fig. 12; text fig. 2).

If later studies on more extensive collections of *Cleistopora* confirm the association of growth form and stratigraphic horizon, these fossils would serve as stratigraphic markers even though some intergrading specimens may be difficult or impossible to place reliably. Accordingly, the more distinctive growth forms or stages are here recognized tentatively as subspecies. *Cleistopora typa gorbyi* (MILLER), includes coralla that lack a complete second circlet of corallites and is characteristic of the lower Chouteau limestone. *C. typa typa* (WINCHELL) JEFFORDS, n. comb., comprises larger coralla having several circlets of corallites (commonly 25 to 35) and occurring near the top of the Chouteau limestone. This subspecies corresponds to *M.? placenta* WHITE which is presumed to be a synonym of *L. typa* WINCHELL. Inasmuch as EASTON (1944, p. 60) noted that the syntypes of *L. typa* seem to represent dissimilar forms, and the holotype is not illustrated or described adequately, *L. typa* may prove to be intermediate between *C. typa gorbyi* and *M.? placenta*. Illustrations of a specimen called *L. typa* by VAN TUYL (1925, pl. 3, fig. 1) from about the stratigraphic horizon of the holotype in Iowa do suggest the general similarity of these corals.

A third subspecies, *Cleistopora typa winchelli* (WHITE) JEFFORDS, n. comb., seems to include forms like *C. typa typa* but having markedly thin walls as well as corallites that are much smaller in diameter.

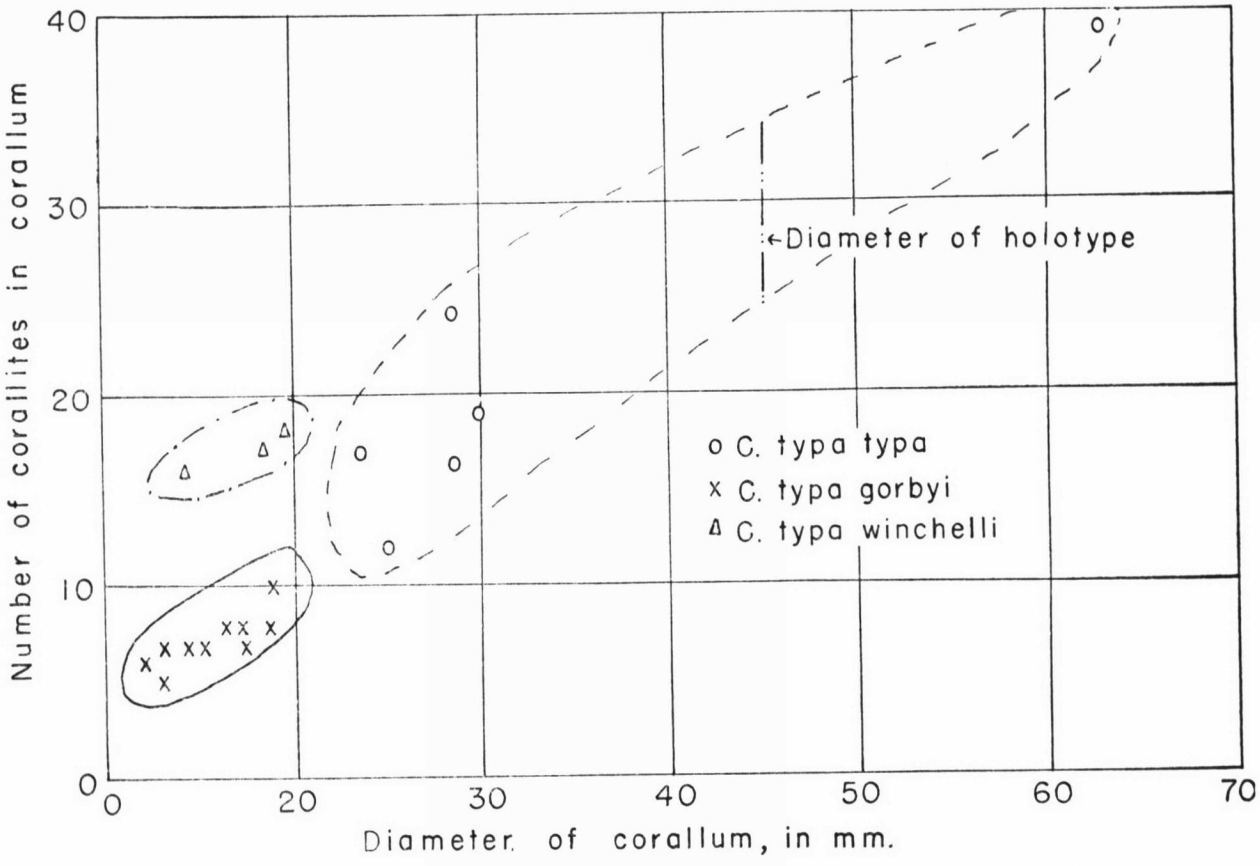

FIGURE 2.—Diagram showing relation of diameter of corallum to the number of corallites in *Cleistopora*.

The specimens from New Mexico are nearly identical with the corals described by MILLER (1892) and illustrated by EASTON (1944, pl. 16, figs. 1-4). Typically, the coralla comprise 7 corallites, but examination of twelve specimens, which is an inadequate sample for statistical purposes, showed one corallum each having four, five, and six corallites, six coralla having seven corallites, and three coralla having eight corallites. Large massive coralla resembling *C. typa typa* were not observed.

One or two specimens (as Pl. 2, fig. 1) seem to differ somewhat in the deeper calices and thicker walls. These differences, however, do not seem sufficient to merit special designation of the coralla.

Occurrence.—Caballero formation, Kinderhookian Series, Lower Mississippian, New Mexico. The fossils were collected by L. R. LAUDON and A. L. BOWSHER in the Sacramento Mountains from Deadman Branch of Alamo Canyon, north side of Alamo Canyon, Indian Wells Canyon, Marble Canyon, and an outlier south of Marble Canyon. Also, specimens were obtained from San Andres Canyon, at cen. W. line NW SW sec. 17, T. 18 S., R. 4 E., in the San Andres Mountains.

Material studied.—About 30 specimens were available for study, but many of the coralla were incompletely preserved or enclosed in matrix.

SUBCLASS DOUBTFUL

FAMILY PALAEACIDAE MILLER, 1892

This family including only *Palaeacis* HAIME has the characters given below for that genus. *Microcycathus* HINDE would be placed here also if distinct from *Palaeacis*. Range, Mississippian to Permian.

Discussion.—The first use of the family name Palaeacidae seems to have been by MILLER (1892, p. 614) although he does not indicate that a new family is being proposed and no characterization is given. Thus, Palaeacidae MILLER (1892) has priority over Palaeacidae MOORE & JEFFORDS (1945, p. 195).

GENUS PALAEACIS HAIME, 1857

Sphenopoterium MEEK & WORTHEN, *1860*, Philadelphia Acad. Nat. Sci., Proc., p. 447.
?Ptychochartocyathus LUDWIG, *1866*, Palaeontographica, vol. 14, p. 232.
Microcyathus HINDE, *1896*, Geol. Soc. London, Quart. Jour., vol. 52, pt. 3, p. 447.

This genus includes small to medium sized colonial supposed corals having a variable number of large closely joined calices opening upward or, in part, laterally. The corallum is wedgelike, turbinate, or somewhat irregular in external shape, and it may be attached at the base or free. The interior of well preserved calices is marked by more or less obscure radially arranged vertical striae. These resemble septa in position, but seemingly there is no differentiation as to order of development. The inner walls of the calices are pierced by numerous small openings or pores. The exterior of the corallum aside from the calices is covered by close-set irregular, anastomosing or labyrinthic ridges; these may be continuous or broken into granules. The outer covering surrounding the calices and forming the base of the corallum is composed of dense tissue penetrated by numerous inosculating canals opening into pores on the exterior and in the calyx. Tabulae and dissepiments are lacking; there are no axial structures.

Genotype.—*Palaeacis cuneiformis* HAIME (= *Sphenopoterium cuneatum* MEEK & WORTHEN, *not Palaeacis cuneata* SNIDER, 1915), Salem limestone, Meramecian Series, Mississippian, from Spergen Hill, Indiana.

Discussion.—The affinities and characters of this unique genus have been little understood. It has been regarded as a sponge by some (MEEK & WORTHEN, 1866; MEEK, 1867; ETHERIDGE & NICHOLSON, 1878) but now is referred commonly to the Coelenterata. HINDE (1896) and SMYTH (1929) review rather completely the growth in the knowledge of the genus, and SMYTH (1929) gives a detailed description of the internal structure of a European species.

Thin sections of *Palaeacis axinoides* SMYTH (1929) show the wall of *Palaeacis* to be composed of two types of tissue. Thin inner tissue lining the calices has a fibrous structure more or less at right angles to the surface. This is separated by a dark line from the outer covering which is composed of plates at right angles to the exterior. The median line of a groove on the surface is the surface trace of the plane of contact of the two plates. Pores on the exterior and in the calices are the surface openings of canals. Thin sections of *Palaeacis bifida* WELLER (1909) from the Fern Glen shale of Missouri show the indirect connection through the pores from the calyx to the base (Fig. 3).

The manner of attachment of species referred to *Palaeacis* has been stressed by some authors (ROEMER, 1876; SMYTH, 1929) but this is not judged to be a definitive character of the genus. The species here described seem to have been free as are the numerous specimens of *Palaeacis* from the Fern Glen shale of Missouri that were examined. Also, thin sections of *P. bifida* show no included foreign matter at the base. *Palaeacis testata* MOORE & JEFFORDS (1945) from the Smithwick shale of Texas, however, was attached over a large area of the base.

Reported occurrences of *Palaeacis* are relatively rare and seldom do specimens occur in any abundance. Moreover, the marked variation among coralla has resulted in description of many species

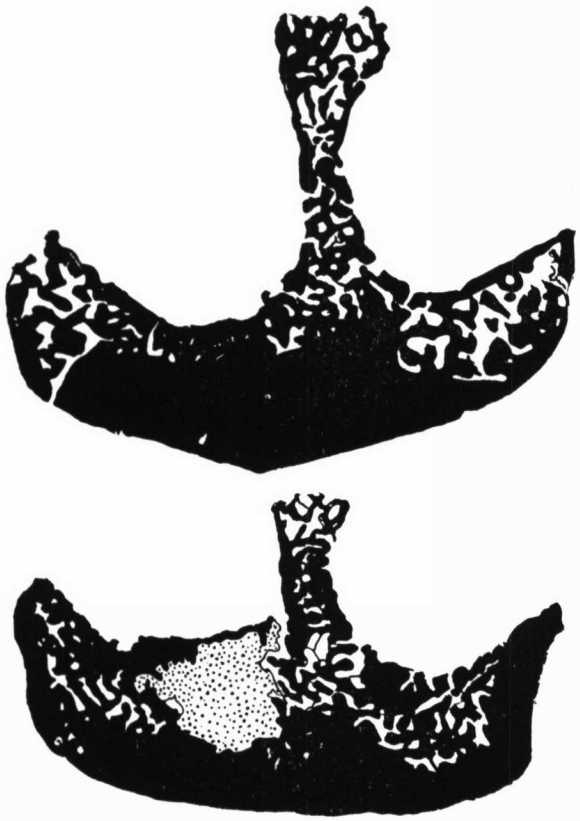

FIGURE 3.—Diagrams showing internal structures of *Palaeacis bifida* WELLER, × 7.5. The specimens are from the Fern Glen shale at Fern Glen Station, Missouri. The photographs from which these diagrams were prepared were taken prior to thinning of the slides and so differ slightly from those on plates 1 and 2.

that seem to intergrade. Examination of specimens of *Palaeacis* from several stratigraphic horizons in the Mississippian and study of available published data suggests that some species may be useful stratigraphic markers. For example, *Palaeacis obtusa* (MEEK & WORTHEN) and *P. compressa* (MEEK & WORTHEN) have been described from the Keokuk limestone of Illinois, and *P. umbonata* SEEBACH (1866) and *P. cymba* SEEBACH (1866) from equivalent rocks of Iowa. These corals are characterized rather uniformly by relatively wide and elongated wedge-like coralla in which the height is less than the greatest width, and by a considerable variation in the number and arrangement of the corallites. The several species seem, therefore, to have been based on individual variation as was indicated by ETHERIDGE & NICHOLSON (1878, p. 226), and *P. compressa, P. umbonata,* and *P. cymba* are considered to be junior synonyms of *P. obtusa.*

A smaller and less elongate species of *Palaeacis* occurs in the Fayetteville shale, Chesteran Series, Upper Mississippian of Arkansas and Oklahoma. This form was described as *Palaeacis carinata* GIRTY (1910) and *Palaeacis cuneata* SNIDER (1915) (*non Sphenopoterium cuneata* MEEK & WORTHEN, 1860). Comparison of the original description and examination of specimens from the Fayetteville shale of Oklahoma indicate that the homonym *P. cuneata* is a junior synonym of *P. carinata* and should not be renamed.

The stratigraphic occurrence of American species of *Palaeacis* is given in Table 1, although it is recognized that additional studies probably will modify the ranges and clarify placement of doubtful specimens.

Tentative conclusions as to synonyms and homonyms among American species of *Palaeacis* are as follows:

(1) *Sphenopoterium enorme depressus* MEEK & WORTHEN (1866) = *Palaeacis enormis* (MEEK & WORTHEN, 1860); (2) *S. compressum* MEEK & WORTHEN (1860) = *Palaeacis obtusa* (MEEK & WORTHEN, 1860); (3) *S. cuneata* MEEK & WORTHEN (1860) = *Palaeacis cuneiformis* HAIME (1857); (4) *Palaeacis cymba* SEEBACH (1866) = *Palaeacis obtusa* (MEEK & WORTHEN, 1860); (5) *Palaeacis umbonata* SEEBACH (1866) = *Palaeacis obtusa* (MEEK & WORTHEN, 1860); (6) *Palaeacis cuneata* SNIDER (1915) [*non Sphenopoterium cuneata* MEEK & WORTHEN (1860)] = *Palaeacis carinata* GIRTY (1910).

TABLE 1. *Stratigraphic distribution of Palaeacis in Mississippian and Pennsylvanian rocks of North America.* K—Kinderhookian, O—Osagian, M—Meramecian, C—Chesteran, Mr—Morrowan, B—Bendian, DM—Desmoinesian, Mo—Missourian, V—Virgilian.

Species	*Stratigraphic Division*								
	MISSISSIPPIAN				PENNSYLVANIAN				
	K	O	M	C	Mr	B	DM	Mo	V
Palaeacis conica EASTON, 1945	-X	--	--	--	--	--	--	--	--
Palaeacis enormis (MEEK & WORTHEN, 1860)	XX	X-	--	--	--	--	--	--	--
Palaeacis bifida WELLER, 1909	-X	X-	--	--	--	--	--	--	--
Palaeacis cuneiformis HAIME, 1857	--	--	X-	--	--	--	--	--	--
Palaeacis cavernosa MILLER, 1892	--	--	X-	--	--	--	--	--	--
Palaeacis obtusa (MEEK & WORTHEN, 1860)	--	--	-X	--	--	--	--	--	--
Palaeacis carinata GIRTY, 1910	--	--	--	X-	--	--	--	--	--
Palaeacis walcotti MOORE & JEFFORDS, 1945	--	--	--	--	--	X-	--	--	--
Palaeacis testata MOORE & JEFFORDS, 1945	--	--	--	--	--	X-	--	--	--
Palaeacis kingi JEFFORDS, n. sp.	--	--	--	--	--	--	--	X-	--

The genus *Microcyathus* was proposed by HINDE (1896, p. 447) to include Mississippian corals differing somewhat in growth form from *Palaeacis*. Besides the genotype which is *Hydnopora? cyclostoma* PHILLIPS, *Sphenopoterium enorme* MEEK & WORTHEN (1860), *S. enorme depressus* MEEK & WORTHEN (1866), and *Palaeacis humilis* HINDE (1896) have been assigned to *Microcyathus* by several workers (HINDE, 1896; ROBINSON, 1917; SMYTH, 1929; WILLIAMS, 1943; EASTON, 1944). *Microcyathus* seems to have been separated from *Palaeacis* chiefly because of the steep or nearly vertical walls of the corallites, the coarser labyrinthic ridges on the surface, the broader base, wide separation of the corallites, the calcareous deposits within the calyx, and whether the corallum was attached or free. Although the species referred to *Microcyathus* do have these characters to a differing degree and comprise a somewhat similar group of species, most of the features used for separation grade into similar features on species of *Palaeacis*. Thus, growth forms like that ascribed to *Microcyathus* are seen in *Palaeacis axinoides* SMYTH (1929, p. 131). Inasmuch as the similarities in the surface ornamentation, microscopic structure, and growth form as well as stratigraphic occurrence seem to more than balance the differences, *Microcyathus* is considered to be a synonym of *Palaeacis*. HILL (1938, p. 6) also has not recognized *Microcyathus*, and has placed *Hydnopora? cyclostoma* PHILLIPS in *Palaeacis*.

Occurrence.—Mississippian to Permian.

Palaeacis bifida WELLER, 1909

Plate 1, figures 5, 9; Plate 2, figures 8, 10; text figure 3

This species is represented by relatively small slightly rounded cuneate coralla which bear two corallites. An occasional specimen contains three corallites. The base seems to lack indication of a point of attachment. Apertures of the corallites are circular in outline and relatively steep sided. A very fine labyrinthine pattern of short ridges and granules covers the base, sides, and portions of the upper surface that are not occupied by the calices. The interior of the coralla contains numerous anastomosing pores or canals leading generally from the exterior to the inner wall of the corallites. The specimens average about 5.3 mm by 10 mm in minimum and maximum diameters, and 7 mm in height.

Discussion.—These specimens from New Mexico are essentially identical to specimens from the Fern Glen shale of Missouri and Illinois that were described by WELLER as *Palaeacis bifida*. Although the number of corallites composing the coralla does not in itself seem to be a very satisfactory basis for distinguishing species of *Palaeacis*, the consistent occurrence of the two-corallite stage together with the rounded cuneate form of the normal coralla are conspicuous features of the specimens of *Palaeacis* in both the Fern Glen shale of Missouri and the Lower Mississippian formations of New Mexico. *Palaeacis bifida* is less sharply cuneate than *P. carinata* GIRTY (1910) from the Fayetteville shale of Oklahoma and *P. cuneiformis* HAIME (1857) from the Salem limestone of Indiana.

Although the relationship between *Palaeacis bifida* and *P. enormis* (MEEK & WORTHEN, 1860) is largely unknown, the coralla similar to *P. bifida* except in the development of a three-corallite corallum do not seem to show characters of *P. enormis*.

Occurrence.—The specimens were collected by L. R. LAUDON and A. L. BOWSHER from the Caballero formation, Kinderhookian Series, Lower Mississippian, at Nigger Ed Canyon in SW SE sec. 7, T. 19 S., R. 11 E., and ¼ mile south of Nigger Ed Canyon in NE NW sec. 18, T. 18 S, R. 11 E. (Univ. Kansas loc. 8004) in the Sacramento Mountains of New Mexico. The species occurs also 10 feet above the base of the *Taonurus* facies of the Alamogordo member, Lake Valley formation, Osagian Series, Mississippian, at a point midway between Marble and Alamo Canyon, and in the lower part of the Arcente member, Lake Valley formation, near Arcente Canyon at SW NE NE sec. 20, T. 16 S., R. 11 E., also in the Sacramento Mountains, New Mexico.

Palaeacis enormis (MEEK & WORTHEN) 1860

Plate 1, figure 4

Sphenopoterium enormе MEEK & WORTHEN, *1860*, Philadelphia Acad. Nat. Sci., Proc., p. 448. ——— MEEK & WORTHEN, *1866*, Illinois Geol. Survey, vol. 2, p. 146, pl. 14, figs. 1a-b.

Palaeacis enormis (MEEK & WORTHEN) ROWLEY, *1908*, Missouri Bur. Geol. and Mines, ser. 2, vol. 8, p. 64, pl. 16, figs. 22-28.

Microcyathus enormis (MEEK & WORTHEN) ROBINSON, *1916*, Connecticut Acad. Arts Sci., Trans., vol. 21, p. 167. ——— WILLIAMS, *1943*, U. S. Geol. Survey, Prof. Paper 203, p. 59, pl. 6, figs. 9-13. ——— EASTON, *1944*, Illinois Geol. Survey, Rept. Invest. 97, p. 60, pl. 16, fig. 18.

Sphenopoterium enorme var. *depressum* MEEK & WORTHEN, *1866*, Illinois Geol. Survey, vol. 2, p. 146, pl. 14, figs. 2a-b.

The single corallum representing this species comprises four equally spaced corallites that have the apertures directed obliquely from the axis of the corallum. The base is broadly flattened so that the corallum has a general quadrate shape; a basal area of attachment seems to be lacking. Fine vermicular anastomosing ridges and granules cover the base, sides, and areas between the apertures. The calices are circular in outline, and a bordering rim projects strongly upward from the labyrinthic surface separating them. The interior of the calices is largely concealed by matrix.

The specimen has a maximum diameter of 16.1 mm and a minumum diameter of 13.6 mm. The height is 10.0 mm.

Discussion.—This specimen from New Mexico is almost identical to the coral called *Sphenopoterium enorme* var. *depressum* by MEEK & WORTHEN (1866, p. 146). These authors regarded their specimen as probably only a variety or modification in growth form, and not sharply set off from *Sphenopoterium enorme*. WILLIAMS (1943, p. 59-60) also indicates that separation of these types of coralla is question-

able. Accordingly, MEEK & WORTHEN's variety is considered to be a synonym of *S. enorme.*

The bases for separation of the two-corallite stage of *Palaeacis enormis* from *P. bifida* WELLER (1910) are not entirely clear, but seemingly the former species has apertures that are appreciably smaller in the two-corallite stage. Although specimens from the Mississippian formations of New Mexico and from the Fern Glen shale of Missouri that are here assigned to *P. bifida* may show a three-corallite stage in development, these coralla do not intergrade with the typical growth form seen in *P. enormis.*

Occurrence.—The single specimen was collected by L. R. LAUDON and A. L. BOWSHER from the blue-gray marl facies at a point 18 feet above the top of the black cherty limestone facies, Alamogordo member, Lake Valley formation, Osagian Series, Mississippian, in the Sacramento Mountains at NW sec. 28, T. 16 S., R. 10 E., New Mexico. The species is reported also from the Rockford limestone of Indiana, the Hampton formation of Iowa, the Fern Glen shale of Illinois, and the Saverton and Louisiana formations of Missouri.

Palaeacis kingi JEFFORDS, n. sp.

Plate 1, figures 1, 3, 10

This species is represented by several nearly complete specimens and other fragmental material. The coralla consist of four large and two or three small undeveloped calices. The external covering of relatively coarse ridges is present only on the sides and base; the calices which are separated by relatively thin partitions occupy all the upper surface. The base of one specimen is without indication of a point of attachment, but another, a more conical form, shows that a small point has broken off, possibly indicating a place for attachment. Apertures of the corallites are subcircular.

The interior of the calices is covered by low radiating ridges that are interrupted by numerous pores. There are about 22 ridges or septa in the largest calyx. The deepest part of the funnel-shaped calyx is adjacent to the axis of the corallum, and the walls next to adjoining corallites are much steeper than on the free side. The largest calyx of the type specimen is 9.7 mm in diameter and the other three mature calices are only slightly smaller. New calices seem to be added in pairs one on each side of the corallum along the outer edge between two adjacent larger calices.

The type specimen has a maximum diameter (parallel to the wall between adjacent calices) of 22.6 mm and a height of 12.5 mm.

Discussion.—This species differs noticeably from described species of *Palaeacis* in its large size, almost rectangular transverse section, and large calices not surrounded by ridged external tissue. This surface is very similar in appearance to that illustrated for *P. axinoides* SMYTH, but the corallum is much broader and has fewer and larger calices. *P. kingi* differs from the genotype species, *P. cuneiformis,* in the much broader shape and relatively larger calices. The Permian species, *P. regularis* and *P. tubifer,* which were described by GERTH (1921) from Timor, are similar in the size of the corallum and calices but the Timor specimens have an external covering surrounding the individual calices and a large number of conspicuous pores over the surface. *P. kingi* differs from *P. testata* MOORE & JEFFORDS (1945, p. 195), a small species from the Smithwick shale, in the lack of a large area of attachment, close packing of the calices, and restriction of the external tissue to sides and base rather than surrounding the calices.

This species is named for R. H. KING, of the University of Kansas, who has collected most of the specimens here described and kindly made them available for study.

Occurrence. — Brownwood shale?, Missourian (Canyon) Series, Pennsylvanian (Upper Carboniferous). Collected in the clay pit at Bridgeport, Wise County, Texas (Univ. Kansas loc. 7089) by R. H. KING and H. J. PLUMMER.

Type.—Univ. Kansas No. 7089-21a.

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