PENNSYLVANIAN LOPHOPHYLLIDID CORALS

by

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ABSTRACT

Lophophyllidid corals comprise solitary conical and conico-cylindrical corallites having an axial column developed in part by a thickening of the counter septum, shortened cardinal septum, tabulae but no dissepiments, and well-defined septal grooves. These corals occur in a larger proportion of Pennsylvanian deposits of the Midcontinent than other types of corals, and they seem to be especially useful in stratigraphic paleontology.

The family Lophophyllidiidae Moore and Jeffords (1945) is recognized to include Lophophyllidium Grabau (1928), Lophocarinophyllum Grabau (1922), Malonophyllum Okulitch and Albritton (1937), Stereostylus, new genus, Lophamplexus Moore and Jeffords (1941), Lophotichium Moore and Jeffords (1945), Claviphyllum Hudson (1942), Kinkaidia Easton (1945), and Fasciculophyllum Thomson (1883). These genera are illustrated and described briefly, and a key is included for the differentiation of lophophyllidid genera. Consideration is given to the morphology, ontogeny, and phylogenetic development of these corals. Also, graphic representation of variation in several characters indicates that statistical treatment of quantitative data is useful in the rigorous comparison of lophophyllidid faunas.

Late Paleozoic lophophyllidid corals which have been referred generally to Lophophyllidium (Lophophyllum of authors) are shown to include several distinct genetic types, each characterized by a combination of several characters. Lophophyllidium (syn. Sinophyllum Grabau, 1928) is restricted to species having a large axial column that contains radiating laminae and septa that are not shortened in maturity. Corals in which lophophyllidoid characters are restricted to the immature region

and resemble Amplexus above are assigned to Lophamplexus. A new genus, Stereostylus, is proposed to include those species characterized by a relatively smaller and laterally compressed column that lacks radiating laminae and by a marked reduction in the length of major septa in maturity. A total of 24 species are described, and 7 species are referred to Lophophyllidium, 10 species to Stereostylus, and 7 species to Lophamplexus. The single previously described form, Amplexus westii Beede (1898) is placed in Lophamplexus.

INTRODUCTION

Numerous investigations of the extensive deposits of Pennsylvanian rocks in central United States during the past twenty years have resulted in relatively precise delineation of a large number of individual formations and units of subordinate rank. As these stratigraphic studies progressed, paleontological research became more detailed, aiding in the correlation of beds over long distances and contributing to the solution of various local problems. Large collections from precisely determined stratigraphic horizons and exact localities became available for study also, so that the need for revision of previous work was apparent. Contributions to the knowledge of Pennsylvanian faunas include studies on practically all the groups of fossils but with attention devoted particularly to the fusulines, brachiopods, and cephalopods.

In spite of the relative abundance of corals throughout the marine deposits of the Midcontinent, late Paleozoic corals have been practically ignored, and until recent years, only sporadically were attempts made to distinguish the many differing types. This lack of interest in North America contrasts strongly with the important use of corals as index fossils in the Lower Carboniferous of Europe and Asia, in the Middle and Upper Carboniferous of Russia, and in the Permian of Asia.

Somewhat intensive study of American late Paleozoic coral faunas was begun at the University of Kansas in 1940 and, although interrupted by the war, has furnished descriptions of many features of these faunas (Moore and Jeffords, 1941, 1945; Jeffords, 1942, 1944, 1945).

Scope of present paper.--Small solitary column-bearing corals that are designated collectively as lophophyllidids are especially widespread and locally very abundant in Pennsylvanian rocks. Accordingly, attention

is directed first to this type rather than to other more distinctive but less widely distributed corals. Studies on these other groups are under way, however, and publication is expected reasonably soon.

Lophophyllidid corals of Morrowan and Bendian (Lampassan or Derryan) age and from Permian rocks have already been described (Moore and Jeffords, 1941, 1945; Jeffords, 1942). Therefore, this study considers primarily material from the Desmoinesian, Missourian, and Virgilian series of Middle and Upper Pennsylvanian (Upper Carboniferous) rocks. The basic coral material has been furnished by the extensive collections of the Kansas Geological Survey, but important additional specimens have been collected or borrowed for study. The collection included specimens from about 550 localities and more than 100 different stratigraphic units throughout the Pennsylvanian section. Lophophyllidid corals are available from practically every formation, and commonly each locality yields more than a dozen specimens; some localities are represented by at least a thousand corallites. The greater proportion of the corals are from Kansas, Missouri, Oklahoma, and Texas; although localities in Nebraska, Colorado, Iowa, Arkansas, West Virginia, Pennsylvania, and Ohio are represented.

It is the purpose of this paper to describe and illustrate the Pennsylvanian lophophyllidid corals now available for study, and to differentiate the several allied lophophyllidoid genera. Consideration is given also to morphologic features and to ontogenetic development of the corals. This report does not, however, represent a complete study of all the lophophyllidid corals; doubtless there are many different types not represented in the collection, and also corals seem not to have been collected as intensively as many better known fossils.

Previous studies.-- Upper Carboniferous corals from North America have been described in several scattered papers, but mostly without consideration of important structural features. Thus, corals were referred to a few long ranging "species" that had little stratigraphic value or taxonomic significance. More recently, the type material of some of these species has been redescribed and new forms characterized so that the stratigraphic utility of Pennsylvanian corals is becoming apparent (Newell, 1935; Kelly, 1942; Jeffords, 1942, 1945; Easton, 1944; Wells, 1944; and Moore and Jeffords, 1945). Upper Carboniferous coral faunas of Europe and Asia have received appreciably more attention than the American faunas, important contributions being those of Reed (1925), Grabau (1928), Smith (1931, 1934), Huang (1932), Dobrolyubova (1935, 1936, 1937), Chi (1935), Heritsch (1936), Felser (1937), Kabakovitch (1937), and Fomitchev (1938).

The development of concepts relating to the North American lophophyllidid corals has been reviewed previously (Jeffords, 1942, pp. 187-189) and so needs only brief consideration here. Subsequent to the designation of the first two species of lophophyllidid corals, which are Cyathaxonia profunda Edwards and Haime (1851, p. 323) from Flint Ridge, Ohio, and C. prolifera McChesney (1860, p. 75) from Missourian rocks near Springfield, Illinois, lophophyllidid corals were reported from many localities throughout Pennsylvanian rocks of North America, but generally they were referred to one of these species. In agreement with proposals by Meek (1872) and Foerste (1888), however, the lophophyllidid species were removed consistently from Cyathaxonia, and placed in Lophophyllum Edwards and Haime (1850). Between 1875 and 1924 other Pennsylvanian lophophyllidid corals were described as Cyathaxonia

distorta [=Stereostylus? distortus] Worthen (1875, p. 526), Lophophyllum profundum sauridens [=Lophyphyllidium sauridens] White (1877, p. 101), Amplexus westii [=Lophamplexus westii] Beede (1898, p. 17), Lophophyllum proliferum radicosum [=Stereostylus? radicosus] Girty (1911, p. 122), Cyathaxonia girtyi Haack (1915, p. 486), and Cyathaxonia sp. [= Stereostylus sp.] Morgan (1924, p. 192). Rowley (1901, p. 349) described a short broadly conical coral from Missouri as Axophyllum? alleni, n. sp., and Girty (1915a, p. 318) referred this species to Lophophyllum. Some corals that are similar to A.? alleni in size, shape, and features of the calyx have been sectioned and found to represent forms allied to the Clisiophyllidae Nicholson and Thomson (1883). Although these species were poorly defined, they have been reported repeatedly in faunal lists. Thus, Pennsylvanian lophophyllidid corals were interpreted as having little stratigraphic value.

In 1937 weathered corallites from Permian rocks of Texas were described as a new species which was designated as the genotype of a new genus Malonophyllum Okulitch and Albritton (1937, p. 24). Studies carried on in conjunction with the present investigations have furnished information on three species of lophophyllidid corals from Permian rocks (Moore and Jeffords, 1941) and 38 species from the Pennsylvanian (Jeffords, 1942; Moore and Jeffords, 1945). These lophophyllidid corals were referred to Lophophyllidium Grabau (1928), Malonophyllum, Sochkineophyllum Grabau (1928), Lophamplexus Moore and Jeffords (1941), and Lophotichium Moore and Jeffords (1945).

Carboniferous and Permian lophophyllidid faunas from areas outside North America are less completely known but comprise species from Asia and Europe that were described by Kayser (1883), Yakovlev (1904), Douglas

(1920), Grabau (1922, 1928), Soschkina (1925, 1928, 1939), Schindewolf (1930), Heritsch (1931, 1933, 1936, 1936a, 1938), Huang (1932a), Yoh and Huang (1932), Smith (1934, 1941), Merla (1934), Dobrolyubova (1936), Felser (1937), Chi (1938), Hill (1940), and Hudson (1942).

Differentiation of the generic types within the lophophyllidids was undertaken by Grabau in 1922 and 1928 by setting up the genera Lophocarinophyllum, Sinophyllum, and Lophophyllidium. Subsequently, Malonophyllum and Lophamplexus were described from Permian rocks of North America, and Lophotichium from Pennsylvanian deposits of Oklahoma. Hudson (1942) separated European Lower Carboniferous corals having many lophophyllidid characters as a new genus called Claviphyllum, and Easton (1945) described Kinkaidia, a new genus from Upper Mississippian rocks of Illinois. Many of the complexities of the taxonomy of these genera have been reviewed previously (Jeffords, 1942).

Methods of study.-- In preparation for this and correlative studies of the Pennsylvanian coral faunas, the fossil collection of the Kansas Geological Survey was examined, and the corals were assembled for study. This material, comprising several thousand lots of corals, was segregated according to major allied types. Inasmuch as the external appearance of average specimens furnishes little information on the affinities of the corallites at first, accurate separation of the solitary corals required study of sectioned material also. The lophophyllidid corals then were examined, and the corallites from each stratigraphic unit were separated according to external features such as size, form, and ornamentation. Several representative corallites were selected from each of these groups for sectioning and preliminary study. Subsequently, additional specimens were sectioned where the original lot seemed to include several

species or to permit more adequate study of variation and ontogenetic development.

The corallites selected for sectioning were cut transversely three or more times to show successive growth stages. These sections were photographed, and the corals were reassembled after identification of the counter-cardinal plane. The corallites or segments of them were cut longitudinally in a plane normal to the counter-cardinal septa, and these sections were photographed also. Most of the sawing was done by means of a toothless band saw using a mixture of carborundum powder and water. The addition of liquid soap or glycerine to the mixture aids appreciably in keeping the powder in suspension during sawing. A thin-bladed diamond saw was used for several dozen corals. The band saw is more satisfactory for the small and medium-sized calcite specimens, inasmuch as the sections do not require additional grinding or polishing, and it is possible to curve the sections so as to follow the curvature of the corallites. Moreover, specimens cut by means of the band saw may be reassembled readily without appreciable loss of external details. Thin sections and celluloacetate peels have been prepared for some of the material, but these techniques do not yield sufficiently better results to compensate for the greater time involved.

The sawed longitudinal and transverse sections were coated by thin oil, and positive prints were prepared at a uniform magnification of five times natural size. Commonly, it is desirable to photograph both the top and bottom of each transverse segment in order to show the rapid development in the immature region and to avoid the influence of abnormal structures or tabulae. The photographs of each specimen were mounted together for study and subsequent use in the preparation of the

illustrations. These mounted photographs having uniform magnifications permit rapid comparison of large numbers of sections such as is impractical under the microscope. Transverse segments of corallites that are cut longitudinally are especially useful in that relationships of skeletal elements may be traced from longitudinal to transverse sections. Also, there is especial advantage in illustrating both longitudinal and transverse sections for the same individual. More than five hundred lophophyllidid corallites were sectioned and photographed, some species being represented by several dozen sectioned specimens. Inasmuch as each cut exposes two more or less different views of the coral and as the majority of the corallites were sawed in four or more places, the number of sections available for study corresponds to at least three thousand thin sections.

The sections contained in this paper were prepared by reproducing the structures shown on photographs by means of waterproof India ink, and removing the original picture by a cyanide bleach. The photographs were compared with the specimens during this inking and in later retouching after bleaching so as to duplicate the skeletal pattern of the particular sections. These black and white illustrations afford a clear representation of the structures by removing adventitious features such as stains, replacement, calcite cleavages, and color variations in the matrix. Also, the relatively low cost of reproduction permits more adequate illustration of a species than by means of half-tones of full-tone plates. Photographs are given also for a few species in which the structural features could not be duplicated by means of line drawings.

Views of the exterior of the corallites were prepared for inexpensive reproduction by drawing the corallite over a photograph printed on

stipple paper, and then bleaching. These diagrams show the major external features of size, shape, curvature, and prominent markings; minor details are not sufficiently diagnostic to merit more precise illustrations. In addition, outline drawings of the corallites were prepared from photographs to facilitate rapid comparison of the size and shape of the species. The internal structures of the genotype species of lophophyllidid genera and a few other types that are discussed were prepared similarly from photographs of original illustrations. The sections and external views of the lophophyllidid corals are given at uniform magnifications, and insofar as practicable each species is represented by several specimens.

Modern biologic studies have increasingly emphasized the importance of individual variation and the use of samples of populations rather than individuals in formulating taxonomic divisions (Simpson and Roe, 1939; Huxley, 1940; Mayr, 1942). Many paleontologists, also, recognize the value of quantitative data as an aid to the objective characterization of fossil forms. As the material representing fossil groups becomes more abundant, the stratigraphic utility of fossils is advanced importantly by the description and statistical treatment of variation. Uncertainties regarding the features subject to quantitative analysis preclude a thorough statistical treatment of the Pennsylvanian lophophyllidid corals. The graphical representation of variation in several of the characters, however, indicates that quantitative data are of practical value in rigorous studies of these corals.

Acknowledgments.-- I am deeply indebted to Dr. R. C. Moore for counsel and guidance in investigations of the late Paleozoic corals. Also, he has given many valuable suggestions regarding the preparation and presentation of this report. The Kansas Geological Survey has made available their extensive collection of Pennsylvanian corals and also the equipment used in preparation of the material. R. C. Moore, J. M. Jewett, L. R. Laudon, A. L. Bowsher, R. H. King, and others of the University of Kansas have generously contributed coral specimens. Drs. L. M. Cline and W. M. Furnish have given several lots of Pennsylvanian corals, and Mr. Joe Harner of Nevada, Mo. has sent me several collections of corals from the Cherokee shale. About 800 corals from the Appalachian region have been loaned for study by the Carnegie Museum through the kindness of E. R. Eller. The cooperation of all these men is greatly appreciated.

Dr. Jewett has been especially helpful in correcting erroneous stratigraphic designations, and in furnishing information on the stratigraphic occurrence of the corals. My wife, Ann Jeffords, has given valued assistance in photography and preparation of the illustrations. The drawings of the exteriors of the corals were prepared mostly by Mrs. Bernita Mansfield of University of Kansas. Appreciation is expressed also to E. C. Galbreath for assistance in the construction of a camera for making positive prints of the sawed sections.

MORPHOLOGY OF LOPHOPHYLLIDID CORALS

Terminology of the varied structures in corals has been largely clarified by several recent studies of morphology and nomenclature as by Grabau (1922), Hill (1935), Wedekind (1937), Sanford (1939), Vaughan and Wells (1943), Easton (1944a), and Smith (1945). Many of the terms are not interpreted uniformly as yet and none of the schemes of terminology has gained general acceptance. Some standardized morphologic terms are needed to facilitate description of the corals. One can hardly assume, however, that the average paleontologist will recognize or search out distinctions between the large number of terms that might be applied to each variant of a mutable structure. For example, vertical structures at the axis of a rugose coral have been described as a columella, pseudocolumella, stereocolumella, cystocolumella acrocolumella, palicolumella, streptocolumella, sclerocolumella, parietal columella, central column, axial column, axial complex, axial structure, axial pillar axial vortex, dibunophylloid axial column, clisiophylloid axial column, aulophylloid axial column, and aulos.

The structural elements in the lophophyllidid corals are notably fewer than in certain other groups, and taxonomic subdivision is deemed to depend upon differences in several characters. Whereas generic separation of these corals is possible on the basis of a few key characters, specific distinctions rest largely on differences in the character of the following features.

External characters

Size, shape, and curvature of corallite

Septal grooves and interseptal ridges

Calyx (commonly incompletely preserved)

Transverse markings

Radicles

Mode of attachment

Internal characters

Theca

Length, arrangement, character, number, and rate of insertion major septa

Minor septa

Fossula and pseudofossulae

Tabulae

Stereoplasm

Axial column

Carinae

Several of the structures are particularly significant in the classification and interpretation of these corals, and so merit brief consideration.

External features.— Study of sectioned material indicates that external features alone are not adequate to differentiate many lophophyllidid species; or even to distinguish these genera from each other or from some unrelated genera. Whereas the collections of corals available for study furnish a reliable indication of the medium and large growth stages, the smaller youthful corallites commonly are not collected. Text figure 1 shows the percentage of individual corallites reaching successive lengths as determined from measurements of the length of all complete individuals that were contained in several lots of corals. The curves are comparatively abrupt for lengths less than the modal length, but the lines slope normally for the larger sizes.

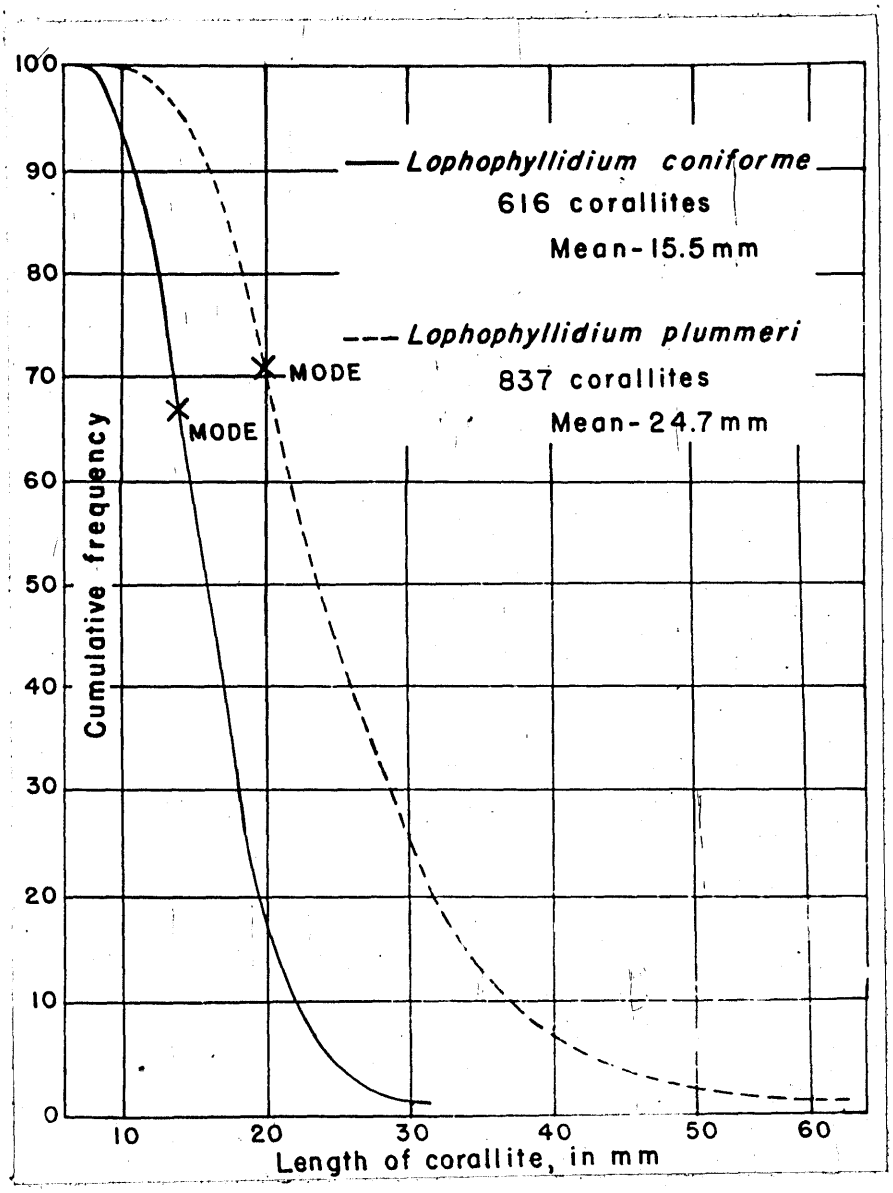

Figure 1. Diagram showing percentages of corallites of Lophophyllidium plummeri, n. sp., and L. coniforme, n. sp., reaching various lengths. These frequency data indicate that the collections contain relatively few of the smaller corallites although they show an even distribution for medium and large corallites.

Presumably, a complete collection of all corals that are present at a given outcrop would yield a smooth symmetrical sigmoidal curve that would differ from those in text figure 1 chiefly by an increase in the frequency of small corallites. The unsymmetrical nature of the frequency distribution suggests that the mode is more useful than the mean or median in comparing such data on coral assemblages.

Although the lophophyllidid corals vary widely in corallite form, they may be divided into two major groups - conical or regularly expanding types and conico-cylindrical types in which a conical apical portion is followed by a cylindrical form. Some corallites follow these basic shapes closely so as to differ only in apical angle or in size. The majority, however, are modified in form by constrictions, wrinkles, and other features. The shape of corals that belong to a particular species is more or less limited in variation and so aids in tentative identifications. Characteristic shapes are seen most readily by plotting measurements of the length and calicular diameter of a large number of individuals, or equivalent measurements made from a single corallite. Whereas the corallite shape of generally similar species may overlap somewhat, the grouping of the plotted points usually differs. On these graphs, conical corallites are indicated by a straight oblique series of points that represent a regular increase in diameter corresponding to the increase in length. For conico-cylindrical corallites, the diameter expands at a progressively decreasing rate as the length increases. Therefore, the median line representing such an assemblage of corallites is distinctly curved toward the vertical (text figs. 2 and 5). Examination of these data shows minor but characteristic differences in the size and form of the corallite such as are missed by a casual inspection

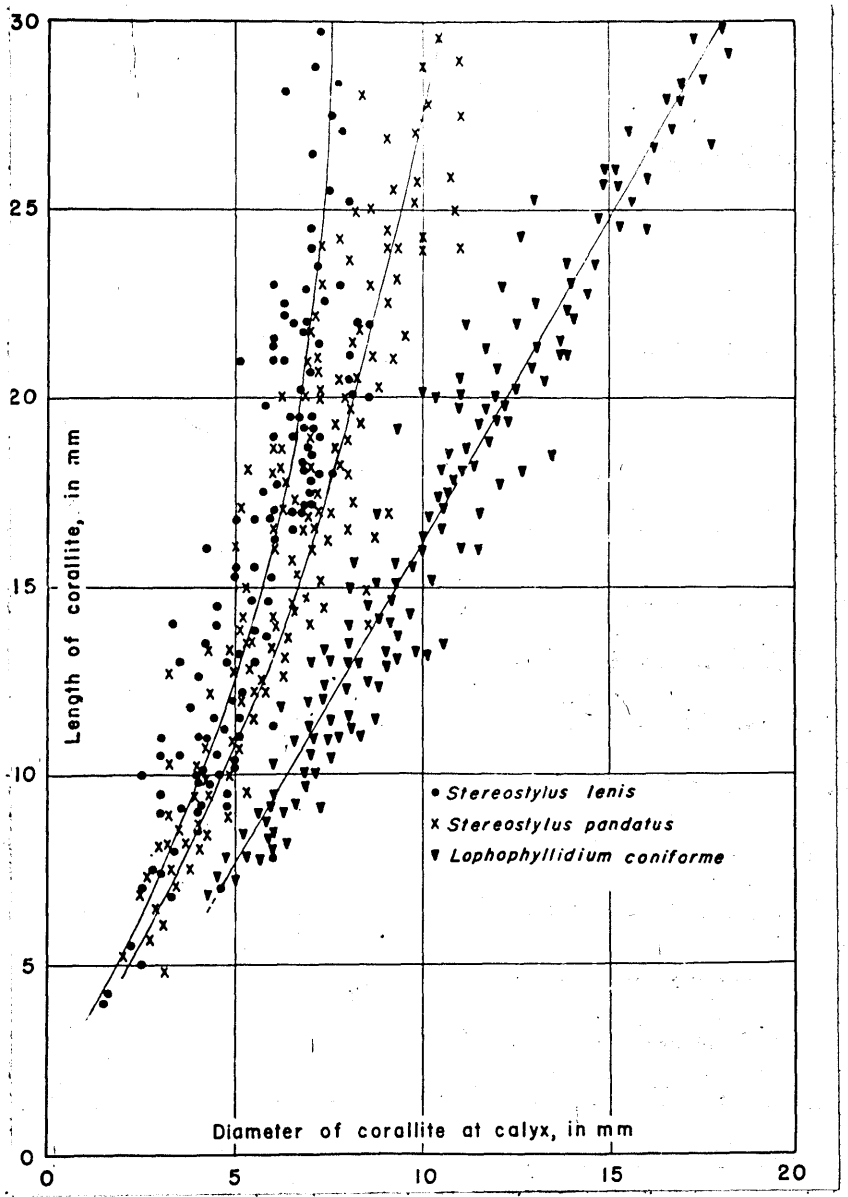

Figure 2. Diagram showing relationship of the length of corallite to diameter at different growth stages in Stereostylus lenis, n. sp., S. pandatus, n. sp., and Lophophyllidium coniforme, n. sp. Corallites belonging to L. coniforme are conical in form and the diameter increases proportionately with vertical growth. S. lenis and S. pandatus are relatively similar in form during youthful stages, but S. pandatus is appreciably more cylindrical in maturity. Measurements were made of the length and calicular diameter of complete corallites so that these data also illustrate the variation in size and form of corallites belonging to these species.

of the corals. Moreover, these graphs give a better indication of the variation in size and form of most individuals in a species than can be represented by measurements of a few corallites in the text.

The corallites may be straight, or gently to strongly curved, and the curvature may be regular or the corallite may be bent abruptly one or more times. The irregular bends occur in the cylindrical portions of the corallites at a point of rejuvenation and probably represent renewed growth following a change in the position of the corallite. Regularly curved forms are not constant in the position of the curvature, although commonly an alar septum is on the concave side.

The majority of the lophophyllidid corals were more or less firmly attached at the base to solid objects such as brachiopod shells or crinoid columnals, but some species seem to have been free throughout life. The attachment may be accomplished by the development of a few short radicles near the apex, or by a thickening of the theca so as to cement one side of the apical region to a foreign object. Where the corallite was attached to the side of an object in the vertical plane, it developed without appreciable curvature; where the base was horizontal, the corallite grew obliquely at first along the base and then curved abruptly upward.

Some species are characterized by the occurrence of small hollow rootlets or radicles that project outward from the theca. Corresponding structures found among the recent Hexacoralla "are developed by temporary extrusions of a tongue of edge-zone peripheral part of polyp over the margin of the wall towards the substratum, the tongue depositing a layer of epitheca around itself, then degenerating, leaving a hollow closed tube as an added element of stability for the corallum" (Vaughan and Wells, 1943, p. 40).

The radicles may be regularly arranged or scattered over the entire corallite, restricted to one or more rows, or located only on one side of the apical region. Radicles near the apex served as a means of attachment for some corallites, but the purpose of numerous radicles that occur abundantly over other corallites is not readily apparent. The very spinose species occur most abundantly in clastic sediments, such as Wewoka, Wayland, and Cherokee shales, which suggests that the radicles may have been an adaptation for lateral support in soft muds on the sea bottom. This explanation is not entirely satisfactory, inasmuch as many spinose species were firmly attached near the apex so that radicles would not have been particularly useful as supports. Moreover, associated species that lack radicles were equally abundant in the same seas. These data suggest that radicles were derived originally as a means of attachment in the apical region and as an aid in the maintenance of an upright position for free corallites in soft muds. The extensive development of radicles, as in Lophophyllidium spinosum, n. sp., may represent adaptation for some biologic function such as in reproduction, or continued specialization associated with senescense.

Other surficial markings that occur in the lophophyllidid corals, such as septal grooves, interseptal ridges, and wrinkles, have been considered previously (Jeffords, 1942, pp. 194-197) and their descriptions need not be repeated here.

Internal features.-- The structural elements of lophophyllidid corallites are divisible into two main types, the vertical elements that comprise the theca, septa, and column, and the horizontal elements, such as tabulae, that are formed between the vertical structures. The calyx, as seen in weathered specimens, shows some features of the septa

and column, but commonly it furnishes little information on the nature of the tabulae. Moreover, the elements in the calyx are incompletely developed and accordingly they seem to be markedly different from similar structures below the calyx.

Septa comprise radially arranged plates that extend from the apex or point of insertion to the calyx. In the lophophyllidid corals, they are joined to the theca at the peripheral edge and are free along the axial edge except where stereoplasm fills in the spaces around them. As seen in transverse section, septa contain a dark median lamina that is bordered by areas of lighter calcite. Hill (1937, p. 48, text fig. 2) has shown for similar septa that "the median dark line . . . is due to the junction of two differently directed sets of fibres, laid down by the opposing sides of a septal invagination." Rhopaloid septa may include also concentric lamination or bounded growth layers that are curved parallel to the axial edge of the septum. A median lamina is present in both the major and minor septa, and it permits identification of the position and extent of the septa in the theca and in the axial region of thickened specimens.

The manner of septal insertion and the characteristics of the resulting pseudofossulae in the lophophyllidid corals has been reviewed at some length previously (Jeffords, 1942, pp. 194-197).

The relatively solid axial column comprises the diagnostic feature of the lophophyllidid corals. Transverse sections near the apex show that the column develops by an elongation and thickening of the counter septum; other septa may be fastened to the column by stereoplasm, but they do not enter it. As the corallite develops, the column becomes larger and separates from the counter septum or disappears in mature

stages. In Stereostylus, Lophamplexus, and early stages of Lophophyllidium the column contains a dark median lamina in the counter-cardinal plane that is continuous with the lamina of the counter septum. Seemingly, therefore, the column is formed by the deposition of material in a short invagination of the base of the polyp along the counter-cardinal plane. Transverse sections of the mature region of corallites belonging to Lophophyllidium show numerous other laminae that radiate outward through the column from different points along the median lamina. Also, there are concentric laminations that seem to be due to variations in the density of the skeletal material. In these forms the column probably was deposited by lateral as well as a median invagination of the basal ectoderm. Median and radiating lamellae in the clisiophyllid genera, such as Dibunophyllum, comprise thin vertical skeletal elements, whereas these laminae in the column of the lophophyllidid corals represent rather the line of junction of two inclined bands of microscopic fibers.

As the height of the calicular wall (theca) increased during growth, the polyp periodically raised itself in the calyx by constructing tabulae at somewhat regular intervals. No dissepiments -- that is, small plates arched convexly upward between the septa and peripheral in position -- are known in the Pennsylvanian corals here referred to the Lophophyllidiidae. Some authors, however, have erroneously identified intercepts of tabulae in transverse section as dissepiments. Although intercepts of tabulae may appear in such sections as occasional or slightly offset bands between the septa so as to simulate dissepiments, tabulae and dissepiments are distinguished readily in longitudinal sections (Jeffords, 1942, text fig. 2). The position of transverse sections in relation to

the tabulae is an important feature in the interpretation of internal structures, inasmuch as septa are more fully developed immediately above a tabula, and characters of fossulae and other structures may appear notably different in sections taken respectively just below and above a tabula.

Ontogenetic tendencies.-- The fossilized remains of Paleozoic corals comprise an exoskeleton that doubtless was formed by the ectoderm of the polyp. Vertical elements, such as the septa and column, represent skeletal material deposited in invaginations at the base of the coral polyp. Horizontal or transverse elements, such as tabulae and dissepiments, were laid down by the more or less horizontal ectoderm at the base, which also probably formed most deposits of stereoplasm within the corallite. The living animal occupied only the calyx, and was excluded from the previously formed portions of the corallite by the transverse structures and by such stereoplasm as may have been deposited. In most lophophyllidid corals the polyp was held up above the floor of the calyx in the axial region by the column, but elsewhere it extended downward between the septa, especially at the cardinal fossula. The relationships of most skeletal elements of rugose corals to the arrangement of the organs within the polyp is little understood. External structures, such as radicles, were formed at the edge of the calyx, and internal features could not be modified after the base of the calyx had been raised by tabulae.

A corallite affords, therefore, a continuous record of the morphologic development of the individual and serial sections permit essentially complete studies of the ontogeny of the corallites (text fig. 8). The classic investigation of the ontogeny and phylogeny of the "Zaphrentis

delanouei gens" by Carruthers (1910) clearly demonstrated the phylogenetic significance of ontogenetic characters shown by these corals, and his work has been confirmed by later research. Available evidence suggests that most, if not all, ontogenetic features are important in the interpretation of phylogeny.

Study of corals is rendered difficult, however, by the occurrence of tendencies in widely different genetic lines to develop similar structures and to evolve along nearly the same lines. These similar trends produce convergence. The common similarities include change from a conical to a cylindrical form, modification of bilateral symmetry to radial symmetry, decrease of tabulae accompanied by increase of dissepiments, and development of a simple axial column into a complex one. Ontogenetic studies are of primary importance in distinguishing closely allied forms from other convergent types that have reached essentially the same stage along an identical general trend.

Among Pennsylvanian lophophyllidid corals, primitive characters comprise prominent bilateral symmetry, large alar pseudofossulae, attachment of the column to the counter septum, long major septa, irregular and slightly anastomosing tabulae, conical form, thick deposits of stereoplasm, insertion of major septa throughout most of the development, and a laterally compressed column that lacks radiating laminae. The general trend among these corals is towards shortening of the septa, separation of the column, disappearance of the pseudofossulae, establishment of radial symmetry, increased size of the cardinal fossula, regular spacing of the tabulae, insertion of major septa near the apex only, and a development of a complex column. Serial sections through species of Lophamplexus illustrate the gradual change from early youth

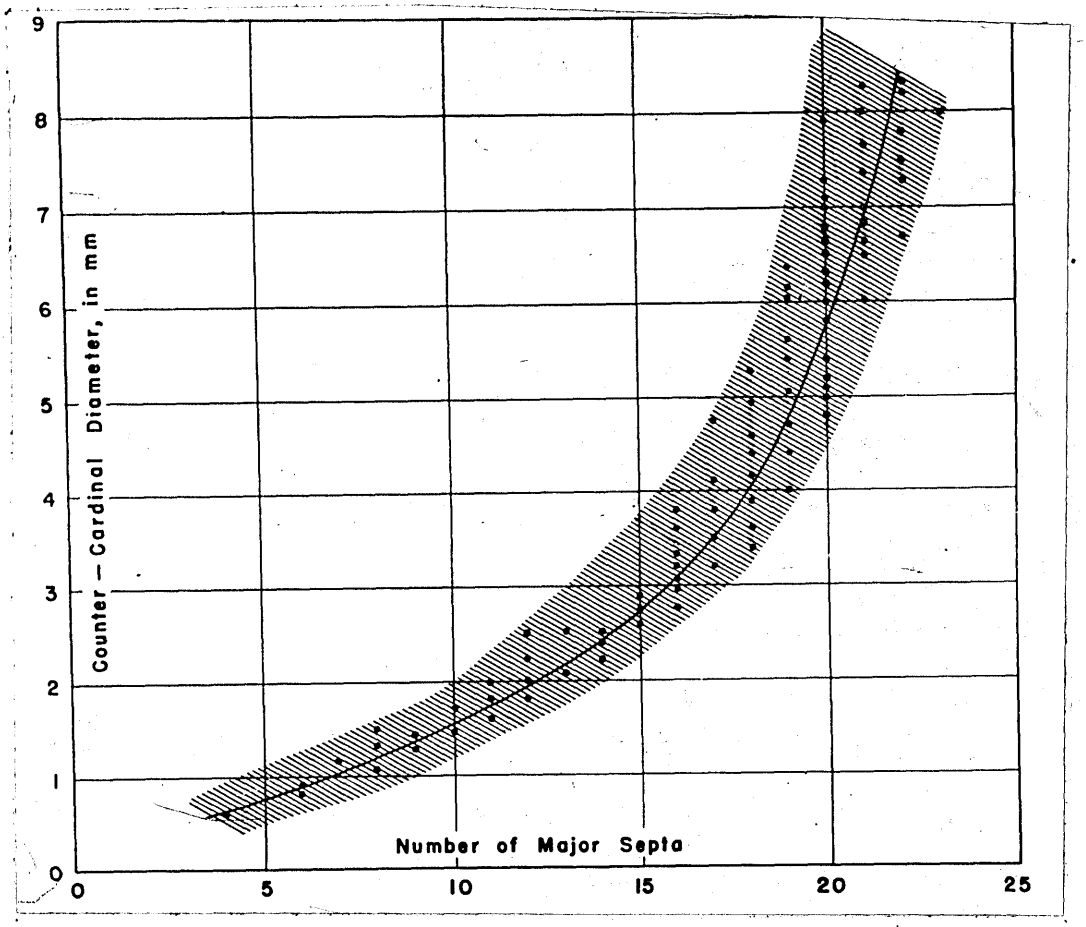

Figure 3. Diagram showing the relationship of the number of major septa to the diameter of the corallite in Stereostylus lenis, n. sp. These data indicate that the number of septa at any particular diameter varies somewhat, but that the rate of increase in septa decreases in maturity. Similar data on other species of lophophyllidid corals show this general pattern although the position of the median lines commonly does not coincide with that shown here.

to the end stage for this type of development (pl. 1, fig. 4). In this genus, the immature lophophyllidoid development, which is confined to the conical part of the corallite, is followed in the cylindrical portion by the loss of the column, shortening of the major septa, and great regularity of the tabulae. This Amplexus-like specialization of the tabulae seems to have been the end stage in several genetic lines so that it probably should be included with Lang's (1923) list of trends as an alternative development that is equivalent to the progressive increase in dissepiments. The method of raising the polyp in the calyx by means of dissepiments is not observed in these Pennsylvanian corals. An undescribed Upper Permian coral that contains a few dissepiments, however, may represent development in this direction.

The trends in development of corallites may be shown by a series of transverse sections, as in text figure 8, or by graphic comparison of several characters seen in a large number of sections (text figs. 3 and 4). These quantitative studies serve to show the variation within a species and also to indicate the gradual development of certain characters. The number of major septa increases rapidly in the immature region as the coral expands, but septa are inserted more slowly in the larger mature parts (text fig. 3). Near the apex the major septa reach nearly to the axis, but they extend inward differing distances near the calyx. As shown on text figure 4, the average radial length of the septa bears a close relation to the diameter of the section in the immature region. This relationship is less exact in larger sections, however, because of the influence of sections made through the calyx where the septa are incompletely developed.

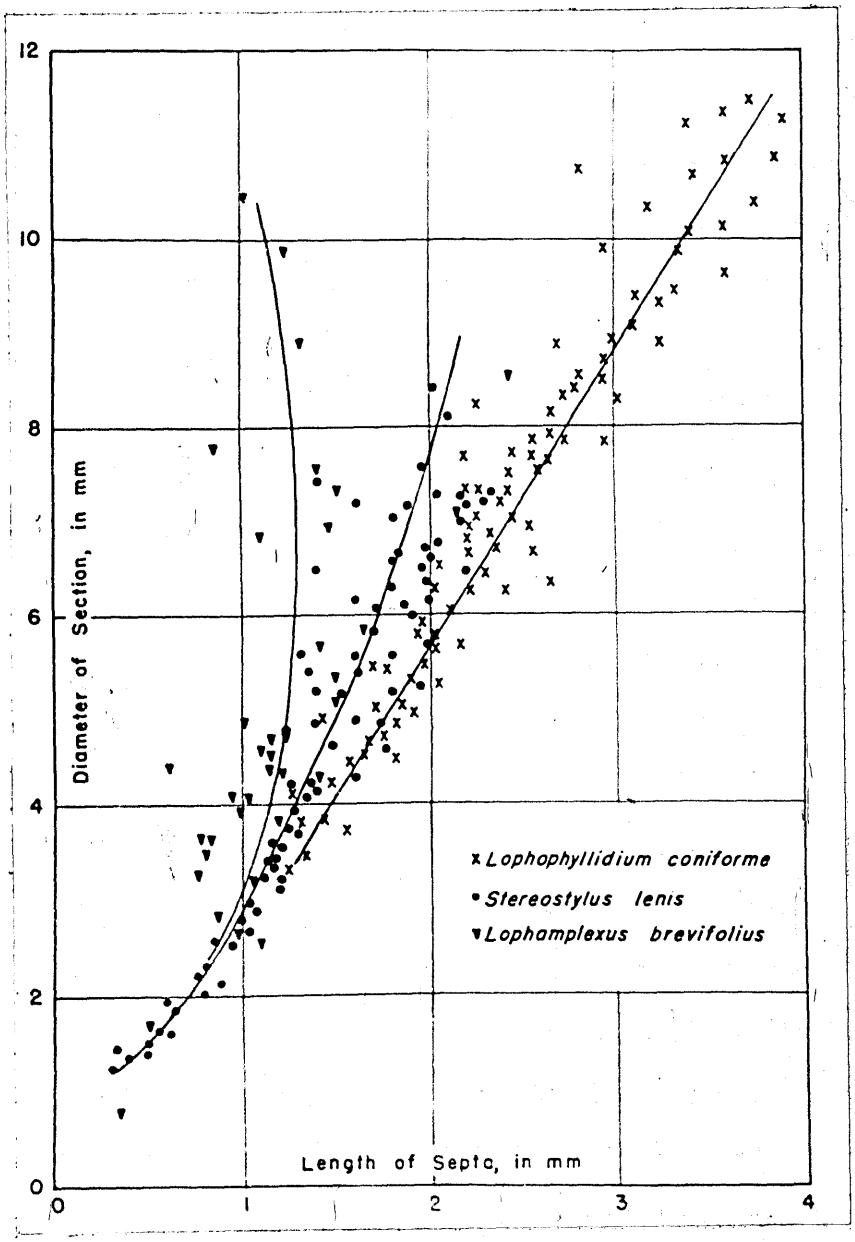

Figure 4, Diagram showing relationship of the diameter of corallite to average radial length of major septa in Lophophyllidium, Stereostylus, and Lophamplexus. Septa increase in length throughout growth proportionate to increase in diameter in Lophophyllidium whereas in Stereostylus the septa are relatively shorter in maturity. The septa of Lophamplexus are long in the lophophyllidoid phases, but shorten markedly in upper portions of the corallite.

Glossary.-- An alphabetically arranged explanation of morphologic terms (mostly after Moore and Jeffords, 1945) is included in order to clarify the terminology used in this paper and as a convenience to readers. More comprehensive glossaries of terms used in other publications on rugose corals have been compiled recently by Easton (1944, pp. 15-21) and Smith (1945, pp. 4-9).

Acceleration is the more rapid introduction of septa in certain quadrants of a coral than in others, giving rise to a greater number of septa in these parts at a given growth stage.

Alar is a term applied to two primary septa (protosepta) on opposite sides of a rugose coral and to more or less defined wide spaces (pseudofossulae) that may border the alar septa on the side facing the counter septum. One of the four insertion points of newly formed major septa adjoins each alar septum on the counter side and this relationship commonly serves for identification of the alar septa. On diagrams and in septal formulae the alar septa are indicated by the symbol A.

Apical indicates the immature lowermost part of a corallite, near the apex of cone-shaped forms.

Axial refers to the mid-line of the upwardly growing coral; this term may be applied to a centrally located columnar structure or to designate a region in the coral skeleton.

Brevisepta are much-shortened radial partitions of a coral that extend inward only part way from the periphery to the axis. The term also is used to describe the ontogenetic stage characterized by short septa and regularly spaced tabulae, as in Amplexus.

Calyx is the more or less deep cuplike hollow at the top of a coral skeleton that was occupied by the living animal.

Cardinal is a term that applies first to one of the four earliest-formed septa of a rugose coral; it lies in the plane of bilateral symmetry and insertion points of newly formed major septa adjoin it on either side. Secondarily, the name cardinal is applied to the depression (fossula) that is formed by the partial or complete abortion of the cardinal septum, and it is used also to designate the quadrants of septa that lie between the cardinal and alar septa. On diagrams and in septal formulae the cardinal septum is indicated by the symbol C. Transverse sections of corals illustrated in this paper are oriented with the cardinal septum directed downward.

Carinae are keel-like ridges on the sides of septa; they are straight or curved and run more or less longitudinally.

Column is a term applicable to varied sorts of axial structures of corals (including columella and pseudocolumella of authors), ranging from dense rodlike growths to delicate open meshwork.

Conical refers to the cone-like form of some corallites.

Conico-cylindrical is a term given to corallites that are conical near the apex but become cylindrical above.

Corallite is the name used for the hard parts of a coral individual.

Counter refers to one of the four first-formed septa of rugose corals, lying in the plane of bilateral symmetry opposite to the cardinal septum; it is also applied to the quadrants of septa contiguous to it. On diagrams and in septal formulae the counter septum is indicated by the symbol K. Transverse sections of corals figured in this paper are oriented with the counter septum directed upward.

Counter-lateral is a term applied to the pair of metasepta immediately adjacent to the counter septum.

Dissepiments are small curved plates built one on another so as to form vesicles; their convex surfaces are directed upward and toward the interior of the coral. Dissepiments do not occur in lophophyllidid corals although several authors have designated intercepts of tabulae in transverse sections as dissepiments.

Fossula is a depression in the floor of a rugose coral calyx formed by the partial or complete abortion of a protoseptum, in nearly all cases the cardinal septum. The presence of a fossula may be indicated in transverse sections of a corallite by a distinct open space extending peripherally between some of the septa.

Growth lines are fine irregularities that encircle the exterior of some corals.

Inner wall is a term most commonly employed to designate a thickened wall-like structure at the inner edge of a zone of dissepiments; it is applied also to a curved wall that is formed by intercepts of tabulae.

Interseptal ridges are longitudinal elevations on the exterior of some rugose corals that mark slight outward bulges of the enclosing theca.

Lamellae are subvertical plates of the axial region of some rugose corals, generally not confluent with septa; they may be discontinuous longitudinally. Some genera are characterized by a median lamella in the plane of the cardinal and counter septa and by radiating lamellae, which intersect the median lamina at different points.

Laminae are sheet-like structures formed by the juxtaposition of two layers of skeletal material in septa and the column. They appear in transverse sections as indefinitely bounded dark bands that are formed by the junction of two differently directed layers of fibers. A lamina

occurring in the plane of the cardinal and counter septa within the column is a median lamina; intersecting laminae are termed radiating laminae. Lamellae, unlike laminae, comprise distinct wall-like structural units.

Major septa are the relatively long septa of rugose corals that comprise the four first-formed protosepta and subsequently inserted pairs of metasepta appearing in definite order in the different quadrants.

Metasepta are major septa other than the protosepta.

Minor septa are secondarily introduced septa, generally short, that appear nearly simultaneously between major septa.

Peripheral refers to the outer zone of a corallite or that part adjacent to the theca.

Polyp is the living organism that occupied the calyx.

Protosepta are the four first-formed septa of rugose corals (cardinal, counter, and two alar) that are introduced nearly simultaneously very early in the growth of the corallite and that define the tetrameral development and bilateral symmetry of these fossils. Except the counter, they are the septa next to which insertion points of newly formed major septa are located. According to some investigators, an additional pair of septa (counter-laterals), which adjoin the counter septum, are classifiable as protosepta but these do not affect the four-fold arrangement of the septa.

Pseudofossula is a depression or space between septa on the floor of the calyx of some rugose corals, not formed by the partial or complete suppression of a septum. Pseudofossulae are developed on the counter side of the alar septa in many corals and are termed alar pseudofossulae.

Quadrant is a term given to areas of the corallite in the Rugosa lying between any two adjacent protosepta; these areas are designated, respectively, as cardinal quadrants (adjoining the cardinal septum) and counter quadrants (adjoining the counter septum).

Radicles are external tubular projections that occur on the theca of some solitary corals.

Rejuvenation is a renewal of immature structural characters that is accompanied by a constriction of the corallite after maturity has been attained.

Rhopaloid is a descriptive term (derived from Greek, rhopalon, war club) applied to septa that thicken toward a rounded axial edge so as to appear club-shaped in transverse section.

Septa are radial partitions that partly or completely divide the interior of rugose corallites into compartments. Commonly, the unqualified term septa refers to the major septa.

Septal formula designates the relative position of protosepta and the number of metasepta in respective quadrants in a consistent abbreviated manner. As employed in this paper, the formula begins with the counter septum, proceeds clockwise around the corallite, and ends at the counter septum — for example, counter septum (K), 9 metasepta, alar septum (A), 4 metasepta, cardinal septum (C), 3 metasepta, alar septum (A), 9 metasepta, and the counter septum again. Expressed as a formula, the septal arrangement of the septa in this section is K 9 A 4 C 3 A 9 K.

Septal grooves are longitudinal depressions on the exterior of some corals that mark inbending of the outer wall along lines at the edges of the septa.

Solitary corals are individuals that grow unattached to other corallites as contrasted with colonial forms.

Stereoplasm consists of organically deposited calcium carbonate and this term is especially used in referring to secondary thickening of various coral structures.

Tabulae are subhorizontal, arched, or upwardly concave platforms that are not limited by septa and that extend at least partly across the axial region of the corallite. Complete tabulae are those that reach across the axial area without intersecting an axial structure or other tabulae and that join the theca or dissepiments peripherally. Other tabulae are incomplete or anastomosing.

Tachylasmoid (derived from the genus Tachylasma)refers to septal development in which some major septa are long and rhopaloid whereas others are short.

Theca is the term given to the outer wall of rugose corals; it is equivalent to epitheca of some authors.

Wrinkles are transverse folds or annulations encircling the theca on some corallites. Abrupt constrictions are caused by rejuvenation.

Family LOPHOPHYLLIDIIDAE, Moore and Jeffords, 1945

Small to medium-sized corallites having straight or gently to strongly curved conical and conico-cylindrical form comprise this family. The theca bears well defined septal grooves and interseptal ridges, and is marked transversely by wrinkles and growth lines of varying prominence. The relatively deep calyx contains a spikelike column that projects from the central portion of the floor at least in immature stages. Septa, which have the "zaphrentid" type of insertion (Hill, 1935, pp. 505-506) are continuous, of one or two orders, and unjoined axially except in the

apical region. These septa may be thin or rhopaloid in character, and they show more or less bilateral arrangement about the counter-cardinal plane. The counter quadrants are slightly to moderately accelerated. Except near the calyx the counter septum extends to the axis where its inner edge is strongly thickened so as to form a rodlike axial column. The cardinal septum is notably shortened and lies in a fossula; other major septa are sub-equal in length. Minor septa are introduced simultaneously between major septa in mature stages or they may be lacking. Alar pseudofossulae are developed in varying degrees of prominence, particularly in the immature stages. The diagnostic feature of these corals is the well-defined dense or relatively solid column that may project into the calyx or be discontinuous in mature stages. The column commonly shows a median lamina along the plane of the counter-cardinal septa and this lamina is continuous with that of the counter septum near the apex. Advanced forms have in addition radiating laminae and concentric growth layers. Tabulae may be numerous, sparse, or lacking, and dissepiments are absent. Range, Mississippian to Permian.

Discussion.-- The lophophyllidid corals have been in an uncertain status as to family relationship, and the taxonomic confusion surrounding some of these genera, plus the lack of reliable information on the internal structure of several types, has not contributed to resolving the uncertainties (Moore and Jeffords, 1945, pp. 80-81). Recognition and verification of the significance of all the features in lophophyllidids is not now possible, in spite of the several different types that have been described and the data on ontogenetic development that have been published recently. The information now available, however, is comparable to that of other coral assemblages that are currently classified as families.

Lophophyllum, in which most early workers included the lophophyllidid corals, has been placed in the broadly construed family Zaphrentidae Edwards and Haime (1850) by Zittel (1900), and this classification has been followed generally for a considerable period. As the phylogenetic relationships of many Paleozoic coral genera became somewhat clearer, more precisely defined families have been proposed for closely allied genera. Reasonably accurate evaluation of significant phylogenetic trends in many instances is rendered difficult or impossible because of the polyphyletic nature of some corals and the absence of pertinent information on the ontogenetic development of other genera. Thus, lophophyllidid corals have been assigned to the Streptelasmaidae Nicholson and Lydekker (Grabau, 1922; Soschkina, 1925; Huang, 1932; Yoh and Huang, 1932), Zaphrentidae Edwards and Haime [Zaphrenthidae Moore and Jeffords, 1945] (Girty, 1915; Okulitch and Albritton, 1937; Soschkina, 1939), Lophophyllidae Grabau (Grabau, 1928, 1936; Chi, 1931, 1935; Heritsch, 1936; Sanford, 1939), Metriophyllidae Hill (Hudson, 1943; Easton, 1945), and as of uncertain family relationship (Girty, 1915a; Hill, 1940; Moore and Jeffords, 1941; Smith, 1941; Jeffords, 1942). In order to segregate these genera that show similar structural characters and phylogenetic relationships, along with somewhat restricted geologic range, the lophophyllidid corals have been assigned to a separate family the Lophophyllidiidae (Moore and Jeffords, 1945, pp. 92-93). Most of the same genera have been included in the Lophophyllidae by Grabau (1928), but Lophophyllum, the family type genus, is now considered to differ widely from the lophophyllidid corals here treated.

The Lophophyllidiidae were established to include Lophophyllidium Grabau (1928), Sinophyllum Grabau (1928), Malonophyllum Okulitch and Albritton (1937), Fasciculophyllum Thomson (1883), Lophamplexus Moore

and Jeffords (1941), and Lophotichium Moore and Jeffords (1945). Sochkineophyllum Grabau (1928) was doubtfully assigned to this family on the basis of similarities of axial structure. Later study has indicated that Kinkaidia Easton (1945) and Claviphyllum Hudson (1942) probably constitute early representatives of the Lophophyllidiidae. The inclusion of Fasciculophyllum and Claviphyllum in this family is tentative, inasmuch as these Mississippian genera may be merely convergent types that belong in another group.

Fasciculophyllum, which has F. dybowski Thomson (1883) as genotype, was interpreted by Hill (1940, pp. 130-132) as including corals similar to Cyathopsis? eruca McCoy (1851). Hudson (1942, p. 262) suggests, however, that C.? eruca is generically distinct from F. dybowski, the syntypes of which have been lost (Hill, 1940, p. 130), and he has proposed the genus Claviphyllum, based on C.? eruca. The original illustrations of F. dybowski (Thomson, 1883, pl. 6, figs. 23-23a) comprise a generalized view of the exterior of the corallite and a single transverse section showing long thin major septa and seemingly an elongated counter septum. These illustrations and the accompanying description are not adequate for distinguishing Fasciculophyllum, but additional sectioned material representing corals accepted as belonging to F. dybowski may show that Claviphyllum is a junior synonym of Fasciculophyllum.

Sochkineophyllum Grabau includes corallites that are much larger than corals here assigned to the Lophophyllidiidae and that have a somewhat thickened counter septum reaching the axis. Typically, one or more pairs of metasepta are elongated and thickened at their inner edges. The internal structure has the general plan characteristic of the lophophyllidid corals and one species from Wolfcampian rocks of

Kansas and Oklahoma has so similar a septal development that it was assigned to Sochkineophyllum (Moore and Jeffords, 1941). Corallites assignable to Sochkineophyllum on the basis of Soschkina's illustrations (1939, pl. 8, fig. 3), however, are characterized by a cylindrical shape, a strong development of transverse wrinkles and growth lines, and an absence of longitudinal septal grooves. The presence or lack of these septal grooves on the exterior of the unweathered theca is judged to merit consideration along with internal structures in distinguishing the phylogenetic relationships of the solitary rugose corals. Therefore, it seems probable that the lophophyllidid structures seen in species of Sochkineophyllum from Russia are the result of convergent development along a phylogenetic line characterized by a Caninia-like theca, much larger size than typical Lophophyllidium, and tachylasmoid septa. Soschkina (1932, pp. 266-267) maintains that the genotype species of Sochkineophyllum, which is Plerophyllum artiense Soschkina (1925), should not be transferred from Plerophyllum, inasmuch as particular arrangements of septa are specific characters and are subject to duplication in different phylogenetic lines. Tachylasmoid septal development has been observed in corals ranging in age from Mississippian to Upper Permian, but the relationships of many of the forms are incompletely resolved as yet (Hudson, 1943a, pp. 82-86).

Timorphyllum Gerth (1921, p. 69) has been assigned by Grabau (1928) to the Lophophyllidae, and the internal structures of this genus, as illustrated by Gerth and Grabau, generally resemble those of corals here included in the Lophophyllidiidae. The genotype and other Permian species of Timorphyllum from Timor, as well as T. simulans Moore and Jeffords (1941, p. 102) from the Middle Permian of Texas, comprise

corallites characterized by a notably small diameter, an elongate cylindrical shape, and commonly an irregularly bent form. Moreover, the theca differs from that of typical Lophophyllidiidae in bearing well-developed transverse wrinkles and numerous fine growth lines, and in lacking prominent septal grooves. Lophophyllidium-like internal characters of Timorphyllum, therefore, like those of Sochkineophyllum, are considered to be the result of homeomorphy.

Lophophyllum Edwards and Haime (1850), Koninckophyllum Thomson and Nicholson (1876), Arachnolasma Grabau (1922), Thysanophyllum Nicholson and Thomson (1876), Yuanophyllum Yü (1931), Rossophyllum Stuckenberg (1888), and some other genera that have been allied with the lophophyllidid corals differ importantly in the specialized development of dissepiments and in having an axial column of distinctly different type from that of Lophophyllidium. Cyathaxonia Michelin (1847) and other genera included in the Cyathaxonidae Edwards and Haime (1850) agree with the Lophophyllidiidae in having a solid axial column and in lacking dissepiments. The Lophophyllidiidae are distinguished, however, by the insertion of the minor septa subsequent to the metasepta — not at the same time, as in the Cyathaxonidae — and by the presence of an axial column that is formed largely by a thickening of the counter septum.

NATURE AND RELATIONSHIPS OF LOPHOPHYLLIDID CORALS

Early work on the rugose corals was limited to description of the external features of the corallites, supplemented by delineation of such few internal characters as were visible in the calyx or in weathered specimens. Thus, many species and genera had been introduced before the

importance of internal structures became recognized and techniques for sectioning were developed. Generic diagnoses were revised gradually to include these internal structures as the primary characters, but the new generic concepts were developed mainly not from study of genotype species but from examination of the internal structures of species presumed on the basis of external features to be congeneric with the genotype species. Therefore, well-defined assemblages of species have come to be designated by old generic names and workers have tended to accept such generic assignments, inasmuch as they have lacked contradictory evidence derived from the genotype and have not attached to the genotype species and the holotype specimen the importance now accorded to them by the International Rules of Zoological Nomenclature. This procedure has resulted in the taxonomically incorrect use by many paleontologists of generic names such as Zaphrentis for Mississippian zaphrenthid types, Campophyllum for specialized caninids from Mississippian and Pennsylvanian rocks, and Lophophyllum for corals like Cyathaxonia prolifera. In view of this confusion, generic concepts as applied to the Rugosa should be based on examination and evaluation of the characters shown by authentic type material of the genotype rather than the misleading generic concepts proposed by these early workers.

Characters of Lophophyllidid Genera

The genera assigned to the Lophophyllidiidae are illustrated, described briefly, and compared mainly on the basis of internal structures seen in authentic genotype material.

Lophophyllidium Grabau, 1928, (pl. 1, figs. 2-3; pl. 2, figs. 23-24; text fig. 6).— This genus is distinguished especially by the nature of its axial column which is relatively large in diameter and contains well-

EXPLANATION OF PLATE 1

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are mostly at right angles to the counter-cardinal plane; the position of transverse sections in indicated by small italic figures.)

Page

1--*Stereostylus lenis* Jeffords, n. gen.,n. sp., genotype of *Stereostylus*, from the Frisbie limestone member, Wyandotte limestone, Missourian series, Pennsylvanian (Upper Carboniferous),at Kansas City, Missouri (Univ. Kansas specimen, no. 1875-21b). - - - - - - - - - 41

2-3--*Lophophyllidium proliferum* (McChesney), genotype of *Lophophyllidium*, from beds over Coal No. 8, Trivoli cyclothem, Missourian series, Pennsylvanian (Upper Carboniferous), near Springfield, Illinois (After Jeffords, 1942). - - - - - - - - - - 37

4--*Lophamplexus eliasi* Moore and Jeffords, genotype of *Lophamplexus*, from the Hughes Creek shale member, Foraker limestone, Council Grove group, Wolfcampian series, Lower Permian, near Grand Summit, Cowley county, Kansas (After Moore and Jeffords, 1941). - - - - - - - - - - - - - - - - - - 42

5-6--*Lophotichium vescum* Moore and Jeffords, genotype of *Lophotichium*, from the Hale formation, Morrowan series, Lower Pennsylvanian (Upper Carboniferous), southeast of Braggs, Oklahoma (After Moore and Jeffords, 1945). - - - - 42

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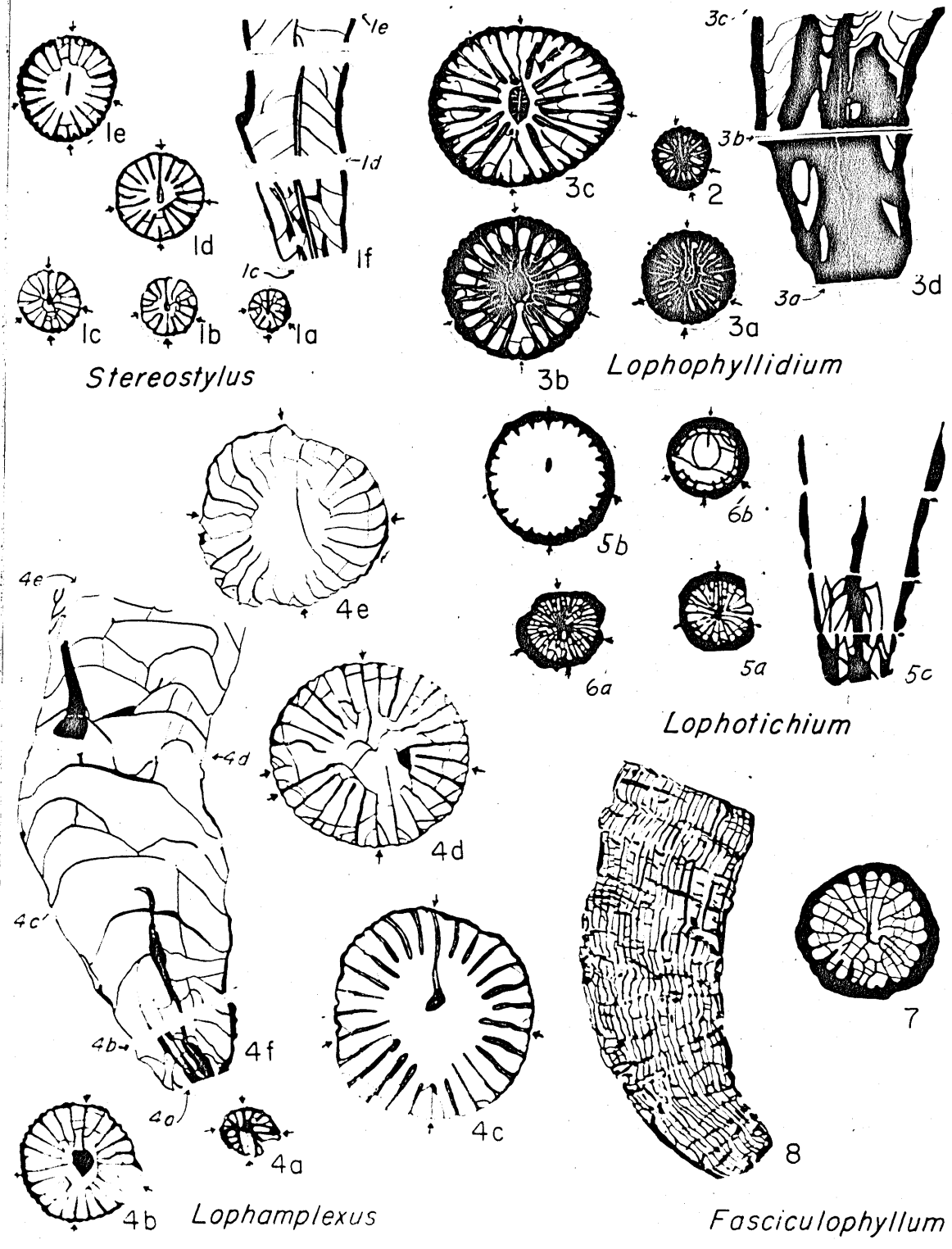

1e
1d
1f
1c
1b
1a
Stereostylus
3c
3b
2
3a
3d
Lophophyllidium
4e
4d
4c
4b
4a
4f
Lophamplexus
5b
6b
6a
5a
5c
Lophotichium
7
8
Fasciculophyllum

Plate 1

defined radiating laminae associated with a distinct median lamina. Tabulae commonly are few and the lower one-third of the corallite may be filled by stereoplasm. Septa are long and stout. The corallites commonly are slightly curved and conico-cylindrical in form. Syn. Sinophyllum Grabau (1928), Lophophyllum (in part) of authors. Genotype, Cyathaxonia prolifera McChesney (1860). Pennsylvanian (Upper Carboniferous) and Permian.

Lophocarinophyllum Grabau, 1922 (pl. 2, figs. 12-16).— The distinctive features of this genus are hooklike carinae developed on the major septa and sides of the axial column. Septa unite with the large column near the apex but become shortened higher in the corallite. Tabulae are regularly spaced and nearly horizontal. Genotype, L. acanthiseptum Grabau (1922). Mississippian (Lower Carboniferous).

Malonophyllum Okulitch and Albritton, 1937 (pl. 9, fig. 5).— This genus is based on badly weathered corallites and fragments that are reported to lack tabulae. The septa extend to the column in the mature region, but become shortened near the calyx. Pseudofossulae are indistinct. The interior of the axial column weathers more readily than the outer part, indicating possible a structure like that of Lophophyllidium. Data now available are not adequate to permit positive recognition of Malonophyllum. Genotype, M. texanum Okulitch and Albritton (1937). Permian.

Stereostylus Jeffords, new genus (pl. 1, fig. 1; pl. 12; pl. 18, figs. 3-4, 6; text fig. 8).— The axial column is moderately thick and laterally compressed; it contains a median lamina which is continuous with that of the counter septum but radiating laminae are lacking. Separation of the column and counter septum occurs only in late stages.

Tabulae are numerous and slightly inosculating. Septa are joined about the column near the apex and are thin and rhopaloid in higher sections. The corallites commonly are conical or conico-cylindrical in form. Alar pseudofossulae are recognized, but they are not prominent in the immature regions. Syn. Lophophyllum (in part) of authors, Lophophyllidium (in part) Moore and Jeffords (1941, 1945), Jeffords (1942). Genotype, Stereostylus lenis, n. sp. Pennsylvanian (Upper Carboniferous) and Permian.

Lophamplexus Moore and Jeffords, 1941 (pl. 1, fig. 4).— Structural features are similar to those of Stereostylus except for the disappearance or discontinuity of the axial column in the upper part of the corallite. Septa and axial column are thin or only moderately thickened, and tabulae extend across the corallite above the calicular end of the column. Genotype, L. eliasi Moore and Jeffords (1941). Pennsylvanian (Upper Carboniferous) and Permian.

Lophotichium Moore and Jeffords, 1945 (pl. 1, figs. 5-6).— Steeply sloping or vertical tabulae near the apex simulate septa but become less inclined upward in the corallite. Thus, the number of structures resembling septa seems to decrease in sections successively higher in the corallite. Thin major septa are joined in palmate groups about the axial column in immature stages, but become shortened near the calyx. Genotype, L. vescum Moore and Jeffords (1945). Pennsylvanian (Upper Carboniferous).

Claviphyllum Hudson, 1942 (pl. 2, figs. 1-11).— Relatively small corallites are assigned to this genus. They are characterized by an elongate, only slightly thickened counter septum, and in mature stages, by the elongated, rhopaloid nature of the third and fourth pairs of major septa on the cardinal side of the counter septum, and the second

EXPLANATION OF PLATE 2

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are mostly at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

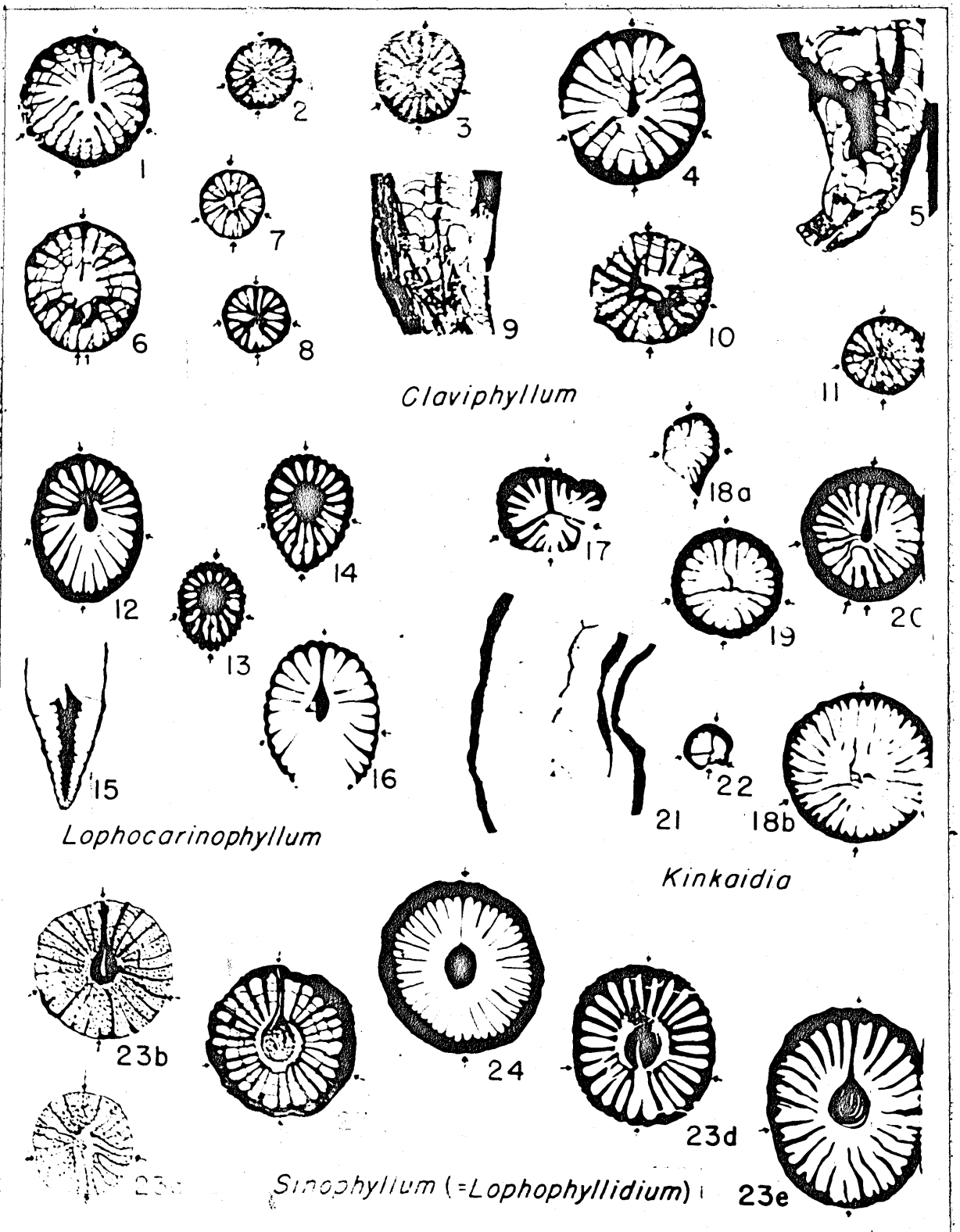
Page

1-11--*Claviphyllum eruca* (McCoy), genotype of *Claviphyllum*, from the E_1 zone, Mississippian (Lower Carboniferous) in Scotland and England (Figure 1 after Thomson, 1883; figures 2-3,7-9 after Hudson, 1942; figures 4-6,10-11 after Hill, 1940). - 42

12-16--*Lophocarinophyllum acanthiseptum* Grabau, genotype of *Lophocarinophyllum*, from the Taiyan series, Mississippian (Lower Carboniferous) in China (After Grabau, 1922). - - - - - - - - - - - - - - - - 41

17-22--*Kinkaidia trigonalis* Easton, genotype of *Kinkaidia*, from the Kinkaid limestone, Elvira group, Mississippian (Lower Carboniferous) in Illinois (After Easton, 1945). - - - - - - - - - - 45

23-24--*Sinophyllum pendulum* (Grabau), genotype of *Sinophyllum*, from the Permian in South China (After Grabau, 1928). *Sinophyllum* is here considered to be a junior synonym of *Lophophyllidium*. - 37


1
2
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11
Claviphyllum
12
13
14
15
16
17
18a
19
20
Lophocarinophyllum
21
22
18b
Kinkaidia
23b
24
23d
23e
Sinophyllum (=Lophophyllidium)

Plate 2

and third pairs of septa on the cardinal side of the alar septa. Tabulae are numerous, anastomosing, and steeply inclined. Alar pseudofossulae are not well defined. Genotype, Cyathopsis? eruca McCoy (1851). Mississippian (Lower Carboniferous).

Kinkaidia Easton, 1945 (pl. 2, figs. 17-22).— The corallites are characterized by a relatively open interior that lacks deposits of stereoplasm even near the apex. The counter septum is elongated but not consistently thickened. Alar and counter lateral septa are distinctly elongated also. Tabulae rise regularly from the theca to the column. Alar pseudofossulae are not well developed. Genotype, K. trigonalis Easton (1945). Mississippian (Lower Carboniferous).

Fasciculophyllum Thomson, 1883 (pl. 1, figs. 7-8).— This genus is poorly known if F. dybowski is generically distinct from C.? eruca. The type specimen is relatively small and bears a thick theca. Septa are long, thin, and not thickened axially. Ontogenetic development and features shown by longitudinal sections are lacking. Genotype, F. dybowski Thomson (1883). Mississippian (Lower Carboniferous).

Key to Lophophyllidid Genera[1]

Family Lophophyllidiidae: Solitary corallites having solid axial column, shortened cardinal septum, elongate counter septum extending to the column near the apex, counter quadrants accelerated, and well-defined septal grooves.

Septa and column bearing carinae . . . . . Lophocarinophyllum

Septa and column lacking carinae

Axial column absent or discontinuous in mature stages . . . . . Lophamplexus

Axial column continuous in mature stages

Tabulae steeply inclined, vesicular

Major septa unequal: third and fourth pairs of septa on cardinal side of counter septum and second and third pairs of septa on cardinal side of alar septa elongated and rhopaloid . Claviphyllum

Major septa subequal: septa-like structures near apex formed by tabulae . . . . . Lophotichium

Tabulae not notably vesicular or steeply inclined

Axial column large, cylindrical, characterized by radiating laminae and intercepting growth layers . . . . . Lophophyllidium

Axial column laterally compressed, containing median lamina but no radiating laminae

Major septa unequal: alars and counterlaterals elongated . . . . . Kinkaidia

Major septa subequal: none consistently elongated . . . . . Stereostylus

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1. Data are insufficient to include Fasciculophyllum and Malonophyllum in this key.

PHYLOGENETIC RELATIONSHIPS

This study of Pennsylvanian species of lophophyllidid corals furnishes few data on the relationships of these corals, inasmuch as the oldest types -- Lophocarinophyllum, Claviphyllum, Kinkaidia, and Fasciculophyllum -- occur in Mississippian (Lower Carboniferous) rocks, and Lophophyllidium, Lophamplexus, Stereostylus, and Lophotichium are first recognized in early Pennsylvanian deposits. Moreover, phylogenetic relationships are not easily determined for most rugose corals (Lang, Smith, and Thomas, 1940, pp. 1-5).

Tentative conclusions regarding the development of the lophophyllidid corals and their interrelations are presented here in order to illustrate the status of present knowledge and to indicate needed additional study.

Features shown by the apical region of lophophyllidid corals, such as accelerated development, zaphrenthid[2] pattern of the septa, lack of specialization of the counter septum, and prominent pseudofossulae of many species, suggest that the ancestral forms were similar or allied to the so-called zaphrenthid types of Mississippian age. The nature of

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2. Zaphrenthid, as used by most authors, refers to simularity with the Mississippian (Lower Carboniferous) species which have been placed in Zaphrenthis (Zaphrentis of authors) but now are regarded as distinct from that genus. The term hapsiphyllid might be used more properly but the characters of Hapsiphyllum are comparatively uncertain, inasmuch as internal features of the type are not known. Therefore, use of the term zaphrenthid is continued until the relationships of these corals and the several taxonomic problems are resolved.

the theca and the character of the horizontal elements (tabulae and dissepiments) also suggest affinity with these corals.

Zaphrenthid species of the Lower Carboniferous of Europe, such as "Zaphrentis" parallela Carruthers (1910), "Z." disjuncta Carruthers (1910), and "Z." delanouei Edwards and Haime (1851), include solitary conical to cylindrical corallites that contain a cardinal fossula, alar pseudofossulae, and a zaphrenthid manner of septal insertion. Tabulae are present, but dissepiments are lacking -- a primitive trait. Certain species are characterized in the immature stages by a pinnate arrangement of the major septa about the large cardinal fossula and the alar pseudofossulae. The cardinal septum is short, and the counter, alar, and metasepta are more or less joined axially. This union of the septa seems to be located at the axis in sections close to the apex, whereas it shifts toward the counter septum higher in the corallite. Subsequent development of this group seems to have occurred by divergence along several different lines. The accentuation of the breviseptal development is seen in "Z." disjuncta, "Z." tenuis Hudson (1944a), and in the species assigned to Allotropiophyllum Grabau (1928) by Hill (1940, p. 125). Development along a tachylasmoid trend seems to have led to the species included in Rhopalolasma[3] Hudson (1935). A tendency towards the strengthening of the axial region by continued close proximity of the major septa and the deposition of stereoplasm about their inner edges may have resulted in pre-lophophyllidid types. Rotiphyllum Hudson (1942)

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3. Rhopalelasma [sic] of Lang, Smith, and Thomas (1940). These authors have emended the original spelling of numerous generic names applied to corals, but such changes are considered to be invalid (Moore, Weller, and Knight, 1942).

has long major septa that are joined axially by stereoplasm so as to form a relatively large axial column. As shown by Hudson (1944, pls. 56 and 57), some species of Rotiphyllum show a tendency towards elongation and axial swelling of the counter septum, and a slight reduction in the cardinal septum. Similarly, Z. tenella Miller (1891), which is the genotype of Neozaphrentis Grove (1935), has an elongated counter septum that is superimposed on an earlier zaphrenthid septal pattern (Grove, 1935, pl. 13, figs. 8 and 10). A similar tendency towards the elongation of the counter septum in advanced stages is seen in Triplophyllites palmatus Easton (1944a, pl. 8). Seemingly, a continued specialization of the inner edge of the counter septum as an axial support, and a more rapid shortening of the major septa could have led to the lophophyllidid types.

The transition from a Mississippian zaphrenthoid coral, such as Rotiphyllum, Neozaphrentis, or Triplophyllites, to a lophophyllidoid coral is not demonstrated now by any known series of species or ontogenetic development within a species. Moreover, it is probable that more than one of the related zaphrenthids or other ancestral coral have given rise to lophophyllidids. Continued ontogenetic study of these and allied corals should clarify the relationships.

The ontogenetic and phylogenetic development of rugose corals, as has been observed in a large number of genera, precludes the derivation of lophophyllidoid corals that lack dissepiments from the specialized Mississippian species included in Lophophyllum and Koninckophyllum.

Lophocarinophyllum, which is reported from Mississippian rocks of China, seems ancestral in time and structural features to the Pennsylvanian genera Lophophyllidium, Stereostylus, and Lophamplexus. Serial

transverse sections of corallites referred to Lophamplexus show a gradual development from Stereostylus by a reduction in the axial column and a tendency towards a breviseptal phase. The stratigraphic occurrence of the species of Lophamplexus and their relative specialization indicates, however, that this genus is polyphyletic in origin. The apical region in Stereostylus and Lophophyllidium is relatively similar in major structural features. Thus, Lophophyllidium may have developed from Stereostylus by increasing specialization of the column and other elements. Continued accentuation of radiating and circumscribing laminae of the column and increasing specialization in Lophophyllidium seem to have produced an undescribed Upper Permian coral that contains a few scattered dissepiments.

The anastomosing nature of the steeply inclined tabulae and numerous septa of Claviphyllum suggest that further modification might have produced corals similar to Lophotichium. Kinkaidia, however, seems too specialized in septal development to have given rise to Stereostylus.

CLASSIFICATION OF PALEOZOIC CORALS

Solitary and colonial Paleozoic corals that are characterized by insertion of major septa at four points are included in the Rugosa Edwards and Haime (1850). This group is recognized as a subclass of the Anthozoa in the phylum Coelenterata. The terms Tetracoralla Haeckel (1872) and Tetraseptata Grabau (1922) have been used also to indicate this four-fold grouping of the septa, but the Rugosa is an older and much more generally adopted name. Practically all rugose corals have only two cycles of septa (major and minor septa), and commonly they contain tabulae. Dissepiments may form an important part of the internal structure or they may be lacking. Rugose corals differ from Mesozoic and Cenozoic corals that are included in the subclass Hexacorallia chiefly in the nature of the insertion of septa.

Although several early authors have proposed classificatory terms intermediate between the Rugosa and family units (Dybowski, 1873; Haęckel, 1876; Nicholson and Lydękker, 1889; and Pocta, 1902), there is no generally accepted basis for division of rugose corals into orders. Seemingly, microscopic characters of the septa and the manner of septal insertion comprise important distinctions that may merit diagnosis as characters of ordinal rank when they can be applied to a larger percentage of the genera.

DESCRIPTIONS OF GENERA AND SPECIES

Genus LOPHOPHYLLIDIUM Grabau, 1928

Solitary lophophyllidid corallites of medium size and having gently curved or straight conico-cylindrical form are included in this genus.

The relatively thick theca bears prominent septal grooves, and transverse wrinkles and growth lines are developed in varying degrees. Radicles are well developed or absent. The calyx, which is deep, is characterized by a spikelike column that projects upward from the central part of the sloping calicular floor. Major septa may be straight or slightly curved; and they are thickened at the inner edge in the immature region. Except for the counter septum, they do not reach the column, although deposits of stereoplasm commonly join the septa and axial region more or less solidly. The counter septum is elongated and thickened axially to form the column. The cardinal septum is thin, appreciably shortened, and lies in a large fossula. Alar pseudofossulae are not developed prominently. In the mature region, major septa are subequal, straight, relatively long, and separated from the axial column. Short minor septa may be observed in the upper portions of some species, although their grooves on the exterior of the theca suggest earlier insertion.

A relatively large axial column is present in all stages and bears a distinct median lamina, which, in the apical region, is seen to be a continuation of the lamina along the mid-line of the counter septum. Higher in the corallite the column becomes more cylindrical, separated from the counter septum, and shows numerous radiating laminae. These radiating laminae join the median lamina at several points and are surrounded by relatively dense deposits of stereoplasm. Tabellae-like structures, which probably are growth layers, may develop within the column so as to intersect these laminae. Transverse sections of advanced forms near the calyx show a slight protrusion of the column into the cardinal fossula; this feature may give the appearance of a former attachment with the cardinal septum.

Tabulae are more or less numerous in some species, although the interior of many corallites is so thickened by stereoplasm as to conceal these structures. The tabulae, when observed, slope upward rather steeply from the periphery, flatten out somewhat, and then rise abruptly as they approach the axial column. Because of the thickening about the edges of the major septa in early mature portions of corallites, tabulae may be visible in longitudinal section only between the theca and this inner wall, and between the inner wall and the axial column. Dissepiments are absent.

Genotype.— Cyathaxonia prolifera McChesney (1860), Missourian, Pennsylvanian (Upper Carboniferous), Illinois.

Discussion.— Many features of the relationships and taxonomic difficulties involved in the recognition of this genus have been reviewed at some length (Jeffords, 1942, pp. 201-213), and they are merely summarized here.

Late Paleozoic lophophyllidid corals of North America and other parts of the world were assigned for many years to the genus Lophophyllum Edwards and Haime (1850), which has L. konincki Edwards and Haime as genotype. Re-examination of corals from the type locality of the genotype (Carruthers, 1913) has suggested that L. konincki is a junior synonym of Cyathaxonia tortuosa Michelin (1846). On the basis of features observed in C. tortuosa, Lophophyllum is recognized to include solitary corals having septa, peripheral dissepiments, and a specialized axial column. Grabau (1928) proposed the genus Lophophyllidium, with Cyathaxonia prolifera McChesney (1860, p. 75) as genotype, to include Pennsylvanian corals which differ from Lophophyllum in having a more simple septal structure, prominent solid axial column, and lack of dissepiments.

Lophophyllidium, however, has not yet been accepted in all quarters. Some workers are reluctant to submerge widely adopted usage in order to follow requirements of the International Rules for Zoological Nomenclature; others have been confused by certain misleading descriptions of morphologic features, such as the erroneous identification of tabulae as dissepiments; and some European workers have concluded that Carruthers was mistaken in concluding his specimens to be conspecific with L. koninckí. Inasmuch as available objective information suggests that L. koninckí is not congeneric with C. prolifera (Lang, Smith, and Thomas, 1940; Smith, 1941), taxonomic confusion is lessened appreciably by the recognition of Lophophyllidium as a valid genus until such time as further studies are made on L. koninckí.

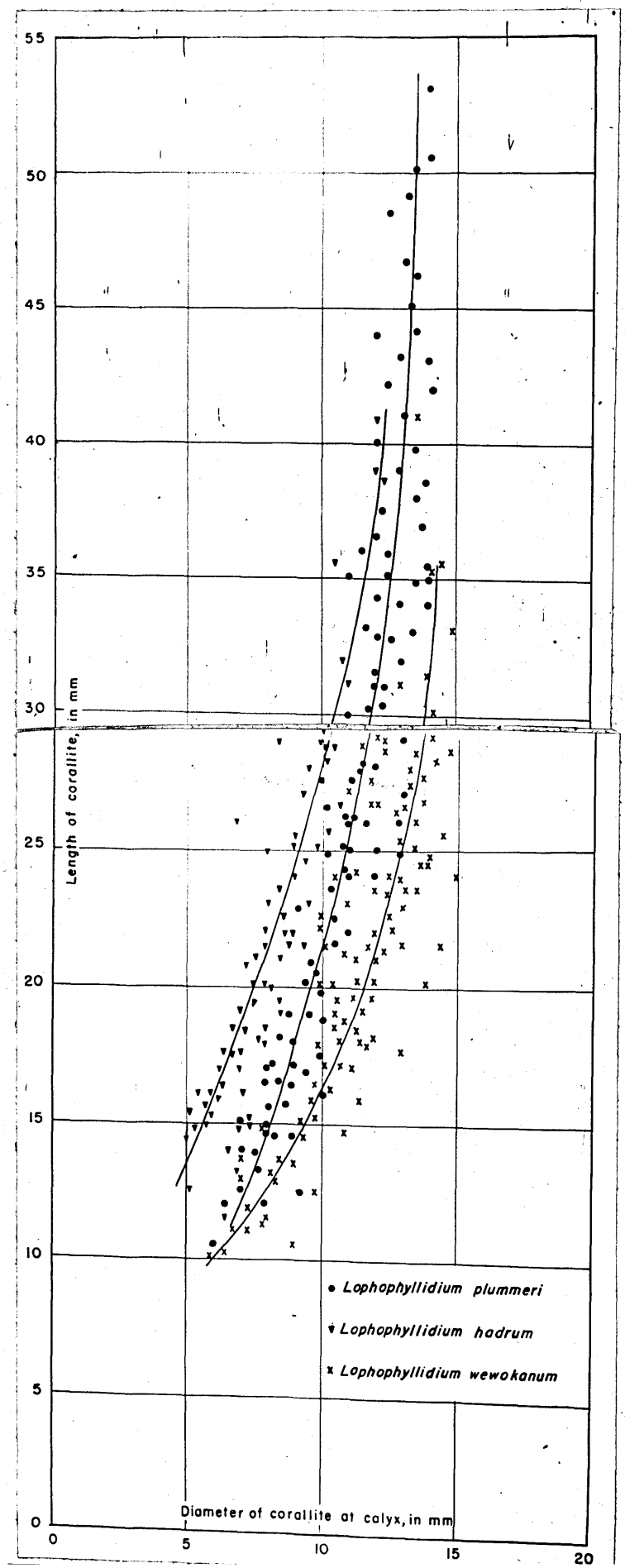
Preliminary studies of the Pennsylvanian lophophyllidid corals (Jeffords, 1942) have suggested that several different genetic lines are present among the species assigned to Lophophyllidium. Available data were insufficient to permit reliable interpretation of the significance of various features, however, and so all lophophyllidid corals having a persistent column were included in Lophophyllidium. Subsequent studies have shown that distinct types of lophophyllidids can be recognized in the Pennsylvanian coral faunas, each type being characterized by a combination of several characters. Therefore, Lophophyllidium is here restricted to species having a relatively large axial column that contains radiating laminae and commonly a much thickened apical portion. The curved elongate conico-cylindrical shape is characteristic of all but the spinose species.

The genus Sinophyllum Grabau (1928), with Lophophyllum pendulum Grabau (1922, p. 48) as genotype, was proposed to include corals

differing from Lophophyllidium in the thick, pendulum-shaped outline of the axial column as seen in transverse section. Sinophyllum was stated to differ also in having an inner wall formed by flexed ends of major septa. Inasmuch as observations on Pennsylvanian and Permian lophophyllidid corals have indicated that the inner wall seen in illustrations of the genotype species of Sinophyllum (pl. 2, figs. 23-24) does not differ from that of other lophophyllidid corals, and as the diameter and shape of the axial column alone were judged not sufficiently diagnostic to warrant generic separation, Sinophyllum was considered a junior synonym of Lophophyllidium (Jeffords, 1942, pp. 209-210). Later study, embracing a considerably larger number of specimens, indicates, in fact, that features of the axial column can be correlated with other characters so as to constitute a valid basis for generic division of these corals. Thus, corallites having a relatively large cylindrical column that contains radiating and intersecting laminae form one genetic group (Lophophyllidium), whereas another group (Stereostylus) includes those species characterized by a relatively smaller and laterally compressed column that lacks radiating laminae. Inasmuch as both Lophophyllum pendulum, the genotype of Sinophyllum, and C. prolifera, the genotype of Lophophyllidium, are characterized by these radiating laminae and circumscribing layers, they belong with the former group. Therefore, Sinophyllum is still considered to be a junior synonym of Lophophyllidium.

Lophophyllidium is distinguished from Lophocarinophyllum by the lack of carinae, from Lophamplexus by the persistence of the axial column throughout the corallite, and from Lophotichium by the larger column and the markedly less inclined character of the tabulae.

Figure 5. Diagram showing relationship of the length of corallite to diameter at different growth stages in Lophophyllidium hadrum, n. sp., L. wewokanum, n. sp., and L. plummeri, n. sp. Corallites belonging to these species are rather similar in form and size. These data, however, indicate that L. hadrum is the most cylindrical, L. wewokanum the most conical, and L. plummeri intermediate in form. Measurements of length and diameter were made on complete corallites so that these data also indicate the variation in size and form within these species.


55
50
45
40
35
30
25
20
15
10
5
0
Length of corallite, in mm
0
5
10
15
20
Diameter of corallite at calyx, in mm
• Lophophyllidium plummeri
▼ Lophophyllidium hadrum
× Lophophyllidium wewokanum

Lophophyllidium seems most closely allied to Stereostylus, and in earlier papers these corals were not separated. The character of the axial column as seen in transverse section, however, particularly the radiating laminae of Lophophyllidium, readily distinguish this genus from Stereostylus. Other characters of Lophophyllidium that are absent in Stereostylus include the more cylindrical form (text fig. 5), thicker theca, extensive deposits of stereoplasm, and a rounded projection of the column into the cardinal fossula in adult stages. Moreover, the septa in Lophophyllidium increase in radial length proportionately with increases in the diameter of the corallite, whereas in Stereostylus the septa become relatively short in relation to the diameter of transverse sections (text fig. 4).

Besides the genotype and other species here referred to Lophophyllidium, the genus includes the corals described as Lophophyllum proliferum (McChesney) Brown (1909), Girty (1915a, p. 19), Soschkina (1928, p. 371), and Huang (1932, p. 23); L. profundum (Edwards and Haime) Croneis (1930, p. 134); L. pendulum Grabau (1922, p. 48; 1928, p. 100); L. proliferum sauridens White (1877, p. 101) and Kayser (1883); Lophophyllidium magnificum Jeffords (1942, p. 238); L. extumidum Moore and Jeffords (1945, p. 93); and L. eastoni Moore and Jeffords (1945, p. 108), and probably other forms too scantily described and illustrated to permit recognition of significant features.

Occurrence.-- Pennsylvanian (Morrowan to Virgilian) and Permian (Wolfcampian to lower Guadalupian) of North America, and Lower Permian of Russia and China.

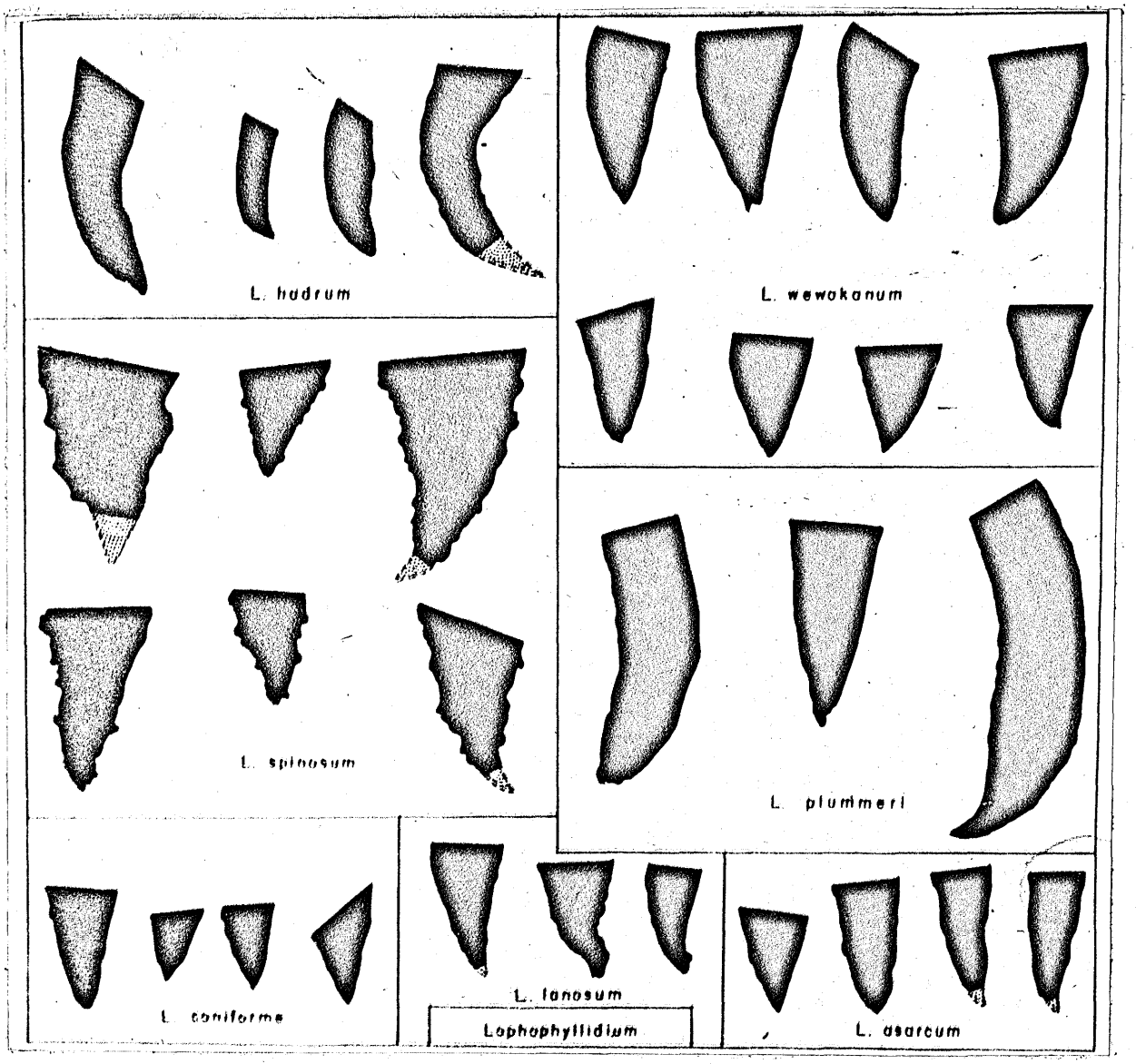


Figure 6. Outline drawings at natural size prepared from photographs of described species of Lophophyllidium showing the form, variation, and relative size of the corallites. The stippled portions indicate probable restoration of incomplete specimens.

Lophophyllidium hadrum Jeffords, n. sp.

Plate 3, figures 1-4; plate 8, figure 1; text figures 5-6.

This species comprises elongate corals that are conico-cylindrical in the lower part and cylindrical above. Commonly the corallites are curved slightly in the alar plane, particularly in the apical region. The theca is very thick, and externally it bears sharply incised longitudinal grooves and ridges. Transverse markings consist of a few growth lines and relatively numerous narrow wrinkles. The calyx is deep and contains the large column at the axis. Radicles are lacking. The complete type specimen is 37 mm. in length and 16.3 mm. in diameter at the calyx. The variation in size and form is shown on text figure 5.

The distinctly conical apical part of these corallites is characterized by a shortened cardinal septum, a counter septum that is long and considerable thickened axially, and long thickened major septa. These septa are joined to the column and to each other by thick deposits of stereoplasm. Typically, the corallite is completely filled except for the interseptal spaces midway between the theca and the axial region. Somewhat higher in the corallite, the septa withdraw slightly from the column and become rhopaloid. Stereoplasm may fill some of the spaces between the septa and the column. The counter septum is attached to the column, although it is very thin in relation to the large cylindrical column. In higher sections the septa maintain their slightly rhopaloid character except in the calyx where they are thin. The cardinal septum remains notably shortened, and the counter septum withdraws from the column so as to become shorter than adjacent metasepta. The septal formula in the apical region of the type specimen is K 6 A 3 C 3 A 7 K.

In the calyx it is K 8 A 3 C 3 A 8 K. Minor septa are relatively short.

The axial column is joined to the counter septum in the apical region, and the median lamina of the septum is continuous with the lamina of the column. Slightly higher sections show a large oval column that is separated from the counter septum. A median lamina and several radiating laminae, which seem not to match the position of septa, characterize this and later stages. The column is cylindrical in the upper part of the corallite and lacks any indication of attachment with the counter septum. In the calyx of large corallites, the column may be more or less open so that the laminae appear as solid structures that are enclosed in porous stereoplasm. Tabulae are largely concealed by stereoplasm in the apical region, but in the cylindrical portion of the corallite they are closely spaced and rise regularly towards the column. The cardinal fossula is moderately large and persists into the calyx; pseudofossulae are inconspicuous in the immature stages and are lacking higher in the corallite.

Discussion.-- The corals referred to this species are distinguished readily from associated corallites belonging to Stereostylus by the elongated curved conico-cylindrical form and the lack of radicles. These corals are notably smaller in diameter than Lophophyllidium plummeri, n. sp. and L. wewokanum, n. sp. (text fig. 5), and the mature corallites are much larger than those of L. asarcum, n. sp. and L. lanosum, n. sp. L. hadrum approaches L. proliferum (McChesney, 1860) in the number of tabulae and moderate specialization of the axial column. These species may be separated, however, by the greatly thickened theca and lesser amounts of stereoplasm found in L. hadrum.

Occurrence.— Cherokee shale, Desmoinesian series, Pennsylvanian (Upper Carboniferous). The type material was collected by J. B. Owen from the Cherokee shale at Tillman pit, NE NE sec. 23, T. 42 N., R. 26 W., Henry county, Missouri (Univ. Kansas loc. 323). Other specimens are from the Cherokee shale, 2 miles west of Pittsburg, Cherokee county, Kansas (Univ. Kansas loc. 5136), and the State Park, Crawford county, Kansas (Univ. Kansas loc. 999); abundant material from the cap rock above the Mineral coal collected by R. C. Moore and H. W. Compton along the road in secs. 4 and 8, T. 31 S., R. 24 E., southwest of Pittsburg, Kansas (Univ. Kansas locs. 7870 and 7874); and from a limestone in the upper Cherokee shale at a strip pit, 3 miles west of Oneta, Oklahoma (Univ. Kansas loc. 2959).

Material studied.— About 200 corallites were included in the available material, and representative specimens were sectioned for study.

Type.— University of Kansas, specimen 323-21b, from Tillman pit, Henry county, Missouri.

EXPLANATION OF PLATE 3

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of the transverse sections is indicated by small italic figures.)

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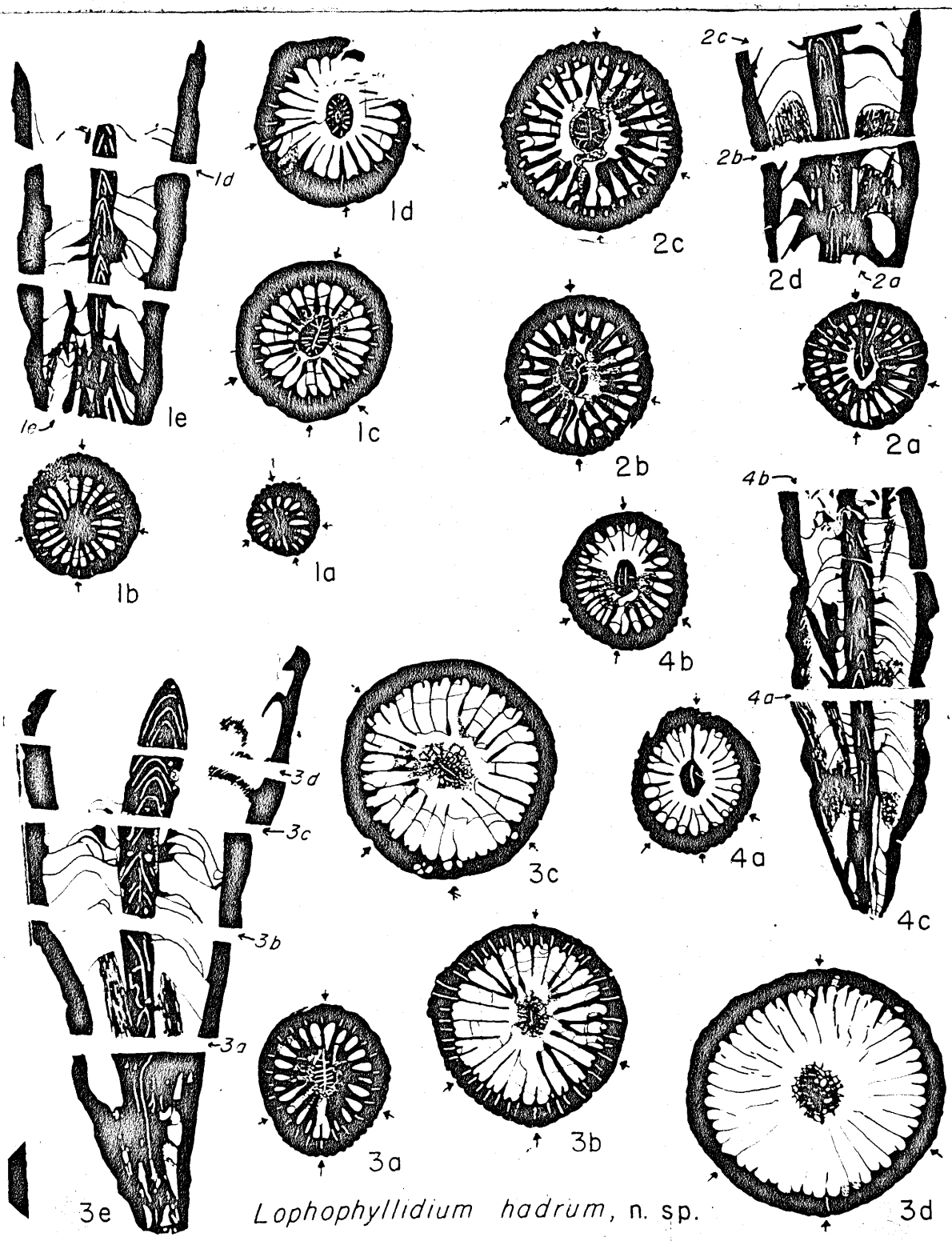
Lophophyllidium hadrum Jeffords, n. sp., from the Cherokee shale, Desmoinesian series, Pennsylvanian (Upper Carboniferous), Kansas and Missouri. - - - - - - - - - 60

1a-e--Specimen (Univ. Kansas no. 5136-21a) from the Cherokee shale, 2 miles west of Pittsburg, Cherokee county, Kansas. a-d, Transverse sections showing the gradual decrease in stereoplasm and increase in complexity of the column upward in the corallite. e, Longitudinal section slightly out of the axial plane at the base.

2a-d--Specimen (Univ. Kansas no. 323-21c) from the Cherokee shale at the type locality, Tillman pit, NE NE sec. 23, T. 42 N., R. 26 W., Henry county, Missouri. a-c, Transverse sections. d, Longitudinal section.

3a-e--Type specimen (Univ. Kansas no. 323-21b) from the same locality as figure 2. a-d, Transverse sections indicating the porous nature of the axial column within the calyx. e, Longitudinal section showing the thickened apical region and numerous tabulae in the mature portion.

4a-c--Specimen (Univ. Kansas no. 7870-21b) from the cap rock above the Mineral coal, Cherokee shale, along road in secs. 4 and 8, T. 31 S., R. 24 E., southwest of Pittsburg, Kansas. a-b, Transverse sections. c, Longitudinal section showing the elongate conico-cylindrical form typical of this species.



Lophophyllidium hadrum, n. sp.

Plate 3

Lophophyllidium wewokanum Jeffords, n. sp.

Plate 4, figures 4-7; plate 8, figures 4-5; plate 9, figure 4; text figures 5-6.

Lophophyllum profundum GIRTY, 1915, U. S. Geol. Survey Bull. 544, page 19, plate 2, figures 1-6a, plate 6, figures 12, 14.

This species includes moderately large corallites having an evenly curved conico-cylindrical form. The theca, which is thick, bears sharp septal grooves and broad flattened interseptal ridges; transverse wrinkles are rare although growth lines occur in abundance. Radicles are lacking. The calyx is relatively deep and contains a large striated bladelike column in the lower portion. The type specimen is 36 mm. in length and 13.3 mm. in maximum diameter at the calyx. The form of the corallite and range in size are shown in text figure 5.

The interior of these corallites is notably thickened by stereoplasm so that features of the immature region are largely concealed. Near the apex septa are long except for the much shortened cardinal septum. The counter septum is extended into the column. In early maturity septa reach nearly to the column and they are slightly rhopaloid; the cardinal septum is very short and the counter septum is not continued into the column. At the base of the calyx the cardinal septum is about one half the length of other septa, the counter septum is slightly shorter than adjacent metasepta, and other major septa extend as thin plates nearly to the column. Minor septa are developed near the calyx but they remain rudimentary. The septal formula about 6 mm. above the apex of the type specimen is K·7 A 3 C 3 A 7 K, and in the calyx it is K 8 A 4 C 4 A 8 K. These formulae indicate the strong counter acceleration.

The axial column is relatively large throughout the corallite and in longitudinal section it appears to be made up of conical laminae. In transverse sections near the apex the column is oval in outline and attached to the counter septum. Sections higher in the corallite show that the column is nearly cylindrical except for a sharp point projecting into the cardinal fossula. A median lamina, radiating laminae, and circumscribing layering is conspicuous in transverse sections. These circumscribing markings and the conelike structures seen in longitudinal sections represent growth layers that are secondary to the median and radiating laminae. Whereas these growth layers constitute a conspicuous feature of the column in polished sections, the median and radiating laminae alone are evident in thin sections of the column. Tabulae are largely concealed by stereoplasm; near the calyx they may be observed to rise abruptly from the theca to the column at irregular intervals. The cardinal fossula is very large and it forms a conspicuous open space as seen in transverse sections in the thickened immature region. Alar pseudofossulae are scarcely identifiable.

Discussion.— Girty (1915) classified the corals of the Wewoka formation as a conico-cylindrical form, Lophophyllum proliferum (McChesney) and a radicle-bearing form described as L. proliferum var. radicosum. He noted many features of corals here described as Lophophyllidium wewokanum and recognized that these corals differed materially from some other lophophyllidid corals. Girty's observations on these corals are confirmed except that the radicle-bearing species do not seem to be gradational from the conico-cylindrical species, here named Lophophyllidium wewokanum.

This species closely resembles L. plummeri, n. sp. from the Wayland shale of Texas in general shape of the corallite, large axial column, and extensive deposits of stereoplasm. L. wewokanum is distinguished, however, by the broader corallite form (text fig. 5), greater number of major septa, and notably shorter cardinal septum. The breadth of the corallite and the larger column clearly separate L. wewokanum from L. hadrum, n. sp. which occurs in the Cherokee shale.

Occurrence.— Wewoka formation, Desmoinsian series, Pennsylvanian (Upper Carboniferous). The type material is from cen. W. side sec. 25, T. 5 N., R. 8 E., 1 mile northwest of Allen, Colgate quadrangle, Oklahoma (Univ. Kansas loc. 2109). Other specimens are from near railroad, cen. S. side sec. 32, T. 7 N., R. 9 E., west of Lake Holdenville, Wewoka quadrangle, Oklahoma (Univ. Kansas loc. 1166); west of cen. sec. 24, T. 5 N., R. 8 E., Colgate quadrangle, Oklahoma (Univ. Kansas loc. 2480 and 3223); and just south of SE cor. sec. 32, T. 7 N., R. 9 E., 2 miles northwest of New Holdenville, Oklahoma (Univ. Kansas loc. 2103). These corals have been collected by R. C. Moore, N. D. Newell, and L. M. Cline.

Material studied.— Approximately 300 corallites were contained in the collection, and 23 specimens were sectioned for study.

Type.— University of Kansas, specimen no. 2109-21d from 1 mile northwest of Allen, Okla.

EXPLANATION OF PLATE 4

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of the transverse sections is indicated by small italic figures.)

Page

Lophophyllidium asarcum Jeffords, n. sp., from the Burroak shale member, Deer Creek formation, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous), at a quarry along U. S. Highway 60, 3 miles west of Pawhuska, Osage county, Oklahoma. - 83

1a-e--Specimen (Univ. Kansas no. 2675-21e). a-d, Transverse sections. e, Longitudinal section.

2a-c--Specimen (Univ. Kansas no. 2675-21c). a-b, Transverse sections. c, Longitudinal section.

3a-f--Type specimen (Univ. Kansas no. 2675-21a) showing the increasing complexity of the axial column upward in the corallite. a-e, Transverse sections. f, Longitudinal section.

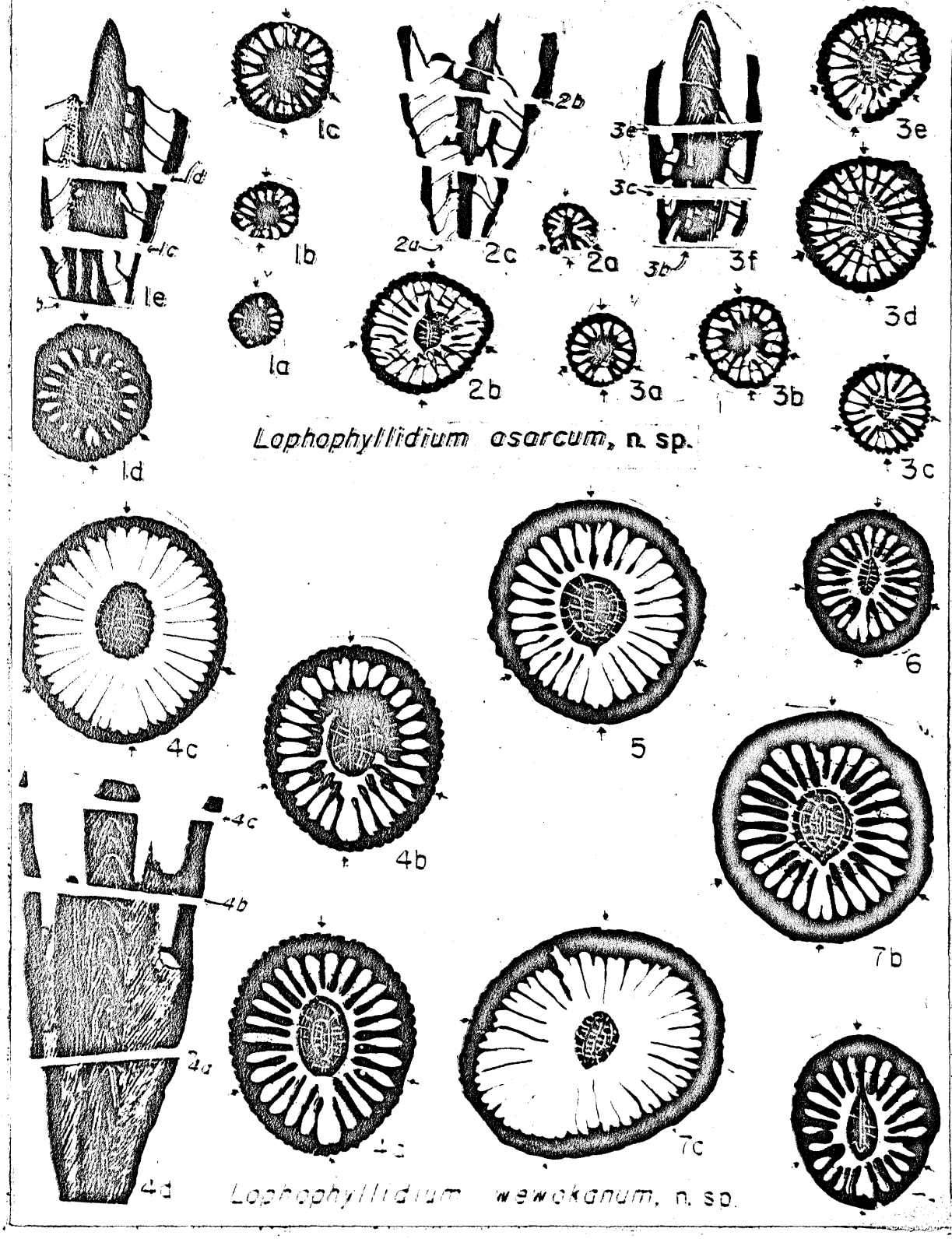
Lophophyllidium wewokanum Jeffords, n. sp., from the Wewoka formation, Desmoinesian series, Pennsylvanian (Upper Carboniferous), Oklahoma. - - - - 66

4a-d--Specimen (Univ. Kansas no. 2480-21a) showing the decrease in stereoplasm in the upper parts of the corallite. Collected from west of cen. sec. 24, T. 5 N., R. 8 E., Colgate quadrangle, Oklahoma. a-c, Transverse sections. d, Longitudinal section.

5--Transverse section in the calyx of specimen (Univ. Kansas no. 2109-21c) from the type locality, cen. W. side sec. 25, T. 5 N., R. 8 E., 1 mile northwest of Allen, Oklahoma.

6--Transverse section of a small specimen (Univ. Kansas no. 1166-21a) from cen. S. side sec. 32, T. 7 N., R. 9 E., west of Lake Holdenville, Wewoka quadrangle, Oklahoma.

7a-c--Transverse sections of the type specimen (Univ. Kansas no. 2109-21d) from the same locality as figure 5.


1d
1c
1e
1c
1b
1a
2b
2c
2a
2a
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3e
3c
3f
3b
3e
3d
3a
3b
3c
Lophophyllidium asarcum, n. sp.
4c
4b
5
6
4c
4b
4a
4d
7b
7c
Lophophyllidium wewokanum, n. sp.

Plate 4

Lophophyllidium coniforme Jeffords, n. sp.

Plate 5, figures 3 and 5, plate 6, figures 1-9, plate 9, figures 1-2; text figures 1-2, 4-6.

Relatively small straight corallites having a conical form are included in this species. Exceptionally large individuals become slightly cylindrical in the upper parts, and the lowermost few millimeters of a few specimens may be strongly curved. The theca is thick and it bears sharply incised septal grooves; transverse wrinkles are inconspicuous. The point of attachment is confined to a very small area at the apex, and radicles are lacking. A striated bladelike axial column projects strongly into the lower part of the deep calyx. The type specimen is 17 mm. in length and 10.8 mm. in maximum diameter at the calyx. Variation in size and form of these corallites is indicated in text figures 1 and 2.

The immature region of this species is characterized by relatively long septa that are joined to the column and about their inner edges by stereoplasm. The cardinal septum is thin but not markedly shortened, and the counter septum extends into the column. In early maturity stereoplasm is restricted to the axial region about the column and rhopaloid edges of the major septa; interseptal spaces at the periphery are open. The cardinal septum is thin and short; the counter septum is separated from the column although it may reach to the periphery of the column. Other major septa extend more than half the distance to the axis. In the mature region septa are long and rhopaloid except for the short cardinal septum. Within the lower part of the calyx the septa are long, thin, and bilaterally directed about the counter-cardinal plane. Major septa increase in length regularly throughout growth

(text fig. 4), and the rate of insertion of septa decreases but slightly in maturity. The septal formula about 3 mm. above the apex of the type specimen is K 4 A 2 C 2 A 4 K, and in the calyx it is K 6 A 3 C 3 A 6 K. Minor septa occur as rudimentary ridges in maturity.

The axial column is laterally compressed in the apical region, firmly attached to the counter septum, and united with the axial edges of other major septa by stereoplasm. Higher in the corallite the column separates from the counter septum and becomes more cylindrical in form; it contains prominent circumscribing growth layers and indistinct median and radiating laminae. Tabulae are largely concealed by the dense deposits of stereoplasm, but in a few longitudinal sections they are observed as relatively rare structures that rise steeply from the theca to join the column or thickened area about the axial edges of the septa. The cardinal fossula is large and in early stages it forms a prominent open space about the thin cardinal septum. Alar pseudofossulae are not large, but in the thickened immature region they form slightly larger spaces than those between metasepta.

Discussion.— This species is characterized by a small conical form that becomes cylindrical only in a few large individuals. It may be separated from other species of Lophophyllidium readily by the small size, conical form, and bilateral arrangement of the septa in the calyx about the counter-cardinal plane. L. coniforme seems to show several primative characters, such as a conical form, prominent alar pseudofossulae, strong bilateral symmetry, and a relatively simple column for this genus. Whereas the structure of the axial column indicates that this species belongs in Lophophyllidium, other features approach those of Stereostylus distinctus (Jeffords, 1942) and other species of the S. newelli group.

Occurrence.-- Lansing and Pedee groups, Missourian series, Pennsylvanian (Upper Carboniferous). The type specimen is from the Vilas shale, Lansing group, 2.5 miles west of Wann, Washington county, Oklahoma (Univ. Kansas loc. 1764). Other specimens are from the same formation 0.25 mile northwest of Wann, Oklahoma (Univ. Kansas loc. 1874 and 2212); SE sec. 20, T. 29 S., R. 13 E., north of Copan, Washington county, Oklahoma (Univ. Kansas loc. 2209); along Kansas Highway 47, 6 miles east and 0.5 mile south of Fredonia, Wilson county, Kansas (Univ. Kansas loc. 7713). This species occurs also in the Hickory Creek shale member, Plattsburg limestone, Lansing group at NW cor. sec. 10, T. 27 S., R. 17 E., Wilson county, Kansas (Univ. Kansas loc. 1727); on east-west road, SE cor. sec. 32, T. 28 S., R. 16 E., about 2.5 miles east of Roper, Wilson county, Kansas (Univ. Kansas loc. 1745); brick plant quarry, cen. sec. 33, T. 29 S., R. 16 E., Wilson county, Kansas (Univ. Kansas loc. 1753); and SE NE sec. 3, T. 30 S., R. 15 E., southeast of Fredonia, Wilson county, Kansas (Univ. Kansas loc. 4844). The Eudora shale member, Stanton formation, Lansing group, has yielded this species at cen. W. edge sec. 24, T. 23 S., R. 18 E., Allen county, Kansas (Univ. Kansas loc. 1735); SE cor. sec. 6, T. 34 S., R. 15 E., Montgomery county, Kansas (Univ. Kansas loc. 1782); railroad cut SW cor. 23, T. 29 N., R. 13 E., northeast of Copan, Oklahoma (Univ. Kansas loc. 2342); 7 miles northwest of Copan, Oklahoma (Univ. Kansas loc. 6751); 5 miles northeast of Copan, Oklahoma (Univ. Kansas loc. 6802); 3 miles north and 2 miles east of Copan, Oklahoma (Univ. Kansas loc. 7159); cen. S. line sec. 21, T. 29 S., R. 13 E., Washington county, Oklahoma (Univ. Kansas loc. 7885); and old railroad cut, 5 miles north of Copan, Oklahoma (Univ. Kansas loc. 7023). Representatives of this species were identified also from the

Weston shale, Pedee group at a brick plant quarry, near cen. SE sec. 1, T. 9 S., R. 22 E., southeast of Leavenworth, Leavenworth county, Kansas (Univ. Kansas loc. 1710); quarry north of airfield, Leavenworth, Kansas (Univ. Kansas loc. 5071); railroad cut near brick plant, east of Peru, Chautauqua county, Kansas (Univ. Kansas loc. 6784); and 0.75 mile east of Beverly Station, Platte county, Missouri (Univ. Kansas loc. 1725).

Material studied.-- This species occurs abundantly at most of the localities, and the collections contain more than 1500 corallites. Approximately 30 representative corallites were sectioned for study.

Type.-- University of Kansas, specimen no. 1764-21f from the Vilas shale, 2.5 miles west of Wann, Okla.

EXPLANATION OF PLATE 5

(All figures 3 times natural size.)

Page

Lophophyllidium spinosum Jeffords, n. sp., from the Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - 100

1--Specimen (Univ. Kansas no. 7768-21a) from the Jacksboro limestone, at Rock Island railroad cut, 3.5 miles southeast of Jacksboro, Jacks county, Texas.

2--Type specimen (Univ. Kansas no. 1157-22c) from the Wayland shale, 1 mile west of Graham, Young county, Texas.

Lophophyllidium coniforme Jeffords, n. sp., from the Lansing and Pedee groups, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 72

3--Specimen (Univ. Kansas no. 7023-21h) from the Eudora shale member, Stanton formation, Lansing group, at old railroad cut, 5 miles north of Copan, Washington county, Oklahoma.

5--Specimen (Univ. Kansas no. 7023-21g) from the same locality as figure 3.

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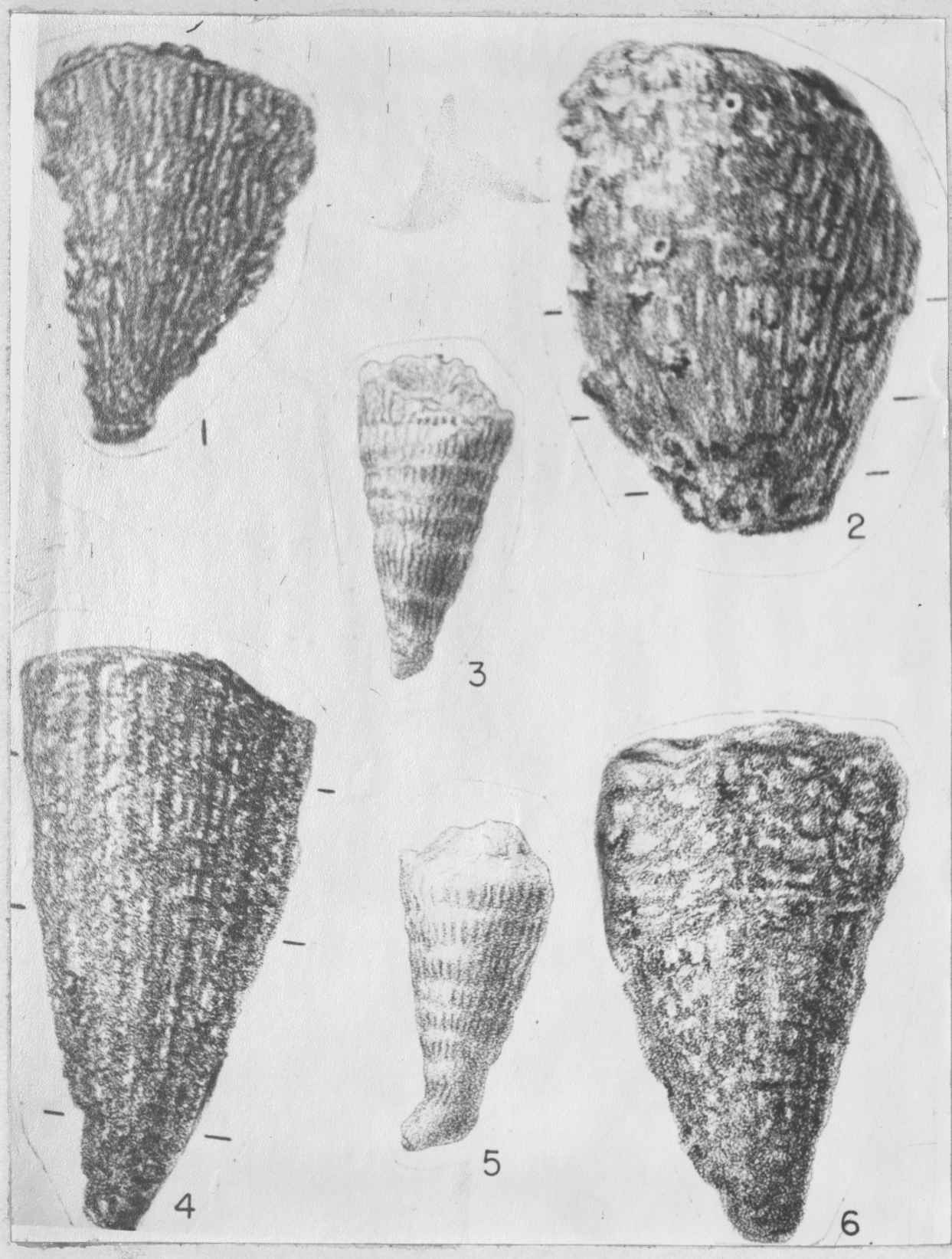


Plate 5

EXPLANATION OF PLATE 6

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at the bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Lophophyllidium coniforme Jeffords, n. sp., from the Lansing and Pedee groups, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 72

1a-d--Specimen (Univ. Kansas no. 7023-21c) from the Eudora shale member, Stanton formation, Lansing group, at old railroad cut, 5 miles north of Copan, Washington county, Oklahoma. a-c, Transverse sections. d, Longitudinal section.

2--Transverse section in the immature region of specimen (Univ. Kansas no. 1764-21g) from the Vilas shale, Lansing group at the type locality of the species, 2.5 miles west of Wann, Washington county, Oklahoma.

3a-c--Specimen (Univ. Kansas no. 1710-21c) from the Weston shale, Pedee group at a brick plant quarry, near cen. SE sec. 1, T. 9 S., R. 22 E., southeast of Leavenworth, Leaven-

worth county, Kansas. a-b, Transverse sections. c, Longitudinal section.

4a-b--Transverse sections of a large specimen (Univ. Kansas no. 4844-21b) from the Hickory Creek shale member, Plattsburg limestone, Lansing group, SE NE sec. 3, T. 30 S., R. 15 E., southeast of Fredonia, Wilson county, Kansas.

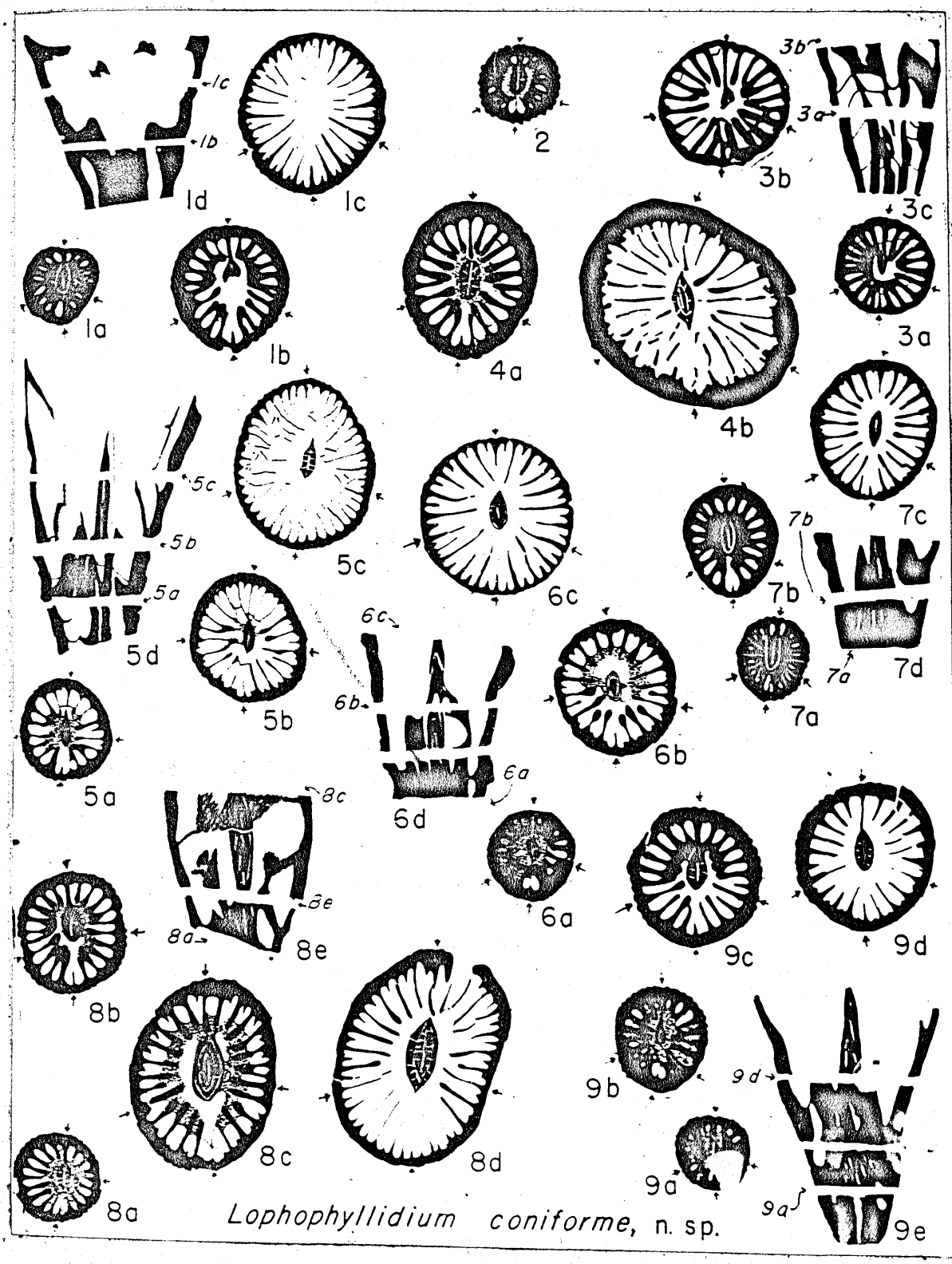
5a-d--Specimen (Univ. Kansas no. 1753-21i) containing relatively small amounts of stereoplasm. Collected from the Hickory Creek shale member, Plattsburg limestone, cen. sec. 33, T. 29 S., R. 16 E., Wilson county, Kansas. a-c, Transverse sections. d, Longitudinal section.

6a-d--Specimen (Univ. Kansas no. 1753-21n) from the same locality as figure 5. a-c, Transverse sections. d, Longitudinal section.

7a-d--Specimen (Univ. Kansas no. 5071-21a) from the Weston shale at a quarry north of airfield, Leavenworth, Kansas. a-c, Transverse sections. d, Longitudinal section.

8a-e--Moderately large specimen (Univ. Kansas no. 7023-21d) from the same locality as figure 1. a-d, Transverse sections. e, Longitudinal section.

9a-e--Type specimen (Univ. Kansas no. 1764-21f) from the same locality as figure 2. a-d, Transverse sections. e, Longitudinal section.



Lophophyllidium coniforme, n. sp.

Plate 6

Lophophyllidium asarcum Jeffords, n. sp.

Plate 4, figures 1-3; plate 9, figure 3; text figure 6.

Small conico-cylindrical corallites that are slightly curved in the plane of the alar septa are included in this species. The lowermost 2 or 3 mm. are bent abruptly, and a small thickened base for attachment occurs commonly on the cardinal side. The theca is very thick and bears sharply incised septal grooves and ridges. Low wrinkles occur at more or less regular intervals; radicles are absent. The calyx is deep and contains the prominent cylindrical axial column. The type specimen is 20 mm. in length and 5.8 mm. in maximum diameter at the calyx. Other specimens average 20 mm. in length and 7 mm. in diameter; the maximum length is 23 mm. and the maximum diameter is 10 mm.

The apical region of these corals contains long septa that are firmly joined in the axial area by dense deposits of stereoplasm. Slightly higher sections show long thick septa that are joined to the column only by scattered deposits. The cardinal septum is short and thin, whereas the counter septum is extended into the column. In the early mature portions of the corallites the septa are appreciably thickened and extend two-thirds the distance to the column. They may be slightly rhopaloid. Minor septa are present as distinct ridges between the major septa at this stage. The counter septum is partially or completely separated from the column. Near the calyx the major septa are long and slightly rhopaloid, the counter septum is equal in length to the metasepta, and the cardinal septum is short. The quadrants are accelerated subequally in the apical region, but in maturity the counter quadrants are strongly accelerated as shown by the septal formula of the upper part of the type section, which is K 6 A 3 C 3 A 6 K.

The axial column is functionally joined to the counter septum in the apical region, but it becomes distinctly separated higher in the corallite. The column is laterally compressed in the youthful stages, but it is large and nearly cylindrical near the calyx. Typically, a median lamina and several radiating laminae are evident in the column, and near the calyx concentric laminations are recognized. In longitudinal section the upper part of the column seems to be formed by superposed cones of thickened stereoplasm, possibly adapted from the axial portions of tabulae. Tabulae are mostly concealed in the apical portions, but they appear as rather evenly spaced inclined structures in the mature regions. The cardinal fossula is prominent throughout growth, but alar pseudofossulae are inconspicuous even in immature stages.

Discussion.-- This species is characterized by its small size, comparatively few septa, and distinctly thickened area of attachment at the apex. Typically, the axial column remains attached to the counter septum until late maturity. Lophophyllidium asarcum is much smaller than L. plummeri, n. sp., L. wewokanum, n. sp., and L. hadrum, n. sp., and is separated from L. lanosum by the more cylindrical form, abundant tabulae, and inconspicuous pseudofossulae.

Occurrence.-- Burroak shale member, Deer Creek formation, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous). Collected at a quarry along U. S. Highway 60, 3 miles west of Pawhuska, Osage county, Oklahoma (Univ. Kansas loc. 2675).

Material studied.-- Sixteen well preserved corallites were available, and six representative specimens were sectioned.

Type.-- University of Kansas, specimen no. 2675-21a.

Lophophyllidium lanosum Jeffords, n. sp.

Plate 7, figures 1-2; test figure 6.

This species includes small to medium-sized corallites having a straight to slightly curved conico-cylindrical form. The theca bears conspicuous longitudinal grooves and ridges that are crossed by sharp wrinkles and coarse growth lines. Radicles are lacking. The calyx is moderately deep and contains in the lower part the laterally compressed axial column. The type specimen, which is about average size for mature individuals, is 17.5 mm. in length and 9.6 mm. in maximum diameter at the calyx.

The lower part of these corallites is essentially solid; spaces between the septa and around the column are filled by stereoplasm. The median lamina of the septa, excepting that of the counter septum, do not enter the axial area occupied by the column. In the more open mature portions of the corallite transverse sections show long major septa that are joined about their inner edges by stereoplasm. The cardinal septum is very short and the counter septum has withdrawn from the column. In late maturity the major septa extend nearly to the column and they are comparatively thin. The counter septum is not distinct from the metasepta. Minor septa occur as short vertical elements alternating between the major septa. Typically, the septa assume a radial arrangement about the counter-cardinal plane, and alternating major septa may be slightly shortened. The septal formula about 5 mm. above the apex in the type specimen is K 5 A 3 C 3 A 5 K, and in the calyx of the same corallite is K 6 A 3 C 3 A 6 K.

The axial column in the mature stage is characterized by a median lamina and numerous radiating laminae that project to the periphery of

the column. The column is large and slightly compressed in transverse section. Tabulae are not observed in the apical region owing to the dense thickening. They are relatively scarce in the mature region. The cardinal fossula is large, and it forms a conspicuous open space in the lower portions of the corallites. Alar pseudofossulae are relatively prominent near the apex, although they disappear in maturity.

Discussion.— This species is characterized by prominent alar pseudofossulae and large cardinal fossulae in the immature region, and the somewhat laterally compressed axial column. L. lanosum is much smaller than L. plummeri, n. sp., and lacks the abundant radicles seen in L. spinosum, n. sp. The apical region is solidly filled by stereoplasm, but the mature portions of the corallites are notably open. Strongly developed alar pseudofossulae and other primative characters are generally similar to those of the Stereostylus newelli group although L. lanosum is distinguished by the character of the axial column.

Occurrence.— Jacksboro limestone, Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous). The representatives of this species have been collected by R. H. King from Rock Island railroad cut, 3.5 miles southeast of Jacksboro, Jacks county, Texas (Univ. Kansas loc. 7768).

Material studied.— The available material comprises 4 corallites, three of which were sectioned for study.

Type.— University of Kansas, specimen no. 7768-22c.

EXPLANATION OF PLATE 7

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Lophophyllidium lanosum Jeffords, n. sp., from the Jacksboro limestone, Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous), at Rock Island railroad cut, 3.5 miles southeast of Jacksboro, Jacks county, Texas. - - - - 85

1a-d--Specimen (Univ. Kansas no. 7768-22b) showing characters of a large individual. a-c, Transverse sections. d, Longitudinal section.

2a-d--Type specimen (Univ. Kansas no. 7768-22a). a-c, Transverse sections. d, Longitudinal section.

Lophophyllidium plummeri Jeffords, n. sp., from the Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous), Texas. - - - - - - 90

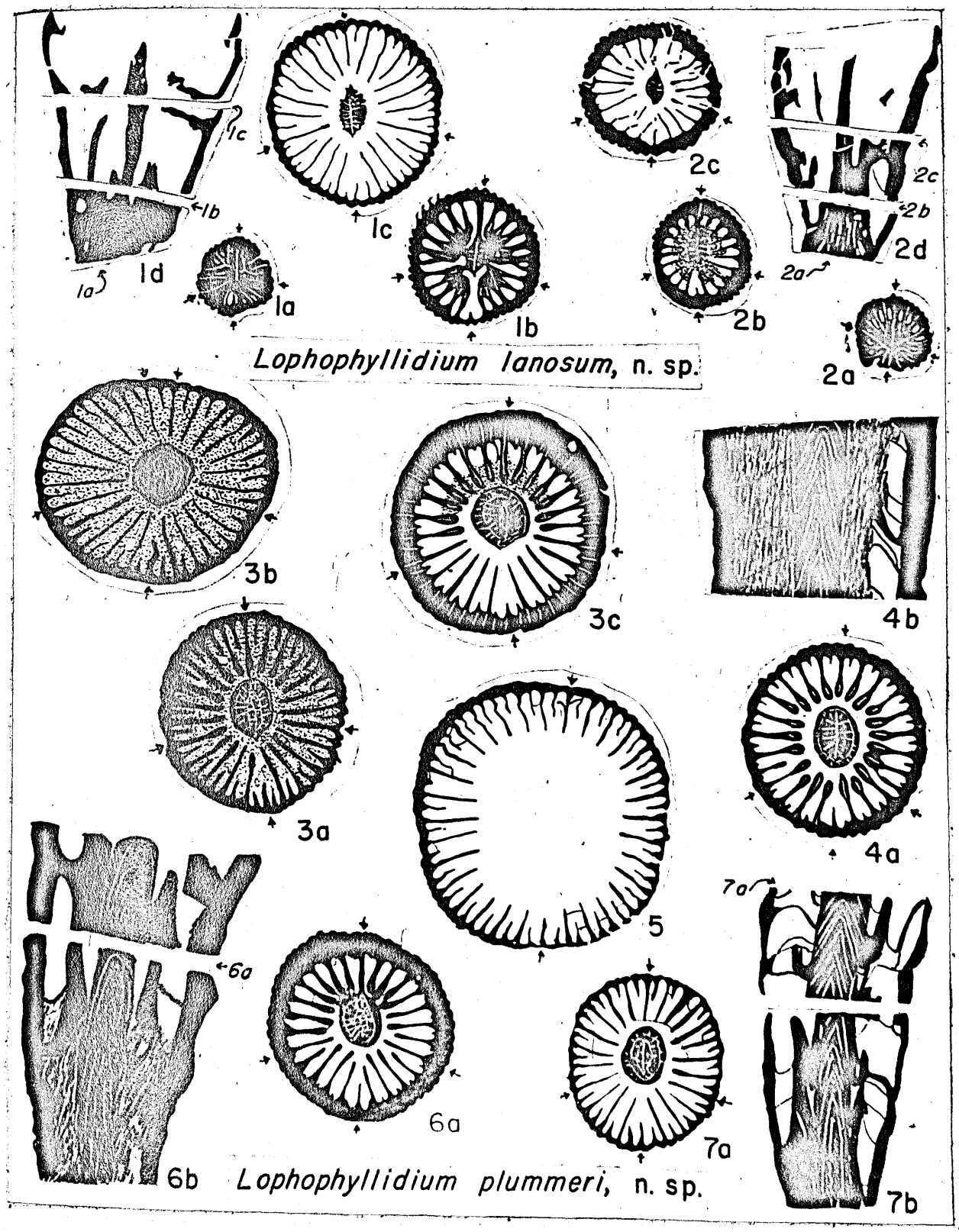
3a-c--Transverse sections of specimen (Univ. Kansas no. 49-21c) from the Wayland shale, 1 mile south of Gunsight, Eastland county, Texas. The decrease in stereoplasm upward in the corallite is notable.

4a-b--Specimen (Univ. Kansas no. 1157-21b) from the Wayland shale, 1 mile west of Graham, Young county, Texas. a, Transverse section in the calyx. b, Longitudinal section slightly below the calyx.

5--Transverse section in the upper part of the calyx of specimen (Univ. Kansas no. 7767-21a) from the Jacksboro limestone, 4.5 miles east of Jacksboro, Texas.

6a-b--Type specimen (Univ. Kansas no. 894-21b) from the Wayland shale, 1 mile north of Gunsight, Texas. a, Transverse section just below the calyx. b, Longitudinal section.

7a-b--Relatively small specimen (Univ. Kansas no. 2317-21a) from the Gunsight limestone, 1 mile south of Gunsight, Texas. a, Transverse section. b, Longitudinal section.


1c
1b
1d
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1a
1c
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2c
2c
2b
2d
2a
2b
2a
Lophophyllidium lanosum, n. sp.
3b
3c
4b
3a
4a
5
7a
6a
6b
7b
Lophophyllidium plummeri, n. sp.

Plate 7

Lophophyllidium plummeri Jeffords, n. sp.

Plate 5, figure 4; plate 7, figures 3-7; plate 8, figures 2-3; plate 9, figures 6-10; text figures 1, 5-6.

Lophophyllum profundum PLUMMER and MOORE, 1921, Univ. Texas Bull. 2132, Page 147, plate 20, figures 1, 2, 4, 5.

This species includes elongate slightly curved corallites having a conical form near the apex and being cylindrical above. In about one half the individuals an alar septum is on the concave side; the others are straight or the concavity lies on the cardinal, or counter side or is intermediate in position. The theca, which is thick, bears very sharp ridges and septal grooves. Broad wrinkles and coarse growth lines run transversely across the corallites. Radicles are lacking, and the corals seem to have been attached by a very small area at the apex. The calyx is moderately deep and it contains the large striated column at the axis. The type specimen is 35 mm in length and 13 mm. in maximum diameter at the base of the calyx. These corals range greatly in size as shown in text figures 1 and 5.

The corals referred to this species are more or less solidly filled in the lower parts by stereoplasm. Transverse sections near the apex show a large oval column that is continuous with the counter septum. The axial edges of the closely packed major septa extend to the periphery of the column, and the intervening spaces are filled with stereoplasm. The cardinal septum is very short. The thickening of the vertical elements decreases gradually upward, although stereoplasm is entirely absent only near the calyx in larger corallites. The cardinal septum is about two thirds the length of adjacent septa in early maturity, and

the counter septum is equal in length to the metasepta. The major septa are closely joined to the column by stereoplasm. Median lamina represent minor septa between the major septa, but commonly they do not appear within the theca until late maturity. Near the calyx the septa are long and rhopaloid, excepting the cardinal septum. In the calyx the septa are relatively thin. The septal formula about 6 mm. above the apex of the type specimen is K 5 A 4 C 3 A 6 K, and the septal formula near the calyx is K 6 A 5 C 5 A 6 K. Moderately large corallites have about 28 major septa in the mature regions.

The axial column is laterally compressed near the apex and contains a median lamina that is continuous with the lamina of the counter septum. Progressively upward in the corallite the column becomes larger and more cylindrical in shape. The median lamina is joined at different points by numerous pairs of laminae that radiate outward through the column. The column is concentrically laminated as seen in transverse section, but thin sections indicate that these concentric markings are due largely to differences in color and density of the stereoplasm; the median and radiating laminae are the fundamental structural elements. The column is evenly rounded in the counter quadrants, but it develops a short projection into the cardinal fossula. Tabulae are largely concealed in the lower portions; a few tabulae are observed in the mature region between the theca and the thickened axial area. The cardinal fossula is large and may form an open space that is surrounded by dense calcite near the apex. Alar pseudofossulae are identifiable near the spex by the short septa on the counter side of the alar septa, but they are relatively weak.

Discussion.-- The external features of this species resemble conico-cylindrical corallites from the Wewoka shale that are called Lophophyllidium wewokanum, n. sp., L. plummeri, however, is slightly more cylindrical and elongated in form (text fig. 5), and contains fewer major septa in the mature region. Moreover, the cardinal septum is thicker and stouter than in L. wewokanum. General similarity in external form and in many features of internal structure as shown by these species from widely separated stratigraphic horizons in the Pennsylvanian clearly indicates that careful study is necessary to avoid confusing such convergent types that occur in similar facies. This species is named for F. B. Plummer of the Texas Bureau of Economic Geology. Dr. Plummer has contributed importantly to knowledge of Pennsylvanian fossils and rock formations.

Occurrence.-- Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous). The type specimens are from the Wayland shale, 1 mile north of Gunsight, Eastland county, Texas (Univ. Kansas loc. 894). Other corallites are from the same formation 1 mile south of Gunsight, Texas (Univ. Kansas loc. 49); 1 mile north of Weeden school, northwest of Brownwood, Brown county, Texas (Univ. Kansas loc. 2170); 1 mile west of Graham, Young county, Texas (Univ. Kansas loc. 196); above the creek on Exall Lease, 4.5 miles southwest of Gunsight, Texas (Univ. Kansas loc. 393); 5 miles west of Eastland, Eastland county, Texas (Univ. Kansas loc. 51); and at the point of a hill on the south side of road, west of creek, 1 mile west of Graham, Texas (Univ. Kansas loc. 1157). Other specimens are from the Gunsight limestone in Breckenridge quadrangle, Stevens county, Texas (Univ. Kansas loc. 116); southwest side hill, 1.5 miles south of Avis, Jack county, Texas (Univ. Kansas loc. 4716); 5 miles

east of Cisco, Texas (Univ. Kansas loc. 3268); 1 mile south of Gunsight, Texas (Univ. Kansas loc. 2317); and at Weeden school, 12 miles northwest of Brownwood, Texas (Univ. Kansas loc. 895). The Jacksboro limestone 4.5 miles east of Jacksboro, Jack county, Texas (Univ. Kansas loc. 7767) also contains representatives of this species. The corals from the Wayland shale and Gunsight limestone were collected by R. C. Moore, and those from the Jacksboro limestone by R. H. King.

Material studied.-- About 1500 well-preserved corallites were contained in the collections, and 33 specimens were sectioned for study.

Type.-- University of Kansas, specimen no. 894-21b from the Wayland shale, 1 mile north of Gunsight, Texas.

EXPLANATION OF PLATE 8

(All figures 3 times natural size.)

Page

Lophophyllidium hadrum Jeffords, n. sp., from the Cherokee shale, Desmoinesian series, Pennsylvanian (Upper Carboniferous). - 60

1--Specimen (Univ. Kansas no. 7870-21j) from the cap rock above the Mineral coal along road in secs. 4 and 8, T. 31 S., R. 24 E., southwest of Pittsburg, Cherokee county, Kansas.

Lophophyllidium plummeri Jeffords, n. sp., from the Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - 90

2--Specimen (Univ. Kansas no. 49-21b) from the Wayland shale, 1 mile south of Gunsight, Texas.

3--Specimen (Univ. Kansas no. 49-21r) from the same locality as figure 2.

Lophophyllidium wewokanum Jeffords, n. sp., from the Wewoka formation, Desmoinesian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - 66

4--Specimen (Univ. Kansas no. 2103-22d) from just south of SE cor. sec. 32, T. 7 N., R. 9 E., 2 miles northwest of New Holdenville, Oklahoma.

5--Specimen (Univ. Kansas no. 3223-21c) from west of cen. sec. 24, T. 5 N., R. 8 E., Colgate quadrangle, Oklahoma.

Plate 8

EXPLANATION OF PLATE 9

(All figures 3 times natural size except as indicated. Transverse sections are oriented with the cardinal septum at bottom, longitudinal sections are at right angles to the counter-cardinal plane.)

Page

Lophophyllidium coniforme Jeffords, n. sp., from the Lansing and Pedee groups, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 72

1--Transverse section in the upper part of specimen (Univ. Kansas no. 1753-21n) from the Hickory Creek shale member, Plattsburg limestone, Lansing group, cen. sec. 33, T. 29 S., R. 16 E., Wilson county, Kansas.

2a-b--Transverse sections of specimen (Univ. Kansas no. 1753-21g) from the same locality as figure 1.

Lophophyllidium asarcum Jeffords, n. sp. from the Burroak shale member, Deer Creek formation, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous), at a quarry along U. S. Highway 60, 3 miles west of Pawhuska, Osage county, Oklahoma. - - - - - - - - - - - - - - - - - - - 83

3a-b--Specimen (Univ. Kansas no. 2675-21d). a, Transverse section. b, Longitudinal section.

Page

section (x12) of the axial column shown in figure 7a.

8a-b--Transverse sections of specimen (Univ. Kansas no. 3268-21c) from the Gunsight limestone, 5 miles east of Cisco, Texas.

9--Transverse section of specimen (Univ. Kansas no. 4716-23f) from the Gunsight limestone, 1.5 miles south of Avis, Jacks county, Texas.

10--Longitudinal section of specimen (Univ. Kansas no. 2317-21a) from the Gunsight limestone, 1 mile south of Gunsight, Texas.

1

2a

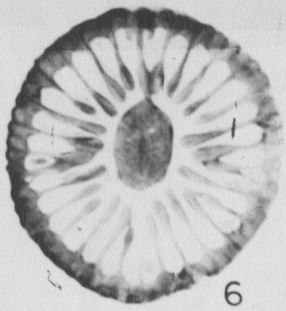
2b

3a

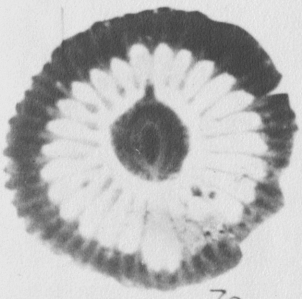
3b

4

5

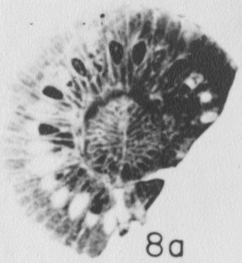


6

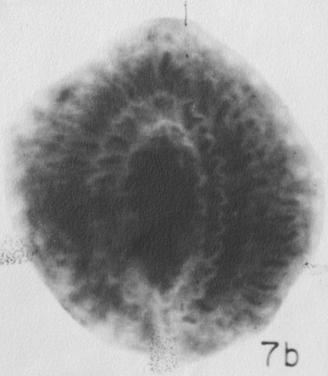


7a

10



8a



7b

Lophophyllidium

9

8b

Plate 9

Lophophyllidium spinosum Jeffords, n. sp.

Plate 5, figures 1-2; plate 10, figures 1-4; plate 11, figures 1-4; text figure 6.

Lophophyllum profundum radicosum PLUMMER AND MOORE, 1921, Univ. Texas Bull. 2132, plate 20, figure 3.

Relatively large conical corals having a slight bend in the apical region are included in this species. Commonly, the cardinal septum is on the concave side of the corallite. The theca is thin and it bears sharp ridges and broad septal grooves; transverse markings comprise numerous low wrinkles and growth lines. The surface of the corallite from the apex to the top is covered by numerous radicles that are arranged in horizontal rows about 2.5 mm apart. These radicles are conical in form and contain a central hollow tube. The calyx, which is deep, contains the large bladelike axial column in the lower part. The type specimen is 29 mm in length and 20.3 mm in maximum diameter at the top of the calyx.

Transverse sections in the apical region of these corals show a long counter septum that is continuous with the laterally compressed column. The median lamina of the septum is continuous with that of the column. The cardinal septum is short, and other major septa extend nearly to the column where they are thickened and joined by stereoplasm. In early maturity the counter septum is separate from the column, and it resembles the metasepta in length. The cardinal septum remains notably short and thin, and strongly rhopaloid major septa extend close to the column. Just below the calyx in large specimens alternating major septa may be slightly shorter than those on either side. Minor septa

develop in early maturity and attain a length of less than one fourth that of the longer major septa. The septal formula in the lower part of the type specimen is K 9 A 5 C 5 A 9 K, and near the calyx in the same corallite it is K 9 A 6 C 6 A 9 K. Mature corallites contain about 35 major septa near the calyx.

The axial column has a well defined median lamina in the apical region, and radiating and circumscribing laminae increase in prominence upward as the column become progressively larger. In longitudinal section the column is not completely solid; small openings and tentlike laminae are conspicuous in most specimens. Tabulae are relatively numerous and rise steeply to join the column. They are spaced about 1.8 mm apart at the periphery. The cardinal fossula is indicated by the conspicuously shortened cardinal septum; alar pseudofossulae are weak. Stereoplasm forms about the rhopaloid edges of the septa in the immature region, but it does not form an extensive filling. In longitudinal section the corallite is divisable into a peripheral area crossed by tabulae, a more or less solid area representing the rhopaloid septa, a narrow tabular area, and the broad axial column.

Discussion.— This species is characterized by an abundance of radicles over the corallite and by the tachylasmoid development of the septa in maturity. The conical form, radicles, and open character of the immature region readily distinguish Lophophyllidium spinosum from the associated species, L. plummeri, n. sp., and from other species of Lophophyllidium described in this paper.

These corals differ notably from L. proliferum and other conico-cylindrical species referred to Lophophyllidium in the moderate occurrence of stereoplasm, numerous tabulae, and unequal length of the major

septa in mature regions. The axial column, however, has the structure typical of Lophophyllidiuum and the septa increase in length throughout growth in the manner shown on text figure 4 for L. coniforme, n. sp. A few individuals (pl. 10, figs. 1-2) are characterized by thin septa and axial column, but they are referred to L. spinosum inasmuch as they seem to grade into typical representatives of this species.

Occurrence.-- Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous). The type material is from the Wayland shale at the point of a hill on the south side of the road, west of creek, 1 mile west of Graham, Texas (Univ. Kansas loc. 1157). Other specimens are from the same formation above the creek on Exall Lease, 4.5 miles southwest of Gunsight, Texas (Univ. Kansas loc. 393); 1 mile north of Gunsight, Stephens county, Texas (Univ. Kansas loc. 894); 1 mile south of Gunsight, Texas (Univ. Kansas loc. 49); 5 miles west of Eastland, Eastland county, Texas (Univ. Kansas loc. 51); and 1.5 miles southeast of Necessity, Stephens county, Texas (Univ. Kansas loc. 2788). This species occurs also in the Gunsight limestone 5 miles east of Cisco, Texas (Univ. Kansas loc. 3268); 1 mile south of Gunsight, Texas (Univ. Kansas loc. 2317); 1.1 mile southeast of Avis, Jack county, Texas (Univ. Kansas loc. 5089); and at Weeden school, 12 miles northwest of Brownwood, Brown county, Texas (Univ. Kansas loc. 895). Additional corals from the Jacksboro limestone at the Rock Island railroad cut, 3.5 miles southeast of Jacksboro, Jack county, Texas (Univ. Kansas loc. 7768) and 4.5 miles east of Jacksboro, Texas (Univ. Kansas loc. 7767) are referred to this species. The corals from the Wayland shale and Gunsight limestone were collected by R. C. Moore, and those from the Jacksboro limestone by R. H. King.

Material studied.— About 500 individual specimens, represent this species in the collection studied. Fifteen corallites were sectioned.

Type.— University of Kansas, specimen no. 1157-22c from the Wayland shale, 1 mile west of Graham, Texas.

EXPLANATION OF PLATE 10

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

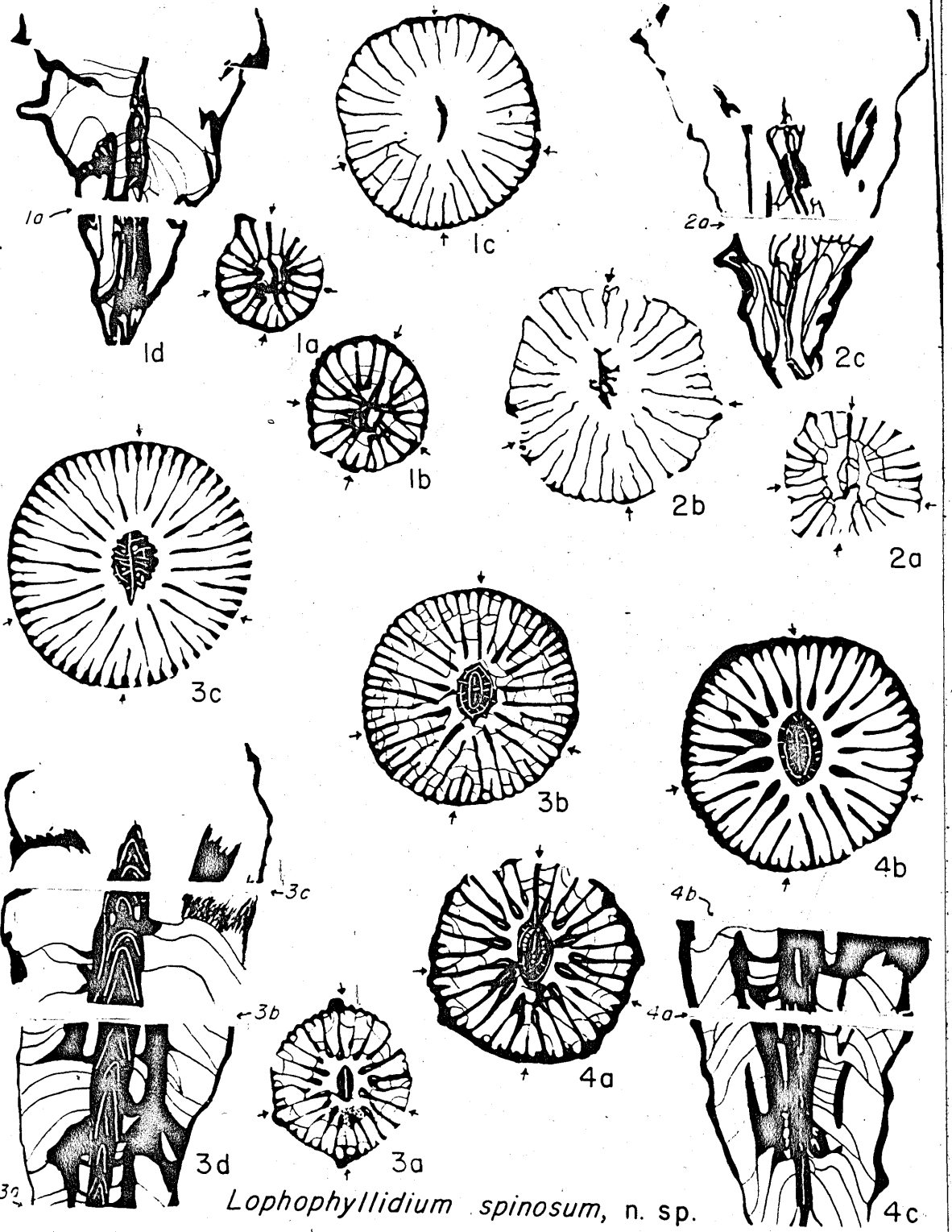
Lophophyllidium spinosum Jeffords, n. sp., from the Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous), Texas. - - - - - - - 101

1a-d--Specimen (Univ. Kansas no. 7767-22a) from the Jacksboro limestone, 4.5 miles east of Jacksboro, Jacks county, Texas. a-c, Transverse sections. d, Longitudinal section.

2a-c--Specimen (Univ. Kansas no. 7768-21a) from the Jacksboro limestone, at the Rock Island railroad cut, 3.5 miles southeast of Jacksboro, Texas. a-b, Transverse sections. c, Longitudinal section.

3a-d--Specimen (Univ. Kansas no. 49-22a) from the Wayland shale, 1 mile south of Gunsight, Eastland county, Texas. a-c, Transverse sections. d, Longitudinal section.

4a-c--Specimen (Univ. Kansas no. 1157-22a) from the Wayland shale at the type locality for the species, 1 mile west of Graham, Texas. a-b, Transverse sections. c, Longitudinal section.



Lophophyllidium spinosum, n. sp.

Plate 10

EXPLANATION OF PLATE 11

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at the bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

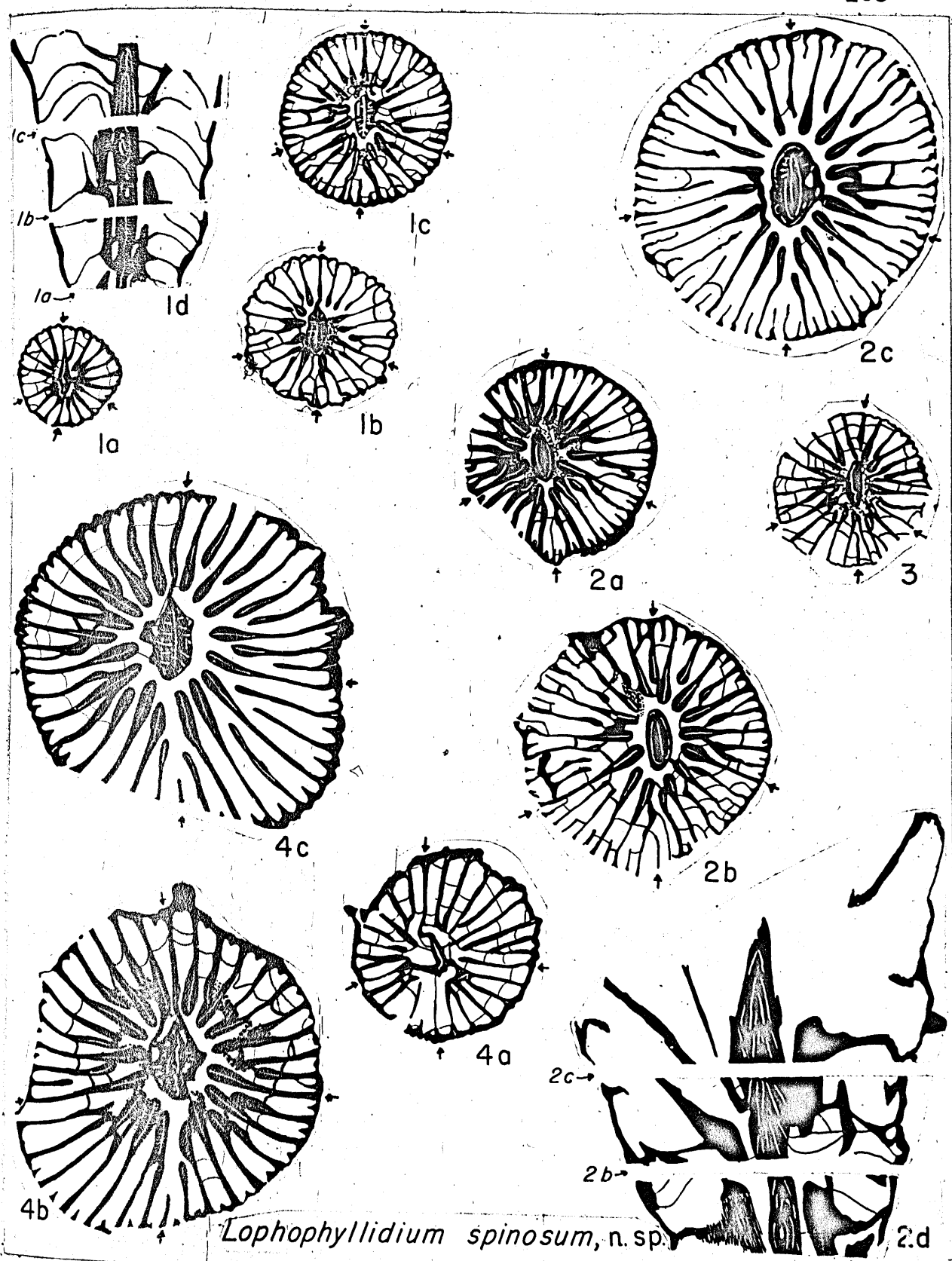
Lophophyllidium spinosum Jeffords, n. sp., from the Graham group, Cisco (Virgilian) series, Pennsylvanian (Upper Carboniferous), Texas. - - - - - - - - - - - - 101

1a-d--Specimen (Univ. Kansas no. 2788-22a) from the Wayland shale, 1.5 miles southeast of Necessity, Texas. a-c, Transverse sections. d, Longitudinal section.

2a-d--Type specimen (Univ. Kansas no. 1157-22c) from the Wayland shale, 1 mile west of Graham, Young county, Texas. a-c, Transverse sections. d, Longitudinal section.

3--Transverse section in the immature region of specimen (Univ. Kansas no. 51-21b) from the Wayland shale, 5 miles west of Eastland, Eastland county, Texas.

4a-c--Transverse sections of a large specimen (Univ. Kansas no. 2767-22b) from the Jacksboro Limestone, 4.5 miles east of Jacksboro, Texas.



Lophophyllidium spinosum, n. sp.

Plate 11

Genus STEREOSTYLUS Jeffords, new genus

This genus comprises small to large lophophyllidid corals that have a moderately deep calyx. These corallites are conical to conico-cylindrical in form and straight or slightly curved. The theca is marked externally by distinct septal grooves, low transverse wrinkles, and growth lines. Rejuvenation occurs rarely and is confined to the more cylindrical types. The immature or apical region is characterized by long alar and metasepta that are joined to each other and to the axial column by stereoplasm. The cardinal septum is shortened and lies in a relatively large fossula, whereas the counter septum is elongated and somewhat thickened about the inner edge. Higher in the corallites the cardinal septum remains notably short, the counter septum long, and other major septa somewhat shortened, but they may be more or less united axially by stereoplasm. In the mature regions the counter septum separates from the column, and except for the short cardinal septum, the major septa are long and commonly rhopaloid. Within the calyx the septa are short and not rhopaloid. Minor septa may alternate with major septa in the upper parts of the corallites of some species.

The axial column, which persists throughout the corallite, is laterally compressed and contains a median lamina that is continuous with that of the counter septum, but lacks other elements. In the lower and middle parts of the corallite, the column is attached to the counter septum but it may be separated in mature stages. Tabulae generally are relatively abundant, arch upward in varying degree, and incomplete. Dissepiments are lacking. The cardinal fossula is relatively conspicuous throughout the development of these corallites but alar pseudofossulae are prominent only in the apical region. The amount of stereoplasm deposited about

the skeletal elements is variable but, except in the Stereostylus newelli group, is confined to deposits about the column and axial edges of the septa, particularly in the apical region.

Genotype.-- Stereostylus lenis Jeffords, n. sp., Missourian, Pennsylvanian, Kansas and Missouri.

Discussion.-- Corals here referred to Stereostylus were included in Lophophyllidium in earlier studies (Moore and Jeffords, 1941, 1945; Jeffords, 1942), inasmuch as the significance of many lophophyllidid features was incompletely understood. Additional investigations now have furnished data that permit recognition of at least two genetic lines -- Lophophyllidium and Stereostylus. The latter genus may be distinguished generally from Lophophyllidium by examination of external features of the corallite. The form of the corallites referred to Stereostylus varies, but generally they are conical and bear low wrinkles. Lophophyllidium, on the other hand, is characterized by the more elongate conico-cylindrical, smoothly curved form of corallites, absence of prominent transverse wrinkles, and in some species by an abundance of large radicles. Sections of species of Stereostylus are distinguished by the smaller apical areas filled by stereoplasm, thinner or more rhopaloid septa, laterally compressed axial column, and lack of radiating and circumscribing laminae in the column. Also, the septa in the upper portions of corallites belonging to Stereostylus are shorter in relation to the diameter than in Lophophyllidium (text fig. 4).

Stereostylus is separated from Lophamplexus by the persistence of the column and longer septa, and from Lophotichium by the more gentle inclination of the tabulae, which do not simulate septa in the apical region.

Some or all the major septa of Stereostylus may become rhopaloid in mature parts of the corallites. Commonly, all these septa, except the cardinal and counter, are approximately equal in length, but in some species alternate major septa are shortened or particular septa or pairs of septa are similarly elongated. However, distinct tachylasmoid patterns like those of Claviphyllum are absent.

This genus includes many described lophophyllidid corals, such as specimens referred to Lophophyllum proliferum (McChesney) Meek (1872, p. 144), and Soschkina (1925, p. 88); L. profundum (Edwards and Haime) Worthen (1890, p. 79), Mather (1915, p. 91), Sayre (1930, p. 85), Kelly (1930, p. 136), and Morse (1931, p. 305); L. acostatum Soschkina (1928, p. 373); L. inaequale Merla (1934, p. 210); L. orientale Smith (1934, p. 128); L.? sp. 4 Dobrolyubova (1936, P. 90); Sinophyllum pendulum (Grabau) Heritsch (1933, p. 218); S. carnicum Heritsch (1936, p. 113); S. multiseptum irregulare Felser (1937, p. 10); S. pendulum carinthiaca Felser (1937, p. 9); and Cyathaxonia sp. Morgan (1924, p. 192). The Permian species called Lophophyllidium dunbari and Sochkineophyllum mirabile by Moore and Jeffords (1941) are considered to belong to Stereostylus also. Lophophyllidium mundulum, L. confertum, L. compressum, L. expansum, L. girtyi, L. elongatum, and L. radiatum, which have been described from Lower Pennsylvanian deposits of Kansas and Oklahoma (Jeffords, 1942) are referred to Stereostylus, as are the corals described by Moore and Jeffords (1945) as Lophophyllidium conoideum, L. adapertum, L. blandum, L. angustifolium, L. metum, and L. exile.

In previous discussions of Pennsylvanian lophophyllidid corals (Jeffords, 1942, p. 213) several species, as Lophophyllidium newelli, L. minutum, and L. distinctum were distinguished from the other species

assigned to Lophophyllidium by

> "restriction of the immature characters to a very small part of the apical region, the scarcity or absence of tabulae, and the large alar pseudofossulae. The youthful septa are separated into four symmetrical groups by the cardinal fossula, the two prominent alar pseudofossulae, and the two large interseptal spaces between the counter-laterals and counter septum. Mature parts have very straight septa with little or no axial thickening. Minor septa are very short or absent."

Also, the corallites have a characteristic broadly conical form. The evolutionary significance and classificatory importance of the characters of the axial column and other features of the lophophyllidids are difficult to evaluate. Whereas Stereostylus is distinguished readily from Lophophyllidium on the basis of the internal structure of the column and correlated features of the septa and external form, the S. newelli group can not be separated clearly from some species that seem assignable to Stereostylus. S. newelli, S. distinctus, and a few other species are strikingly different from the genotype and similar species of Stereostylus. Intervening forms show a gradation from no tabulae to numerous tabulae, from inconspicuous alar pseudofossulae to prominent pseudofossulae, from a solidly filled apical region to a more or less open section, and from corallites having rapid development in immature stages to those developed normally. Therefore, corals of the S. newelli group are retained in Stereostylus until knowledge of their peculiarities can be considerably extended.

Occurrence.— Pennsylvanian (Upper Carboniferous) and Permian, North America, Europe, and Asia.

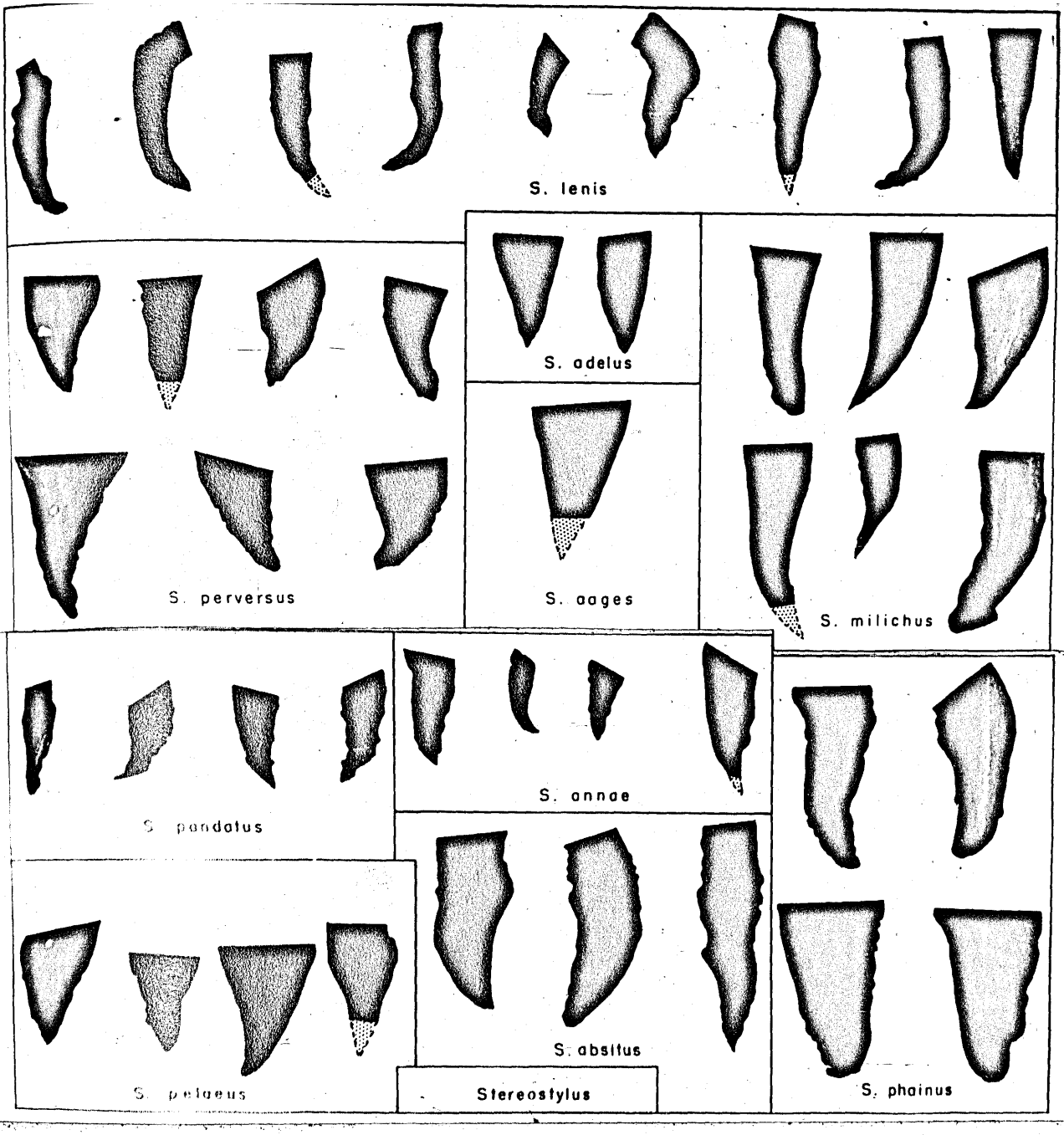


Figure 7. Outline drawings at natural size prepared from photographs of described species of Stereostylus showing the form, variation, and relative size of the corallites. The stippled portions indicate probable restoration of incomplete specimens.

Stereostylus lenis Jeffords, n. sp.

Plate 1, figure 1; plate 12, figures 1-15; plate 18, figures 3-4, 6; text figures 2-4 and 7-8.

This species is characterized by small to medium-sized conical corallites that become cylindrical in maturity. Commonly, they are slightly curved in the apical region, and the convex side bears a few short radicles or a flattened area of attachment. The position of the curvature is generally in the counter-cardinal plane. However, examination of 50 curved corallites from the type locality showed that the concavity was on the cardinal side in 22 individuals, the counter side in 19 individuals, the left alar side in 5 individuals, and the right alar side in 4 individuals. The theca, which is thin, bears distinct septal grooves and ridges that are crossed by growth lines and conspicuous wrinkles in the cylindrical portion. The calyx is deep and bears the spikelike axial column. The type specimen is 22 mm in length and 6.5 mm in diameter at the calyx. The variation in the size of the corallites is shown on text figure 2.

In the immature region of these corals the counter septum is thickened axially to form a distinct column, the cardinal septum is short, and other major septa extend nearly to the column. Progressively upward in the corallite the counter septum gradually separates from the column, the cardinal septum remains very short, and the major septa retreat slightly from the axial area. The septa are thickened throughout the corallite, but they do not become rhopaloid or joined axially. In the calyx the major septa are approximately equal in length except for the cardinal septum, and they are arranged bilaterally about the counter-cardinal plane. Minor septa are present in maturity as low ridges

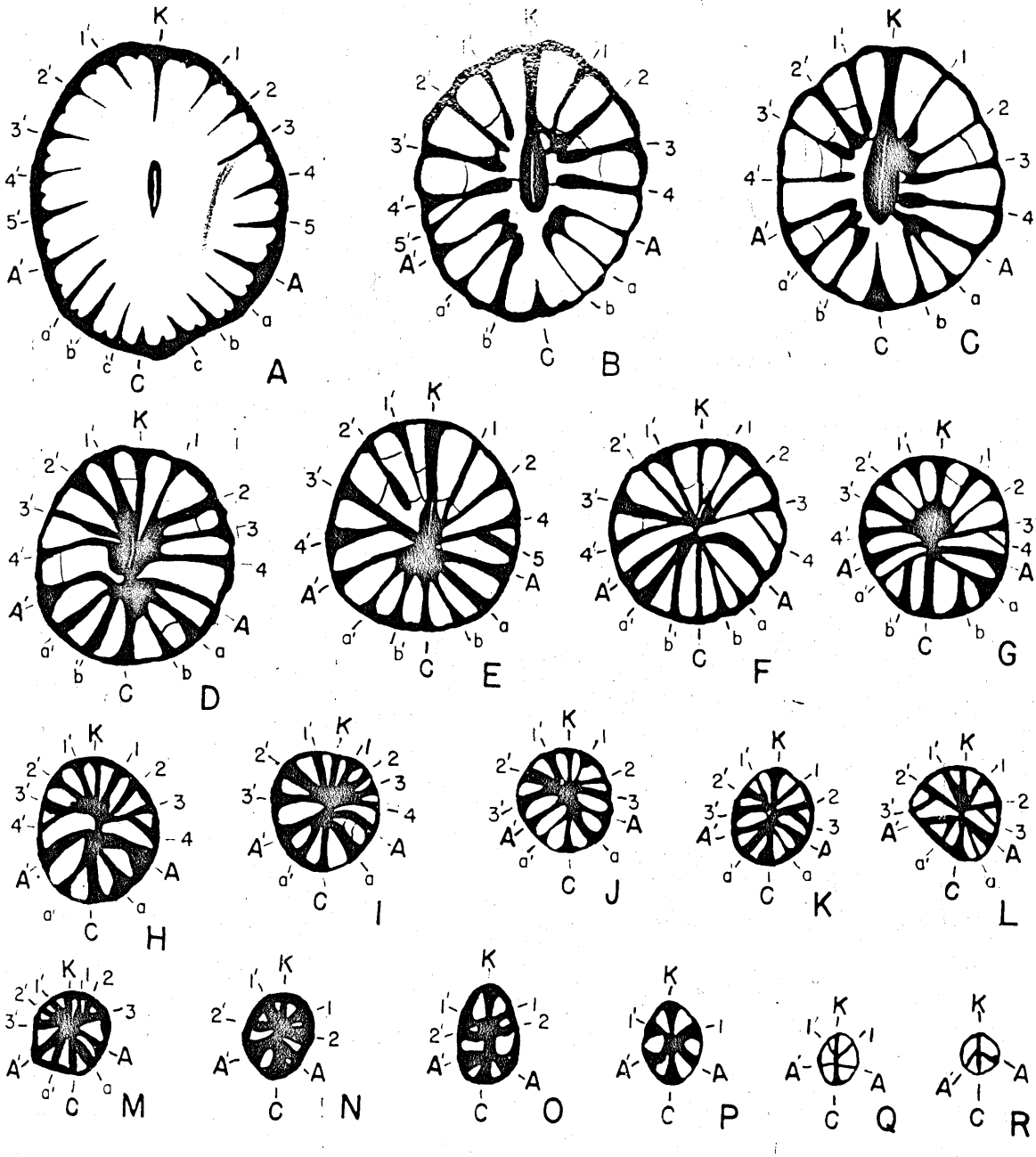
alternating between major septa. The septal formula for the type specimen about 1.5 mm above the apex is K 4 A 1 C 1 A 3 K, and in the mature stage it is K 5 A 3 C 3 A 5 K.

The axial column is laterally compressed throughout growth, and it persists as a separate structure into the calyx. The column contains a median lamina that is continuous with the lamina of the counter septum in youthful stages. Radiating laminae are lacking. Tabulae are numerous, spaced about 1 mm apart, and mostly extending from the periphery to the column although a few may abut adjacent tabulae. The position of the cardinal fossula is indicated by the short cardinal septum, but the fossula is not prominent. Alar pseudofossulae are inconspicuous.

Discussion.-- This species is characterized by thin theca, moderately thickened septa, and laterally compressed axial column. Although the apical region of these corals seems complete, microscopic examination showed that only rarely were there less than 6 major septa present at the tip. The apex is solidly filled by stereoplasm so that the earliest developmental stage could not be identified positively. There seems, however, to be a non-septate stage during which the corallite was cemented to the substratum, and the subsequent development of a single median septum in the counter-cardinal plane. Several corallites confirmed the appearance of the alar septa prior to the counter-lateral septa, however. The increase in number of septa and progressive development in other characters are shown on text figure 8. These sections, which were drawn by camera lucida, represent successive stages as thin transverse slices were ground away from a single small corallite.

The variation in the rate of insertion of major septa in S. lenis is shown also on text figure 3. Whereas the number of septa is not

Figure 8. Camera lucida drawings (x10) showing the insertion of major septa and development of other characters in Stereostylus lenis n. sp. A small corallite that showed the four-septa stage at the apex was ground so as to reveal successive growth stages. Although the earliest development could not be interpreted positively, other specimens suggest that the four-septa stage is preceded by a single counter-cardinal septum, and this by a non-septate stage. Metasepta in the counter quadrants are indicated by numbers and in the cardinal quadrants by letters. Protosepta are designated by letters C (cardinal), K (counter), and A (alars).


A
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C
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constant for particular diameters, there is a general trend toward a decrease in the rate of septal insertion in maturity.

S. lenis is distinguished from Lophamplexus ulius, n. sp., which also occurs in the Kansas City group, by the persistence of the axial column into the calyx. This species is separated from S. milichus, n. sp., S. pandatus, n. sp., and S. blandus (Moore and Jeffords, 1945) by the elongate cylindrical form and thinner skeletal elements.

Occurrence.— Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). The abundant type material is from the Frisbie limestone member, Wyandotte limestone, from the quarry at 33 d. and Roanoke St., Kansas City, Missouri (Univ. Kansas locs. 1875 and 7176). This species is identified also from the Frisbie limestone member at the north end of Bell St., Kansas City, Mo. (Univ. Kansas loc. 7523); the Quindaro shale member, Wyandotte limestone, at Kansas City, Mo. (Univ. Kansas loc. 3107); the Farley limestone member, Wyandotte limestone, at Kill Cr. bridge east of De Sota, Johnson county, Kansas (Univ. Kansas loc. 1708), at the bridge over Marshall Cr. on north-south highway, southeast of Wolcott, Wyandotte county, Kansas (Univ. Kansas loc. 1861), middle of east side sec. 25, T. 10 S., R. 23 E., Wyandotte county, Kansas (Univ. Kansas loc. 3171), and at Penner's Ford, south side sec. 33, T. 12 S., R. 22 E., 2 miles south of De Sota, Johnson county, Kansas (Univ. Kansas loc. 1712). Other specimens are from the Iola limestone at Kansas City, Missouri (Univ. Kansas loc. 804); Main St. cut, south of Union Station, Kansas City, Missouri (Univ. Kansas loc. 332); Monarch cement quarry, Humboldt, Allen county, Kansas (Univ. Kansas loc. 338); Lehigh cement quarry, Iola, Allen county, Kansas (Univ. Kansas loc. 3112); and near the waterworks, Kansas City, Missouri (Univ. Kansas loc.

3010). A single coral from the Westerville limestone at the quarry in Muncie, Kansas (Univ. Kansas loc. 352), seems to belong to this species also. These corals were collected by R. C. Moore, J. M. Jewett, N. D. Newell, R. M. Jeffords, and others of the Kansas Geological Survey.

Material studied.— This species occurs abundantly at the type locality and at many of the other localities. Approximately 2500 well preserved corallites are contained in the collection, and about 35 specimens were sectioned for study.

Type.— University of Kansas, specimen no. 1875-21b from the Frisbie limestone, 33d. and Roanoke St., Kansas City, Missouri.

EXPLANATION OF PLATE 12

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal pplane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus lenis Jeffords, n. gen., n. sp., from the Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - - - - 114

1--Longitudinal section of specimen (Univ. Kansas no. 7176-24b) from the Frisbie limestone member, Wyandotte limestone, at 33d and Roanoke quarry, Kansas City, Missouri. This longitudinal section shows the appearance of sections that do not pass through the axial plane.

2--Transverse section of specimen (Univ. Kansas no. 7176-24a) from the same locality as figure 1. The plane of the section slopes slightly from the counter toward the cardinal septum.

3--Transverse section of specimen (Univ. Kansas no. 7176-24c) from the same locality as figure 1. The section is cut obliquely similar to figure 2.

4--Transverse section in the immature region of specimen (Univ. Kansas no. 7176-24d) from the same locality as figure 1. The plane of the section slopes steeply from the cardinal to the counter quadrants.

5--Transverse section of specimen (Univ. Kansas no. 7176-24e) from the same locality as figure 1. The plane of the section slopes steeply from the right alar to the left alar septum.

6--Transverse section of specimen (Univ. Kansas no. 7176-24f) from the same locality as figure 1. The plane of this section slopes at an angle of about 45 degrees from the counter to the cardinal quadrants.

7a-c--Transverse sections of specimen (Univ. Kansas no. 804-21c) from the Iola limestone at Kansas City, Missouri.

8--Transverse section near the apex of specimen (Univ. Kansas no. 7176-21i) from the same locality as figure 1.

9a-b--Transverse sections near the apex of specimen (Univ. Kansas no. 7176-21j) from the same locality as figure 1.

10a-c--Specimen (Univ. Kansas no. 1875-21d) from the same locality as figure 1. a-b, Transverse sections. c, Longitudinal section.

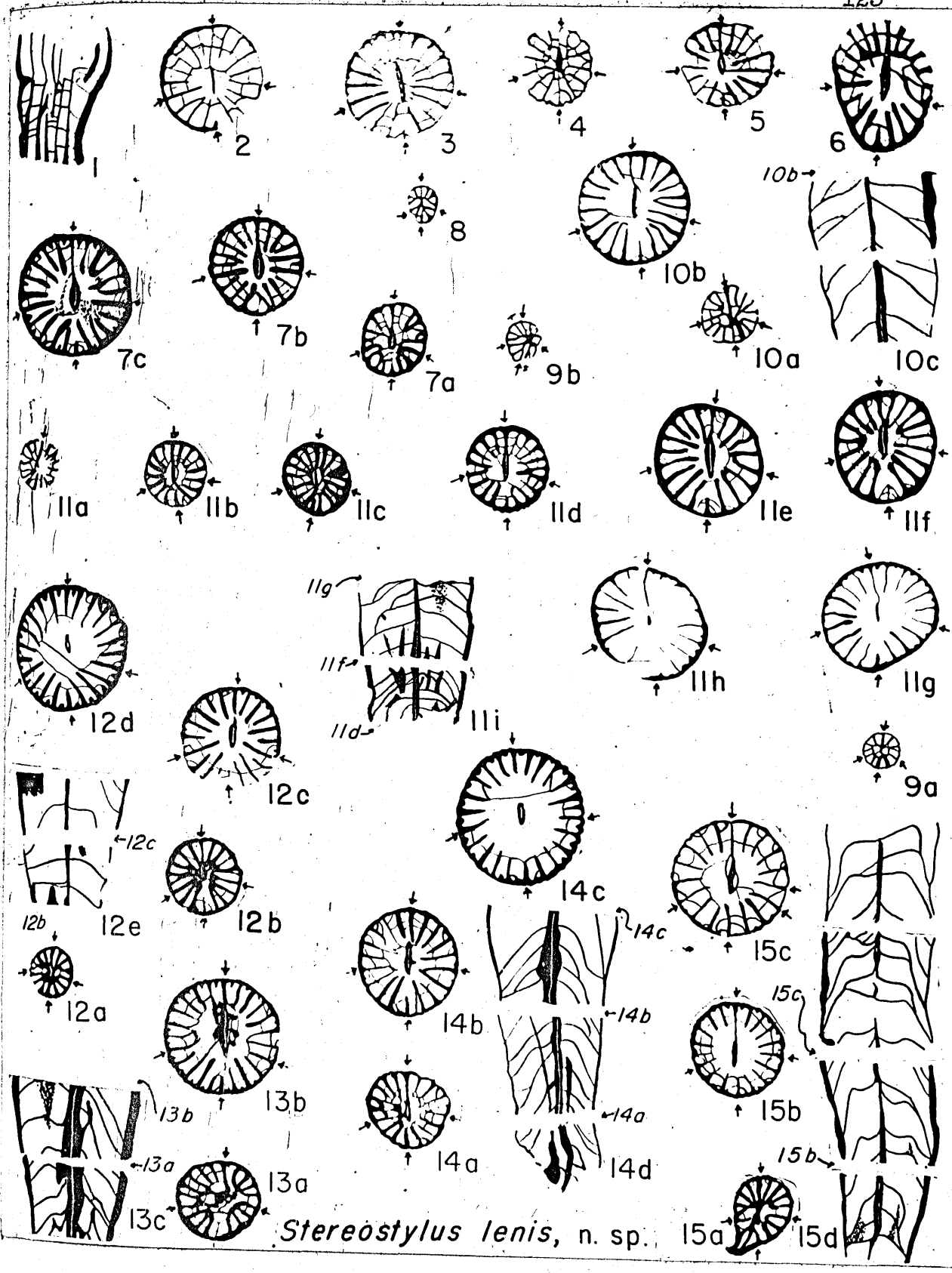
11a-i--Specimen (Univ. Kansas no. 804-21b) from the same locality as figure 7. a-h, Transverse sections at closely spaced intervals. i, Longitudinal section.

12a-e--Specimen (Univ. Kansas no. 1875-21c) from the same locality as figure 1. a-d, Transverse sections. e, Longitudinal section.

13a-c--Specimen (Univ. Kansas no. 1875-21a) from the same locality as figure 1. a-b, Transverse sections. c, Longitudinal section.

14a-d--Specimen (Univ. Kansas no. 1875-21e) from the same locality as figure 1. a-c, Transverse sections. d, Longitudinal section.

15a-d--Specimen (Univ. Kansas no. 3107-21a) from the Quindaro shale member, Wyandotte limestone, at Kansas City, Missouri. a-c, Transverse sections. d, Longitudinal section.



Stereostylus lenis, n. sp.

Plate 12

Stereostylus aages Jeffords, n. sp.

Plate 19, figures 1-6; text figure 7.

Moderately large conical corallites that are straight or only slightly curved are included in this species. The theca, which is relatively thick, bears broad rounded septal grooves and narrow interseptal ridges. Transverse markings comprise a few fine growth lines and low wrinkles. Radicles are lacking, but rejuvenation may occur in the largest corallites. The calyx is deep and the column projects strongly into it. The type specimen is 27 mm in length and 14 mm in maximum diameter at the top of the calyx. Other mature corallites reach approximately the same size.

The apical region is characterized by long septa that abut the thickened axial portion of the counter septum. The cardinal septum is not shortened in this stage. Slightly higher in the corallite major septa reach almost to the column, and commonly they are united to it and to each other by stereoplasm. The cardinal septum becomes notably shorter and thinner than other major septa. In early maturity the septa maintain their long length although they are relatively thin; they may be united at their axial edges by stereoplasm. Sections near the calyx of mature individuals show long septa that are somewhat rhopaloid; alternating septa may be slightly shortened. The counter septum separates from the column only in very late development, and the cardinal septum remains shortened throughout growth. Minor septa occur as rudimentary structures just below and in the calyx of large individuals. However, the minor septa adjacent to the counter septum are introduced relatively early and are distinctly longer than the others. The septal formula of the type specimen at the base of the calyx is K 8 A 4 C 4 A 7 K.

The axial column is firmly attached to the counter septum except in the upper parts of the corallites and it remains laterally compressed throughout growth. Relatively numerous tabulae arch steeply towards the column in the upper half of the corals, but they are concealed by thickened skeletal elements near the apex. The alar pseudofossulae are moderately well developed near the apex; the cardinal fossulae is prominent throughout the corallites.

Discussion.— This species is characterized by large conical corallites having thick theca, long sub-equal major septa, and a long minor septum on either side of the counter septum. Stereostylus aages differs from S. distinctus (Jeffords, 1942) in the larger size and inconspicuous nature of the pseudofossulae, and from S. expansus (Jeffords, 1942) in the more elongated form of the corallite and thicker theca in the apical region. S. absitus from the Oread limestone is also characterized by a considerable thickening of the skeletal elements, but S. aages is distinguished readily by its more conical form and thinner major septa in the upper parts of the corallite.

Occurrence.— Ardmore limestone, Cherokee group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). The type specimen is from the bank of Whitebreast Creek, NW NW NE sec. 33, T. 73 N., R. 22 W., Lucas county, Iowa (Univ. Kansas loc. 7779). Other specimens are from SW NW NE sec. 19, T. 73 N., R. 21 W., Lucas county, Iowa (Univ. Kansas loc. 7854); and from Warren county, Iowa at NE SW SW sec. 14, T. 74 N., R. 22 W., (Univ. Kansas locs. 7502 and 7546), and center of north line NE sec. 11, T., 74 N., R. 23 W. (Univ. Kansas loc. 7852). These corals were collected by M. H. Wallace, a former student at the University of Kansas.

Material studied.— One or two well preserved corallites were available from each of the localities, and 4 representative specimens were sectioned for study.

Type.— University of Kansas, specimen no. 7779-21a from Whitebreast Creek, Lucas county, Iowa.

Stereostylus adelus Jeffords, n. sp.

Plate 5, figure 6; plate 6, figures 6-8; text figure 7.

Relatively small conical corallites that are straight or slightly curved are referred to this species. The theca, which is thick, bears conspicuous fine grooves and broad interseptal ridges. These longitudinal markings are crossed transversely by a few low wrinkles and numerous deep growth lines. Radicles are not observed, and most of the corallites seem to have been free or attached only by a very small area at the apex. The calyx is deep and broad. The type specimen is 21 mm in length and 8.2 mm in diameter at the calyx; other individuals may reach a slightly larger size.

The immature region is characterized by long thin septa that are joined to the column by stereoplasm. The cardinal septum is short whereas the counter septum is thickened at the axis to form a distinct column. In the mature stage, septa are thin and rhopaloid. Except for the short cardinal septum, major septa reach nearly to the column. Minor septa are observed only in the larger specimens and they remain rudimentary. The septal formula in the apical region of the type specimen is K 4 A 2 C 2 A 5 K, and in the mature stage it is K 7 A 3 C 3 A 6 K.

In the lower part of the calyx the counter septum is separated from the column, and it is not longer than other major septa. At this stage the septa are thin and distinctly rhopaloid, and the cardinal septum is very short. The axial column is relatively large near the apex, but it becomes relatively thinner and more compressed upward. Tabulae rise steeply from the periphery to the column, and in the mature immature region they are slightly inosculating. The cardinal fossula is large, and alar pseudofossulae are prominent in the youthful stage.

Discussion.-- Corals referred to Stereostylus adelus are distinguished by their small size and conical form, and by the palmate grouping of the thin major septa in the mature region. The cardinal septum is relatively long near the apex, but rapidly shortens higher in the corallite. This species is separated readily from S. compressus (Jeffords, 1942) which occurs in the Millsap Lake group of Texas by the narrower form, thinner septa, and more open apical region. S. adelus resembles S. pelaeus in the shape of the corallite but the former species is appreciably smaller and has thinner major septa.

Occurrence.-- Strawn (Desmoinesian) series, Pennsylvanian (Upper Carboniferous). The type specimens were collected by R. C. Moore from the East Mt. shale, Lone Camp group, at the brickplant 1 mile east of Mineral Wells, Texas (Univ. Kansas loc. 546). Other specimens were collected by M. H. Wallace from the Millsap Lake group, 3.6 miles east and 1 mile south of Rochelle, Texas (Univ. Kansas loc. 7170).

Material studied.-- This species is representated by about 50 corallites from the type locality and 6 from the other outcrop. Representative specimens were sectioned for study.

Type.-- University of Kansas, specimen no. 546-21a from the East Mt. shale, east of Mineral Wells, Texas.

Stereostylus phainus Jeffords, n. sp.

Plate 13, figures 1-6; plate 18, figure 5; text figure 7.

Lophophyllum profundum SAYRE, 1930, Kansas Geol. Survey Bull. 17, page 85, plate 1, figures 3-5.

Moderately large slightly curved to straight corallites that develop from a conical to a cylindrical form comprise this species. The exterior of the theca is marked by prominent septal grooves and inter-septal ridges that are crossed transversely by conspicuous rounded wrinkles and coarse growth lines. The apical region is somewhat flattened to serve as a point of attachment. The calyx is relatively deep. The type specimen is 43.5 mm in length and 12 mm in diameter at the calyx. Other individuals reach an observed maximum diameter of 15 mm.

The immature region of these corallites contains long and thickened major septa. The cardinal septum is slightly thinner and shorter than the other septa, and the counter septum is thickened axially to form the laterally compressed column. In early maturity the septa reach nearly to the column, and they are slightly rhopaloid. The cardinal septum is about three-fourths the length of the metasepta. Near the calyx the major septa are long and extend three-fourths the distance to the axis; a few of the septa may be somewhat shorter than others. The cardinal septum is only one-half as long as adjacent metasepta, and the counter septum is separated from the column or joined to it only by tabulae. Minor septa occur as short elements alternating between the other septa. The septal formula about 5 mm above the apex of the type specimen is K 7 A 3 C 3 A 7 K; about 15 mm higher near the calyx there is an additional pair of metasepta in the counter quadrants but the same number

in the cardinal quadrants. Sections in the mature region of these corals show approximately 26 major septa.

The axial column is well developed throughout the corallite, and it is attached directly to the counter septum in youthful stages. Near the calyx the counter septum is joined to the column commonly by tabulae so that in transverse section the counter septum appears to extend around the column to join it at the cardinal side. Tabulae are numerous, slightly inosculating, and gently arched. Typically these tabulae are spaced about 0.4 to 0.6 mm apart at the periphery. Alar pseudofossulae are relatively inconspicuous, but the cardinal fossula is distinguished readily by the short cardinal septum.

Discussion.— This species is distinguished by the large conico-cylindrical form, regularly spaced tabulae, sub-equal major septa in maturity, and tendency in mature regions for the counter septum to be joined to the cardinal end of the axial column. Stereostylus phainus resembles S. elongatus (Jeffords, 1942) in the elongate form, but contains appreciably less stereoplasm and the corallites are somewhat more cylindrical. This species is larger than other species that occur in Missourian rocks such as S. lenis, n. sp., and S. pelaeus, n. sp.

Occurrence.— Drum linestone, Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). The type material was collected at the Atlas cement quarry, Independence, Montgomery county, Kansas (Univ. Kansas loc. 752). Other corallites are from the brickplant quarry, Cherryvale, Montgomery county, Kansas (Univ. Kansas loc. 734); 3.5 miles southeast of Independence, Kansas (Univ. Kansas loc. 356); highway cut SW NW sec. 5, T. 33 S., R. 16 E., 1 mile southeast of Independence, Kansas (Univ. Kansas loc. 4987); 2 miles east of Independence,

Kansas (Univ. Kansas loc. 469); NW sec. 5, T. 33 S., R. 17 E., 2 miles southeast of Independence, Kansas (Univ. Kansas loc. 354); and on Old Standpipe Hill, 2 miles south of Cherryvale, Kansas (Univ. Kansas loc. 873). The corals were collected by J. M. Jewett, A. N. Sayre, and others of the Kansas Geological Survey.

Material studied.-- About 30 well preserved corallites and other fragmentary remains were included in the collections. Twelve corallites were sectioned for study.

Type.-- University of Kansas, specimen no. 752-21a from the quarry at Independence, Kansas.

EXPLANATION OF PLATE 13

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus phainus Jeffords, n. sp., from the Drum limestone, Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 129

1a-b--Specimen (Univ. Kansas no. 469-21a) from 2 miles east of Independence, Montgomery county, Kansas. a, Transverse section; b, Longitudinal section.

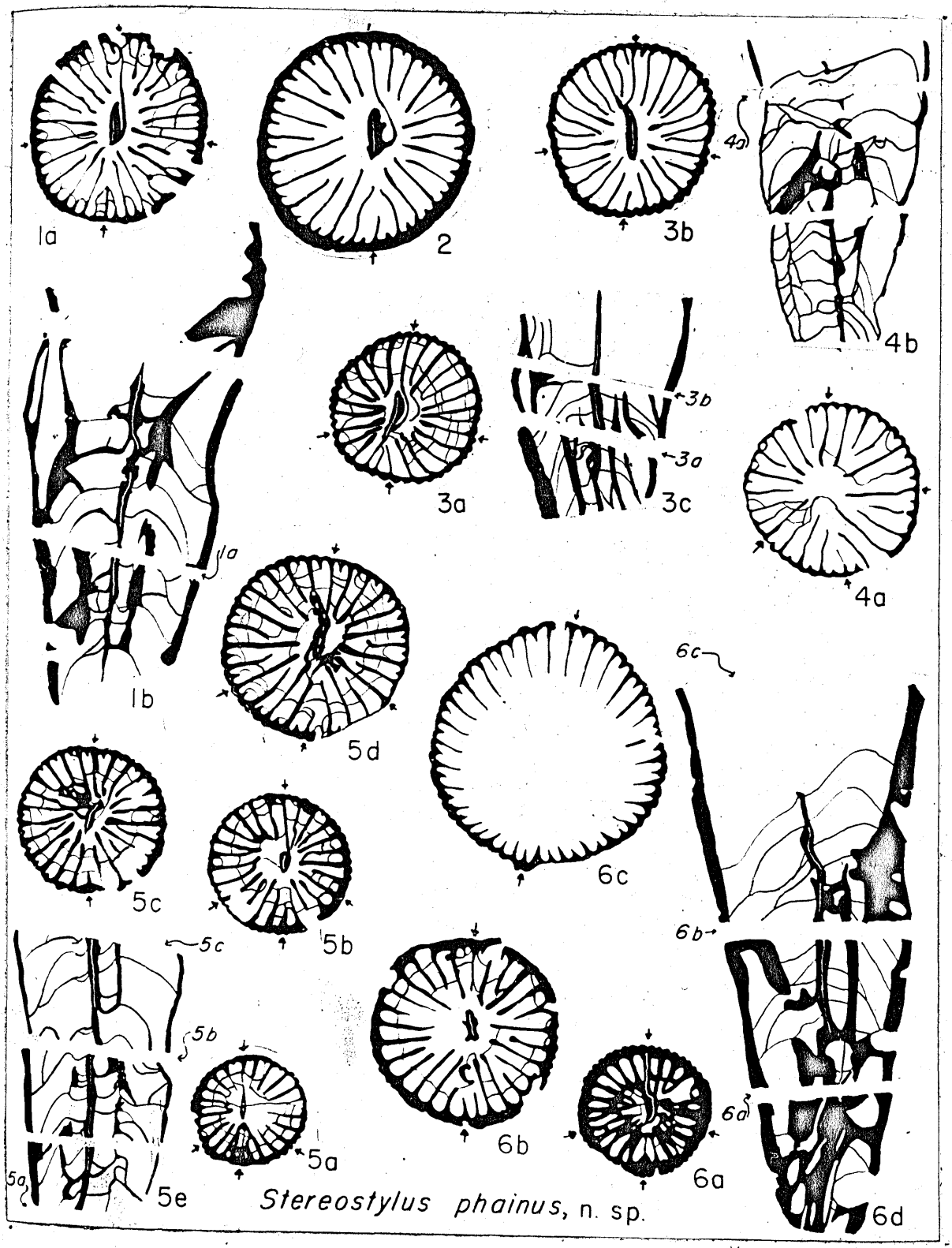
2--Transverse section in the calyx of specimen (Univ. Kansas no. 873-21b) from Old Standpipe Hill, 2 miles south of Cherryvale, Montgomery county, Kansas.

3a-c--Specimen (Univ. Kansas no. 873-21a) from the same locality as figure 2. a-b, Transverse sections. c, Longitudinal section.

4a-b--Specimen (Univ. Kansas no. 354-21b) from NW sec. 5, T. 33 S., R. 17 E., 2 miles southeast of Independence, Kansas. a, Transverse section. b, Longitudinal section slightly out of the axial plane in the upper portion.

5a-e--Type specimen (Univ. Kansas no. 752-21a) from the Atlas Cement Quarry at Independence, Kansas. a-d, Transverse sections. e, Longitudinal section.

6a-d--Specimen (Univ. Kansas no. 4987-21a) from highway cut, SW NW sec. 5, T. 33 S., R. 16 E., 1 mile southeast of Independence, Kansas. a-c, Transverse sections. d, Longitudinal section.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6d
Stereostylus phainus, n. sp.

Plate 13

Stereostylus pelaeus Jeffords, n. sp.

Plate 14, figures 1-8; plate 18, figures 1 and 7; text figure 7.

This species includes broadly conical corallites that are gently to strongly bent near the apex. The curvature is irregular in position so that any of the protosepta may be on the concave side. The theca is moderately thick, and it bears sharply incised septal grooves and fine interseptal ridges. Transverse markings comprise low wrinkles and fine growth lines. The convex side of the bent apical portion bears a few short radicles or other thickening to provide for attachment. Some of the corallites seem to have been free; others are attached to small crinoid columnals. The calyx is deep and contains the broad bladelike column in the center. The type specimen is 20.3 mm in length and 17.5 mm in maximum diameter at the calyx. Most of the specimens are approximately 19 mm in length and 12 mm in diameter.

Transverse sections in the apical region show a counter septum that is thickened slightly at the axis, a thin cardinal septum, and long major septa that are joined to each other and to the column by stereoplasm. In early maturity the cardinal septum is very short, and the counter septum is long and thin except for the enlargement at the axis. The major septa are distinctly rhopaloid and they are joined in a palmate arrangement about the column. Characteristically, there is a broad open area in the counter-cardinal plane that is divided in the counter quadrants by the column and thin counter septum. The grouping of the axial edges of the septa and the open area in the counter-cardinal plane persist to the calyx in mature corallites. Full maturity is shown in transverse sections by the separation of the column from the counter septum, the presence of long and slightly rhopaloid septa, and

the bilateral arrangement of the septa about the counter-cardinal plane. Minor septa are rudimentary. The septal formula in the apical region of the type specimen is K 4 A 2 C 2 A 4 K; and about 7 mm higher it is K 8 A 4 C 4 A 8 K. There are about 30 major septa in the mature stages of these corals.

The axial column of this species is distinctly compressed laterally, and it remains attached to the counter septum until late maturity. In transverse sections above the apical region the column is separated from the fused edges of the septa by conspicuous open spaces although bars of stereoplasm may extend to the septa normal to the median lamina of the column. Tabulae are relatively numerous and rise steeply from the periphery to flatten somewhat as the column is reached. The cardinal fossula is very large and prominent throughout growth. Alar pseudofossulae are moderately well developed, but confined to the apical region.

Discussion.— This species is characterized by long sub-equal major septa, conical form, and open spaces between the counter laterals and counter septum. These features, together with the large alar pseudofossulae and cardinal fossula, resemble similar structures in the Stereostylus newelli group, but S. pelaeus is distinguished by the abundance of tabulae, lesser quantities of stereoplasm in the immature region, and the strong counter acceleration. This species differs notably from S. lenis, n. sp., S. milichus, n. sp., and S. phainus, n. sp. which occur in Missourian rocks also, but corals from shale and limestone deposits are expected to represent somewhat divergent types.

Occurrence.— Missourian series, Pennsylvanian (Upper Carboniferous). The type material was collected by N. D. Newell from the Francis

formation at the brickplant quarry, sec. 4, T. 3 N., R. 6 E., Ada, Oklahoma (Univ. Kansas loc. 154). Other specimens referred to this species are from the same formation at the cen. W. side sec. 20, T. 7 N., R. 8 E., Oklahoma (Univ. Kansas loc. 2266); the Wann formation, Ochelata group, 1.5 miles north and 0.5 mile east of Copan, Oklahoma (Univ. Kansas loc. 7544); the Nellie Bly formation, Skiatook group, at a railway cut north of the highway, 1.5 miles west of Castle, Oklahoma (Univ. Kansas loc. 2203); the Belle City Limestone (=Drum limestone), NE sec. 4, T. 4 N., R. 6 E., north of Ada, Oklahoma (Univ. Kansas loc. 105); and the Drum limestone, Kansas City group, at SW sec. 3, T. 33 S., R. 16 E., 3.5 miles southeast of Independence, Montgomery county, Kansas (Univ. Kansas loc. 356).

Material studied.-- This species is represented by approximately 250 corallites, 20 of which are from the type locality. About 25 specimens were sectioned for study.

Type.-- University of Kansas, specimen no. 154-21a from the Francis formation, at Ada, Okla.

EXPLANATION OF PLATE 14

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at the bottom; protosepta are indicated by small arrows; Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus pelaeus Jeffords, n. sp., Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 135

1a-f--Type specimen (Univ. Kansas no. 154-21a) from the Francis formation at the brick plant, sec. 4, T. 3 N., R. 6 E., Ada, Oklahoma. a-e, Transverse sections. f, Longitudinal section.

2--Transverse section in the immature region of specimen (Univ. Kansas no. 154-21d) from the same locality as figure 1.

3--Transverse section of specimen (Univ. Kansas no. 2266-21a) from the Francis formation at cen. W. side sec. 20, T. 7 N., R. 8 E., Oklahoma.

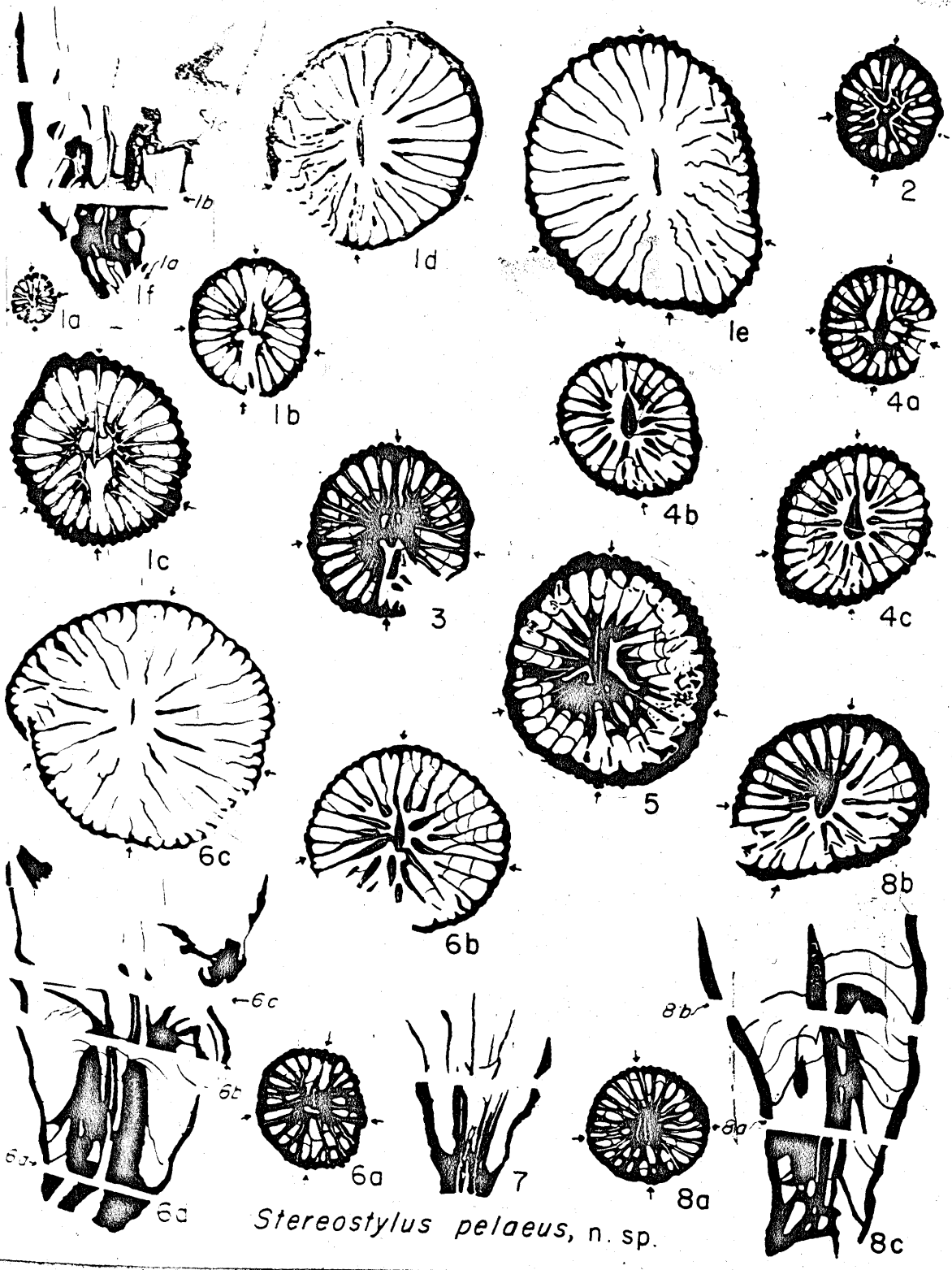
4a-c--Transverse sections of specimen (Univ. Kansas no. 7544-21c) from the Wann formation, Ocheleta group, 1.5 miles north and 0.5 mile east of Copan, Washington county, Oklahoma.

5--Transverse section of specimen (Univ. Kansas no. 154-21b) from the same locality as figure 1.

6a-d--Specimen (Univ. Kansas no. 2203-21a) from the Nellie Bly formation, Skiatook group, at railroad cut, north of highway, 1.5 miles west of Castle, Oklahoma. a-c, Transverse sections. d, Longitudinal section.

7--Slightly oblique longitudinal section of a small curved specimen (Univ. Kansas no. 154-21c) from the same locality as figure 1.

8a-c--Specimen (Univ. Kansas no. 7544-21a) from the same locality as figure 4. a-b, Transverse sections. c, Longitudinal section.



Stereostylus pelaeus, n. sp.

Plate 14

Stereostylus milichus Jeffords, n. sp.

Plate 15, figures 1-5; text figure 7.

This species includes moderately large corallites that are conical near the apex and cylindrical above. The apical region is strongly curved and upper parts of the corals may be straight, evenly curved, or strongly bent. The theca, which is relatively thin, bears low ridges and grooves, numerous prominent wrinkles, and short radicles near the apex. A large area of attachment occurs along the convex side of the apical region. The calyx is moderately deep and contains a spikelike axial column at the base. The type specimen, which represents a large individual, is 44 mm in length and 13.5 in maximum diameter at the calyx.

The apical region of these corals contains numerous moderately thick septa that reach nearly to the column. The counter septum is thickened axially to form a thin column, and the cardinal septum is slightly shorter than the metasepta. Somewhat higher in the corallite numerous stout septa extend two thirds the distance to the axis, the counter septum is attached to the column, and the cardinal septum is only slightly shorter than other septa. In maturity major septa are long, subequal in length, and arranged radially about the axis. The septa do not become rhopaloid at any stage, and the counter septum separates from the column only in mature stages of the largest corallites. Minor septa occur as inconspicuous ridges between major septa in late maturity. The septal formula about 5 mm above the apex of the type specimen is K 5 A 2 C 2 A 6 K, and just below the calyx of the same specimen it is K 8 A 3 C 3 A 8 K. The axial column is relatively thin and laterally compressed through the corallite, and it is attached to the counter

septum except in the largest individuals. The cardinal fossula is not prominent although identifiable by the slightly shortened cardinal septum; alar pseudofossulae are inconspicuous. Tabulae are numerous, spaced about 0.75 mm apart, generally to steeply arched, and reaching mostly from the theca to the column.

Discussion.— This species is characterized by large corallites that contain long major septa and very numerous tabulae. These corallites are appreciably larger than in Stereostylus lenis, n. sp., and S. pandatus, n. sp., and the concentration of tabulae and lack of skeletal thickening serve to distinguish this species from other species of Stereostylus described in this paper. Counter acceleration is especially marked in S. milichus and the counter quadrants may contain more than twice the number of septa in the cardinal quadrants. A few of the larger corallites show several periods of rejuvenation. Seemingly these corallites reached the maximum diameter for the species and then underwent constriction to permit additional upward growth.

Occurrence.— Stanton limestone, Lansing group, Missourian series, Pennsylvanian (Upper Carboniferous). The type material occurs in the Eudora shale member at the Santa Fe railroad cut near Vilas, Wilson county, Kansas (Univ. Kansas locs. 4519 and 5418). Other representatives of this species occur also in the same member off Kansas Highway 39, 3 miles west of Vilas, Kansas (Univ. Kansas loc. 7712); cen. S. side NE sec. 14, T. 24 S., R. 17 E., Allen county, Kansas (Univ. Kansas loc. 7724); just west of NE cor. sec. 22, T. 24 S., R. 17 E., Woodson county, Kansas (Univ. Kansas loc. 1823); and cen. W. side sec. 36, T. 27 S., R. 16 E., Wilson county, Kansas (Univ. Kansas loc. 1718). The species occurs also in the Stoner ("Olathe") limestone member at Ross

quarry, 1 mile southeast of Ottawa, Franklin county, Kansas (Univ. Kansas loc. 4321); SE sec. 5, T. 17 S., R. 20 E., east of Ottawa, Kansas (Univ. Kansas loc. 6839); cement plant quarry, Fredonia, Wilson county, Kansas (Univ. Kansas loc. 1743); and sec. 12, T. 29 S., R. 15 E., east of Fredonia, Kansas (Univ. Kansas loc. 4846).

Material studied.— This species is represented by approximately 100 corallites, and 12 representative specimens were sectioned for study.

Type.— University of Kansas, specimen no. 5418-21a from the Eudora shale at the Santa Fe railroad cut near Vilas, Kansas.

EXPLANATION OF PLATE 15

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at the bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus milichus Jeffords, n. sp., from the Stanton limestone, Lansing group, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 141

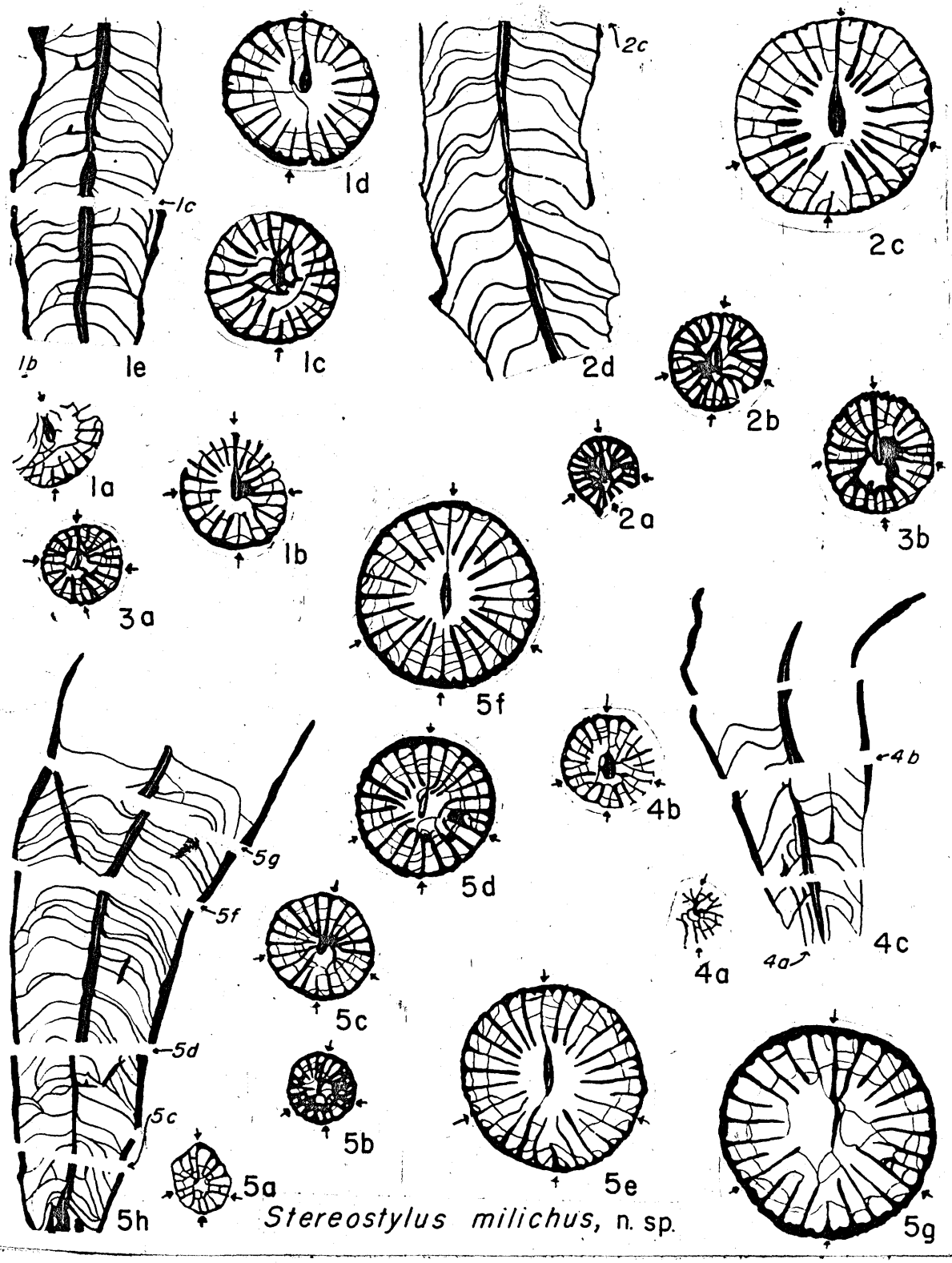
1a-e--Specimen (Univ. Kansas no. 4321-21a) from the Stoner limestone member at Ross Quarry, 1 mile southeast of Ottawa, Franklin county, Kansas. a-d, Transverse sections. e, Longitudinal section.

2a-d--Specimen (Univ. Kansas no. 5418-21d) from the Eudora shale member at Santa Fe railroad cut, near Vilas, Wilson county, Kansas. a-c, Transverse sections. d, Longitudinal section showing the closely spaced tabulae.

3a-b--Transverse sections of specimen (Univ. Kansas no. 4321-21z) from the same locality as figure 1.

4a-c--Specimen (Univ. Kansas no. 4321-21x) from the same locality as figure 1. a-b, Transverse section. c, Longitudinal section.

5a-h--Type specimen (Univ. Kansas no. 5418-21a) from the same locality as figure 2. a-g, Transverse sections. h, Longitudinal section.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Stereostylus milichus, n. sp.

Plate 15

Stereostylus pandatus Jeffords, n. sp.

Plate 16, figures 1-5; text figure 7.

Relatively small cylindrical corallites that are straight or irregularly bent are included in this species. The theca is relatively thin, and it bears fine longitudinal grooves and ridges that are crossed transversely by numerous low wrinkles and growth lines. Radicles occur rarely near the apex. The calyx is not well preserved; presumably it was moderately deep. The type specimen, which represents a mature individual, is 27 mm in length and 6.8 mm in maximum diameter at the calyx. Other specimens commonly are not appreciably larger in diameter although they may be somewhat longer.

The immature region of this coral is relatively free from thickening and stereoplasm. The septa are thin and extend nearly to the column, but they are not joined consistently by stereoplasm. The cardinal septum is only slightly shorter than the metasepta. In mature stages, the major septa extend one-half to two-thirds the distance to the column, and they do not become distinctly rhopaloid. The cardinal septum is slightly shortened, and the counter septum has withdrawn from the column. Sections in the calyx show thin septa that may be connected by tabulae at their inner edges. The septual formula in the apical region of the type specimen about 5 mm above the apex K 3 A 2 C 2 A 4 K, and in the mature stage it is K 6 A 3 C 3 A 6 K. Mature corallites contain about 22 major septa near the calyx. Minor septa occur as low ridges alternating between the major septa in the uppermost parts of the larger corallites.

The axial column is relatively small in proportion to the diameter of the corallite. In the apical region it is oval in outline and

attached to the counter septum. Near the calyx the column is a separate structure that may be irregular in shape. A median lamina is present but radiating laminae are lacking. However, the column may bear irregular projections and intercepts of tabulae so as to appear branching or radiating in transverse section. Tabulae are closely spaced; about 0.5 mm apart. They extend regularly from the periphery to the column, and rarely are they inosculating. The cardinal fossula and alar pseudofossulae are inconspicuous.

Discussion.-- This species is distinguished from S. absitus, n. sp., which occurs also in the Oread formation by the smaller size of the corallites and the thinner skeletal structure. In the mature regions of S. pandatus the counter quadrants are more strongly accelerated than near the apex, just the opposite relationship occurs in S. absitus. The tabulae are closely spaced as in S. milichus, n. sp., but the column is more irregular in form. S. pendatus is separated from S. phainus, n. sp., by the smaller and more cylindrical form and the pattern of the major septa in the mature region.

Occurrence.-- Oread limestone, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous). The type material is from the Plattsmouth limestone member at Hartwell quarry, north of Baldwin, Douglas county, Kansas (Univ. Kansas loc. 4849). Other specimens are from the same member at a quarry NW SW NE sec. 15, T. 15 S., R. 18 E., northwest of Centra, Douglas county, Kansas (Univ. Kansas loc. 8001); Adams quarry, Midland, Kansas (Univ. Kansas loc. 1101); a quarry east of Barnhart, 12 miles west and 2 miles south of Baldwin, Kansas (Univ. Kansas loc. 5027); and at NE sec. 15 T. 15 S., R. 17 E., Douglas county, Kansas, (Univ. Kansas loc. 4977). Also, representatives of this species

occur in the Toronto limestone member, Oread limestone, at the quarry on the west edge of the University of Kansas campus, Lawrence, Douglas county, Kansas (Univ. Kansas loc. 3272); 0.75 mile southwest of "Three Sisters", 6 miles southwest of Lawrence, Kansas (Univ. Kansas loc.7707); quarry at top of hill, 1 mile north of Baldwin, Douglas county, Kansas (Univ. Kansas loc. 4831); quarry in sec. 27, T. 13 S., R. 19 E., southwest of Lawrence, Kansas (Univ. Kansas loc. 4832); and at a quarry on Quayle farm, NW sec. 27, T. 14 S., R. 20 E., 1.5 miles north of Baldwin, Kansas (Univ. Kansas loc. 4830). Most of this material was collected for the Kansas Geological Survey by Arthur Bridwell.

Material studied.— Each of the above localities are represented by numerous corallites so that more than a thousand specimens were available. About 20 representative specimens were sectioned.

Type.— University of Kansas, specimen no. 4849-21d from the Plattsmouth limestone member, Oread limestone, at Hartwell quarry, north of Baldwin, Kansas.

EXPLANATION OF PLATE 16

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus pandatus Jeffords, n. sp., from the Oread limestone, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 147

1a-e--Type specimen (Univ. Kansas no. 4849-21d) from the Plattsmouth limestone member at Hartwell quarry, north of Baldwin, Douglas county, Kansas. a-d, Transverse sections. e, Longitudinal section.

2a-d--Specimen (Univ. Kansas no. 4849-21c) from the same locality as figure 1. a-c, Transverse sections. d, Longitudinal section.

3a-e--Specimen (Univ. Kansas no. 4831-21b) from the Toronto limestone member at a quarry 1 mile north of Baldwin, Kansas. a-d, Transverse sections. e, Longitudinal section.

4a-d--Transverse sections showing slightly irregular nature of the column in specimen (Univ. Kansas no. 1101-21b) from the Plattsmouth limestone member, Adams quarry, Midland, Kansas.

Page

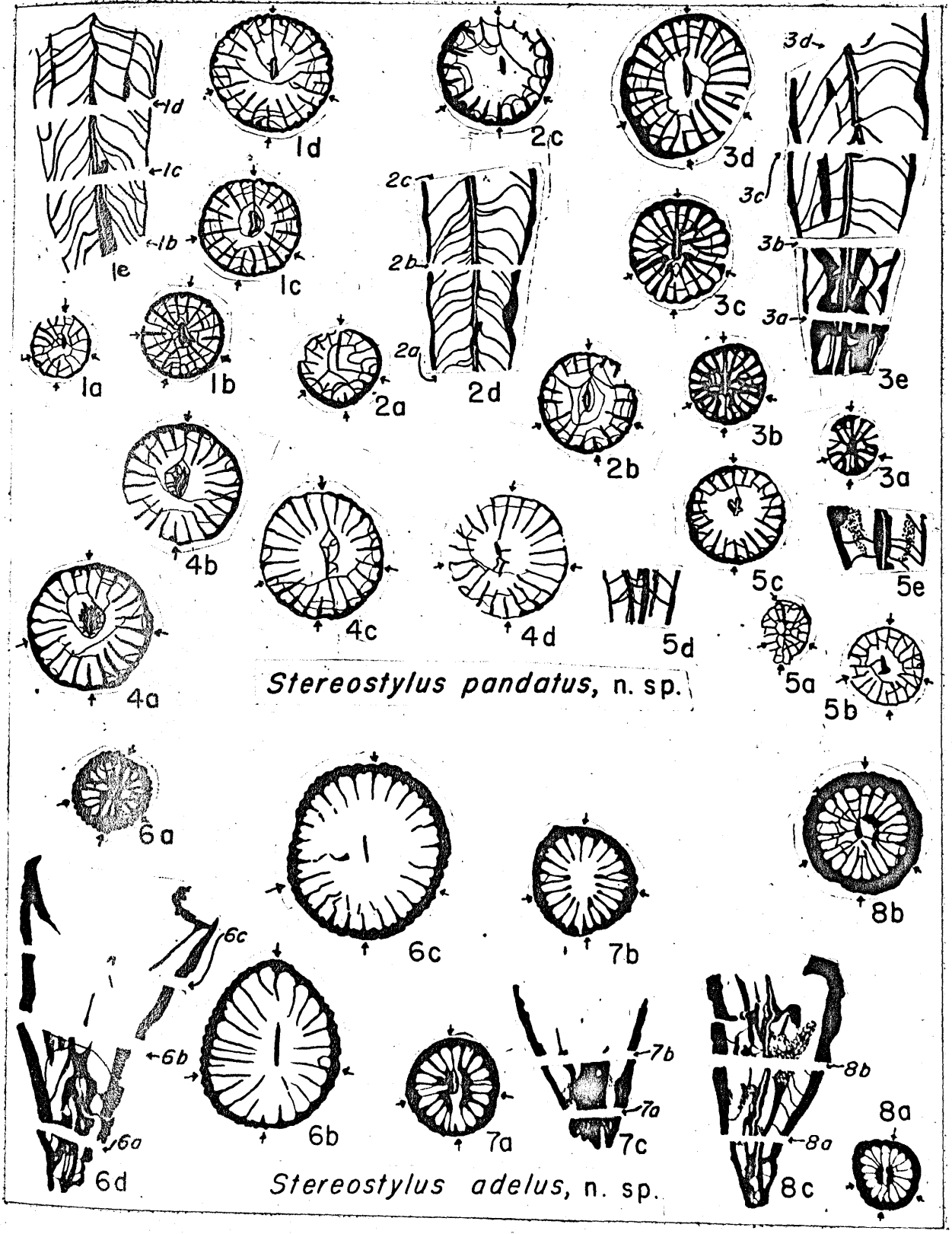
5a-e--Specimen (Univ. Kansas no. 4849-21b) from the same locality as figure 1. a-c, Transverse sections. d-e, Longitudinal sections.

Stereostylus adelus Jeffords, n. sp., from the Strawn (Desmoinesian) series, Pennsylvanian (Upper Carboniferous). - 127

6a-d--Specimen (Univ. Kansas no. 546-21b) from the East Mountain shale, Lone Canyon group, at brick plant quarry, 1 mile east of Mineral Wells, Texas. a-c, Transverse sections. d, Longitudinal section.

7a-c--Specimen (Univ. Kansas no. 7170-21a) from the Millsap Lake group, 3.6 miles east and 1 mile south of Rochelle, Texas. a-b, Transverse sections. c, Longitudinal section.

8a-c--Type specimen (Univ. Kansas no. 546-21a) from the same locality as figure 1. a-b, Transverse sections. c, Longitudinal section.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5d
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5b
Stereostylus pandatus, n. sp.
6a
6c
6c
7b
8b
6b
6b
6a
6d
6b
7a
7b
7a
7c
8b
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8a
8c
Stereostylus adelus, n. sp.

Plate 16

Stereostylus absitus Jeffords, n. sp.

Plate 17, figures 1-7; text figure 7.

The corals included in this species comprise large conical cylindrical corallites that are slightly curved in the lower conical portion. The theca is thick, and it bears narrow septal grooves and broad interseptal ridges. Low wrinkles and growth lines occur irregularly. Radicles are lacking. The calyx is deep and contains the large pointed axial column in the center. The type specimen is 29 mm in length and 11 mm in diameter at the calyx. Other individuals range from much smaller in size to slightly larger.

The apical region contains considerable thickening of the structural elements; septa are thick and joined to the column by stereoplasm. Somewhat higher sections show long septa that are joined together about the column by deposits of stereoplasm, a short cardinal septum, and a counter septum that is continued into the column. In the mature stage, the major septa are very long and distinctly rhopaloid except for the short cardinal septum. The septal formula about 4 mm above the apex of the type specimen is K 5 A 2 C 2 A 4 K. At the base of the calyx the septal formula is K 6 A 4 C 4 A 7 K. Minor septa occur as broad ridges in the mature stage, but they do not become elongated.

The axial column is large throughout the corallite. At the apex it is oval in outline and functionally joined to the counter septum; near the calyx it becomes more circular in outline and proportionately larger. The column is separated from the counter septum only in late maturity or in the calyx. Tabulae are relatively numerous; about 1.3 mm apart. Properly oriented longitudinal sections show tabulae that are inclined regularly from the column to the periphery. In the apical

region the thickened septa and deposits of stereoplasm largely conceal the tabulae. The cardinal fossula is representated by the short cardinal septum, but this structure is not conspicuous. Alar pseudofossulae are distinct in youthful stages but become inconspicuous above.

Discussion.-- This species is characterized by its large size and thickened skeletal elements. Stereostylus absitus resembles S. perversus, n. sp., from the Brownsville limestone in the rhopaloid septa and thick theca, but the former species is less conical in form and has fewer major septa in the mature region. The corallites of S. absitus are larger than those of S. annae, n. sp., and skeletal elements are notably thicker. Comparison of this species with associated corals from the Oread formation is given under description of S. pandatus, n. sp.

Occurrence.-- Oread limestone, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous). The type material is from the Toronto limestone member at a quarry near the top of a hill, 1 mile north of Baldwin, Douglas county, Kansas (Univ. Kansas loc. 4831). Other specimens are from the same horizon in a quarry in sec. 27, T. 13 S., R. 19 E., southwest of Lawrence, Douglas county, Kansas (Univ. Kansas loc. 4832); 0.75 mile southwest of "Three Sisters", 6 miles southwest of Lawrence, Kansas (Univ. Kansas loc. 7707); and a quarry at the west end of the University of Kansas campus, Lawrence, Kansas (Univ. Kansas loc. 3272). This species was identified also in the Plattsmouth limestone member, Oread limestone, from a quarry east of Barnhart, 12 miles west and 2 miles south of Baldwin, Kansas (Univ. Kansas loc. 5027); and at Hartwell quarry, north of Baldwin, Kansas (Univ. Kansas loc. 4849). Much of this material was collected by Arthur Bridwell.

Material studied.-- The collection includes several hundred representatives of this species, especially from the outcrops of the Toronto

limestone. About 15 corallites were found among the sectioned material.

Type.-- University of Kansas, specimen no. 4831-21E from the Toronto limestone, 1 mile north of Baldwin, Kansas.

EXPLANATION OF PLATE 17

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus absitus Jeffords, n. sp., from the Oread limestone, Shawnee group, Virgilian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 153

1a-e--Specimen (Univ. Kansas no. 4849-21a) from the Plattsmouth limestone member at Hartwell quarry, north of Baldwin, Douglas county, Kansas. a-d, Transverse sections. e, Longitudinal section.

2a-d--Specimen (Univ. Kansas no. 4831-21d) from the Toronto limestone member at a quarry, 1 mile north of Baldwin, Kansas. a-c, Transverse sections. d, Longitudinal section.

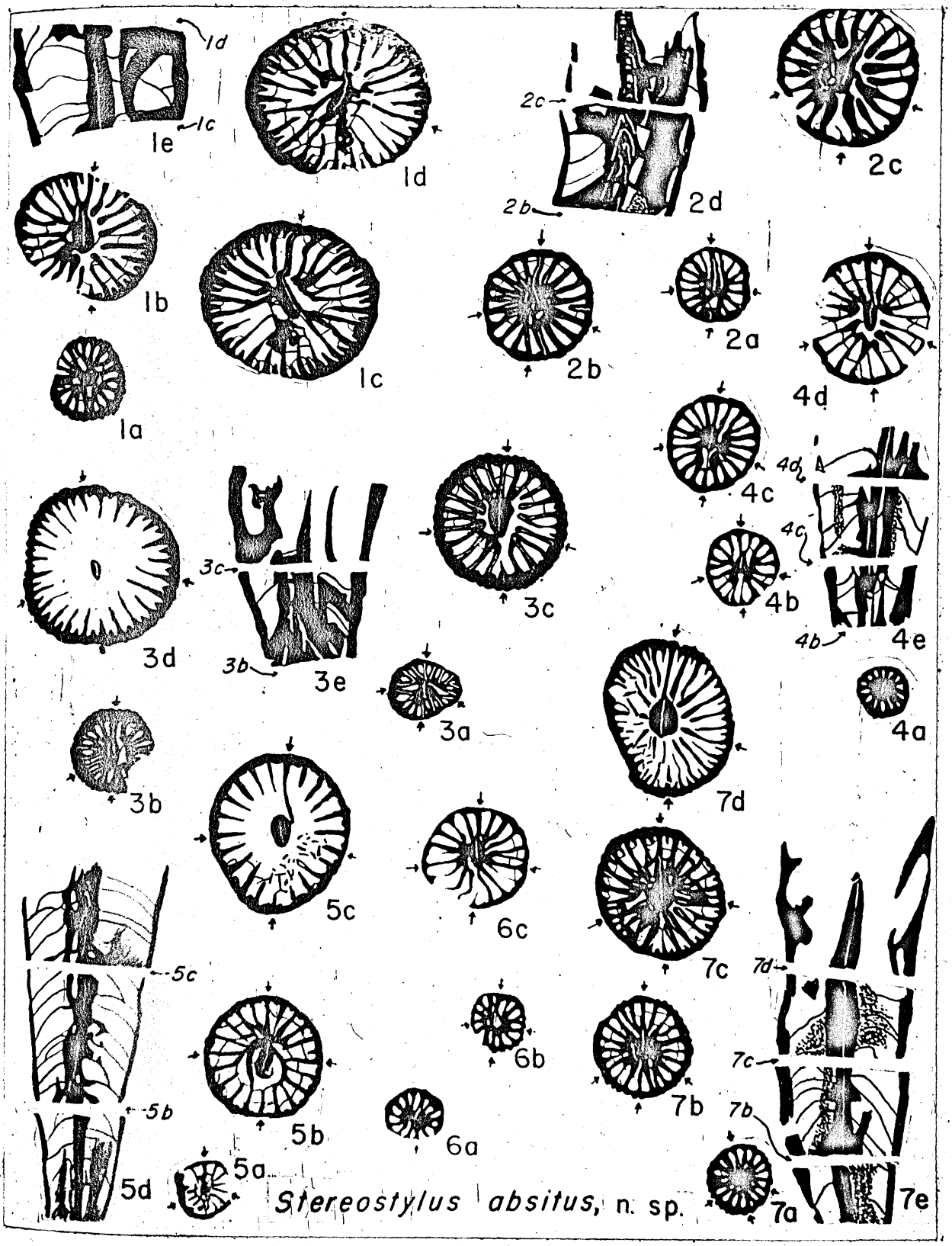
3a-e--Specimen (Univ. Kansas no. 4831-21c) from the same locality as figure 2. a-d, Transverse sections. e, Longitudinal section.

4a-e--Specimen (Univ. Kansas no. 7707-21e) from the Toronto limestone member, 0.75 mile southwest of "Three Sisters", 6 miles southwest of Lawrence, Douglas county, Kansas. a-d, Transverse sections. e, Longitudinal section.

5a-d--Specimen (Univ. Kansas no. 5027-21b) from the Plattsmouth limestone member at a quarry east of Barnhart, 12 miles west and 2 miles south of Baldwin, Kansas. a-c, Transverse sections. d, Longitudinal section.

6a-c--Transverse sections of specimen (Univ. Kansas no. 7707-21b) from the same locality as figure 4.

7a-e--Type specimen (Univ. Kansas no. 4831-21e) from the same locality as figure 2. a-d, Transverse sections. e, Longitudinal section.



Stereostylus absitus, n. sp.

Plate 17

EXPLANATION OF PLATE 18

(All figures 3 times natural size.)

Page

Stereostylus pelaeus Jeffords, n. sp., from the Missourian series, Pennsylvanian (Upper Carboniferous). - 127

1--Specimen (Univ. Kansas no. 154-21f) from the Francis formation, sec. 4, T. 3 N., R. 6 E., Ada, Oklahoma.

7--Specimen (Univ. Kansas no. 154-21e) from the same locality as figure 1.

Stereostylus perversus Jeffords, n. sp., from the Dover and Brownsville limestones, Wabaunsee group, Virgilian series, Pennsylvanian (Upper Carboniferous). - 167

2--Specimen (Univ. Kansas no. 5997-21b) from the Brownsville limestone at Admire Junction, 0.5 mile north of Admire, Lyons county, Kansas.

Stereostylus lenis Jeffords, n. sp., from the Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - - - - - - - 114

3--Specimen (Univ. Kansas no. 7176-21f) from the Frisbie limestone member, Wyandotte limestone, at 33d. and Roanoke quarry, Kansas City, Missouri.

4--Specimen (Univ. Kansas no. 7176-21h) from the same locality as figure 3.

6--Specimen (Univ. Kansas no. 7176-21g) from the same locality as figure 3.

Stereostylus phainus Jeffords, n. sp., from the Drum limestone, Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous).- - - - 129

5--Specimen (Univ. Kansas no. 4987-21b) from a highway cut, SW NW sec. 5, T. 33 S., R. 16 E., 1 mile southeast of Independence, Montgomery county, Kansas.

Plate 18

Stereostylus annae Jeffords, n. sp.

Plate 19, figures 1-6; text figure 7.

Small conical corallites having a slightly to strongly curved form comprise this species. The theca is relatively thick and bears sharp septal grooves and ridges; transverse wrinkles are widely spaced. Commonly, the convex side of the apical portion is thickened or bears very short radicles for attachment; some corallites are attached to a crinoid columnal, brachiopod shell, or other hard object by a relatively large area of the corallite. The calyx is deep and contains a spikelike column at the axis. The type specimen, which represents approximately the average size of the corallites, is 16.5 mm in length and 7 mm in diameter at the calyx.

The apical tip of the corallites is essentially solid, due to thickening of the septa. Slightly higher sections show long major septa that may be joined together at their axial edges by stereoplasm, a short cardinal septum, and a long counter septum that is thickened axially to form the column. The septa in mature regions are irregular in length, and at the calyx the counter septum is separated from the column. Minor septa occur in a rudimentary manner only in the largest of the corallites. The septal formula near the apex of the type specimen is K 4 A 2 C 2 A 4 K, and at the calyx it is K 5 A 3 C 3 A 5 K.

The axial column is thin and laterally compressed throughout the corallite. Separation from the counter septum occurs only in advanced stages of development. The median lamina can be traced from the column into the counter septum in early maturity, but these laminae are discontinuous above this stage. Tabulae are relatively numerous, and they rise at an angle of about 45 degrees from the periphery to the inner

edges of the septa where they flatten slightly. The cardinal fossula is indicated by the short cardinal septum but it is not conspicuous. Alar pseudofossulae are weakly developed in the apical region.

Discussion.-- This species is represented by small conical corallites that seem restricted to the Howard limestone. Whereas the theca is moderately thick, septa are thin and stereoplasmic filling is mostly lacking. Stereostylus annae resembles S. lenis, n. sp., in the thinness of the structural elements but the corallites are shorter and more conical in form. Also, the cardinal septum is consistently longer in S. annae.

This species is named for my wife, Ann, in acknowledgment of her assistance in the study of lophophyllidid corals.

Occurrence.-- Howard limestone, Wabaunsee group, Virgilian series, Pennsylvanian (Upper Carboniferous). The type material was collected by R. M. Jeffords and Allen Graffham from a mine dump, east of U. S. Highway 50N. at the southwest edge of Osage City, Osage county, Kansas (Univ. Kansas loc. 7717). Other specimens were collected by Arthur Bridwell at SW sec. 20, T. 14 S., R. 16 E., Osage county (Univ. Kansas loc. 8129), and by R. M. Jeffords from a strip pit south of U. S. Highway 50N, 10 miles west of junction of U. S. Highways 75 and 50N, Osage county, Kansas (Univ. Kansas loc. 7716).

Material studied.-- The type locality is representated by about 75 corallites and the other localities by about 15 specimens. Eight corals were sectioned for study.

Type.-- University of Kansas, specimen no. 7717-21a from Osage City, Kansas.

EXPLANATION OF PLATE 19

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus annae Jeffords , n. sp., from the Howard limestone, Wabaunsee group, Virgilian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - 162

1a-d--Specimen (Univ. Kansas no. 7717-21c) from the same locality as the type specimen, a mine dump east of U. S. Highway 50N at southwest edge of Osage City, Osage county, Kansas. a-c, Transverse sections. d, Longitudinal section.

2a-b--Transverse sections of specimen (Univ. Kansas no. 7717-21m) from the same locality as figure 1.

3a-c--Transverse sections of specimen (Univ. Kansas no. 7717-21e) from the same locality as figure 1.

4a-f--Type specimen (Univ. Kansas no. 7717-21a) from the same locality as figure 1. a-e, Transverse sections. f, Longitudinal section.

Page

5a-d--Specimen (Univ. Kansas no. 7717-21b) from the same locality as figure 1. a-c, Transverse sections. d, Longitudinal section.

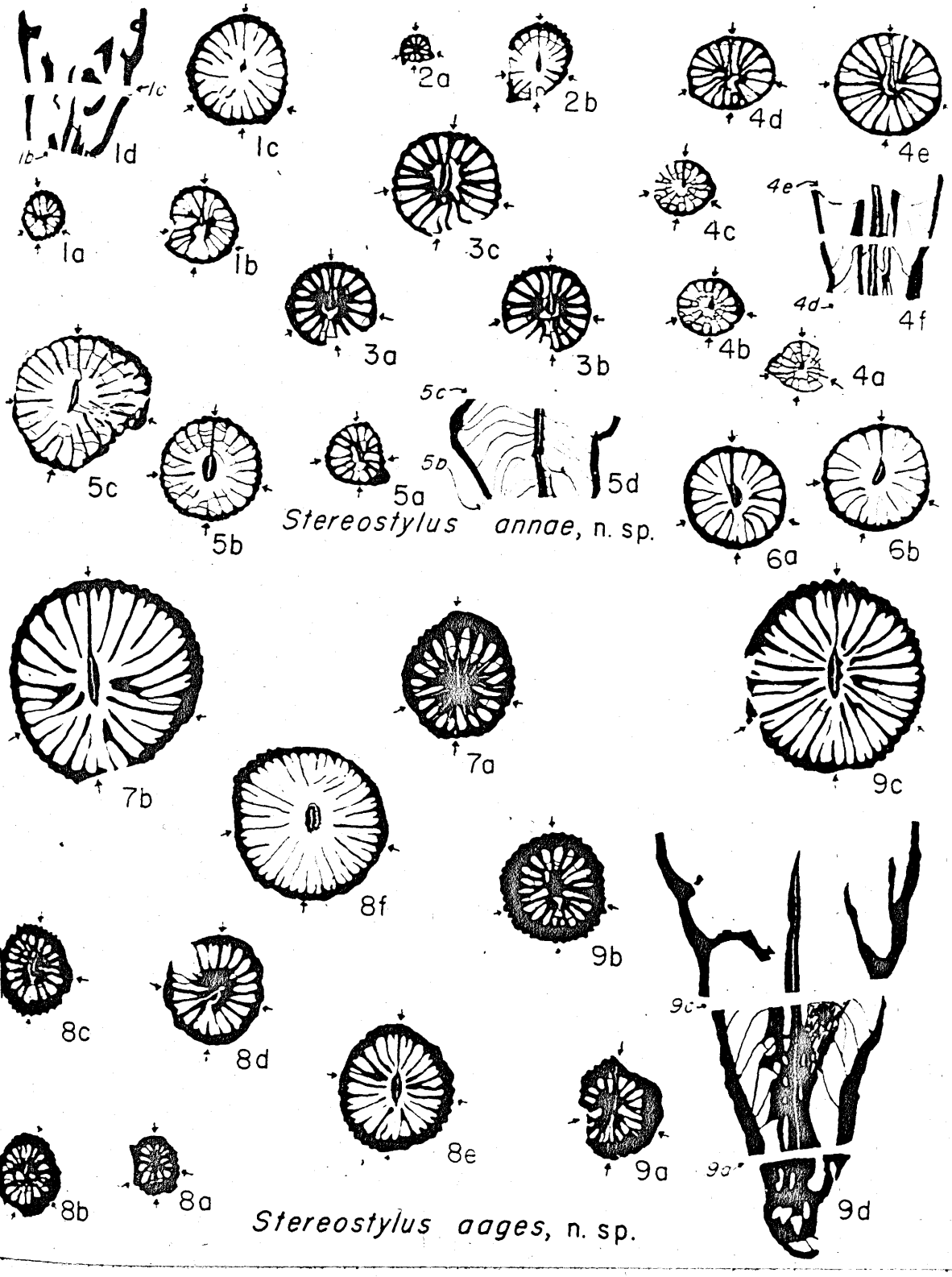
6a-b--Transverse sections of specimen (Univ. Kansas no. 7717-21d) from the same locality as figure 1.

Stereostylus aages Jeffords, n. sp., from the Ardmore limestone, Cherokee group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). - - - - - - - 124

7a-b--Transverse sections of specimen (Univ. Kansas no. 7781-21a) from a road cut along W. line NE SW sec. 27, T. 74 N., R. 22 W., 1 mile south of Lacona, Iowa.

8a-f--Transverse sections of specimen (Univ. Kansas no. 7502-21a) from NE SW SW sec. 14, R. 74 N., R. 22 W., Warren county, Iowa.

9a-d--Type specimen (Univ. Kansas no. 7779-21a) from bank of Whitebreast Creek, NW NW NE sec. 33, T. 73 N., R. 22 W., Lucas county, Iowa. a-c, Transverse sections. d, Longitudinal section.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Stereostylus annae, n. sp.
6a
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7b
7a
9c
8f
9b
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8d
9c
8e
9a
9d
9a
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8a
Stereostylus aages, n. sp.

Plate 19

Stereostylus perversus Jeffords, n. sp.

Plate 18, figure 2; plate 20, figures 1-5; text figure 7.

This species comprises small to medium-sized conical corals that are slightly curved, particularly near the apex. The theca, which is thick, bears longitudinal markings of distinct septal grooves and ridges that are crossed transversely by numerous growth lines and narrow wrinkles. Radicles are not observed on any of the specimens. The calyx is deep where preserved. The incomplete type specimen is 14 mm in length and 17.6 mm in maximum diameter at the top of the calyx. A few of the corallites reach a somewhat larger size.

These corals are characterized by a considerable dilation of the skeletal elements; the apical region commonly is open only in the interseptal spaces midway between the theca and axis. The septa are joined about the column except for the somewhat shortened cardinal septum. In the mature region the septa are long and distinctly rhopaloid; a few may be slightly shorter than the others. The cardinal septum is about one half the length of other septa, and the counter septum may be joined to the column. Near the calyx the septa become thin and unequal in length; the counter septum is not distinguished in length from the metasepta. Minor septa occur as rudimentary ridges in the mature stages. The septal formula for the upper part of the type specimen is K 6 A 4 C 4 A 5 K. The septal formula of a larger individual is K 7 A 4 C 4 A 8 K.

The column in the apical region is formed by a thickening and elongation of the counter septum, and it is oval in cross-section. The column becomes more cylindrical and larger in relation to the corallite progressively upward and near the calyx it is separated from the counter septum.

Tabulae are numerous and slightly inosculating except just below the calyx where they become regularly spaced. The cardinal fossula is indicated by the shortened cardinal septum, although the fossula does not form a conspicuous open space. Alar pseudofossulae are moderately well developed in the youthful stages but disappear later.

Discussion.-- This species is characterized by relatively broad conical corallites having a large axial column. Alar pseudofossulae are not as well marked as in Stereostylus pelaeus, n. sp., and major septa are more numerous than in S. absitus, n. sp. A single specimen of coral from the Dover limestone (pl. 20, fig. 1) is tentatively included in this species inasmuch as it is similarly thickened. The corallite, however, shows somewhat longer minor septa as well as other minor differences.

Occurrence.-- Brownville limestone, Wabaunsee group, Virgilian series, Pennsylvanian (Upper Carboniferous). The type specimens were collected by R. C. Moore and others at Admire Junction, 0.5 mile north of Admire, Lyon county, Kansas (Univ. Kansas locs. 2175, 3405, and 4776). Other corallites were collected by R. C. Moore 7 miles southwest of Strohm, Oklahoma (Univ. Kansas loc. 5997); by M. H. Wallace at NE sec. 31, T. 18 S., R. 11 E., Lyon county, Kansas (Univ. Kansas loc. 7574); and by R. M. Jeffords at NW cor. sec. 21, T. 16 S., R. 12 E., Lyon county, Kansas (Univ. Kansas loc. 1277). A single corallite collected by R. M. Jeffords (Univ. Kansas loc. 8130) from the Dover limestone, Wabaunsee group, along U. S. Highway 50N, 3.8 miles east of Admire, is tentatively assigned to this species.

Material studied.-- About 30 specimens, mostly from the type locality, are contained in the collection, and 8 representative corallites were sectioned for study.

Type.— University of Kansas, specimen no. 3405-21f, from Admire Junction, Kansas.

EXPLANATION OF PLATE 20

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Stereostylus perversus Jeffords, n. sp., from the Brownsville and Dover limestones, Wabaunsee group, Virgilian series, Upper Pennsylvanian (Upper Carboniferous). - 167

1a-b--Transverse sections of specimen (Univ. Kansas no. 8130-21a) from the Dover limestone along U. S. Highway 50N, 3.8 miles east of Admire, Lyons county, Kansas.

2a-c--Type specimen (Univ. Kansas no. 3405-21f) from the Brownsville limestone at Admire Junction, 0.5 mile north of Admire, Kansas. a-b, Transverse sections. c, Longitudinal section.

3a-d--Specimen (Univ. Kansas no. 3405-21c) from the same locality as figure 2. a-c, Transverse sections. d, Longitudinal section.

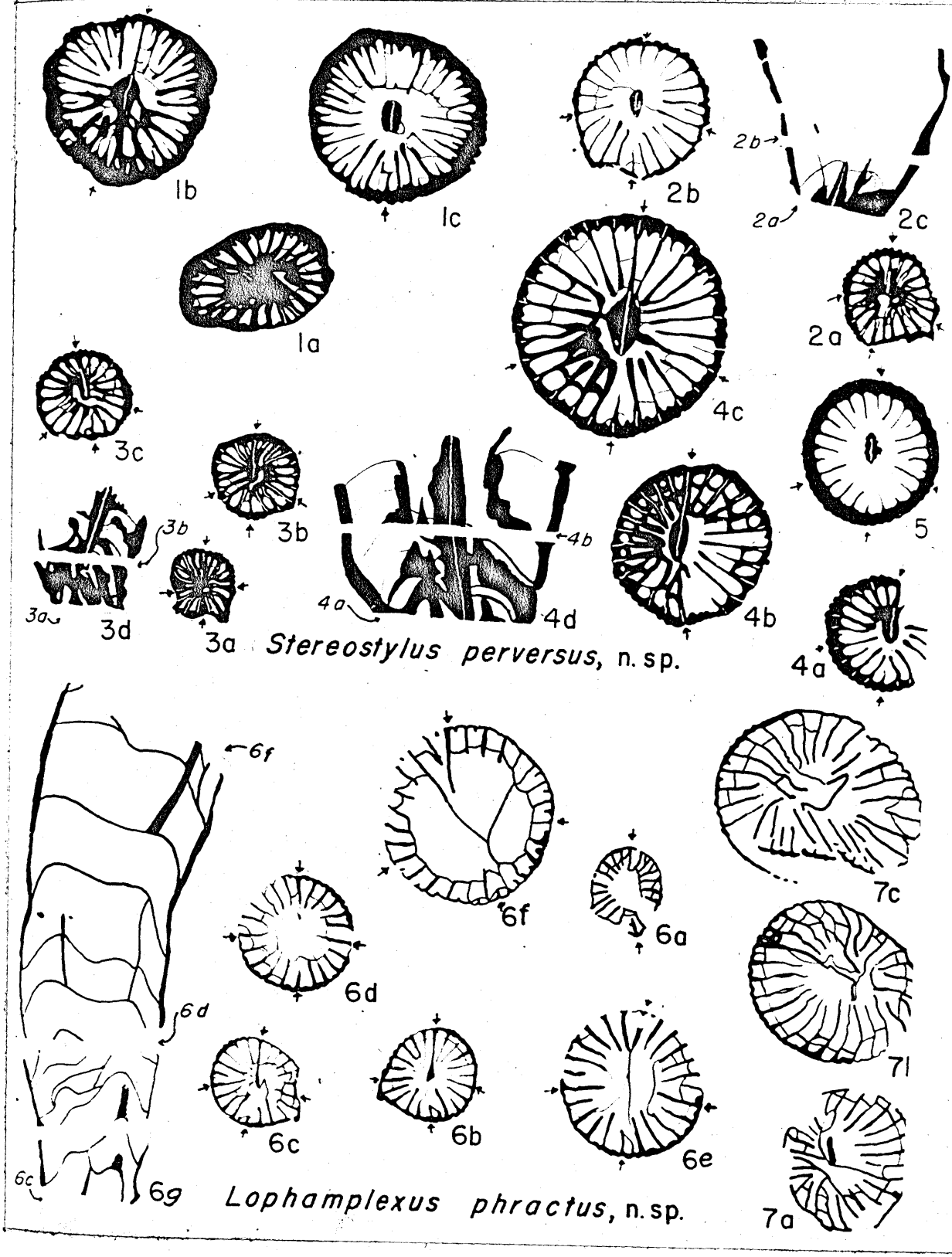
4a-d-- Specimen (Univ. Kansas no. 3405-21e) from the same locality as figure 2. a-c, Transverse sections. d, Longitudinal section.

5--Transverse section in the calyx of specimen (Univ. Kansas no. 3405-21b) from the same locality as figure 2.

Lophamplexus phractus Jeffords, n. sp., from the horizon of the Stoner-Eudora members, Stanton limestone, Lansing group, Missourian series, Pennsylvanian (Upper Carboniferous), at NE cor. sec. 27, T. 24 S., R. 17 E., near Piqua, Woodson county, Kansas. - 199

6a-f--Type specimen (Univ. Kansas no. 1877-21a). a-e, Transverse sections. f, Longitudinal section in which the axial column is seen only near the base of the section.

7a-c--Transverse sections of a slightly crushed specimen (Univ. Kansas no. 1877-21b).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3a
4d
Stereostylus perversus, n. sp.
6f
6f
7c
6a
6d
6d
7l
6c
6b
6e
6c
6g
Lophamplexus phractus, n. sp.
7a

Plate 20

Genus LOPHAMPLEXUS Moore and Jeffords, 1941

Corals assigned to this genus comprise solitary conical to conico-cylindrical, straight, curved, or irregularly bent corallites of moderate size. The well developed theca bears distinct septal grooves and interseptal ridges, and is marked transversely by fine growth lines and low wrinkles. Rejuvenation may occur in mature corallites. In the immature region of the corallites, major septa extend to the thickened inner edge of the counter septum; minor septa are lacking. The counter quadrants are moderately accelerated. Somewhat above the apex the cardinal septum is shortened and lies in an open fossula, but the counter septum is long and thickened at the inner edge so as to form the strong axial column. A median lamina, which is continuous from the counter septum through the column, is observed in most specimens but radiating laminae are absent. Numerous tabulae rise steeply from the theca but tend to flatten out as they join the axial column. The mature portion of the corallite is characterized by a marked shortening of the septa and a disappearance of the axial column. Complete or incomplete tabulae extend across the interior of the corallite at more or less regular intervals. These tabulae rise steeply from the periphery but become subhorizontal or sagging within the inner edges of the major septa. Minor septa may be present as low ridges alternating between the major septa, or they may be entirely lacking.

Genotype.-- Lophamplexus eliasi Moore and Jeffords (1941), Wolfcampian, Permian, Kansas and Oklahoma.

Discussion.-- An "amplexoid" or breviseptal phase that is characterized by short septa, regularly spaced tabulae, and an absence of dissepiments seems to be a specialized phase reached independently by

corals along several phylogenetic lines. The genotype of Amplexus, A. coralloides Sowerby (1814, p. 165), is incompletely known, so that its relationships are in doubt. Ampleximorphs, however, are reported to have developed from "Zaphrentis" and Columnaria by Weissermel (1897), Plerophyllum and Pentaphyllum by Schindewolf (1940), Allotropiophyllum by Hill (1940), and "zaphrentids" by Easton (1945a). Lophamplexus seems certainly to be derived from corals belonging to Stereostylus or to forms ancestral to that genus.

Lophamplexus was proposed to include Permian lophophyllidid corals in which the axial column was discontinuous in the mature region, and Morrowan corals were referred to this genus in a later paper. The additional knowledge of these corals in which the corallite develops from a youthful lophophyllidoid phase to a mature breviseptal phase lacking a column indicates a wide variation in the structural features of the species. Some species referred to Lophamplexus have a persistent lophophyllidoid development, whereas in other forms the lophophyllidoid stage is abbreviated and the cylindrical amplexoid characters are pronounced. Ontogenetic study of these corals indicates that the appearance of the breviseptal phase relates to the specialization of the species. Thus, advanced species are characterized by a restriction of the lophophyllidoid characters to a very small apical portion and by a strong development of the breviseptal phase. The tabulae are regularly spaced, arched at the periphery, horizontal in the axial region, and mostly complete in the highly developed species. The degree of specialization, however, is not related to stratigraphic occurrence. Advanced species, such as L. brevifolius, n. sp., L. phractus, n. sp., and L. vagus, n. sp., occur in Desmoinesian and Missourian rocks, whereas

structurally less advanced forms, such as L. spanius, n. sp., and L. eliasi Moore and Jeffords, occur in Virgilian and Lower Permian rocks, respectively. It seems probable, therefore, that the species included in Lophamplexus are polyphyletic in origin and developed independently and at different times from Stereostylus. Thus, the degree of specialization can not be used reliably as an indication of stratigraphic horizon.

Smith and Lang (1930, p. 179) have shown that one or more corallites of a corallum may develop distinctive characters. One such genomorphic group comprises normal corallites of Lithostrotion and also individuals in which the column is lacking (diphymorphs). The occurrence of similar variation in solitary rugose corals is less easily determined inasmuch as the ancestry of these corallites can not be identified as certainly as in the case of a colonial form. The consistent occurrence of the characters ascribed to Lophamplexus in large numbers of corallites from single localities, as well as the areal distribution of several of the species, suggests strongly that these characters are of generic importance.

The apical portion of corallites assigned to this genus has a structure like that of Stereostylus, whereas a mature region of varying duration shows distinct breviseptal characters and the absence of an axial column. Thus, longitudinal and transverse sections made in this portion of the corallite resemble closely the structures of Amplexus Sowerby (1814) and Amplexocarinia Soschkina (1928). However, Amplexocarinia has been interpreted (Moore and Jeffords, 1945, p. 140) as lacking lophophyllidoid characters in the apical region, and as having the immature region restricted to an extremely small part of the corallite.

The discovery of corals in which the lophophyllidoid characters are well developed, although confined to a few millimeters of the corallite, as in Lophamplexus brevifolius, n. sp., suggests that Amplexus corrugatus Mather (1951) from Morrowan rocks of Oklahoma may belong with Lophamplexus rather than with Amplexocarinia as was concluded previously (Moore and Jeffords, 1945, p. 142). Lophamplexus is distinguished readily from Lophophyllidium, Stereostylus, and other lophophyllidid genera by the absence of the column in the mature portion of the corallite and by the tendency for all the major septa to become distinctly shortened (text fig. 4).

Identification of Lophamplexus is made largely by characters shown in longitudinal sections. Such sections may be cut obliquely in other genera, however, so as to conceal the presence of the column. Moreover, transverse sections through the calyx of many species of Stereostylus show shortened septa (incompletely developed), and the column may be lacking in the uppermost portion of the calyx. In properly oriented sections of Lophamplexus, however, the axial column can be observed to terminate below the floor of the calyx which is formed by tabulae. Careful examination of the transverse sections in the upper portion of the same or another corallite furnishes a check on whether the column actually disappears or was missed by an oblique section.

Occurrence.— Pennsylvanian (Morrowan to Virgilian) and Lower Permian (Wolfcampian); Kansas, Oklahoma, and Missouri.

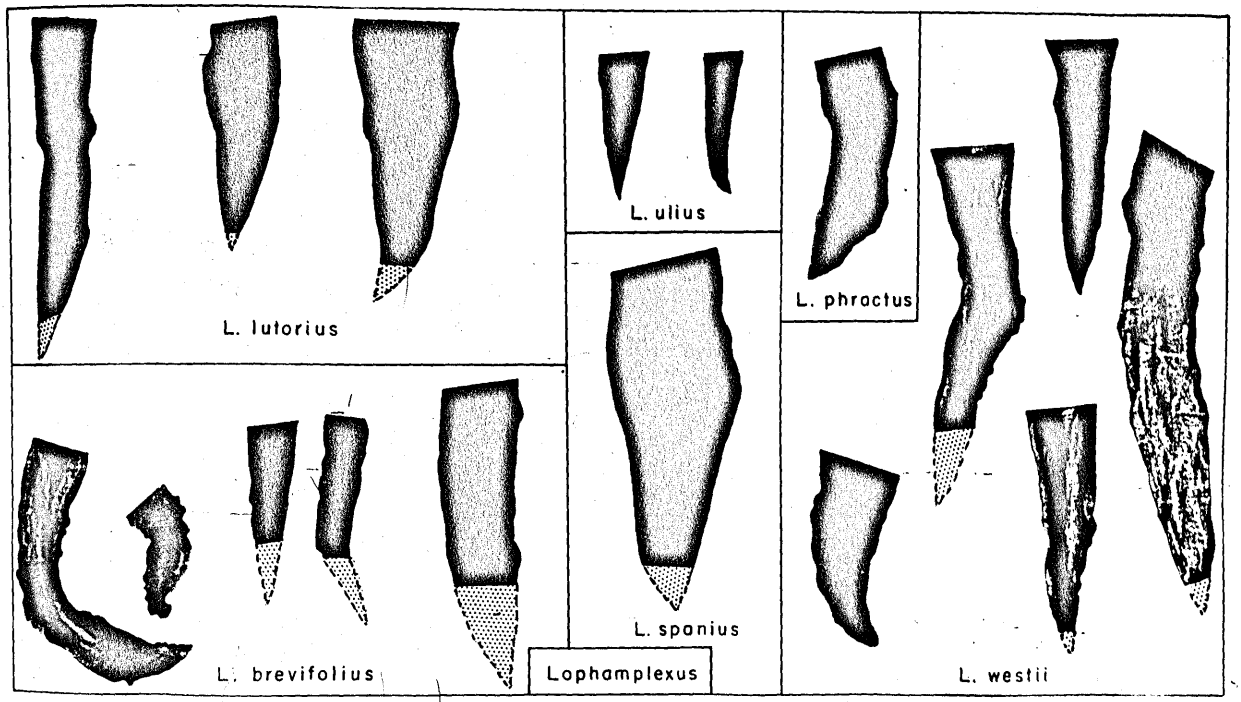


Figure 9. Outline drawings at natural size prepared from photographs of described species of Lophamplexus showing the form, variation, and relative size of the corallites. The stippled portions indicate probable restoration of incomplete specimens.

Lophamplexus brevifolius Jeffords, n. sp.

Plate 21, figures 1-16; plate 23, figures 2 and 6; text figures 4 and 9.

Large cylindrical corallites that may be slightly bent in an irregular manner are included in this species. The theca, which is relatively thin, bears sharp ridges and septal grooves, numerous prominent growth lines, and a few low transverse wrinkles. Short radicles occur near the apex. The calyx has relatively thin walls so that it is not well preserved; seemingly it was steep-sided and flat across the floor. The type specimen is a relatively small corallite, 28.5 mm in length and 8.5 mm in maximum diameter. The maximum observed length is 45 mm for an incomplete corallite, and the maximum diameter in another specimen is 16 mm.

This species is characterized by a very rapid development from the lophophyllidoid to breviseptal stage, so that lophophyllidoid characters are not apparent more than about 10 mm above the apex. Transverse sections in this portion of the corallite show a long counter septum, which is thickened axially, and major septa that reach nearly to the column. The cardinal septum is not notably shortened. A few millimeters higher the major septa are shortened appreciably, and they are joined at their inner edges by uparched tabulae. The counter septum is long and not thickened. Sections in the breviseptal region just above this stage show short major septa that extend only about one fourth the distance to the axis, a slightly shortened cardinal septum, and a counter septum that is equal in length to other major septa. Major septa, excepting the counter septum, are not thickened or rhopaloid at any stage in development. Minor septa appear only as low ridges alternating between

the major septa in mature regions. The septal formula, indicating the strong counter acceleration, is K 5 A 2 C 2 A 5 K for the type specimen. Transverse sections through the corallite just below the calyx show about 25 to 30 major septa.

The axial column persists only a short distance upward from the apex and has not been observed to separate from the counter septum. The tabulae rise steeply from the periphery and flatten out abruptly in the axial area between the inner edges of the septa; in the apical region they terminate against the column but later they are relatively horizontal within the axial edges of the septa. The regular nature of the tabulae is indicated by the uniformity of the intercepts in transverse section where they seem to form an inner wall at differing distances from the theca. The cardinal fossula is scarcely distinguished, and alar pseudofossulae are not larger than other interseptal spaces.

Discussion.-- This species is distinguished readily from other species assigned to Lophamplexus by the much shortened duration of the lophophyllidoid stage in relation to the breviseptal period. L. brevifolius resembles L. westii (Beede) in length and cylindrical form of the corallite but differs in the rare occurrence of rejuvenation and in rapid and persistent change to the breviseptal stage. The much smaller corals that were called Amplexocarinia corrugata (Mather) by Moore and Jeffords (1945, p. 142) are characterized also by a long breviseptal stage and the restriction of the immature region to the very apical part of the corallite. L. brevifolius is distinguished, however, by its much larger size and the pronounced lophophyllidid character of the immature region.

The corallites of this species occur commonly as fragments that rarely have the lophophyllidoid stage preserved. Such fragments give

little indication of the generic relationships. However, the large size and cylindrical form permit recognition of the species.

Occurrence.— Marmaton group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). The type material was collected by R. C. Moore, J. M. Jewett, and others from the Oologah limestone at Garnett Quarry, sec. 28, T. 20 N., R. 14 E., northeast of Tulsa, Oklahoma (Univ. Kansas loc. 1053). Other specimens were collected from the Fort Scott limestone at Claremore, Rogers county, Oklahoma by W. M. Furnish (Univ. Kansas loc. 7727); the Altamont limestone at a ford 1 mile east of Uniontown, Bourbon county, Kansas by J. W. Beede (Univ. Kansas loc. 4424); and from the base of the Oologah limestone, cen. north side sec. 2, T. 19 N., R. 14 E., near Tulsa, Okla. (Univ. Kansas loc. 3257).

Material studied.— About 250 well preserved specimens were available from the Garnett quarry, and about 15 specimens from the other localities. In all, 35 corallites were sectioned for study.

Type.— University of Kansas, specimen no. 1053-22E from the Oologah limestone at Garnett quarry, northeast of Tulsa, Okla.

EXPLANATION OF PLATE 21

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Lophamplexus brevifolius Jeffords, n. sp., from the Marmaton group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - 178

1a-g--Transverse sections of specimen (Univ. Kansas no. 1053-22r) in which the lophophyllid characters extend higher in the corallite than normal. Collected from the Oologah limestone, Garnett quarry, northeast of Tulsa, Oklahoma.

2a-b--Apical portion of specimen (Univ. Kansas no. 1053-22b) from the same locality as figure 1. a, Transverse section. b, Longitudinal section showing the axial column just below the lowermost tabula.

3--Transverse section of the breviseptal phase in a large corallite (Univ. Kansas no. 1053-22h) from the same locality as figure 1.

4a-b--Specimen (Univ. Kansas no. 1053-23b) from the same locality as figure 1. a, Transverse section. b, Longitudinal section showing the constriction at the top caused by rejuvenation. The axial column reappears immediately above some of the tabulae.

5a-h--Specimen (Univ. Kansas no. 7727-21a) from the Ft. Scott limestone at Claremore, Oklahoma. a-f, Transverse sections illustrating the transition from a lophophyllidoid to a breviseptal stage. g-h, Longitudinal sections.

6a-e--Transverse sections spaced about 1 mm apart in the apical region of specimen (Univ. Kansas no. 1053-23f) from the same locality as figure 1.

7--Longitudinal section of specimen (Univ. Kansas no. 1053-22s) from the same locality as figure 1.

8a-c--Specimen (Univ. Kansas no. 1053-22d) from the same locality as figure 1. a-b, Transverse sections. c, Longitudinal section indicating the regular spacing of the tabulae.

9a-c--Specimen (Univ. Kansas no. 1053-21i) from the same locality as figure 1. a-b, Transverse sections in the breviseptal region. c, Longitudinal section.

10--Transverse section in the apical region of specimen (Univ. Kansas no. 1053-22f) from the same locality as figure 1.

11--Transverse section of a large corallite (Univ. Kansas no. 1053-22m) from the same locality as figure 1. The long septa indicate that the section is immediately above a tabula.

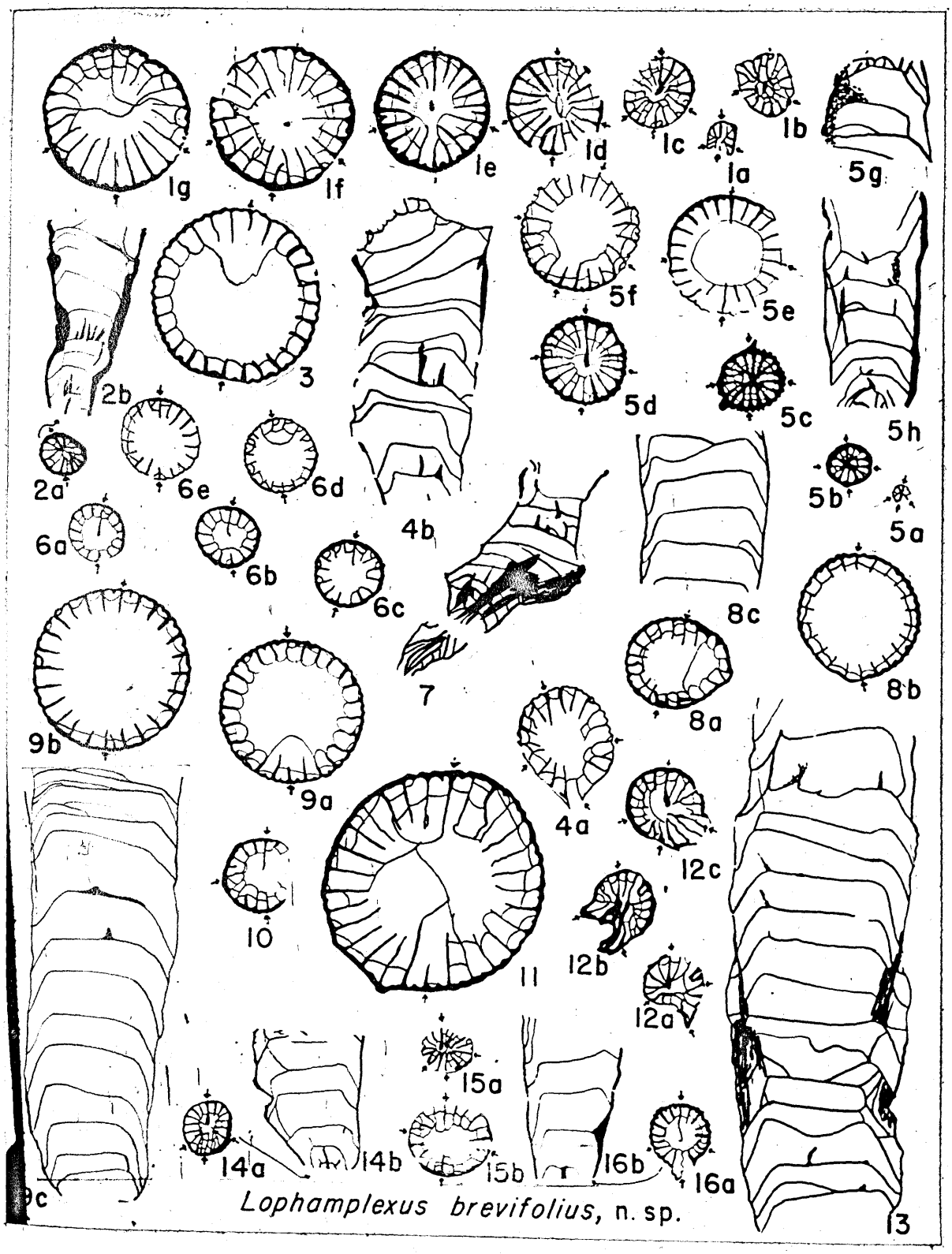
12a-c--Transverse sections about 1.5 mm apart in specimen (Univ. Kansas no. 1053-23d) from the same locality as figure 1.

13--Longitudinal section of specimen (Univ. Kansas no. 1053-22p) from the same locality as figure 1.

14a-b--Type specimen (Univ. Kansas no. 1053-22e) from the same locality as figure 1. a, Transverse section in the apical region. b, Longitudinal section showing disappearance of the lophophyllidoid characters in the breviseptal phase.

15a-b--Transverse sections of specimen (Univ. Kansas no. 1053-23a) from the same locality as figure 1.

16a-b--Specimen (Univ. Kansas no. 1053-22c) from the same locality as figure 1. a, Transverse section. b, Longitudinal section showing short axial column at the base.



Lophamplexus brevifolius, n. sp.

Plate 21

Lophamplexus westii (Beede)

Plate 22, figures 1-8; plate 23, figures 4-5; text figure 9

Amplexus westii BEEDE, 1898, Kansas Univ. Quart., vol. 7, p. 17, pl. 1.

Lophophyllum westi [sic] BEEDE, 1900, Kansas Geol. Survey, vol. 6, p. 18, pl. 2, figs. 8-8b, pl. 3, fig. 12, and pl. 5, fig. 7.

Lophophyllum distortum GIRTY, 1915, Missouri Bur. Geol. and Mines, ser. 2, vol. 13, pp. 318-320.

[not] Cyathaxonia distorta WORTHEN, 1875, Illinois Geol. Survey, vol. 6, p. 526, pl. 32, fig. 4.

This species includes long cylindrical corallites that are straight or gently to markedly bent. The relatively thin theca bears broad low interseptal ridges, sharply incised septal grooves, and rather closely spaced prominent transverse wrinkles and growth lines. A few corallites bear short projections or radicles which are confined to one side of the apical region and seem to have served to attach the corallite to the substratum. The calyx is not well preserved in the available material; seemingly it was moderately deep and the floor was approximately flat. The incomplete type specimen, which is a relatively small individual, has a maximum diameter of 9 mm and a length of 26 mm. The largest corallite, which is nearly complete, is 60 mm in length. The corallites average about 40 mm in length. Most of the specimens are abruptly constricted one or more times as a result of rejuvenation and may be bent abruptly at such points. This rejuvenation occurs after the corallites have reached the cylindrical stage and are 9 to 12 mm in diameter.

Near the apex, the counter septum is elongate and slightly thickened at the inner edge and the cardinal is short; other major septa are long

and reach to or nearly to the column. Somewhat higher in the corallite the major septa (except the cardinal) extend about two-thirds the distance to the axis and the column is separated from the counter septum. In the mature region of the corallites the column disappears and the septa gradually shorten, commonly reaching less than one-half the distance to the axis. The cardinal septum is not distinctly shorter than other major septa. Minor septa are indicated by grooves on the exterior, but they are not seen in transverse section. The septal arrangement of a specimen from Neosho county in the adolescent stage is K 5 A 3 C 3 A 5 K, and in early maturity it is K 6 A 4 C 3 A 6 K. Minor septa are present in the mature breviseptal stage as low ridges alternating between major septa.

The axial column, which is developed from the counter septum, is laterally compressed and not appreciably thickened in the apical region. Higher in the corallite the column is distinct from the counter septum and may become somewhat irregular in shape. Characteristically, the column is lacking in the breviseptal portions, but it appears commonly after rejuvenation. Regularly spaced tabulae, which are mostly 0.8 to 2 mm apart, rise from the theca at an angle of about 45 degrees and become horizontal about one third the distance to the column. Where the column is absent, tabulae extend completely across the interior of the corallite. The cardinal fossula is only moderately distinct in transverse sections of the lower parts and is scarcely distinguished in the breviseptal stages. Alar pseudofossulae are inconspicuous and can be determined in sections only by the position of an incompletely developed septum in the counter quadrants.

Repeated periods of rejuvenation affect the corallites after maturity is reached so that adolescent characters may reoccur. Thus, a long septal stage having the axial column may be present immediately above an amplexoid

breviseptal stage.

Discussion.—Beede (1898) first described these corals as Amplexus westii inasmuch as the tabulae resemble those of Amplexus and the counter septum did not seem distinctly elongated and thickened. Later this species was redescribed as Lophophyllum westi (Beede, 1900) after other specimens had indicated that the counter septum was long in at least some of the corallites. However, it was recognized that the characters were intermediate between those of Amplexus and those ascribed to Lophophyllum. Similar specimens were studied by Girty (1915a), and he recognized the intermittent character of the column. Although the structural features were considered to be somewhat at variance with those of other species referred to Lophophyllum, the corals were not separated generically. As the studies of Beede and Girty indicated, this species resembles the corals that have been assigned to Lophamplexus. The reappearance of the column after a breviseptal stage is merely the result of rejuvenation and does not represent a character generically distinct from the other forms included in Lophamplexus.

Beede suggested that Amplexus westii was conspecific with corals from upper Missourian rocks of Illinois that were described as Cyathaxonia distorta Worthen (1875), and Girty (1915a) concurred in this view. Both of these forms are characterized by elongated, irregularly bent cylindrical corallites. However, in view of the lack of information on the internal structures of C. distorta and the difference in stratigraphic horizon, L. westii is considered to be distinct from the Illinois species.

The type collection of the University of Kansas contains several lots of corals labelled "Lophophyllum westi (Beede) - type", and presumably most of this material was studied by Beede. The holotype is not identi-

fied by number in publication and seemingly different specimens furnished the basis for measurements given in the two descriptions (Beede, 1898, p. 17; 1900, p. 18). However, the small specimen described as "the type" (Beede, 1900, p. 177, description of figure 13, plate 3) is considered to represent the holotype.

Occurrence.—Bronson group, Missourian series, Pennsylvanian (Upper Carboniferous). The type material was collected by E. P. West at Kansas City, Mo., probably from the Hertha limestone (Univ. Kansas loc. 8110). Other specimens were collected by Beede and Rogers from the Hertha limestone at a railroad cut near Trent, about 3.5 miles east of Erie, Neosho county, Kansas (Univ. Kansas loc. 813, 5804, and 573). Single specimens of this species are recognized from the "Bethany Falls limestone" [?Hertha limestone], sec. 6, T. 26 S., R. 22 E., Bourbon county, Kansas (Univ. Kansas loc. 5224) and from the Bronson group at a cut west of Shaw, Neosho county, Kansas (Univ. Kansas loc. 5774).

Material studied.—The type material used by Beede, which comprises the type and 4 other specimens from Kansas City, Mo. and about 500 specimens from the Neosho county locality, were available for study. One specimen was identified from each of the other two localities. About 35 representative corallites were sectioned.

Type.—University of Kansas, specimen no. 8110-21a from the "Upper Coal Measures" [Hertha limestone] at Kansas City, Missouri.

EXPLANATION OF PLATE 22

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

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Lophamplexus westii (Beede), from the Bronson group, Missourian series, Pennsylvanian (Upper Carboniferous), - 186

1a-c--Specimen (Univ. Kansas no. 813-21b) from the Hertha limestone at a railroad cut near Trent, about 3.5 miles east of Erie, Neosho county, Kansas. a-b, Transverse sections c, Longitudinal section.

2a-f--Specimen (Univ. Kansas no. 573-21c) from the same locality as figure 1. a-e, Transverse sections. f, Longitudinal section.

3a-c--Specimen (Univ. Kansas no. 5804-21a) from the same locality as figure 1. a-b, Transverse sections. c, Longitudinal section.

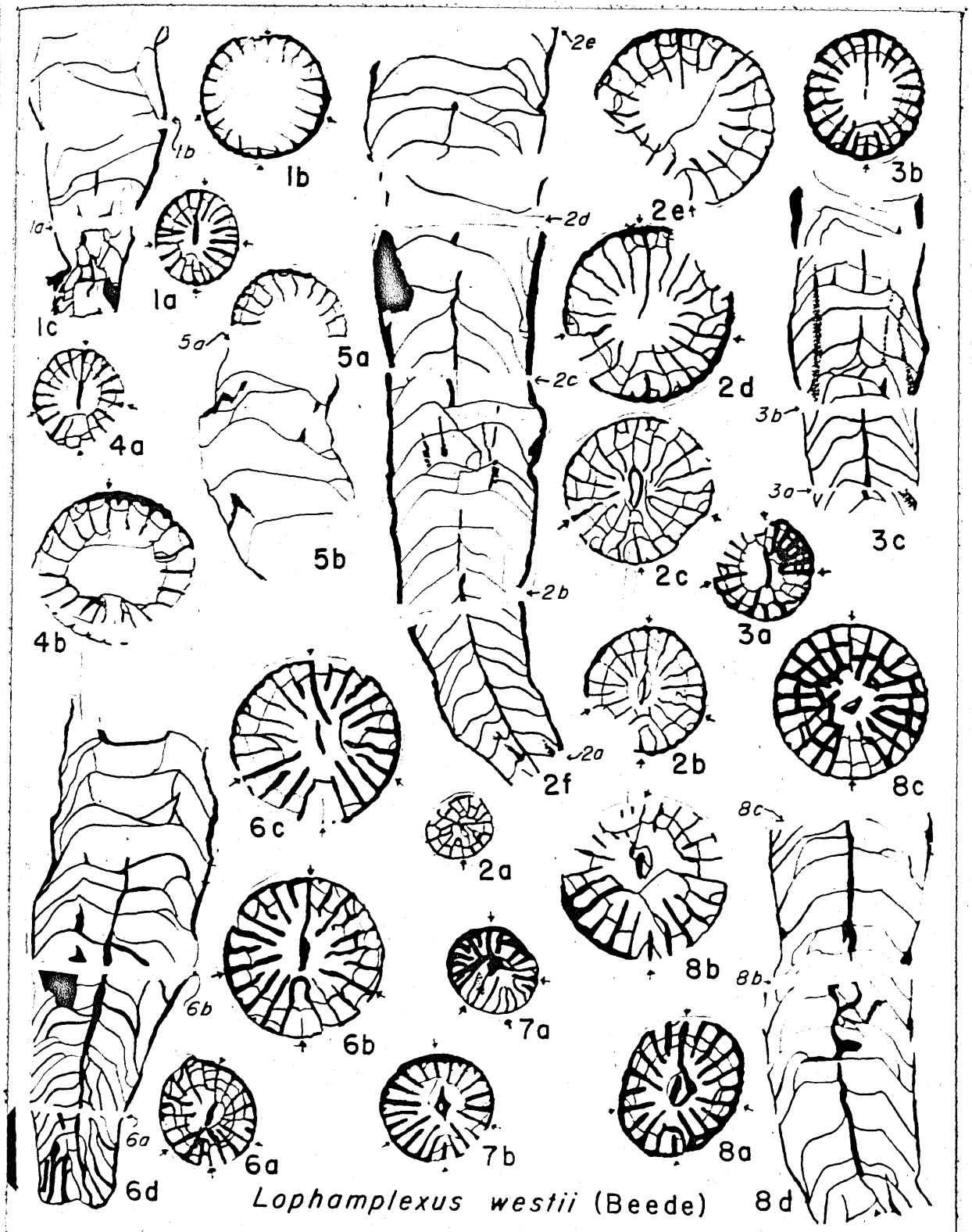
4a-b--Transverse sections of specimen (Univ. Kansas no. 813-25f) from the same locality as figure 1.

5a-b--Topotype specimen (Univ. Kansas no. 8110-21d) from the Hertha limestone at Kansas City, Missouri. a, Transverse section. b, Longitudinal section.

6a-d--Specimen (Univ. Kansas no. 573-21b) from the same locality as figure 1. a-c, Transverse sections. d, Longitudinal section.

7a-b--Transverse sections of topotype specimen (Univ. Kansas no. 8110-21c) from the same locality as figure 5.

8a-d--Specimen (Univ. Kansas no. 813-22d) from the same locality as figure 1. a-c, Transverse sections. d, Longitudinal section.



Lophamplexus westii (Beede)

Plate 22

Lophamplexus ulius Jeffords, n. sp.

Plate 23, figure 3; plate 24, figures 1-7; text figure 9

Small gently curved corallites that develop from a conical to a cylindrical shape are included in this species. The theca, which is moderately thick in the lophophyllidoid stage and thin above, bears fine longitudinal grooves and ridges, and relatively conspicuous transverse growth lines and sharp wrinkles. Rejuvenation is indicated in most specimens by abrupt constrictions of the corallite. The type specimen is 27 mm in length and 7 mm in maximum diameter just below the calyx. Other mature specimens may be a few millimeters greater in diameter and slightly longer.

The lower part of the complete corallites is characterized by a distinct development of the lophophyllidoid stage. The counter septum is long and distinctly thickened at the axis, the cardinal septum is shortened, and other major septa are long and approximately equal in length. These septa are moderately thick but not rhopaloid. Lophophyllidoid characters become less marked towards the calyx as the corallite assumes a cylindrical form. In this breviseptal stage the septa are shortened and the column is lacking. The septal formula in the apical region of the type specimen is K 4 A 3 C 4 A 4 K. Minor septa may develop near the calyx, but they remain rudimentary. Tabulae are more or less irregular in the apical region, and they become typically amplexoid above. They are rather closely spaced, mostly about 1 mm apart. The column is distinctly thickened in the apical region and may be independent of the counter septum in the upper portion of the lophophyllidoid stage. The cardinal fossula is relatively distinct throughout the early growth and persists into the lower part of the breviseptal stage. Alae pseudofossulae are not identified easily.

Discussion.--The corallites assigned to this species comprise a somewhat varied assemblage and may include representatives of distinct species. However, the divergent forms are mostly individual specimens, so that quantitative evaluation of the differences are not possible at this time. Several of the corals are represented only by the upper breviseptal portion of the corallite and resemble the Morrowan corals referred to Amplexocarinia Soschkina by Moore and Jeffords (1945, p. 142) in their small size and thin structural elements. One locality (Univ. Kansas loc. 1828) has yielded 3 specimens, one characterized by a protracted lophophyllidid stage, another by the small and distinctly breviseptal characters, and a third corallite that seems to show a gradation between these types. Seemingly, under certain ecologic conditions these corals developed a breviseptal stage rapidly, without a great increase in diameter. This stage was then continued in certain specimens, but in others a lophophyllidoid stage developed subsequently and the diameter was increased.

Lophamplexus ulius is distinguished readily from L. westii (Beede), L. brevifolius, n. sp., and L. vagus, n. sp. by the small diameter of the corallites. The well-developed lophophyllidoid stage and thick column also are characteristic of this species.

Occurrence.--Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). The type specimen was collected from the Argentine limestone member of the Wyandotte limestone at Wyandotte Dam, sec. 18, T. 10 S., R. 24E., Wyandotte county, Kansas (Univ. Kansas loc. 7489). Other corallites which are referred to this species were collected from the Raytown limestone member of the Iola limestone at Main Street cut, Kansas City, Mo. (Univ. Kansas loc. 332); the Farley limestone member of the Wyandotte limestone at the Lone Star Cement Quarry, Bonner Springs by R. M.

Jeffords (Univ. Kansas loc. 1828), at Camp Nash, east of Bonner Springs, Wyandotte county, Kansas (Univ. Kansas loc. 1881), and from the Wyandotte limestone at the quarry in Loring, Wyandotte county, Kansas (Univ. Kansas loc. 6896).

Material studied.--This species is represented by 1 sectioned specimen from each of the localities except for the Bonner Springs quarry where 3 specimens were identified with this species.

Type.--University of Kansas, specimen no. 7489-21a from the Argentine limestone at Wyandotte Dam.

EXPLANATION OF PLATE 23

(All figures 3 times natural size.)

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Lophamplexus phractus Jeffords, n. sp., from the horizon of the Stoner-Eudora members, Stanton limestone, Lansing group, Missourian series, Pennsylvanian (Upper Carboniferous), at NE cor. sec. 27, T. 24 S., R. 17 E., near Piqua, Woodson county, Kansas. - - - - - - - - - - - - - - - - 199

1--Type specimen (Univ. Kansas no. 1877-21a).

Lophamplexus brevifolius Jeffords, n. sp., from the Marmaton group, Desmoinesian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - 178

2--Specimen (Univ. Kansas no. 1053-22s) from the Oologah limestone, Garnett quarry, sec. 28, T. 20 N., R. 14 E., northeast of Tulsa, Oklahoma.

6--Specimen (Univ. Kansas no. 1053-22k) from the same locality as figure 2.

Lophamplexus ulius Jeffords, n. sp., from the Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). - - - - - - - - - - - - - - - - 193

3--Specimen (Univ. Kansas no. 332-21h) from the Raytown limestone member, Iola limestone, at Main Street cut, Kansas City, Missouri.

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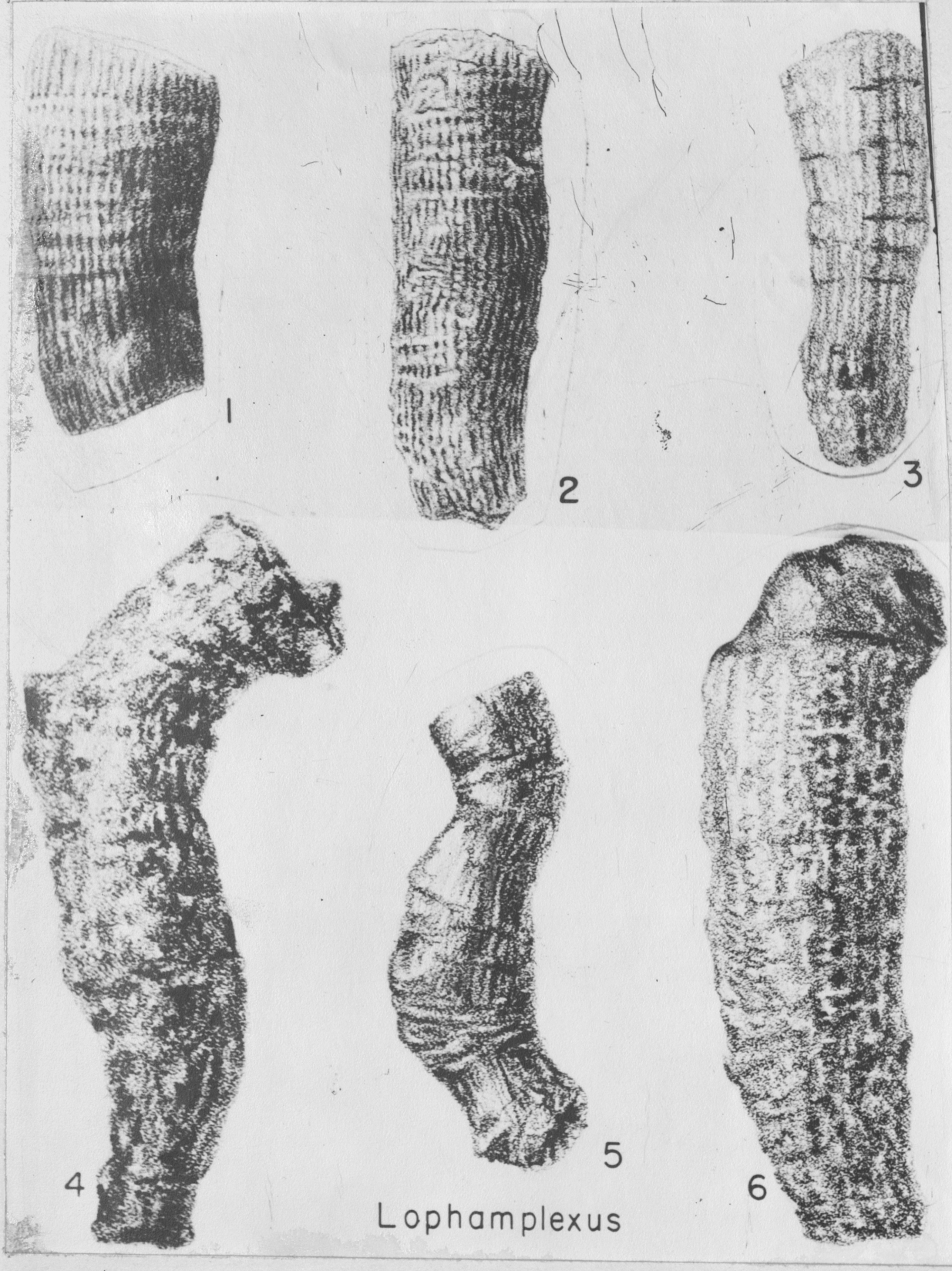

Plate 23

Lophamplexus phractus Jeffords, n. sp.

Plate 20, figures 6-7; plate 23, figure 1; text figure 9

This species includes moderately large cylindrical corallites that are gently curved in the plane of the alar septa. The theca, which is relatively thick, bears fine longitudinal grooves and interseptal ridges, and transverse markings consisting of a few low wrinkles and fine growth lines in the cylindrical portions. The nature of the calyx is not observed. The type specimen is 32 mm in length and 17.5 mm in maximum diameter at the calyx. Another specimen reaches about the same maximum diameter. Periods of rejuvenation appear to be rare.

The apical region is characterized by long thin major septa except for the distinctly shortened cardinal septum and the thickened counter septum. At a distance of about 15 mm above the apex, the counter septum is equal in length to the other major septa and the axial column has disappeared. In the early part of the breviseptal portion of the corallites the major septa extend three fourths the distance to the axis and are relatively stout. Near the calyx the septa become greatly shortened and connected about their inner edges by intercepts of the tabulae. The septal formula as seen in the apical portion of the type specimen is K 5 A 4 C 4 A 5 K. There are about 26 major septa in the mature portions of these corallites. Minor septa appear in the later part of the lophophyllidoid stage but they remain inconspicuous. The column is prominent in the apical region and decreases gradually upward by a progressive shortening of the counter septum. Tabulae are rather irregular in the lophophyllidoid portion of the corallites, but they assume the typical amplexoid character in the breviseptal stage, where they are regularly spaced and complete. Pseudofossulae are inconspicuous, whereas the cardinal fossula is a well developed feature

that persists far into the breviseptal region.

Discussion.—The species here described resembles Lophamplexus brevifolius, n. sp., in the external appearance of the theca, but it has a much more extended lophophyllidoid stage. L. phractus may be separated from L. westii (Beede) by the greater number of septa and the rarity of periods of rejuvenation which results in the more or less complete disappearance of the column in mature stages. This Lansing species is distinguished readily from L. lutarius, n. sp., by the lack of radicles, stouter septa, and more regular intercepts of the tabulae in sections across the breviseptal region. L. ulius, n. sp., is a distinctly smaller coral.

Occurrence.—Horizon of the Stoner-Eudora members, Stanton limestone, Lansing group, Missourian series, Pennsylvanian (Upper Carboniferous). Collected by N. D. Newell from NE Cor. sec. 27, T. 24 S., R. 17 E., near Piqua, Woodson county, Kansas (Univ. Kansas loc. 1877).

Material studied.—One relatively complete corallite and the upper part of another specimen were available for study of this species.

Type.—University of Kansas, specimen no. 1877-21a.

Lophamplexus vagus Jeffords, n. sp.

Plate 24, figures 8-9; text figure 9

This coral comprises straight cylindrical corallites which have a moderately thick theca. The exterior is marked by narrow low ridges and broad shallow septal grooves and by numerous transverse growth lines and low wrinkles. The calyx is not preserved. The type specimen is 29 mm in length and 10 mm in diameter near the calyx.

The lophophyllidid portion of the corallite shows long thin major septa that extend nearly to the thin column. The cardinal septum is distinctly shortened. In the breviseptal stage the major septa shorten to only one-half the radius, and they never are rhopaloid. The septal formula in the upper part of the type specimen is K 6 A 3 C 3 A 6 K. Minor septa occur as ridges between some of the major septa, particularly in the counter quadrants. The axial column is thin and reappears above a breviseptal stage as the result of rejuvenation. Pseudofossulae are not easily identified, whereas the cardinal fossula is prominent throughout all growth stages.

Discussion.—This species is distinguished from other species referred to Lophamplexus by the broad shallow character of the septal grooves and by the somewhat anastomosing irregular character of the tabulae in the breviseptal stage. L. westii (Beede) also has an axial column that appears subsequent to a breviseptal stage, but L. vagus differs in the shorter septa, and more regular appearance of the axial column as seen in transverse section.

A single corallite comprising only the cylindrical portion agrees with this species in the characters of the septa and tabulae of the mature region. However, the assignment of this coral from the Farley limestone to

L. vagus is questionable inasmuch as its immature characters are unknown.

Occurrence.--Missourian series, Pennsylvanian (Upper Carboniferous). The type specimen is from the Nellie Bly formation, Skiatook group, at the brickplant, sec. 1, T. 19 N., R. 11 E., northeast of Sand Springs, Okla. (Univ. Kansas loc. 2202). Another specimen questionably assigned to this species was collected by N. D. Newell from the Drum limestone, Kansas City group, at Kill Creek, 1 mile southeast of De Soto, Johnson county, Kansas (Univ. Kansas loc. 1712).

Material studied.--The well preserved type specimen and one other incomplete corallite were identified from the sectioned material.

Type.--University of Kansas, specimen no. 2202-21a from the Nellie Bly formation, northeast of Sand Springs, Okla.

EXPLANATION OF PLATE 24

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

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Lophamplexus ulius Jeffords, n. sp., from the Kansas City group, Missourian series, Pennsylvanian (Upper Carboniferous). - 193

1a-d--Specimen (Univ. Kansas no. 332-21d) from the Raytown limestone member, Iola limestone, at Main Street cut, Kansas City, Missouri. a-c, Transverse sections. d, Longitudinal section.

2a-e--Transverse sections of specimen (Univ. Kansas no. 1828-22b) from the Farley limestone member, Wyandotte limestone, at Lone Star Cement Quarry, Bonner Springs, Wyandotte county, Kansas.

3a-f--Type specimen (Univ. Kansas no. 7489-21a) from the Argentine limestone member, Wyandotte limestone, at Wyandotte Dam, Wyandotte county, Kansas. a-e, Transverse sections. f, Longitudinal section.

4a-b--Specimen (Univ. Kansas no. 1828-21a) from the same locality as figure 2. a, Transverse section. b, Longitudinal section.

5a-b--Specimen (Univ. Kansas no. 1881-21a) from the Farley limestone member, Wyandotte limestone, at Camp Nash, east of Bonner Springs, Kansas. a, Transverse section. b, Longitudinal section.

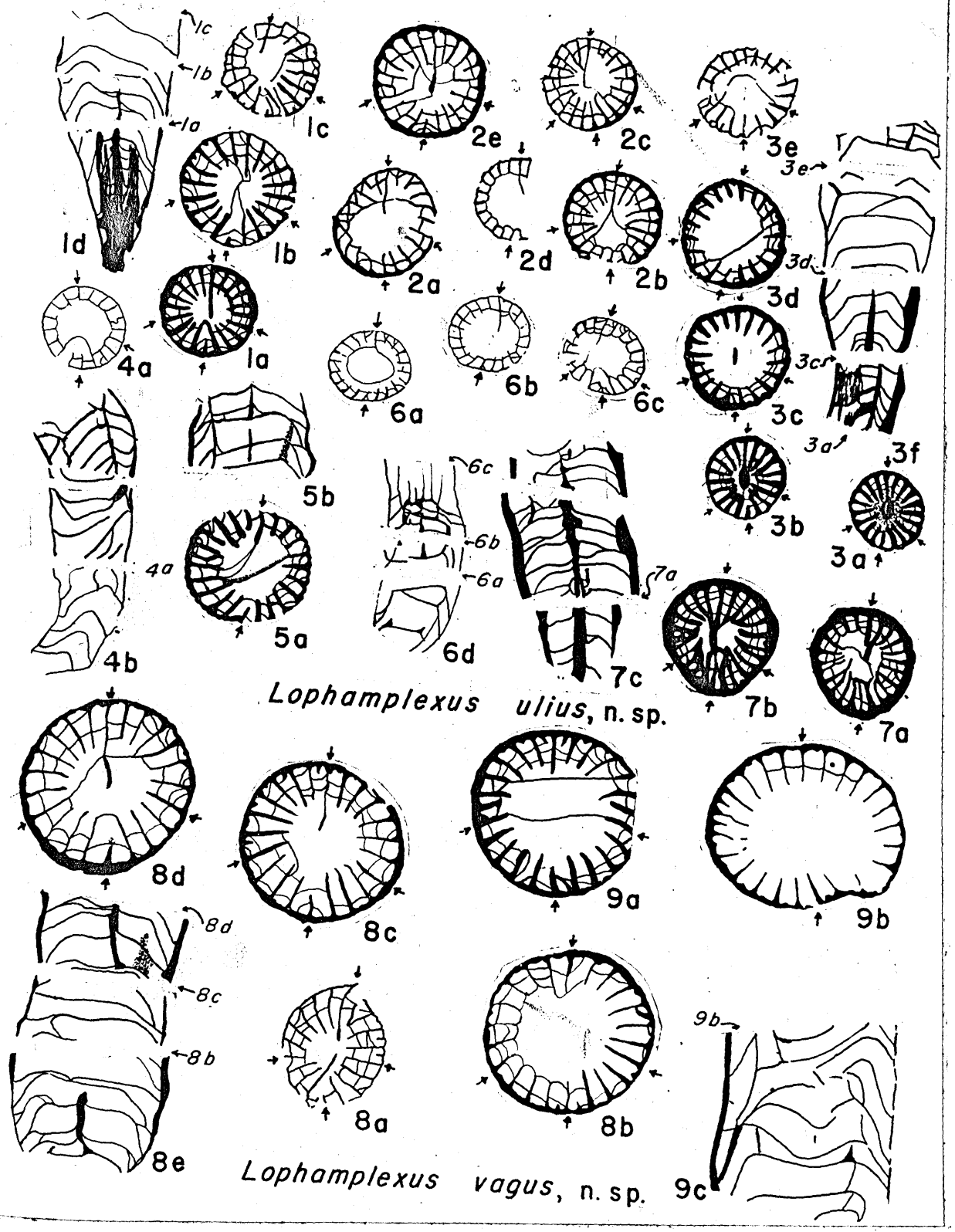
6a-d--Specimen (Univ. Kansas no. 6896-21a) from the Wyandotte limestone at a quarry in Loring, Wyandotte county, Kansas. a-c, Transverse sections. d, Longitudinal section.

7a-c--Specimen (Univ. Kansas no. 1828-21b) from the same locality as figure 2. a-b, Transverse section. c, Longitudinal section.

Lophamplexus vagus Jeffords, n. sp., from the Missourian series, Pennsylvanian (Upper Carboniferous). - 201

8a-e--Type specimen (Univ. Kansas no. 2202-21a) from the Nellie Bly formation, Skiatook group, at brick plant, sec. 1, T. 19 N., R. 11 E., northeast of Sand Springs, Oklahoma. a-d, Transverse sections. e, Longitudinal section.

9a-c--Specimen (Univ. Kansas no. 1712-21a) from the Drum limestone, Kansas City group, at Kill Creek, 1 mile southeast of De Sota, Johnson county, Kansas. a-b, Transverse sections. c, Longitudinal section.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3f
5b
6c
6b
6a
3b
3a
4a
5a
7a
4b
6d
7c
7b
7a
Lophamplexus ulius, n. sp.
8d
8c
9a
9b
8d
8c
8b
8a
8b
9b
8e
Lophamplexus vagus, n. sp.
9c

Plate 24

Lophamplexus spanius Jeffords, n. sp.

Plate 25, figure 7; text figure 9

Relatively large, gently curved corallites that are conical near the apex but cylindrical above, are included in this species. The type specimen is slightly curved in the counter-cardinal plane so that the counter side is concave. The moderately thick theca bears distinct longitudinal markings that are crossed by fine growth lines and low wrinkles. The calyx comprises a horizontal floor surrounded by a high vertical wall. The apical portion of the corallite bears a broad area of attachment by which it was firmly fastened to the substratum. The type specimen is 51 mm in length and 18 mm in maximum diameter just below the calyx.

The apical region is characterized by a strong development of the lophophyllidoid characters. The counter septum is long and markedly thickened at the axis, the cardinal septum is thin but not shortened, and other major septa mostly reach to the column. Somewhat higher sections show major septa that are long and slightly rhopaloid, a thin shortened cardinal septum, and short minor septa. The column at this stage is large and laterally compressed. The septal formula of the type specimen, showing the slight counter acceleration, is K 6 A 5 C 5 A 7 K. The breviseptal portions of the corallite are characterized by the cylindrical shape, the disappearance of the column, and thick shortened major septa. The minor septa are relatively long and appreciably thickened.

Tabulae are rather closely spaced and somewhat inosculating in the breviseptal region. Commonly, they rise gently from the periphery to the inner edges of the septa and are flat or slightly sagging across the axial region. The cardinal fossula is well marked in the lophophyllidoid stage

but becomes inconspicuous in the adult portions. Alar pseudofossulae are evident only in the early part of the lophophyllidoid stage.

Discussion.--The large diameter, stout septa, and long minor septa separate this species from other corals assigned to Lophamplexus, such as L. brevifolius, n. sp., L. captiosus Moore and Jeffords (1945, p. 121), and L. eliasi Moore and Jeffords (1941, p. 91). Moreover, the continuation of many of the major septa to the column and the palmate pattern of the septa, as seen in transverse sections of the apical region, is characteristic in L. spanius. The constriction of the corallite and concentration of the tabulae seen in the upper part of the longitudinal section (plate 25, fig. 7) are the result of partially completed rejuvenation. The column has started to reappear also.

Occurrence.--Wildhorse limestone, Nelagoney formation, Virgilian series, Pennsylvanian (Upper Carboniferous). Collected along Numing road, 15.7 miles west of Skiatook, Okla. (Univ. Kansas loc. 7993).

Material studied.--A single lophophyllidid coral was found among a number of specimens of an undescribed species of Pseudozaphrentoides from this locality. This corallite is well preserved and shows distinctive characters that warrant its description as a new species.

Type.--University of Kansas, specimen no. 7993-21d.

EXPLANATION OF PLATE 25

(All figures 3 times natural size. Transverse sections are oriented with the cardinal septum at bottom; protosepta are indicated by small arrows. Longitudinal sections are at right angles to the counter-cardinal plane; the position of transverse sections is indicated by small italic figures.)

Page

Lophamplexus? lutarius Jeffords, n. sp., from the upper part of the Boggy formation, Desmoinesian series, Pennsylvanian (Upper Carboniferous), at cen. sec. 7, T. 3 N., R. 8 E., southeast of Ada, Pontotoc county, Oklahoma. - 211

1a-e--Specimen (Univ. Kansas no. 1604-21c) showing well-developed breviseptal characters. a-d, Transverse sections. e, Longitudinal section.

2a-e--Transverse sections of the type specimen (Univ. Kansas no. 1604-21h).

3--Transverse section of specimen (Univ. Kansas no. 1604-21a).

4--Longitudinal section of specimen (Univ. Kansas no. 1604-21n).

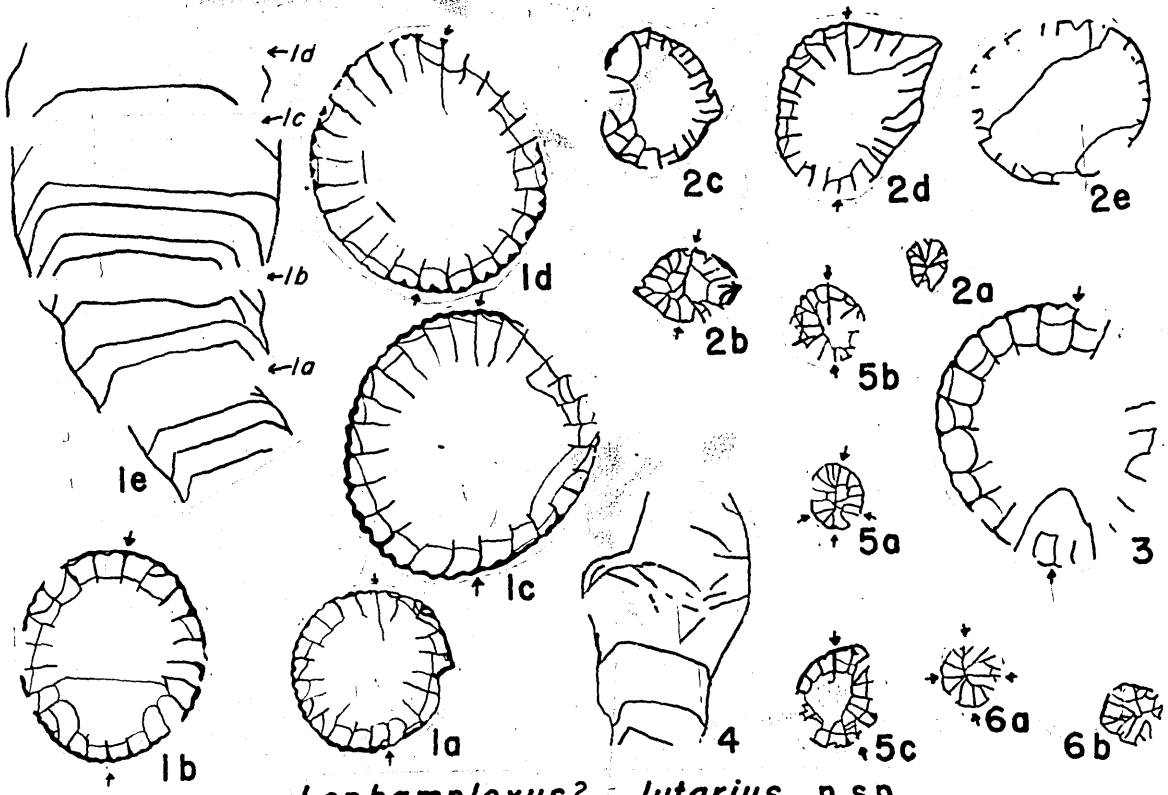
5a-c--Transverse sections in the apical region of specimen (Univ. Kansas no. 1604-21m).

6a-b--Transverse sections near the apex of specimen (Univ. Kansas no. 1604-21k).

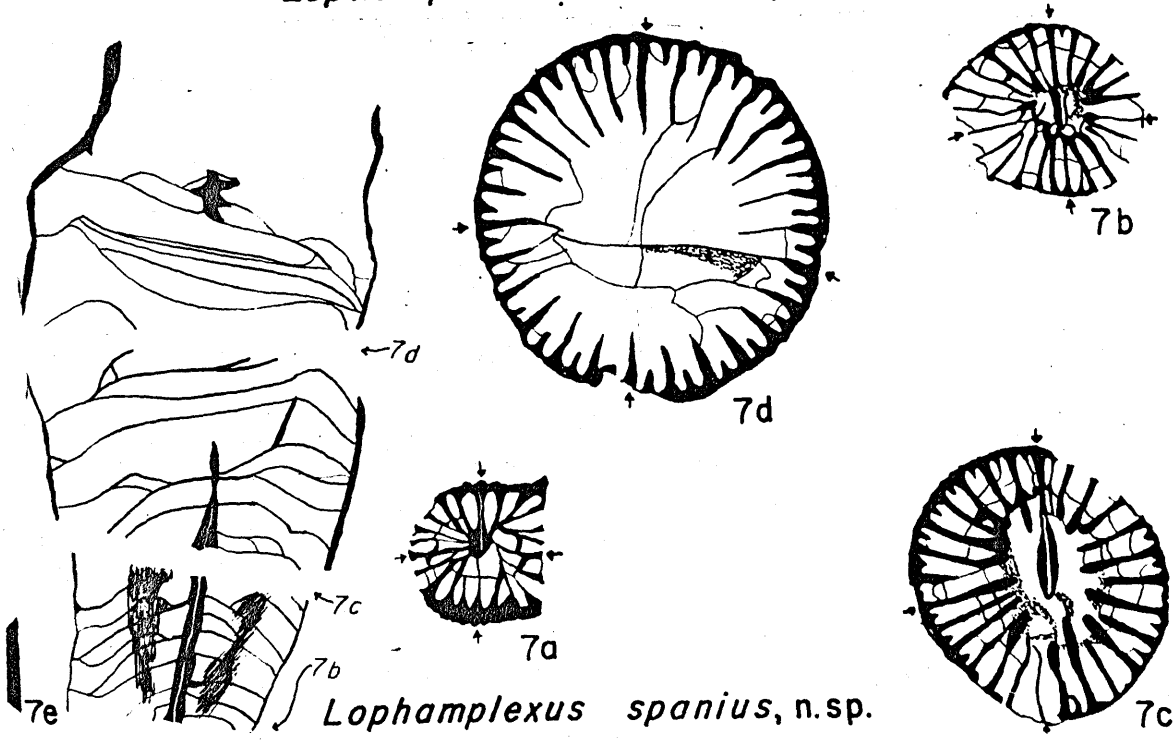
Lophamplexus spanius Jeffords, n. sp., from the Wildhorse limestone, Nelagoney formation, Virgilian series, Pennsylvanian (Upper Carboniferous), along Numing road, 15.7 miles west of Skiatook, Oklahoma. - - - - 206

7a-e--Type specimen (Univ. Kansas no. 7993-21d).

a-d--Transverse sections. e, Longitudinal section.



Lophamplexus? lutarius, n.sp.



Lophamplexus spanius, n.sp.

Lophamplexus?lutarius Jeffords, n. sp.

Plate 25, figures 1-6; text.figure 9

Relatively straight conico-cylindrical corallites bearing fine septal grooves and rounded ridges that are crossed transversely by broad growth lines and numerous prominent wrinkles are included in this species. The calyx is deep and broad, and the theca is thin. The apical portion of the corallites is characterized by a few scattered spines or radicles. The type specimen is 19 mm in length and 10.5 mm in diameter just below the calyx; the largest corallite is 14 mm in diameter.

The apical portion of these corallites indicates the development of long thin septa that join axially or abut other major septa. The counter septum is not observed to be distinctly thickened axially. These immature characters give way upward to the breviseptal stage in which the septa are markedly shortened and approximately equal in length. Mature specimens show about 26 major septa; the protosepta are not identified in the sections of the mature portions of the corallites. Minor septa are rudimentary. Tabulae are spaced regularly about 1.5 mm apart in the breviseptal region. They arch upward at the periphery and level abruptly at the inner edges of the major septa. Thus, in transverse section tabulae seem to form an inner wall connecting the septa. The fossula and pseudofossulae are inconspicuous.

Discussion.—This species develops the distinct breviseptal characters of Lophamplexus, but the available material does not furnish adequate data on the lophophyllidoid characters. Although these specimens may have been derived from a coral that lacked lophophyllidoid features, it seems preferable to assign this species to Lophamplexus, which is relatively common

in Pennsylvanian deposits.

Lophamplexus? luterius resembles L. phractus, n. sp., from Missourian rocks in the reduction of the minor septa and thickness of the theca. However, the former species is characterized by the appreciably thinner and shorter septa. The corallites of L.? luterius do not become completely cylindrical in upper portions as L. brevifolius, n. sp., and L. vagus, n. sp.. This species also seems to lack prominent periods of rejuvenation.

Occurrence.—Shale in upper part of the Boggy formation, Desmoinesian series, Pennsylvanian (Upper Carboniferous). Collected by N. D. Newell from cen. sec. 7, T. 3 N., R. 8 E., southeast of Ada, Pontotic county, Okla. (Univ. Kansas loc. 1604).

Material studied.—About 15 corallites were available for study and 10 representative specimens were sectioned.

Type.—University of Kansas, specimen no. 1604-21h.

STRATIGRAPHIC SUMMARY

The occurrence of corals in Pennsylvanian deposits of the Midcontinent is related closely to conditions under which these rocks were deposited. Moreover, particular assemblages of corals occur in rather narrowly limited facies. Such distinctive coral faunas include nodular masses or mound-like reefs of Chaetetes that occur immediately above persistent limestones in the Marmaton group, Dibunophyllum and other clisiophyllids in thick massive limestones, and Pseudozaphrentoides (Campophyllum of authors) and Syringopora in shallow-water calcareous shales and thin limestones. Lophophyllidid corals are found most abundantly in limestones and shales associated with brachiopods and bryozoa, although their occurrence is not uniform throughout any particular formation.

Species of Lophophyllidium are confined largely to shales or calcareous zones within a predominantly shaly section, such as the Cherokee, Wewoka, and Wayland shales. These species may be associated with a mixed fauna of brachiopods, sponges, and molluscs. Stereostylus occurs in shales, limestones, and sediments that are intermediate in composition. Species such as S. lenis, S. milichus, S. pandatus, and S. annae from relatively pure limestones are characterized by an elongate conico-cylindrical form, relatively thin skeletal elements, and minor deposits of stereoplasm. Species from shales, on the other hand, commonly are broadly conical in form and contain stout structures that are secondarily thickened by stereoplasm. Lophamplexus occurs in both shaly and limey sediments, but seems to be more abundant in the limestones.

The short range, abundant occurrence, and numerous mutable characters of Pennsylvanian lophophyllidids suggests that these corals have considerable stratigraphic usefulness. Care is needed, however, to avoid

correlation of faunas representing merely similar facies rather than faunas that are contemporaneous. Also, each sedimentary facies is represented by a distinct series of species so that the observed range of most species is dependent upon minor changes in conditions of deposition. Therefore, it is not practicable at this time to attempt definition of zones on the basis of lophophyllidid corals.

Species of Lophophyllidium, Stereostylus, and Lophamplexus are described from rocks of Desmoinesian, Missourian, and Virgilian age as indicated on the following table. Desmoinesian corals include especially the conical species of the Stereostylus newelli type, radicle-bearing corals like S. girtyi (Jeffords, 1942) which may be a synonym of S. radicosus (Girty, 1911), Lophophyllidium hadrum, and L. wewokanum. In the Missourian series, Lophamplexus westii (Beede) occurs abundantly in the Hertha limestone, S. lenis is present throughout the pure limestone members of the Kansas City group, and S. pelaeus is recorded from the shaly facies of Oklahoma. Upper Missourian rocks (Lansing and Pedee groups) are distinguished particularly by a small conical species of Lophophyllidium, L. coniforme. Virgilian rocks in the northern Midcontinent contain species of Stereostylus such as S. pandatus, S. absitus, and S. perversus whereas equivalent deposits of north-central Texas are characterized by several species of Lophophyllidium.

Stratigraphic Distribution of Species

Species	Stratigraphic Divisions		
	Desmoinesian	Missourian	Virgilian
Lophophyllidium hadrum	- x -	- - -	- - -
Lophophyllidium wewokanum	- - x	- - -	- - -
Lophophyllidium coniforme	- - -	- x x	- - -
Lophophyllidium asarcum	- - -	- - -	- x -
Lophophyllidium lanosum	- - -	- - -	- x -
Lophophyllidium plummeri	- - -	- - -	- x -
Lophophyllidium spinosum	- - -	- - -	- x -
Stereostylus aages	- x -	- - -	- - -
Stereostylus adelus	- - x	- - -	- - -
Stereostylus pelaeus	- - -	x x -	- - -
Stereostylus phainus	- - -	- x -	- - -
Stereostylus lenis	- - -	- x -	- - -
Stereostylus milichus	- - -	- - x	- - -
Stereostylus absitus	- - -	- - -	- x -
Stereostylus pandatus	- - -	- - -	- x -
Stereostylus annae	- - -	- - -	- - x
Stereostylus perversus	- - -	- - -	- - x
Lophamplexus? lutorius	x - -	- - -	- - -
Lophamplexus brevifolius	- - -	- - -	- - -
Lophamplexus westii	- - -	x - -	- - -
Lophamplexus vagus	- - -	- x -	- - -
Lophamplexus ulius	- - -	- x -	- - -
Lophamplexus phractus	- - -	- - x	- - -
Lophamplexus spanius	- - -	- - -	x - -

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