

OSTRACOD MICROFAUNA OF THE LOWER PERMIAN
OF WINN COUNTY, KANSAS

by

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B. S., University of Notre Dame, 1947

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

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INTRODUCTION

Purpose of the Investigation

This study of the ostracod faunas of the Lower Permian System of Riley County was undertaken in an attempt to compile a functional inventory of ostracod species occurring within the stratigraphic units. It seemed desirable to establish the distribution of ostracods within the stratigraphic units and, at the same time, to gain an indication of the relative abundance of the several species.

It was also hoped to obtain a correlation between the ostracod species and the lithology of the local units in which they were found. This effort was limited by the impossibility of sampling every distinctive zone in each of the rock units outcropping in the county. An attempt was made to compare the lithology of the various zones in which a given species appeared in order to learn, as far as possible, the environment in which that species existed. However, it was understood that a study of ecology was distinctly secondary to the primary purpose of establishing the stratigraphic distribution and abundance of species.

Area Covered by the Investigation

Riley County (Fig. 1) is in the northeastern quarter of the State of Kansas. It is in the second tier of counties south of

the Nebraska border, and in the fifth tier of counties west of the Missouri border. Riley County is bounded on the north by Washington and Marshall Counties, on the east by Pottawatomie and Wabaunsee Counties, on the south by Wabaunsee and Geary Counties, and on the west by Clay County.

Stratigraphy of the Area

General. For the most part, the outcropping rocks of Riley County belong to the Wolfcamp Series of the Lower Permian System. In the southeastern part of the county, the upper units of the Pennsylvanian System are exposed, and near the northwest corner there are outcrops of Cretaceous age (Table 1).

In this work, only the rocks of the Wolfcamp Series were sampled, and of these only the ones which contained an ostracod fauna are described here.

Register and Description of Sample Localities. In this register, the number appearing beside each sample is the number which corresponds to that sample throughout this report:

1. Pawxby shale, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 7, T. 11 S., R. 9 E., lower half of shale. Shale: calcareous; gray, weathers tan.
2. Pawxby shale, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, T. 11 S., R. 9 E., limestone lens in upper half of shale. Limestone: mottled gray, weathers gray.
3. Falls City limestone, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 12, T. 11 S., R. 8 E., lower bed of the limestone. Limestone: pyritiferous; brecciated; gray, weathers light gray; limonite stained. Sample taken from stream bank.
4. West Branch shale, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 8, T. 11 S., R. 9 E., beneath thin fossiliferous limestone.
5. Five Point limestone, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 12, T. 11 S., R. 8 E. Sample taken from stream bank.
6. Stine shale, center of SW $\frac{1}{4}$ sec. 30, T. 10 S., R. 9 E. Shale: pyritiferous; green, weathers gray.

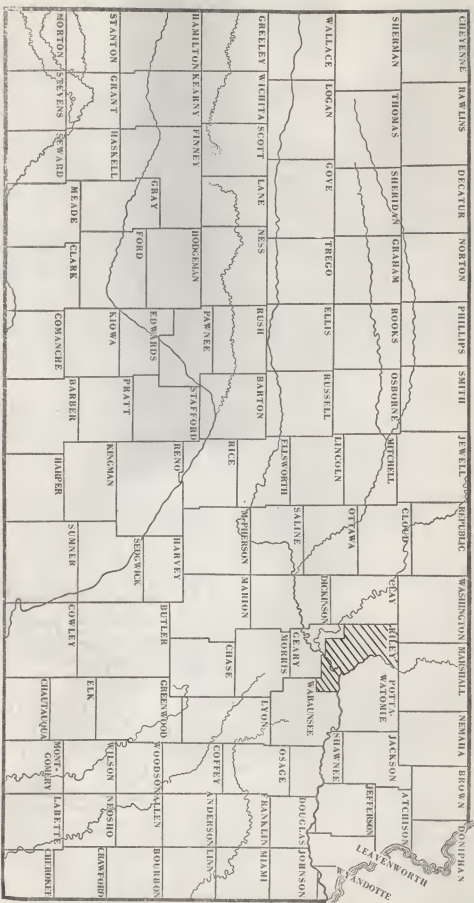


Fig. 1. Index map showing location of Riley County.

7. Houchen Creek limestone, center of SW $\frac{1}{4}$ sec. 30, T. 10 S., R. 9 E. Limestone: calcareous; gray, weathers gray; porous.
8. Americus limestone, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., top of unit. Limestone: siliceous; blue gray, weathers tan-gray; fossiliferous. Sample taken from road cut.
9. Hughes Creek shale, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., top of unit. Shale: non-calcareous; light gray to black, weathers light gray. Fossiliferous. Sample taken from road cut.
10. Long Creek limestone, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 12, T. 11 S., R. 8 E., from shale break. Shale: calcareous; gray, weathers tan; limonite stained. Sample taken from stream bank.
11. Johnson shale, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., 1 foot below base of Glenrock limestone. Shale: calcareous; gray, weathers gray. Sample taken from road cut.
12. Bennett shale, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., above middle limestone bed. Shale: black, weathers dark gray; fissile; fossiliferous. Sample taken from road cut.
13. Bennett shale, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., base of unit. Shale: silty; calcareous; blocky; dark gray, weathers light gray; calcareous concretions. Sample taken from road cut.
14. Burr limestone, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 23, T. 10 S., R. 7 E., beneath top limestone bed. Shale: calcareous; gray, weathers gray; brecciated; cut by many thin veins of calcite. Sample taken from abandoned road cut.
15. Neva limestone, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, T. 10 S., R. 7 E., from top shale break. Shale: calcareous; platy; gray, weathers light gray.
16. Eskridge shale, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, T. 9 S., R. 7 E., calcareous zone 1 foot below base of Cottonwood limestone. Shale: calcareous; light gray, weathers tan gray; limonite stained. Sample taken from road cut.
17. Cottonwood limestone, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, T. 9 S., R. 7 E., top of unit. Limestone: massive; buff, weathers gray; fossiliferous. Sample taken from road cut.
18. Florena shale, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 8 S., R. 7 E., base of unit. Shale: calcareous; gray, weathers yellow-gray. Sample taken from road cut.
19. Florena shale, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 34, T. 10 S., R. 8 E., 1 foot below base of Morrill limestone. Shale: calcareous; light gray, weathers tan. Sample taken from road cut.
20. Morrill limestone, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 8 S., R. 7 E., shale break 1 foot below top. Shale: calcareous; gray, weathers light gray.
21. Eiss limestone, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 32, T. 10 S., R. 8 E., middle shale break. Shale: calcareous; gray. Sample taken from road cut.
22. Middleburg limestone, NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 34, T. 10 S., R. 8 E., shale break at base. Shale: calcareous; tan, weathers light gray. Sample taken from road cut.

23. Grouse limestone, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 29, T. 8 S., R. 7 E.
Shale: calcareous; gray, weathers green-gray; fossiliferous. Sample taken from road cut.
24. Threemile limestone, center of sec. 29, T. 8 S., R. 7 E.,
first shale break above base. Shale: light gray,
weathers light gray; fossiliferous. Sample taken from
road cut.
25. Havensville shale, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 16, T. 11 S., R. 8 E.
Shale: calcareous; gray. Sample taken from road cut.
26. Schroyer limestone, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 16, T. 11 S., R. 8 E.,
2 feet below base of Wymore shale. Limestone: argil-
laceous; light gray; fossiliferous. Sample taken from
road cut.
27. Wymore shale, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 21, T. 11 S., R. 8 E., top
of unit. Shale: calcareous; buff, weathers light gray.
Sample taken from road cut.
28. Kinney limestone, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 21, T. 11 S., R. 8 E.,
middle shale parting. Shale: calcareous; buff, weathers
light gray; fossiliferous. Sample taken from road cut.
29. Florence limestone, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T. 9 S., R. 6 E.,
top shaly parting. Sample taken from stream bank.
30. Oketo shale, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T. 9 S., R. 6 E., top of
unit. Shale: calcareous; green-gray to tan; fossil-
iferous. Sample taken from pond spillway.
31. Gage shale, NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 9 S., R. 4 E., 0.5 foot
below base of Stovall limestone. Sample taken from rail-
road cut.
32. Grant shale, NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 9 S., R. 4 E., 2 feet
above top of Stovall limestone. Shale: calcareous;
tan, weathers light tan; fossiliferous. Sample taken
from railroad cut.

Field Procedure

Field samples consisted entirely of "surface" samples and were taken from outcrops in road cuts, railroad cuts, and stream banks. No samples were taken from float rock.

The amount of the sample varied with the lithology of the unit. A smaller amount was required for the limestones and calcareous shales than was needed for non-calcareous, slaking shales. The average amount of the field sample was approximately 2 pounds.

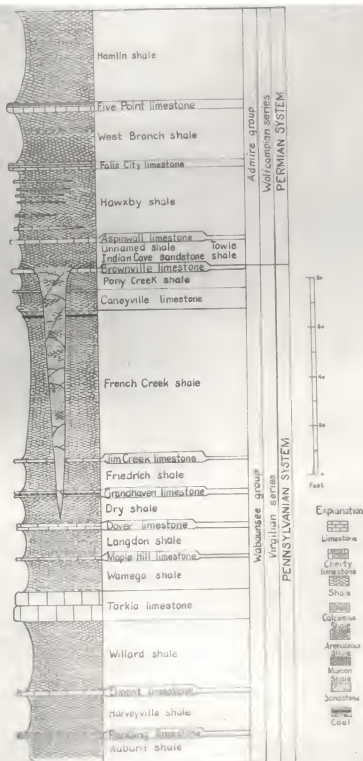


Table 1. Generalized Stratigraphic section of Riley County, Kansas

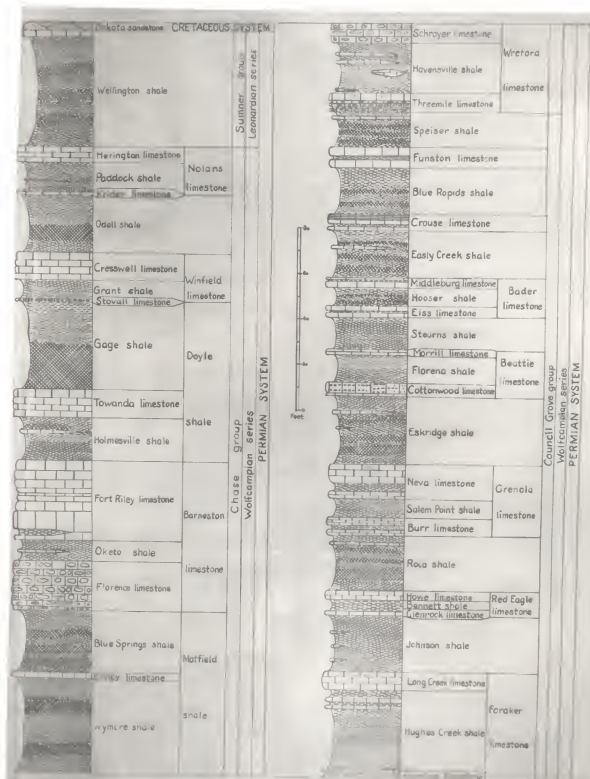


Table I (cont'd). Generalized Stratigraphic section of Riley County, Kansas

The necessity of maintaining correct stratigraphic orientation required a detailed study of stratigraphic sections previously measured in Riley County. Measured sections compiled by Melville R. Hudge (10) proved invaluable.

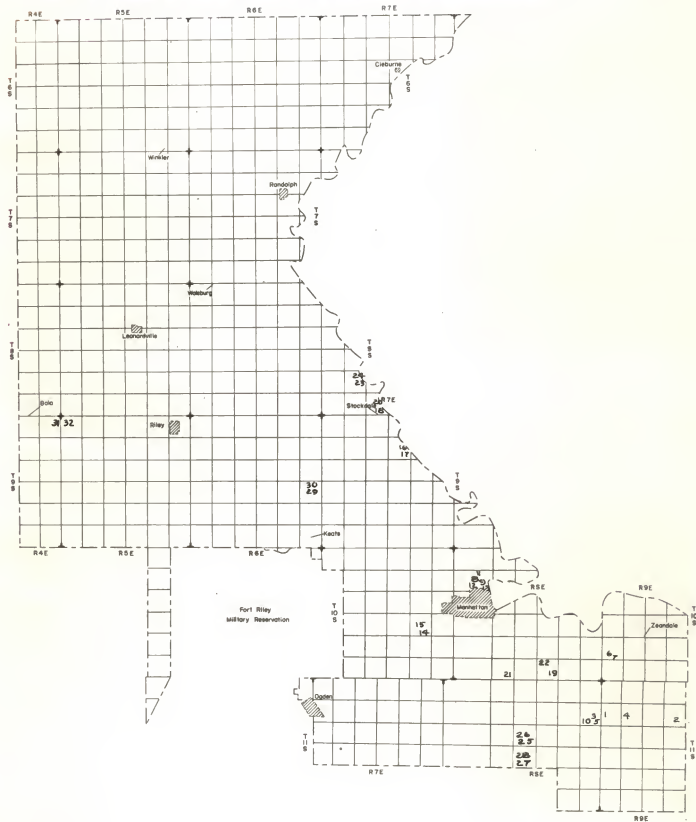
Care was taken to sample only the fresh, unweathered face of the outcrop in order to avoid contamination from overlying units. It was also thought advisable to sample only unweathered rock to avoid the possibility of obtaining eroded and poorly preserved specimens. This consideration might safely have been disregarded though for, according to Glaessner (3), well-preserved specimens are frequently found in the much-eroded portion of an outcrop.

Each sample, after being sacked, was numbered and the number recorded in a field notebook, along with the name of the unit, the zone within the unit (where this was ascertainable at the outcrop), and the location from which the sample was taken according to the section, township, and range system (Fig. 2).

Laboratory Procedure

Preparation of Samples. The field samples were crushed with a steel mortar and pestle, placed in an ordinary No. 10 can which was given a number corresponding to the sample number, and allowed to soak for several hours in a strong solution of sodium hydroxide. The sodium hydroxide served a deflocculant in breaking down the rock. A period of soaking was permitted to allow the sodium hydroxide to saturate the sample thoroughly.

Map of Riley County, Kansas showing town locations.



The amount of sample used varied widely with each stratigraphic unit. Some of the shales slaked quite readily and with these as much as 90 percent of the original sample was lost in washing. It was necessary to prepare enough material to provide at least 20 cc of the washed sample, this amount having been arbitrarily chosen as the unit of washed sample to be scanned for each stratigraphic horizon. The correct amount of the field sample to be prepared could be determined only by experience.

After the sample had become sufficiently saturated with the sodium hydroxide solution, it was boiled from 1 to 4 hours over a gas range. Here, too, the lithology of the sample governed the time required to obtain complete separation of the specimens and matrix particles. The calcareous samples needed a longer period of boiling to produce a clean sample than did the easily slaking shales. The boiling was allowed to proceed vigorously to take advantage of the mechanical action of the process.

Upon completion of the boiling, the sample was decanted, care being taken to wash away only the clay- and silt-size particles, and then was dried in an electric oven. After drying, the sample was passed through a sieve having 18 meshes to the inch to remove the larger organic material and nondisintegrated fragments of the matrix. That which passed through the sieve was then placed in a vial along with a card bearing the sample number.

Extreme care was necessary at all times to avoid contamination of material and to prevent losing the identity of a sample when several were being run at the same time.

Scanning of Samples. The material used in scanning the samples consisted of a binocular microscope, a No. 00 sable-hair brush, a black specimen tray, and storage slides.

The sample was sprinkled over the bottom of the tray, which was laid off in a one-inch-square grid of white lines to facilitate complete coverage, and the ostracods removed by moistening the tip of the brush and touching it to the specimen. As the specimens were removed from the tray, they were placed on an indexed glass-covered storage slide pending identification.

Identification of Ostracods. A file of type specimens is desirable for use in classification. Since none was available, all identifications were based on previous identifications and descriptions from the available literature. Current and past issues of the Bulletin of the Nebraska Geological Survey, the Bulletin of the Oklahoma Geological Survey, the Proceedings of the United States National Museum, the American Midland Naturalist, and the Journal of Paleontology all proved valuable as a source of information pertaining to ostracods.

The criteria generally considered to be of the greatest value in the classification of ostracods are:

1. Differences in size, outline, convexity of valves, and location of greatest thickness.
2. Nature of the hinge.
3. Modification of the hinge.
4. Overlap of the edges of the valves.
5. Surface features of the valves.
6. Lobation of the valves.

7. Character of the surface ornamentation.

8. Presence or absence of brood pouch.

Of these, the consideration of the brood pouch was disregarded, since brood-pouch forms do not occur in rocks younger than Silurian. Modification of the hinge line, if present, was usually obscured, and its value in identification of local ostracods is questionable. The dimensions of the carapace were determined by using a straight-tube microscope with a calibrated ocular. The immature moults of most species were considered to be beyond identification in this work, and were discarded.

When each specimen had been identified, it was placed in a glass-covered slide bearing its generic and specific name, the name of the person who originally described the species, the source of the material used in identification, the dimensions of the carapace, and the name and locality of the sample from which the specimen was picked. Except where noted in the text, the assignment of genera to families was adapted from Bassler and Kellett (1).

Illustration Technique. For the purpose of illustration, the identified species were grouped by families and fastened to a small glass plate by means of gum arabic. Where sufficient specimens were available, three orientations were used for each species: left valve, right valve, and dorsal aspect of the carapace. The glass plate was photographed against a black background to provide contrast, and the print enlarged to produce a magnification of the specimens to 20 diameters.

SYSTEMATIC MICROPALAEONTOLOGY

Family PRIMITIIDAE Ulrich and Bassler

Genus Monoceratina Roth, 1928 (Kellett, Jour. Paleo., vol. 9, p. 157. 1935).

Carapace in lateral view subrectangular with the ventral margin approximately paralleling the straight hinge or slightly rounded or oblique; in lateral view anterior end broadly rounded; posterior end tapering, often to a very pronounced degree; carapace usually rather thick in edge view with rapidly tapering ends; a prominent horn-like ventral protuberance located more or less posterior to the center of the carapace and projecting outward and downward or backward; often a faint vertical dorsal sulcus located centrally or slightly to the anterior; other surface ornamentation such as nodes, ridges and spines are found in the later Carboniferous species; surface of the Carboniferous species finely pitted, and of the Cretaceous species sometimes reticulated, right hinge grooved to receive the left; although essentially equivalved Roth notes a tendency for some right valves to be slightly grooved ventrally to receive the left; Alexander states that "the line of concrescence and inner margin coincide throughout, and their course is near and parallel to the outer margin of the shell."

Genotype by original designation: Monoceratina ventrale Roth. Wapanucka limestone, Lower Pennsylvanian, Pontotoc County, Oklahoma.

Middle Devonian to Oligocene.

Monoceratina lewisi Harris and Lalicker (Kellett, Jour. Paleo., vol. 9, p. 158. 1935). Plate I

Carapace very small; elongate for the genus; the posterior end very compressed and tapering and usually more or less broken as that part of the shell is thin and delicate; ventral protuberance long and at the end pointed; a slight dorsal sulcus just in front of the center, with an inconspicuous node just behind it near the hinge line; another larger and slightly more conspicuous node in the anterodorsal region; a fourth faint node is sometimes found at the antero-cardinal angle; anterior margin bordered by a narrow almost flat area; surface finely reticulated, valves so small and thin that no hinge structure can be seen. Measurements: length, .85 mm; height, .36 mm; thickness of the specimen, measured through the spine, .36 mm.

The specimens of Monoceratina lewisi from the Florence limestone were fairly well preserved. Most features were readily discernable, and the form fits the description quite well.

Genus Ulrichia Jones, 1890 (Kellett, Jour. Paleo., vol. 7, p. 92. 1933).

Straight-hinged, elongate Kirkbyidae with angular cardinal extremities, the anterior usually the most acute. Left valve having a slight inside beveling and overlapping the beveled outside edge of the right. Hingement consists of a more or less prominent ridge on the left valve and a groove on the right, with the cardinal teeth on the left valve and the corresponding sockets on the right valve, which are characteristic of the family, sometimes well developed. Two large and prominent nodes located on the upper half of the valve are the distinguishing feature of this genus, the anterior one the larger. Pit located near the antero-ventral corner of the posterior node. Two or more well developed flanges present. Surface reticulated. Genotype, Ulrichia conradi Jones. Devonian.

Ulrichia robusta Kellett (Kellett, Jour. Paleo., vol. 7, p. 92. 1933). Plate I

Ventral edge parallel to hinge, post-cardinal angle usually a right angle and antero-cardinal angle often quite acute. Hinge-line slightly depressed. Hinge and marginal structure typical of the genus, the cardinal teeth and sockets well developed. Nodes large and well developed, somewhat vertically elongate, extending well down to the center of the valve and the larger anterior node extending perceptibly above the hinge-line. Free edges of the valve bordered by a narrow, non-reticulated area, just inside of which is a prominent flange with a smooth, rather flat edge, the upper side of this flange ornamented by one row of reticulations or striations. This flange dies out only at the cardinal angles. Separated from this outer flange by several rows of reticulations is a more prominent inner flange with a wide, smooth edge, and with only one row of reticulations along the inner side of the base. The inner flange varies in width. Measurements: length, 1.30 mm; height, .61 mm.

Specimens of Ulrichia robusta obtained from the Threemile limestone and Oketo shale were not clean, and identification was made largely on a basis of size, general outline, and the projection of the nodes above the hinge line. Specimens from the Oketo were all small.

Family LEPERDITELLIDAE Ulrich and Bassler

Genus Paraparchites Ulrich and Bassler, 1906 (Kellett, Jour. Paleo., vol. 7, p. 63. 1933).

Original description: Carapace small, 1 mm. to

2 mm. in length, leperditoid or subovate in shape; surface smooth, sometimes with a small tubercle or spine in antero-cardinal third of each valve; right valve with ventral edge rabbeted so as to slightly overlap the simply beveled edge of the left valve; dorsal edges of valves usually unequal, the left slightly the more prominent and commonly overlapping the right or receiving its edge in a shallow groove.

Genotype by original designation: Paraparchites humerosus Ulrich and Bassler

Paraparchites humerosus Ulrich and Bassler, 1906 (Kellett, Jour. Paleo., vol. 7, p. 64, 1933). Plate I

Original description: Length of large example, 1.8 mm; height of same, 1.25 mm; thickness of same, 1.05 mm. Carapace subovate, with the outline slightly angulated in the antero-dorsal region; surface rather strongly convex, with greatest thickness near middle of valves. Left valve with dorsal edge straighter than in right valve, the edge in the latter being convex in outline and thickened so that it projects above the hinge line of the left valve. Ventral edge of carapace thick and slightly channelled on each side of a constant line between the valves.

This species is distinguished from all known American Carboniferous species referable to this genus and from those from British rocks described by Jones and Kirkby as of Leperditia, except their L. compressa, in the more ovate outline of its carapace. The valves of L. compressa, however, are much less convex, especially in the middle parts, so that its carapace presents a very different outline in edge views when compared with the comparatively evenly convex profiles presented in corresponding views of P. subovata. In all other Carboniferous Leperditidae the dorsal line is straighter and one or both of the dorsal angles much better defined.

On account of the thickness of the dorsal edge of the right valve and the rounding of the outline thereby produced, this valve may be mistaken for valves of Cythereella like C. richteriana, Jones and Kirkby and C. inflata Jones and Kirkby.

The specimen of P. humerosus from the Middleburg limestone adheres closely to Kellett's identifications and to the generic description. The specimen from the Schroyer limestone fits the specific description by Ulrich and Bassler which, it will be noted, departs from the generic description in the matter of dorsal overlap.

Family BEYRICHIIDAE Jones

Genus Hollinella Coryell, 1928 (Coryell, Jour. Paleo., vol. 2, p. 378. 1928).

Small, subquadrangular, equivalved, and straight hinge-lined ostracods; the surface of each valve is finely or coarsely granulose with a median sinus lying in the dorsal half, about which an irregular U shaped swelling rises; the dorsal ends of the swelling are raised into prominent lobes, the anterior one larger and more regularly hemispherical than the posterior; the free margin may be bordered with a low ridge, a broken or continuous row of spine-like extensions, or there may be no marginal ornamentation present.

Genotype, Hollinella dentata Coryell.

Hollinella crassamarginata Kellett (Kellett, Jour. Paleo., vol. 3, p. 208. 1929). Plate I

Female: Carapace rhomboidal to sub-rectangular. Anterior margin only slightly rounded and protruding, sometimes however having a backward swing. Posterior margin slightly rounded to extremely so, with the greatest protuberance below the center of the valve making the posterior appear obliquely truncate. Dorsal and ventral margins only slightly rounded and nearly parallel. Hinge and marginal structure that of the genus. Marginal beads on left valve lacking.

Sulcus behind center of hinge line, not deep and often short. Anterior node hemispherical, touching the hinge line, and smaller than that of H. emaciata. Posterior node not much elevated above the posterior surface of the valve. Ridge beneath sulcus not prominent and gently rounding down to frill. Valve with frill presenting a rather flat appearance with only the anterior node standing out prominently. Frill thickened, fairly broad posteriorly making a prominent rim at the posterior of the valve which may extend slightly on to the dorsal margin. Frill at the postero-ventral angle flat and at an angle and ending in a short flat spine. Frill of medium width on non-productive female, wide on productive female. Frills set on carapace so that when it is closed they are well apart, not close together as on H. emaciata and H. gibbosa Kellett. Anterior of valve bordered irregularly by a row of papillae. A few small papillae, sometimes arranged in a row running diagonally downward and backward, in front of the anterior node, and often on the anterior node itself. This arrangement of very sparse, inconspicuous papillae is common to almost all of the Hollinellae from Kansas; only on the specimens of H. shawnsensis Kellett is the diagonal row missing. Surface slightly granular.

H. crassamarginata differs from H. emaciata in the following characters; anterior node smaller and flatter:

sulcus shorter and shallower; marginal frill thicker and flatter, the thickening making a prominent rim posteriorly up to the hinge; general appearance flat rather than emaciate. It is distinguished from H. gibbosa by the pronounced posterior rim, by the less prominent node, and by the thicker, flatter and narrower frill which is never convex as is the frill of the productive female of H. gibbosa.

Male: Because H. crassamarginata and H. gibbosa are differentiated chiefly by their frills I have not been able to separate and identify the male forms of each, although perhaps those which are a little higher on the ones having the coarser, bead-like spines are the males of H. crassamarginata.

Dimensions: Large type female, length, 1.09 mm, height, .94 mm; small type female, length, .66 mm, height, .57 mm.

Specimens of H. crassamarginata from the Florence limestone show the wide-set arrangement of the frills with the valves closed, which is typical of the species. The anterior node is flattened but appears to be nearly as large as that of H. emaciata, differing in that one respect from the description. Arrangement of the papillae was obscured by matrix.

Hollinella emaciata (Ulrich and Bassler) (Kellett, Jour. Paleol., vol. 3, p. 202. 1929). Plate I

Female: General outline of the carapace from the side the same as H. nevensis, but much less tumid; marginal structure, frill and cardinal spines also the same. However, the two forms present an exceedingly different appearance; for whereas the valve of H. emaciata is only slightly convex with a great deal of relief above and below the general surface, that of H. nevensis appears inflated and smooth. A deep, narrow, sulcus with a wide, almost straight ventral end extends at least half way to the frill, and anteriorly is bordered by a large regularly rounded node. On specimens from the Cottonwood Falls limestone at Ogden, this node is generally broader and more bulbous, extending from the hinge line half way down the valve. The node behind the sulcus is low and vertically elongate, making only a slight angle posteriorly with the rather flat surface of the valve. The posterior node is a little farther from the hinge line than the anterior. The ventral side of the narrow, almost straight ridge beneath the sulcus descends so sharply toward the frill that it appears to be pinched into shape. The ventral ridge converges smoothly with the posterior of the valve, but is cut off from the anterior node above it by

a distinct sulcus. It is often as much elevated as the anterior node. Bassler has decided that the "short, vertical, curved ridge in the postero-dorsal angle" of the original description is merely a deformation of the type specimen. Surface of the valve irregularly punctate, but rougher than H. nevensis, with granulation on the frill, the sulcus and along the margins. This likeness of surface texture, rectangular side view and broad anterior nodes makes it seem possible that H. nevensis is the ancestor of H. emaciata.

H. emaciata is characterized by a generally emaciated appearance, by a long sulcus with a broad lower end, by a straight, narrow, ventral ridge, and by a prominent node cut off entirely from the ventral ridge by a narrow sulcus.

Male: Like the female, except that it lacks the frill; anterior nodes in the specimens observed are slightly less bulbous also. Marginal spines of medium size, closely placed; however, as they are broken, their length cannot be determined. Only two undoubted specimens have been found--one in the Cottonwood Falls limestone, and the other in the Fort Riley. A similar undescribed form has been found in the Winfield which has long club-shaped spines. The males of H. emaciata and H. nevensis differ from all other previously described frillless forms in their nearly rectangular outline from the side. They differ from each other in the same respects as do the females of the species.

Measurements: Productive females, length, 1.21 mm, height, .69 mm; nonproductive females, length, 1.09 mm, height, .69 mm; male, length, 1.00 mm, height, .62 mm.

The specimens of Hollinella emaciata from the Florence limestone possess the narrow sulcus characteristic of the species; the anterior projection of this sulcus, separating the anterior node from the ventral ridge, is usually filled with matrix but is distinguishable.

Hollinella gibbosa Kellett (Kellett, Jour. Paleo., vol. 3, p. 207. 1929). Plate I

Female: Carapace semi-ovate to rhomboidal, length about twice the height, anterior end slightly rounded, posterior obliquely truncate dorsally and rounding below into the ventral margin. Marginal and hinge structure typical of the genus. An even row of minute beads bordering the beveling on the left valve. Cardinal spines on right valve prominent. Sulcus behind center of hinge line rather short and wide. Anterior node set up above the general surface of the valve, bulbous and somewhat constricted at the base. Posterior node of a small diameter but often well raised above the posterior surface of the

valve--somewhat inflated. Ridge beneath the sulcus having a slight to a prominent curve, and sometimes quite gibbous, especially on those forms occurring near the top of the Pennsylvanian. Generally convexity of the valve not great. Frill on non-productive female fairly wide and beginning with an elevated spine which rises about three-fourths of the way down the anterior margin at a little distance from the edge of the valve; the frill continuing downward and backward so that at the postero-ventral angle it follows the edge of the valve closely. On a closed carapace the frills diverge anteriorly but become almost parallel at the postero-ventral angle. The wider frill of the productive female is posteriorly set up on the valve at a little distance from the margin, and is very convex. A depression occurs along the junction of the frill with the valve. On both female forms the frill widens at the postero-ventral angle and then narrows suddenly, dying out before it reaches the hinge line.

Anterior margin bordered by a few short irregular spines. Surface finely granular, granules extending up on frill. A few very short papillae on anterior node and in front of it, sometimes arranged in a diagonal line running backward.

H. gibbosa is very closely related to H. bassleri Knight, as the species is above enlarged, but H. bassleri is more tumid and slopes more toward the dorsal and ventral margins, with the anterior node on the ventral slope instead of being nearly level as is that of H. gibbosa. The nodes, especially the posterior, are less globular and restricted at the base than those of H. gibbosa. The frill of H. bassleri is of more even width and is wider posteriorly, extends farther up toward the hinge both anteriorly and posteriorly, is more elevated especially at the postero-ventral angle, and is less convex on the productive female.

Male: As stated above the males of H. crassamarginata and H. gibbosa have not been separated.

Measurements: Productive females, length, 1.36 mm, height, .89 mm; nonproductive female, length, 1.18 mm, height, .63 mm; male, length, 1.12 mm, height, .63 mm.

Most of the specimens found of H. gibbosa were of nonproductive females. A specimen of a productive female was found in the Florence limestone, but the carapace of this was poorly preserved.

Genus Cornigella Warthin, 1930 (Kellett, Jour. Paleol., vol. 7, p. 72. 1933).

Original description: Carapace minute, subquadrate; greatest height in posterior half; greatest thickness

EXPLANATION OF PLATE I

(All specimens 20x.)

- Fig. 1. *Monoceratina lewisi* Harris and Lalicker.
a. Right valve; length, .65 mm; height, .29 mm;
Florence ls. (sample no. 29).
b. Left valve; length, .67 mm; height, .32 mm;
Florence ls. (sample no. 29).
- Fig. 2. *Cornigella parva* Kellett; right valve of immature specimen; length, .46 mm; height, .26 mm; Oketo st. (sample no. 30).
- Fig. 3. *Ulrichia robusta* Kellett.
a. Right valve of immature specimen; length, .82 mm; height, .43 mm; Threemile ls. (sample no. 24).
b. Left valve; length, 1.20 mm; height, .61 mm; Threemile ls. (sample no. 24).
c. Dorsal aspect; length, 1.22 mm; breadth, .61 mm; Threemile ls. (sample no. 24).
- Fig. 4. *Hollinella crassamarginata* Kellett.
a. Left valve; length .99 mm; height, .61 mm; Schrover ls. (sample no. 26).
b. Dorsal aspect; length, .92 mm; breadth, .48 mm; Schrover ls. (sample no. 26).
- Fig. 5. *Hollinella gibbosa* Kellett; left valve; length, 1.17 mm; height, .74 mm; Florence ls. (sample no. 29).
- Fig. 6. *Hollinella emaciata* (Ulrich and Bassler).
a. Right valve; length, 1.04 mm; height, .65 mm; Florence ls. (sample no. 29).
b. Dorsal aspect; length, 1.05 mm; breadth, .49 mm; Middleburg ls. (sample no. 22).
- Fig. 7. *Paraparchites humerosus*; left valve; length, .81 mm; height, .57 mm; Middleburg ls. (sample no. 22).



central; hinge-line straight, slightly less than the greatest length of the carapace; valves equal; surface ornamented by about eight prominent spines on each valve, one of which extends well above the hinge-line.

Genotype by original designation--Cornigella minuta Warthin. Pennsylvanian, Wetumka formation, Oklahoma.

Cornigella parva Kellett, 1933 (Kellett, Jour. Paleoc., vol. 7, p. 73. 1933). Plate I

This species is more elongate in side view than Cornigella minuta Warthin and instead of eight spines has only four or possibly five spines or protuberances, the fifth postero-ventral protuberance being faintly evidence on some specimens. The ventral spines of C. parva seem to occur nearer the center of the valve instead of farther down as on C. minuta. This is probably due to the greater elongation of the valve. Surface rough as if it might be very finely pitted or reticulate. Measurements of the holotype: length, .47 mm; height, .26 mm.

C. parva resembles very closely C. tuberculospinosa (Jones and Kirkby) from the Mississippian of England, but the post-ventral protuberance of C. parva is less well developed and the outline in side view more elongate with less backward swing.

Of the two specimens of C. parva found in the Oketo shale, the antero-ventral corner of the mature moult is broken, but the diagnostic features are clear; the immature moult shows only the anterior spines distinctly.

Family KLODENELLIDAE Ulrich and Bassler

Genus Jonesina Ulrich and Bassler, 1908 (Ulrich and Bassler, Proc. U. S. Nat. Mus., vol. 35, p. 324. 1908).

Carapace small, about 1 mm in length, usually elongate, the outline varying from subelliptical to oblong or approximating a parallelogram; greatest thickness in anterior half. Valves strongly convex, variously lobed, unequal, the left being the larger, sometimes overlapping the edge of the right on all sides. The most simple types (J. craterigera and J. arcuata) are marked with a rather deep dorsal sulcus situated somewhat behind the middle. The whole area in front of this sulcus may be almost uniformly convex, or a node may be obscurely defined in its post-dorsal quarter (that is, just in front of the sulcus). Behind the sulcus a more clearly defined node is always observable. In more complex species (J. fastigiata) three nodes are distinguishable, two, sub-equal, situated on opposite sides of the main sulcus, and a larger, less definitely outlined, lobe occupying the

anterior third. Finally, in J. fodicata, the anterior lobe is divided by the separation of a node simulating the other two in size and form, while all three nodes will appear as connecting below with a low marginal ridge. A more or less obscure and variable ridge commonly unites the two median nodes, occasionally producing an effect simulating Bollia.

Genotype: Jonesina fastigiata (Beyrichia fastigiata Jones and Kirkby).

Jonesina sometimes resembles Kloedenella to a marked degree. This is true especially of J. craterigera, but with entire specimens the observer should experience little difficulty in distinguishing them, the matter of relative size of the valves being reversed in the two genera. In the older genus the right valve is the larger, whereas in Jonesina it is the left.

In correlating the nodes of Jonesina with those of a typical Beyrichia, it is to be observed that the median lobe of the latter corresponds to the post-median node of Jonesina, the one, two, or three nodes in front of the median sulcus being equivalent to the single or dissected anterior lobe of Beyrichia. Obviously the location of the homologous parts in the two genera is widely different.

Jonesina bolliaformis (Ulrich and Bassler) (Kellett, Jour. Paleo., vol. 7, p. 78. 1933). Plate II

Original description: Length, .87 mm; height, .52 mm; thickness, .35 mm.

Carapace rather elongate subovate, the posterior end wider and more oblique than the anterior; cardinal angles obtuse; ends nearly equal in thickness. Surface of valves with two rounded and not very prominent nodes, subcentrally situated, one on either side of the deep median sulcus; nodes generally connected by a more or less obscure loop; posterior node rather better defined though smaller than the anterior. Ventral part of valves swollen without being definitely ridge-like. Dorsum channeled; ends and ventral edge, especially of the left valve, distinctly rimmed. Ventral edge of left valve overlapping that of the right.

The two nodes with the connecting loop impart an appearance strongly suggestive of species of Bollia. The loop is sometimes well defined, but in other examples it is scarcely distinguishable. The species evidently is closely related to Beyrichia fodicata Jones and Kirkby and B. fastigata Jones and Kirkby, but its valves are relatively shorter and margined by a distinct rim, a feature not observed on the British species.

Wide variation was noted in the specimens of J. bolliaformis, particularly in the matter of size of the nodes. This form was usually very well preserved.

Jonesina primitioides Harris and Lalicker (Kellett, Jour. Paleco., vol. 7, p. 79. 1933). Plate II

Carapace subrectangular and only slightly elongated; greatest thickness in the center of the valves, except in the young, when it is more toward the venter, a tendency observed also in J. bolliiformis. Overlap of right valve by left slight but distinct, there being very little overlap at all at the posterior margin. The free edge of the left valve is thickened in a narrow line of the largest specimens, and there is sometimes a raised line near the margin of the right valve outlining the overlapping edge of the left valve. Hinge-line depressed slightly in the anterior half. No hinge structure could be observed on the thin edges of the valves. A short sulcus, sometimes so slight as to be almost indiscernible, is the only surface feature. Surface smooth.

Associated with the typical form described above is a form which differs only in being more tumid, especially in the anterior one-third. It sometimes attains a larger size than the less inflated form, and although quite abundant does not seem to occur in the smallest sizes. This tumid form of J. primitioides is considered conspecific with the thinner form, a variation due possibly to sex or age, as is more fully discussed in the foregoing generic description of Jonesina.

Measurements of the holotype: length, .71 mm; height, .41 mm; width, .33 mm.

J. primitioides resembles Jonesina (?) tatei (Jones) from the Mississippian, but the sulcus is not so well developed or long, the sides are more nearly parallel in the Kansas species, and the ventral outline fuller. The tumid form is quite like Jonesina (?) shumardiana (Girty) and the Yaso formation, but it is not quite so thick and the sulcus is much less prominent.

The more tumid form of J. primitioides described by Kellett was not found. Kellett's measurements of the holotype were .26 mm longer and .12 mm higher than the holotype measurements given in the original description by Harris and Lalicker. The specimens found adhered more closely to Kellett's description in the matter of size.

Family KIRKBYIDAE Ulrich and Bassler

Genus Kirkbya Jones, 1859, emend. Knight, 1928 (Kellett, Jour. Paleco., vol. 7, p. 84. 1933).

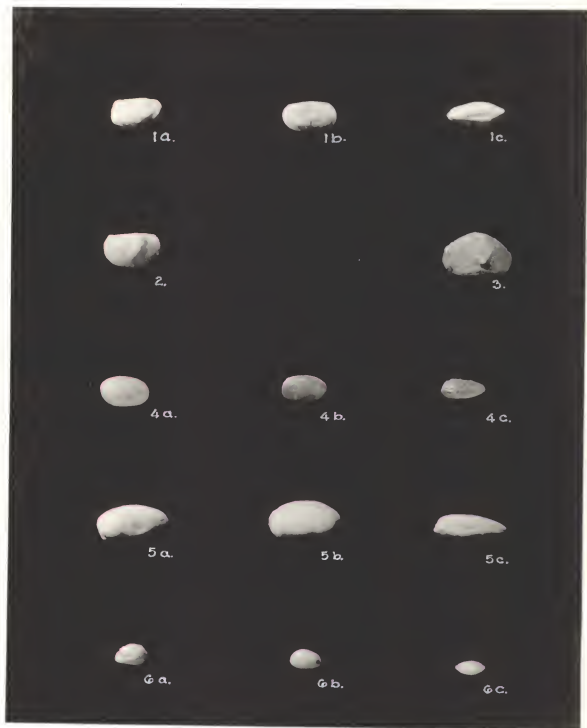
Straight-hinged Kirkbyidae with angular cardinal

EXPLANATION OF PLATE II

(All specimens 20x.)

- Fig. 1. *Jonesina bolliiformis* (Ulrich and Bassler).
a. Right valve; length, .66 mm; height, .40 mm; Eskridge sh. (sample no. 16).
b. Left valve; length, .70 mm; height, .41 mm; Eskridge sh. (sample no. 16).
c. Dorsal aspect; length, .71 mm; breadth, .32 mm; Eskridge sh. (sample no. 16).
- Fig. 2. *Jonesina primitioides* Harris and Lalicker; right valve; length, .75 mm; height, .47 mm; Eskridge sh. (sample no. 16).
- Fig. 3. *Silenites lenticularis* (Knight); left valve; length, .90 mm; height, .55 mm; Long Creek ls. (sample no. 10).
- Fig. 4. *Cavellina edmistonae* (Harris and Lalicker).
a. Right valve; length, .65 mm; height, .41 mm; Florence ls. (sample no. 29).
b. Left valve; length, .59 mm; height, .36 mm; Florence ls. (sample no. 29).
c. Dorsal aspect; length, .56 mm; breadth, .26 mm; Florence ls. (sample no. 29).
- Fig. 5. *Cavellina nebrasensis* (Geinitz).
a. Right valve; length, .93 mm; height, .54 mm; West Branch sh. (sample no. 4).
b. Left valve; length, .96 mm; height, .55 mm; West Branch sh. (sample no. 4).
c. Dorsal aspect; length, .92 mm; breadth, .31 mm; West Branch sh. (sample no. 4).
- Fig. 6. *Basslerella firma* Kellett.
a. Right valve; length, .41 mm; height, .27 mm; Hawxby sh. (sample no. 2).
b. Left valve; length, .41 mm; height, .26 mm; Hawxby sh. (sample no. 2).
c. Dorsal aspect; length, .38 mm; breadth, .19 mm; Hawxby sh. (sample no. 2).

Plate II



extremities, elongate in side view. Hingement consisting of a more or less prominent ridge on the left valve fitting into a groove on the right. In some species there are cardinal teeth on the left valve fitting into cardinal sockets on the right. Free edge of left valve with the slight inside beveling overlapping the outside edge of the right. Two or more sub-marginal flanges are usually present. These come together near the cardinal angles. Surface commonly ornamented by more or less prominent and distinct nodes or ridges, the most persistent and prominent of which is the antero-dorsal "shoulder". A subcentral "pit" or muscle spot is present, the shape of which is usually of specific value. Surface reticulate.

Genotype by subsequent designation--Kirkbya permiana Jones, (Dithyrocaris permiana Jones). Permian, Great Britain.

Kirkbya canyonensis Harlton (Kellett, Jour. Paleoc., vol. 7, p. 89. 1933). Plate III

Carapace rather elongate, sub-rectangular; cardinal teeth and sockets fairly well developed. Greatest thickness in the center of the valve where a thick ridge-like elongate node is located; a second node anterior to it and slightly elevated above the hinge-line; a third node in front of the central node and below and slightly in front of the antero-dorsal node. On the smallest specimens, the two lower nodes are not well developed as individuals but blend into the prominent antero-dorsal node, making one long ridge in the center of the valve which has a slight downward and backward slant. The young, as is usual with the Kirkbyidae, are narrower anteriorly than the mature specimens. Inner flange somewhat narrow, outer flange wider and thus visible in side view extending beyond the inner. On the larger specimens the outer margins of the flanges are non-reticulate. Kirkbyan pit small and elongate, situated below the apex of the central node.

Measurements: length, .99 mm; height, .49 mm.

The specimen of K. canyonensis from the Eiss limestone is smaller than the dimensions given by Kellett and it is assumed that this is due to immaturity.

Kirkbya valida Kellett (Kellett, Jour. Paleoc., vol. 7, p. 86. 1933). Plate III

Carapace short and somewhat inflated. The smaller of the two left valves found shows a tooth at the anterior cardinal angle, the posterior angle of this valve is somewhat broken. There is a distinct but rounded antero-dorsal shoulder. The greatest thickness of the valve, however, is in the center and not at the anterior shoulder. An

outer flange, and an inner flange of moderate width, which is set well up on the sloping side of the valve so that the outer one is partially visible in side view without tilting. Pit small and elongate oval.

Measurements of the holotype: length, 1.03 mm; height, .55 mm.

Occurring with K. valida were other specimens of the genus somewhat distorted and apparently more elongate. These unidentifiable specimens may belong to another species, or they may be conspecific, in which case the holotype is the shortest variation of the species.

K. valida is very similar in side view and arrangement of the flanges to K. clarocarinata Knight, but K. valida is less inflated, has a much more prominent anterior shoulder, a wider inner flange, is smaller and has a small elongate oval instead of a large circular pit. It is shorter than any of the similar species described by Roth, its length being less than twice its height.

Jones and Kirkby described a form from Carlisle as Kirkbya permiana (Jones) which is undoubtedly distinct from the type, and from any other named species known to me. This form has similarly arranged flanges and also a pit like K. valida but the anterior is much more oblique than that of K. valida.

The specimen identified as K. valida from the Gage shale was smaller than the measurements given for K. valida or for K. clarocarinata, which it closely resembled, and is assumed to be an immature form. It was differentiated from K. clarocarinata on the basis of its greater height-length ratio and its pit which, although partially obscured, appeared to be quite small.

Kirkbya wymani Kellelt (Kellelt, Jour. Paleo., vol. 7, p. 91. 1933). Plate III

Carapace large, sub-rectangular and tumid, thickest in the anterior half of the carapace. Cardinal angles approximately right angles. Hingement with teeth and sockets moderately well developed. Hinge-line slightly depressed with broad almost flat areas on either side. Free edges bordered by a very broad, finely reticulated band, almost perpendicular to the plane of juncture of the valves. This band becomes narrower at the ends and dies out at the cardinal angles. It is much wider at the antero-ventral angle than at the post-ventral angle. The edges of this broad band or border are bounded by smooth and somewhat prominent carinae, and in the center of the border is usually a third rather obscure carina. At the extreme

edge of the left valve a fine raised line or carina can usually be seen, while this area on the right is smooth to allow for the overlap of the left valve. A very high but not well defined horizontal ridge runs along the center of the valve, and blends anteriorly with the prominent shoulder elevated above the hinge. The small, oval kirkbyan pit is situated in an elongate, depressed area which lies immediately below the high central ridge and extends forward from the center of the valve to the anterior shoulder. Surface covered with fine reticulations which on the lower half of the valve run in many concentric lines paralleling the border. The juvenile stages show the usual obliquity of the antero-ventral outline in side view.

Measurements: length, 1.15 mm; height, .61 mm.

The measurements of the specimen of K. wymani from the Florence shale coincide almost exactly with the measurements given by Kellett, and it agreed with all points of the type description. The specimen from the Oketo shale is slightly smaller and has very fine reticulations, but otherwise fits the description.

Genus Knightina Kellett, 1933 (Kellett, Jour. Paleo., vol. 7, p. 97, 1933).

Small, elongate, sub-clavate Kirkbyidae with obtuse cardinal angles, the ends rounded, the anterior the more acutely rounded and rather narrow. Free margin of the left valve rabbetted to take the edge of the right, thus slightly overlapping it. Cardinal teeth and sockets poorly developed if present in this genus. An outer flange extends along the free edge with an inner flange just inside and usually directly above it, so that when viewed from the side only this one flange is apparent and it appears to border the valve. Both flanges are narrow. The prominent anterior shoulder, typically non-carinate, rises near the hinge-line and passes downward almost to the inner flange; it has an abrupt anterior face but posteriorly there is only a slight depression or a gentle slope. The surface of the valve in front of this anterior shoulder or node is flattened or gently sloping. Except for this one prominent shoulder the valve shows only very gentle convolutions, the central node being represented by a faint ridge trending obliquely toward the anterior cardinal angle. The muscle spot which is usually rounded or nearly circular, is located in front of this ridge at about mid-length and below the mid-height of the valve.

Genotype, Knightina allorismoides (Knight), (Amphissites allorismoides Knight). Upper Fort Scott limestone, Wernston,

lower Pennsylvanian, St. Louis County, Missouri.

Knightina bassleri Kellett (Kellett, Jour. Paleo., vol. 7, p. 101. 1933). Plate III

Carapace very elongate and rather thin. In side view the anterior end is narrowly rounded and the antero-ventral outline very oblique for the genus, with the widest part of the valve at the post-dorsal angle. Antero-dorsal shoulder quite distinct and very steep anteriorly with a wide flat area in front of it. Central oblique ridge characteristic of the genus trending between the anterior cardinal and the post-ventral angle very indistinct, as are the accompanying depressions in front of and behind it. The two flanges are low thickened and located very close to the edge; they are very close together, being separated by scarcely more than a wide groove even at the venter. This groove shows only a faint tendency toward reticulation. The inner flange is almost directly above the outer. Pit fairly large and oval but ill defined. Reticulations prominent. The young of this species show the usual smaller reticulations, and also in side view the very oblique anterior outline.

Measurements: length, 1.00 mm; height, .47 mm.

The specimens of K. bassleri from the Crouse limestone adhere closely to all points of the type description. The one specimen which possesses smaller reticulations is assumed to be an immature form.

Knightina harltoni Kellett (Kellett, Jour. Paleo., vol. 7, p. 99. 1933). Plate III

Carapace rather short for the genus but more elongate than any Amphisites; in dorsal view it is quite broad, being thickest at the antero-dorsal shoulder and tapering slightly to the anterior node. Ends blunt in side view. Cardinal teeth not developed. Antero-dorsal shoulder prominent and angular, with a steep anterior slope, posterior slope very slight and continuing almost unbroken to the posterior flange. The young specimens show a steeper slope immediately behind the antero-dorsal node. Area in front of this node very restricted. Central node represented by a faint ridge trending diagonally toward the antero-cardinal angle. It is most prominent just behind and above the muscle spot. Outer flange a nonreticulate line set well back from the free edge, about the width of two reticulation pits ventrally. Almost immediately above it and separated by two rows of reticulation meshes is a fine unreticulated line which probably represents the inner flange. This line

is flush with the surface below it and slightly raised above the area immediately inside it. Muscle spot a rather large circular non-reticulate area with no rim and not depressed. It is encircled by six to eight reticulation pits.

Measurements: length, .66 mm; height, .46 mm; thickness, .36 mm.

The specimen of K. harltoni from the Miss limestone is larger than the dimensions given by Kellett, but it possesses the same height-length ratio, and is assumed to be merely larger than normal. The features of the specimen from the Neva limestone are partially obscured.

Knightina minuta (Harris and Lalicker) (Kellett, Jour. Paleoc., vol. 7, p. 102. 1933). Plate III

Carapace thin and in side view fairly elongate and tapering with well rounded ventral corners. The largest specimens show a slight, ventral marginal indentation. Antero-dorsal shoulder well developed and extending above the hinge-line, very steeply sloping at the anterior, at the posterior sloping more gently to the central vertical depression or sulcus. This narrow sulcus does not extend quite down to the inner flange. The posterior surface is evenly rounded except for the abrupt shoulder immediately behind the vertical sulcus at the hinge. From the center of the vertical sulcus, extending toward the posterior is a short, scarcely noticeable, horizontal depression. The outer flange is a well defined ridge, and the inner, though thin, is more prominent, being elevated well above the surface. The outer flange is ventrally well separated from both the free edge and from the inner flange, with the area between the two flanges obscurely reticulate. Ventrally the valve slopes so that both flanges are visible in side view. Surface reticulations small. Pit obscure; a small rounded depression at the ventral end of the sulcus. Young specimens show the greater obliquity of young Kirkbyidae. The dorsal shoulder just behind the sulcus is obsolete on the smallest specimens, and the sulcus is shortened so that it scarcely extends down to the mid-height of the valve.

Measurements: length, .74 mm; height, .36 mm.

The specimens of Knightina minuta from the Oketo shale shows clearly the dorsal extension of the anterior and posterior shoulders resembling the genus Ulrichia, to which this species was originally referred by Harris and Lalicker.

EXPLANATION OF PLATE III

(All specimens 20x.)

- Fig. 1. *Kirkbya canyonensis* Harlton; left valve; length, .73 mm; height, .42 mm; Niss ls. (sample no. 21).
- Fig. 2. *Amphissites contronotus* (Ulrich and Bassler).
a. Right valve; length, .66 mm; height, .39 mm; Florena sh. (sample no. 18).
b. Left valve; length, .79 mm; height, .45 mm; Florena sh. (sample no. 18).
- Fig. 3. *Knightsina bassleri* Kellett; right valve; length, .67 mm; height, .31 mm; Crouse ls. (sample no. 23).
- Fig. 4. *Kirkbya wymani* Kellett; right valve; length, 1.07 mm; height, .56 mm; Florena sh. (sample no. 18).
- Fig. 5. *Knightsina harltoni* Kellett; right valve; length, .79 mm; height, .46 mm; Niss ls. (sample no. 21).
- Fig. 6. *Kirkbya valida* Kellett; left valve; length, .68 mm; height, .39 mm; Gage sh. (sample no. 31).
- Fig. 7. *Amphissites pinguis* (Ulrich and Bassler).
a. Right valve; length, .75 mm; height, .45 mm; Florena sh. (sample no. 18).
b. Left valve; length, .78 mm; height, .41 mm; Florena sh. (sample no. 18).
c. Dorsal aspect; length, .75 mm; breadth, .45 mm; Florena sh. (sample no. 18).
- Fig. 8. *Knightsina minuta* (Farris and Lalleker).
a. Left valve; length, .67 mm; height, .35 mm; Oketo sh. (sample no. 30).
b. Right valve; length, .62 mm; height, .32 mm; Oketo sh. (sample no. 30).
- Fig. 9. *Carbonites* (?) *tumida* (Upson).
a. Dorsal aspect; length, .59 mm; breadth, .31 mm; Johnson sh. (sample no. 11).
b. Right valve; length, .56 mm; height, .35 mm; Falls City ls. (sample no. 3).
- Fig. 10. *Knightsina texana* (Harlton).
a. Right valve; length, .54 mm; height, .26 mm; Oketo sh. (sample no. 30).
b. Left valve; length, .51 mm; height, .27 mm; Grant sh. (sample no. 32).
- Fig. 11. *Amphissites simplicissimus* Knight; right valve; length, .71 mm; height, .41 mm; Neva ls. (sample no. 15).

Plate III



Knightsina texana (Earlton) (Kellett, Jour. Paleo., vol. 7, p. 100. 1933). Plate III

Very small and rather thin species of the genus Knightsina. No hingement observed. Appearance in side view short with ends very blunt and only a slight obliquity of the ventral outline. The most prominent surface feature is the antero-dorsal shoulder which is low, and the indistinct central ridge, characteristic of the genus, running obliquely up toward the anterior cardinal angle. Behind this ridge there is a faint tendency towards a depression, the whole configuration forming the "8" characteristic of the genus.

Outer flange a thin but distinct raised line about the distance of one row of reticulation meshes from the edge of the valve. Inner flange set above or slightly within the outer, smooth at the edge but with one row of reticulation pits extending along the inner side. The area between the flanges is narrow, about the width of one row of reticulation meshes, and is covered by two rows of one-half reticulation meshes. The pit which is a circular depression, and larger than a reticulation mesh, can be seen on most forms.

Measurements: length, .68 mm; height, .32 mm.

The specimens of Knightsina texana adheres closely to the description given by Kellett. One specimen from the Oketo shale is more narrowly rounded anteriorly than are the forms illustrated by Kellett.

Genus Amphissites Girty, 1910, emend. Knight, 1928 (Kellett, Jour. Paleo., vol. 7, p. 93. 1933).

Carapace in side view rather short and sub-rectangular. Ends blunt and of equal height or the anterior slightly the narrower. Cardinal angles obtuse, hinge-line slightly depressed, hingement consisting of a groove in right valve which receives the thin edge of the left, and usually more or less well developed cardinal teeth on the left valve and corresponding cardinal sockets on the right. Left valve, with a slight inside beveling of the free edges overlapping the beveled outside edges of the right. Various nodes and ridges may be present, the most common and prominent of which are the central and the antero-dorsal nodes. Near the free edge of the valve there is commonly an "outer flange" which becomes more or less obscure toward the dorsal angles: converging with this toward the ends and paralleling it at the venter is usually an "inner flange". The inner flange is located, as with all Kirkbyidae, along the line where the surface of the valve is reflexed to be more or less perpendicular to the plane of juncture of the valves. The pit is located near the antero-ventral corner

of the central node. Surface reticulated.

Genotype by original designation--Amphissites rugosus Girty. Payetteville shale, Mississippian; Arkansas.

Amphissites centronotus (Ulrich and Bassler) (Ulrich and Bassler. Proc. U. S. Nat. Mus., vol. 30, p. 159. 1906). Plate III

Cerapace oblong subquadrate, with thick flattened edges, a long, straight back, and rather sharp cardinal angles, the posterior angle the less sharp of the two. Valves with a prominent large rounded node situated very near the middle of the dorsal half. On either side of this a smaller elevation surmounted by a thin curved vertical ridge in old examples. The marginal ridge, which likewise is well developed only in old specimens, is directly over the hinge but runs more or less within the free edges. Test reticulated, the pattern moderately fine. Free margins, ridges, and surface ornament all arranged more or less obviously in a concentric manner. "Pit" of moderate size though readily distinguished from the meshes of the surface ornament, situated at the base of the median node and very near the center of the valve.

Measurements: length, .82 mm; height, .50 mm; thickness, .30 mm.

Specimens of Amphissites centronotus adhere closely to the type description by Ulrich and Bassler. Many forms were not washed clean, probably due to the highly ornamented cerapace. There is considerable variation in the height-length ratio in this species.

Amphissites pinguis (Ulrich and Bassler) (Kellelt, Jour. Paleol., vol. 7, p. 94. 1933). Plate III

Cerapace sub-rectangular, short, thick and with rounded corners, antero-cardinal angle more oblique than the post-cardinal angle. Hinge-line impressed. A narrow non-reticulate border around the free edges. Outer flange represented, except at the posterior where it is absent, by a thin raised line inside the non-reticulate border. Surface smoothly curved, broken only by an antero-cardinal shoulder which has an abrupt anterior face but rounds smoothly into the surface behind it. Central node fairly large, but very low and ill defined. The small elongate kirkbyan pit, pointing obliquely upward toward the front is impressed on the lower side of and slightly anterior to the central node. Surface neatly reticulated.

Measurements: length, .80 mm; height, .48 mm; thickness, .38 mm.

Specimens of Amphissites pinguis adhere closely to the description by Ulrich and Passler. On some forms the central node appears to be quite well defined. Specimens from the Oketo shale are poorly preserved.

Amphissites simplicissimus Knight (Knight, Jour. Paleo., vol. 2, p. 266. 1928). Plate III

Form sub-oblong with rounded almost semi-circular ends so nearly alike that it is impossible to tell one from the other. The angles at the junctures of the ends with the straight hinge-line obscure and alike without a uniformly more distinct angle at either end. Ventral line straight and very similar to dorsal except that it joins the ends more smoothly. Dorsal view narrowly suboblong with parallel sides and bluntly rounded ends. Valves slightly unequal, the left being rabbetted on its inner edge around the free margins to take the edge of the other. There is a narrow smooth margin, widest on the left valve which passes completely around the valves. No sulci, nodes or flanges are developed, except that the antero-dorsal region is slightly wider than the post-dorsal which slopes to the dorsum more flatly. The surface of the valves except on the margins is, typically, obscurely reticulated though the reticulations may be in part or almost entirely lacking, being in such examples either undeveloped or exfoliated. A circular Kirkbyan pit or muscle spot of about the diameter of two reticulation pits and not impressed below the surface is located at the center of each valve. Short spinelets arise irregularly from the points of juncture of the meshes of the reticulations, or may be absent from nondevelopment or exfoliation. These are often most prominent next to the ventral and end margins and may be homologous with the carinate outer flange of some Amphissitidae. Attempts to discover other linear arrangement of spinelets over the surface of the valve were unsuccessful.

My reference of this species to the genus Amphissites is obviously not because it possesses the characteristic nodding, but because of its straight-line, rounded ends, rabbetted and slightly overlapping left valve, Kirkbyan pit and reticulated surface. This form may represent the complete repression of the more typical nodding and ridging of the genus and therefore be its simplest and least typical expression.

The average dimensions of several specimens are: length, .65 mm; height, .36 mm; thickness, .25 mm.

The specimen of Amphissites simplicissimus from the Neva limestone is larger than the average dimensions given by Knight.

The short spinelets at the juncture of the reticulation meshes are absent, and it is assumed that this was due to nondevelopment, since the form does not appear to be exfoliated.

Genus Carbonita (?) Strand, 1923 (Kellett, Jour. Paleo., vol. 9, p. 154. 1935).

Carapace small, subreniform; dorsum arched; venter slightly concave; ends rounded in lateral view, the anterior end lower and more narrowly rounded than the posterior; greatest height at or behind the center; posterior half thicker than the anterior; right valve larger than the left and overlapping it except along the central third of the dorsum where the hinge line is depressed; the left valve sometimes seems to extend a little above the right along this depressed part of the hinge line; overlap of right valve greatest ventrally in front of the center, and on the antero-dorsal slope just above the anterior end; shell rather thin and covered with fine pits which are sometimes obscure, pits arranged in more or less discernible horizontal rows; a circular medium sized muscle spot located in front of the center. Single valves are of rare occurrence and any hinge and marginal structure present is still unknown.

Carbonita (?) tumida (Upson) (Kellett, Jour. Paleo., vol. 9, p. 160. 1935). Plate III

Carapace very tumid posteriorly in dorsal view, the posterior end rounded and the anterior end pointed and sometimes slightly compressed; a short marginal ridge at the antero-ventral corner, anterior extremity of the venter somewhat compressed and ridgelike but venter flattened at the center and just in front of the center.

Measurements: length, .67 mm; height, .39 mm; thickness, .32 mm.

The specimens of Carbonita (?) tumida from both the Falls City limestone and the Johnson shale are smaller than the dimensions given by Kellett. All forms show the marked ventral overlap distinctly.

Family BAIRDIIDAE Lienenklaus

Genus Bairdia McCoy, 1844 (Upson, Wabr. Geol. Sur., Bul. 8, Second Series, p. 24. 1935).

Shell subrectangular or rhomboidal; greatest height near the middle; inequivalved; narrowly rounded anteriorly and more or less acuminate posteriorly, dorsal margin

usually strongly convex; hinge line straight, short; left valve overlaps the right dorsally and along ventral median third; surface smooth.

Genotype by subsequent designation--Bairdia curta McCoy. Mountain limestone, Mississippian, Ireland.

Bairdia beedei Ulrich and Bassler (Kellett, Jour. Paleo., vol. 8, p. 123. 1934). Plate IV

Carapace in lateral view subrhomboidal and rather elongate; ventral margin gently convex, rounding broadly into the extremities; dorsal margin slightly angled in the post-dorsal portion; anterior beak narrowly rounded and at the mid-height of the valve; posterior beak bluntly acuminate and very slightly below the mid-height; carapace moderately thick in ventral view with evenly tapered ends; right valve much more convex than the left; greatest height central; greatest thickness in the central portion in a horizontal line along the mid-height of the valves with almost flat surfaces sloping on either side to the dorsal and ventral peripheries; dorsal apparent overlap conspicuous with a long straight hinge line about one-half the length of the carapace terminated at each end by an obtuse angle; valves meeting smoothly with slight indentation; antero-ventral sinuosity in the line of juncture of the valves characteristic of all Bairdia well developed; muscle scar pattern in an unusually deep pit which is very steep on its posterior side, sloping more gradually on the anterior side; muscle scar pit apparently a little deeper on the more tumid right valve.

Measurements: length, 1.35 mm; height, .77 mm; thickness, .56 mm.

Specimens of Bairdia beedei found throughout the column agree with all points of the type description. On one form from the Hawxby shale, the muscle scar can be seen through the clear wall of the carapace.

Bairdia florensaensis Upson (Upson, Webr. Geol. Sur., Bul. 8, Second Series, p. 24. 1933). Plate IV

Carapace sub-oblong in lateral view; dorsal margin broadly arched, curvature most pronounced over anterior end of hinge, posterior slope long, convex, lower third steeply inclined; anterior slope convex; hinge line short, depressed, located mainly in posterior half; ventral margin usually straight but often concave medially; inclined posteriorly from region of antero-ventral angle; posterior extremity bluntly acuminate, located below median line; anterior extremity broadly rounded, most pronounced dorsally; greatest height about one-third length of shell from anterior

end; ventral profile elongate, extremities thick, greatest thickness in median two-thirds; left valve the larger strongly overlapping the right on anterior dorsal slope and along ventral median third, remaining overlap of free margin slight; surface smooth.

Measurements: length, 1.212 mm; height, .60 mm; thickness, .45 mm.

Specimens of Bairdia florensis adhere closely to the description given by Upson. This species is ordinarily quite well preserved. It is included in what Kellett calls the "Bairdia ampla" group, which is difficult to differentiate and members of which should be used as stratigraphic markers only with great caution.

Bairdia boxbarensis Harlton (Upson, Nebr. Geol. Sur., Bul. 8, Second Series, p. 18, 1933). Plate IV

Carapace small, elongate, length about two and one-half times the height; dorsal margin arched, posterior slope long and straight, anterior slope slightly convex; ventral margin concave on posterior half of median third; anterior extremity broadly rounded, nearly as broad as maximum width of shell; posterior extremity bluntly pointed; greatest height over dorsal angle; dorsal view lanceolate, thickest central; left valve largest, moderately overlapping the right dorsally and along ventral median third. Surface smooth.

Measurements: length, 1.14 mm; height, .525 mm; thickness, .374 mm.

The above description is that of B. nebraskensis Upson which Kellett lists as a synonyme of B. boxbarensis. The literature containing the original description of B. boxbarensis was not available. This form is sufficiently distinctive among local species of Bairdia to permit easy recognition.

Bairdia marmorea Kellett (Kellett, Jour. Paleol., vol. 8, p. 127, 1934). Plate IV

Carapace rather small; in lateral view anterior end narrowly rounded and slightly above the mid-height of the valve; posterior end pointed and slightly below the mid-height; dorsal and ventral margins evenly arched; greatest height slightly anterior to the center; in dorsal view ends

evenly tapered; dorsal line of contact of the valves very slightly if at all depressed and straight in the central part rather than arched.

Measurements: length, 1.06 mm; height, .58 mm; thickness, .39 mm.

The criterion of size was employed to a great extent in differentiating between Bairdia marmorea and B. beedei. The general outline of the two forms varies only slightly and is difficult to distinguish, even on perfectly preserved forms.

Bairdia reussiana Kirkby (Kellett, Jour. Paleo., vol. 8, p. 132. 1934). Plate IV

Carapace elongate tapering; anterior beak broad and blunt with rather square corners; posterior beak high and blunt; greatest height anterior to the center; antero-dorsal slope in side view slightly depressed; apparent overlap narrow.

Measurements: length, 1.34 mm; height, .61 mm; thickness, .41 mm.

Specimens of Bairdia reussiana are generally poorly preserved. Forms from the Oketo shale are smaller than the dimensions given by Kellett, but agree in outline with larger forms, and are assumed to be immature.

Bairdia seminalis Knight (Knight, Jour. Paleo., vol. 2, p. 320. 1928). Plate IV

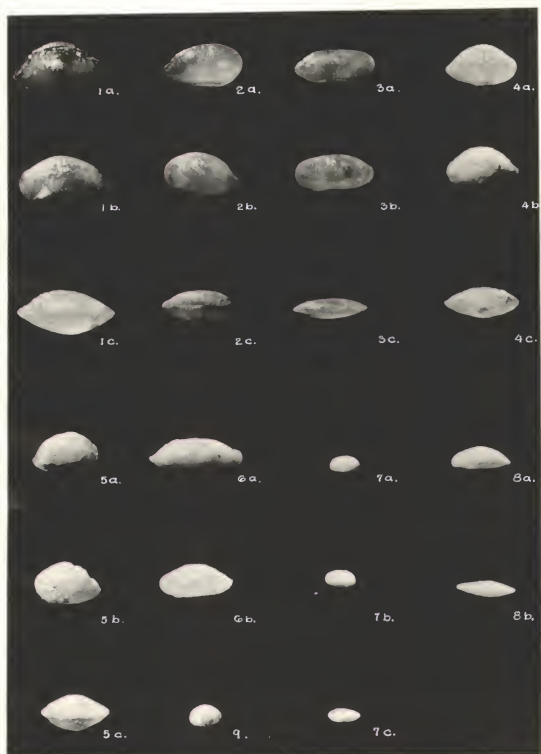
Outline of the larger (left) valve sub-oval, the entire carapace having a seed-like aspect. Dorsal outline roundly curved, slightly flattened on the antero-dorsal and less so on the post-dorsal slope. No angulation over the post-dorsal end of the hinge. Posterior beak bluntly angular but not conspicuous. Ventral outline roundly and gently curved for its posterior three quarters and more abruptly upward to the somewhat more sharply rounded anterior end. Outline when viewed from above broadly lanceolate and gently convex, the broadest point being about mid-way. The outline of the smaller (right) valve is considerably narrower and sub-oblong. The hingeline is comparatively short being about fifty-five percent of the total length. The dorsal margin of the right valve is flatly arched with a backward slope along the hinge with a steeply rounded post-dorsal and more gradual antero-dorsal slope. The anterior end is somewhat drawn out. The overlap of the left valve is rather pronounced, particularly along the dorsal line. It is even

EXPLANATION OF PLATE IV

(All specimens 20x.)

- Fig. 1. *Bairdia beedei* Ulrich and Bassler
a. Right valve; length, 1.29 mm; height, .72 mm; Hawxby sh. (sample no. 1).
b. Left valve; length, 1.25 mm; height, .70 mm; Florena sh. (sample no. 18).
c. Dorsal aspect; length, 1.30 mm; breadth, .60 mm; Florena sh. (sample no. 18).
- Fig. 2. *Bairdia florenaensis* Upson (sample no. 1).
a. Right valve; length, 1.09 mm; height, .59 mm; Hawxby sh.
b. Left valve; length, 1.00 mm; height, .58 mm; Hawxby sh.
c. Dorsal aspect; length, 1.00 mm; breadth, .42 mm; Hawxby sh.
- Fig. 3. *Bairdia hoxborensis* Harlton (sample no. 1).
a. Right valve; length, 1.09 mm; height, .45 mm; Hawxby sh.
b. Left valve; length, 1.06 mm; height, .47 mm; Hawxby sh.
c. Dorsal aspect; length, 1.00 mm; breadth, .27 mm; Hawxby sh.
- Fig. 4. *Bairdia marmorea* Kellett (sample no. 30).
a. Right valve; length, .99 mm; height, .55 mm; Oketo sh.
b. Left valve; length, .97 mm; height, .58 mm; Oketo sh.
c. Dorsal aspect; length, 1.00 mm; breadth, .41 mm; Oketo sh.
- Fig. 5. *Bairdia seminalis* Knight
a. Right valve; length, .90 mm; height, .56 mm; Florena sh. (sample no. 18).
b. Left valve; length, .88 mm; height, .56 mm; Florena sh. (sample no. 18).
c. Dorsal aspect; length, .90 mm; breadth, .42 mm; Hughes Creek sh. (sample no. 9).
- Fig. 6. *Bairdia reussiana* Kirkby.
a. Right valve; length, 1.24 mm; height, .47 mm; Crouse ls. (sample no. 23).
b. Left valve of immature specimen; length, .97 mm; height, .44 mm; Oketo sh. (sample no. 30).
- Fig. 7. *Bythocypris pediformis* Knight (sample no. 2).
a. Right valve; length, .41 mm; height, .23 mm; Hawxby sh.
b. Left valve; length, .41 mm; height, .24 mm; Hawxby sh.
c. Dorsal aspect; length, .43 mm; breadth, .17 mm; Hawxby sh.
- Fig. 8. *Macrocypris garrisonensis* Upson (sample no. 2).
a. Left valve; length, .79 mm; height, .31 mm; Hawxby sh.
b. Dorsal aspect; length, .80 mm; breadth, .22 mm; Hawxby sh.
- Fig. 9. *Healdia winfieldensis* Upson; right valve; length, .43 mm; height, .27 mm; Grant sh. (sample no. 32).

PLATE IV



more conspicuous than usual ventrally. The produced anterior end of the right valve however extends forward almost as far as that of the left.

Measurements: length, .75 mm; height, .48 mm; thickness, .35 mm.

The inconspicuous beak and rounded outline of Bairdia seminalis aided in its differentiation from others of the same genus. This form is smaller than most other members of the genus Bairdia. Specimens of B. seminalis are common in the dense Cottonwood limestone, possibly because their symmetry of form enabled the rock to break around the carapace, rather than through it.

Genus Bythocypris Brady, 1980 (Kellett, Jour. Paleo., vol. 9, p. 135. 1935).

Shell smooth, reniform ovate or elliptical; left valve larger than the right, overlapping it usually on both the dorsal and ventral margins; dorsal margin convex, the ventral edge straighter, sometimes slightly concave.

Genotype: Bythocypris reniformis Brady, Recent. Range, Ordovician to Recent.

Bythocypris pediformis Knight (Kellett, Jour. Paleo., vol. 9, p. 135. 1935). Plate IV

Carapace subovate; greatest height a little behind the center or sometimes at or slightly in front of the center; dorsal margin very slightly to distinctly arched; ventral margin usually a little convex, sometimes slightly concave, anterior half a little narrower than the posterior in side view and broadly rounded; posterior margin slants roundly downward almost to the venter where it makes more or less of a right angle; greatest thickness posterior or posterior and central; left valve overlaps the right all around, most conspicuously at the venter and very little at the ends; the larger left valve has a groove extending along the interior of the entire dorsal margin and a ventral groove from the posterior angle almost to the anterior.

Measurements: length, .60 mm; height, .33 mm.

Specimens on Bythocypris pediformis are usually well preserved. No single valves were found, so that it was impossible to detect the characteristic grooving of the left valve.

Genus Macrocypris Brady, 1867 (Kellett, Jour. Paleol., vol. 9, p. 133. 1935).

Carapace elongate, dorsum broadly arched and venter almost straight, in lateral view anterior rounded and posterior pointed, carapace in dorsal view elongate fusiform with tapering ends, right valve larger than the left and overlapping it or apparently overlapping it more or less completely all around, surface smooth.

Genotype, Macrocypris minna Baird, a recent species. Range, Ordovician to Recent.

Macrocypris garrisonensis Upson (Upson, Nebr. Geol. Sur., Bul. 8, Second Series, p. 25. 1933). Plate IV

Carapace elongate, small, length two and one-half times the height; greatest height over dorsal angle; dorsal margin broadly arched; posterior slope long and straight to faintly convex; anterior slope broadly convex; ventral margin straight; posterior end sharply pointed; anterior end narrowly rounded; dorsal view lanceolate; right valve faintly overlaps the left along upper two-thirds of dorsal slopes and to a greater extent along major portion of ventral margin; the overlap not extending to the extremities either dorsally or ventrally; surface smooth.

Measurements: length, .909 mm; height, .303 mm; thickness, .247 mm.

There appears to be considerable variation in the height-length ratio of the specimens of Macrocypris garrisonensis from the Hawxby shale. The ventral overlap is readily noted, but the dorsal overlap is indistinct.

Genus Healdia Roundy, 1926 (Upson, Nebr. Geol. Sur., Bul. 8, Second Series, p. 27. 1933).

Carapace small; dorsal margin arched, almost angular in the middle; post-dorsal slope usually truncate; posterior extremity more sharply rounded than anterior extremity; ventral profile wedge-like, thickest posteriorly; the thickest portion is modified by one or two small backward pointing spines or a faint vertical ridge on each valve, some species carrying both spines and ridges; left valve grooved to receive the right; surface smooth.

Genotype, Healdia simplex Roundy, 1926.

Healdia winfieldensis Upson (Upson, Nebr. Geol. Sur., Bul. 8, Second Series, p. 28. 1933). Plate IV

Carapace small, sub-oblong in lateral view; dorsal margin moderately arched; anterior slope broadly convex and longer than posterior slope; posterior slope straight; ventral margin broadly convex to nearly straight rounding evenly into the extremities; anterior extremity broadly

rounded; posterior extremity rounded; greatest length median; greatest height over center of dorsal arch; dorsal profile wedge-like, greatest thickness about one-fifth maximum length from posterior end. About one-fifth distance from posterior end occurs an indistinct vertical ridge connecting two short forward-projecting spines, the spines set in a short distance from their respective margins; surface slopes from vertical ridge abrupt posteriorly and broadly convex anteriorly; left valve larger, overlapping ventrally, dorsally and around posterior extremity; inner edge of left valve grooved dorsally and posteriorly to receive the beveled edge of right valve; surface smooth.

Measurements: length, .50 mm; height, .31 mm; thickness, .38 mm.

The specimen of Healdia winfieldensis from the Grant shale shows clearly the posterior spines, but on this form, the spines appear to point posteriorly in agreement with the generic description, rather than anteriorly as described by Upson. The illustrations given by Upson are not in sufficient detail to show the spines.

Family CYTHERELLIDAE Sars

Genus Cavellina Coryell, 1928, emend. (Kellett, Jour. Paleoc., vol. 9, p. 144. 1935).

Carapace oblong or ovate, dorsum moderately arched and venter slightly concave to convex; in lateral view the ends rounded, the post-ventral portion having a truncated appearance; posterior end thicker than the anterior, decidedly thicker in the female than the male; surface smooth; contact margin of the right (larger) valve grooved or rabbeted along its inner edge, to receive the smaller left valve which is sometimes beveled marginally; inner calcareous lamella lacking. Females sometimes shorter than the fully developed males, and thicker and higher, especially at the posterior; the females are also characterized by an internal depression in the posterior third of the valve, deepest ventrally, and set off from the rest of the valve by a more or less well developed vertical ridge reaching from the venter almost to the dorsum. This internal depression and ridge are only very faintly if at all developed in the male. Some young specimens show an external shallow pit over the central muscle spot, or an external vertical posterior ridge.

Genotype by original designation: Cavellina pulchella Coryell, lower Middle Pennsylvanian, Oklahoma.

Cavellina edmistonae (Harris and Lalicker) (Kellett, Jour. Paleol., vol. 9, p. 147. 1935). Plate II

Carapace very small for species of this genus, adults in lateral view rather short and the ends broadly rounded, dorsum slightly arched, venter straight to slightly convex; dorsal overlap narrow, widest at the anterior; posterior third of the interior of the female valves slightly depressed and set off by a low vertical ridge from the rest of the valve; females also show characteristic posterior inflation in dorsal view; the young and rare adults show a shallow central pit located just above the median line; surface smooth.

Measurements: length, .71 mm; height, .43 mm; thickness, .29 mm.

Specimens of Cavellina edmistonae are usually very well preserved and agree with all points of the description given by Kellett.

Cavellina nebrascensis (Geinitz) (Kellett, Jour. Paleol., vol. 9, p. 146. 1935). Plate II

(Kellett does not include a formal description of Cavellina nebrascensis, and the literature containing the original description by Geinitz is not available. The following is a discussion by Kellett, citing the characters which serve to set C. nebrascensis off from other species belonging to the genus Cavellina).

C. nebrascensis is a little smaller than C. pulchella Coryell, found lower in the Pennsylvanian strata, and is less arched dorsally in lateral view. The latter difference is particularly noticeable between the males of the species (the male of C. pulchella was formerly called C. gloria) and the figures of the male of C. pulchella given by Coryell and Sample, Warthin, Delo, and Jones, Kirkby and Brady. C. nebrascensis is also smaller than Cavellina ovoidiformis (Harlton) found lower in the Pennsylvanian, the sides are more nearly parallel than shown in the type figures, the ends more narrowly rounded and the overlap less prominent than on C. ovoidiformis.

The young of C. nebrascensis can be distinguished scarcely, if at all, from those of C. fittsi.

The females of C. nebrascensis show a low interior vertical ridge reaching almost to the dorsum with a deep depression behind it as is typical of the female of this genus.

Measurements: length, 1.97 mm; height, .62 mm; thickness, .43 mm.

Specimens of Cavellina nebrascensis from the West Branch shale are occasionally sufficiently exfoliated to show the interior vertical ridge of the female forms. Some forms from the Stine shale have been partially replaced by pyrite.

Genus Silenites Coryell and Booth, 1935 (Kellett, Jour. Paleo., vol. 9, p. 150. 1935).

Carapace subtriangular; in lateral view dorsal margin arched and sloping into the broadly rounded ends; venter weakly concave just anterior to the center; post-ventral outline more broadly rounded and truncate than the antero-ventral outline; greatest thickness at or just behind the center; apparent overlap of the left valve very conspicuous dorsally and more inconspicuous ventrally and at the ends, greatest at the hinge along the post-dorsal margin; the right valve shows a slight angulation in the post-dorsal region and at the center of the dorsum; carapace smooth and unornamented; edge of left valve distinctly grooved along the hinge to receive the right valve, grooves most distinct in the post-dorsal area and at the center of the dorsum a slight groove also present at the ends and at the venter; interior muscle spot immediately anterior to the center, a distinct, large, circular depression with a pattern of two parallel vertical rows of small, nearly horizontal ridges almost covering it; muscle spot not visible on the exterior; calcareous inner lamellae either not developed or developed only as a very thin and inconspicuous layer along the ventral margins of the left valve; fine normal pores in the shell wall. Dorsal overlap relatively narrower and less conspicuous on the immature than on the mature molts.

Genotype by original designation: Silenites silenus Coryell and Booth, Graham formation, Pennsylvanian Texas, a synonym of Silenites lenticularis (Knight), Marmaton group, Pennsylvanian, Missouri. Range, Mississippian to Permian.

Silenites lenticularis (Knight) (Kellett, Jour. Paleo., vol. 9, p. 151. 1935). Plate II

Small, dorsum highly arched, ventral line gently convex to nearly straight. Anterior end broadly rounded, meeting the ventral line smoothly but with a slight backward obliquity. Posterior end falls downward from the dorsal line with a flat curve almost to the ventral line where it rounds sharply but smoothly into the venter. Outline when viewed from above sub-ovate. End view acutely sub-ovate

with the greatest width above the middle and with the lines of the sides converging ventrally rather flatly. Valves almost equal with the right possibly very slightly the larger but not overlapping. Surface smooth and without ornamentation. A very obscure sub-central stellate muscle spot can be made out in some specimens.

Measurements: length, .57 mm; height, .43 mm.

Kellett, in her discussion of Silenites lenticularis, did not include a formal description. The above description is that of Carbonia (?) lenticularis Knight (Knight, Jour. Paleo., vol. 2, p. 335. 1929) which is listed as a synonym of S. lenticularis.

Family CYTHERIDAE Baird

Genus Basslerella Kellett, 1935 (Kellett, Jour. Paleo., vol. 9, p. 156. 1935).

Carapace small, subtriangular in lateral view; venter almost straight, dorsum arched or slightly angled, anterior end broadly rounded or angled and posterior end very low and narrowly rounded to rather pointed; greatest height anterior to the center; greatest thickness central or posterior to the center; venter broad and flat; in dorsal view the posterior end is broader than the anterior end which may be compressed; left valve larger than the right and overlapping it except in the post-dorsal portions; ventral overlap narrow and almost straight, slightly wider in front of the center; left valve grooved on the inner edge at and just in front of the center of the dorsum to receive the right valve, the genotype showing faint vertical striations or teeth in the central and widest part of this groove, the striations being coarsest and best defined at the anterior of the groove; calcareous inner lamella of medium and even width around the venter and the ends, only slightly developed dorsally and apparently modified by the hingement; line of concrescence paralleling and lying in close proximity to the inner margin of the calcareous inner lamella; outer surface of carapace smooth except for some fine lengthwise striations observed on two species.

Genotype: Basslerella crassa Kellett, Elmdale formation, Early Permian, Kansas. Range, Pennsylvanian and Permian.

Basslerella firma Kellett (Kellett, Jour. Paleo., vol. 9, p. 156. 1935). Plate II

B. firma is quite like B. crassa and B. obesa but it is smaller than either and even in its widest form less inflated.

(Following is a formal description of B. crassa Kellett (Kellett, Jour. Paleo., vol. 9, p. 156. 1935) to supplement the above description of B. firma).

Carapace short and subtriangular in lateral view, anterior end broadly rounded, posterior end blunt and low, dorsum broadly angled at the point of greatest height just in front of the center, venter weakly curved upward at the posterior end; venter broad and flat so that the closed carapace rests easily upon it; in dorsal view the carapace is broadly angled at the posterior end, widest behind the center and tapering rapidly to the pointed anterior end; post-dorsal area somewhat flattened with a slightly indented hinge line; anterior and antero-dorsal overlap prominent and continuous with the ventral overlap; venter shows fine lengthwise striations.

Measurements (of B. firma): length, .46 mm; height, .28 mm; thickness, .24 mm.

The fine lengthwise striations on the venter, described by Kellett as being present on B. crassa, are not discernible on forms of B. firma from the Hawxby shale. The assignment of the genus Basslerella to Family Cytheridae was taken from Kellett (8) rather than from Bassler and Kellett (1), who list no Paleozoic genera under F. Cytheridae.

Table 2 (concl.).

Stratigraphic unit and sample number	
Genera and species	Lawley (1) Lawley (2) Falls City (3) West Branch (4) Five Point (5) Mine (6) Pouchen Cr. (7) Macrurus (8) Pyles Cr. (9) Long Cr. (10) Johnson (11) Bennett (12) Bennett (13) Furr (14) Neva (15) Bekridae (16) Cottonwood (17) Florena (18) Florena (19) Morrill (20) Miss (21) Middleburg (22) Croise (23) Three-mile (24) Lavenaville (25) Celroyer (26) Wyore (27) Kinney (28) Florence (29) Oketo (30) Cave (31) Grant (32)
<i>Bolliaella emaciata</i>	
<i>Bollinella gibbosa</i>	
<i>Jonesina bolliaformis</i>	
<i>Jonesina primitioides</i>	
<i>Kirkbya canyonensis</i>	
<i>Kirkbya valida</i>	
<i>Kirkbya wymani</i>	
<i>Knisthina bassleri</i>	
<i>Knisthina barltoni</i>	
<i>Knisthina minuta</i>	
<i>Knisthina texana</i>	
<i>Macropris garrisonensis</i>	
<i>Monoceratina lewisi</i>	
<i>Paraparelites humerosus</i>	
<i>Silenites lenticularis</i>	
<i>Ulrichia robusta</i>	

SUMMARY AND CONCLUSIONS

A summary of the tabulation (table 2) of the microfaunal assemblages of the stratigraphic units investigated, based upon samples collected from the Wolfcamp Series in Riley County, is as follows:

Hawxby shale. The ostracod fauna of the Hawxby consists entirely of long-ranging forms which occur throughout the Wolfcamp Series. This is the first appearance in the local sequence of Bythocypris pediformis, which is abundant, Bairdia florensaensis, B. boxbarensis, Pasciellerella firma, and Macrocypris garrisonensis, all of which are common, and Bairdia beedei, B. seminalis, and Jonesina bolliiformis, which are rare. The remainder of the microfaunal assemblage consists of rare trilobite fragments, common pecten-like pelecypods, rare arenaceous foraminifers, and rare perforate, trochoid foraminifers. Also present are crinoid columnals, brachiopod spines, and coral fragments.

Falls City limestone. The variety and abundance of ostracods decreases markedly in the Falls City. Bythocypris pediformis, found in abundance in the Hawxby shale, is common and Carbonita (?) tumida, found rarely, makes its first appearance. The presence of other microfossils was not noted in this unit.

West Branch shale. The ostracod fauna of the West Branch is more varied than that of the Falls City limestone. Bythocypris pediformis occurs in abundance, as does Cavellina nebrascensis. Healdia winfieldensis is common, and Pollinella gibbosa is found

rarely. This is the first appearance of Cavellina nebrascensis, Healdia winfieldensis, and Hollinella gibbosa. Other microfossils were not noted in the West Branch.

Five Point limestone. The ostracod fauna of the Five Point consists entirely of Cavellina nebrascensis, which is found only rarely. The remainder of the fauna is made up of low-spined and high-spined gastropod, brachiopod spines, crinoid columnals, and Polypora-type bryozoan fragments.

Stine shale. Hollinella crassamarginata makes its first appearance in the Stine, where it is rare. Bythocypris pediformis and Cavellina nebrascensis again appear in abundance. The remaining fauna consists of rare arenaceous foraminifers, rare conodonts, crinoid brachials and columnals, and brachiopod spines.

Houchen Creek limestone. The ostracod fauna of the Houchen Creek is made up solely of Bythocypris pediformis, which occurs only rarely. Brachiopod spines are common.

Americus limestone. Bairdia marmorea is the only ostracod present in the Americus, and it occurs only rarely. This is the first appearance of B. marmorea. The presence of other microfossils was not noted in the Americus.

Hughes Creek shale. The ostracod fauna of the Hughes Creek consists of Amphissites centronotus, Bairdia florensensis, Cavellina edwinstonae, all of which are rare, and Bairdia marmorea and B. seminalis, which are common. This is the first occurrence in the Wolfcamp Series for the genus Amphissites, as well

as for Bairdia seminalis and Cavellina edmistonae. The remaining microfaunal assemblage is composed of common arenaceous foraminifers, abundant perforate trochoid foraminifers, two kinds of gastropods, abundant fusulinids, crinoid columnals and brachials, echinoid spines, brachiopod spines, and bryozoan fragments.

Long Creek limestone. The ostracod fauna of the Long Creek is composed of Silenites lenticularis, which is rare, and Bairdia florensaensis, which is common. This is the only occurrence of Silenites lenticularis throughout the column. The remainder of the microfauna consists of abundant fusulinids and arenaceous foraminifers, and two kinds of gastropods.

Johnson shale. The ostracod fauna of the Johnson consists solely of Bythocypris pediformis and Carbonita (?) tumida. This is the last occurrence of Carbonita (?) tumida in the Wolfcamp Series. The only other organic material in evidence is brachiopod spines.

Bennett shale. The ostracod fauna of the Bennett is made up of Amphissites centronotus, Bairdia florensaensis, and B. marmorea, which are rare, and Bythocypris pediformis, which is common. The remaining microfaunal assemblage consists of rare arenaceous foraminifers, pelecypods, spinose brachiopods, echinoid spines and plates, and abundant brachiopod spines and crinoid columnals.

Burr limestone. The ostracod fauna of the Burr consists of Bythocypris pediformis, which is common, and Cavellina edmistonae and Hollinella gibbosa, which are rare. Other

microfossils were not noted in this unit.

Neva limestone. The ostracod fauna of the Neva is made up of Amphissites simplicissimus, Bairdia florensaensis, Cavellina edmistonae, and Knightina harltoni, all of which are rare. This is the only appearance in the Wolfcamp Series for Amphissites simplicissimus, and the first appearance for the genus Knightina. Other microfossils encountered in the Neva were rare perforate, trochoid foraminifers, two genera of arenaceous foraminifers, and bryozoan fragments, crinoid columnals, and sponge spicules.

Eskridge shale. The ostracods found in the Eskridge are Rythocypris pediformis and Jonesina primitioides, which are rare, and Jonesina bolliiformis, which is common. This is the first appearance of Jonesina primitioides. Other microfossils noted were common gastropod fragments of two genera, rare scolecodonts, two genera of perforate, trochoid foraminifers, and brachiopod spines.

Cottonwood limestone. The ostracod fauna of the Cottonwood is composed of Bairdia florensaensis, which is rare, and Bairdia seminalis, which is common. Other microfossils in evidence are arenaceous foraminifers, which are common, and abundant fusulinids. Fragmentary remains of other ostracods were noted, but these remained embedded in the matrix and were not identifiable.

Florena shale. The ostracod fauna of the Florena consists of Amphissites centronotus, Bairdia beedel, B. florensaensis, B. marmorea, B. seminalis, Jonesina bolliiformis, Kirkbya canyonensis, and Monoceratina lewisi, which are common; Bairdia boxbergerensis,

Cornigella parva, Ellipsella distenta, Hollinella gibbosa, Jonesina primitioides, Kirkbya wamani, and Knightina texana, which are rare; and Amphissites pinguis, which is common in the lower part of the shale and rare in the upper part. This is the first appearance for Amphissites pinguis, Cornigella parva, Knightina texana, Monoceratina lewisi, and for the genus Kirkbya. The Florena shale marks the last appearance of Bairdia hoxborensis and B. seminalis, and the only appearance for Ellipsella distenta. The remainder of the microfaunal assemblage is composed of two genera of arenaceous foraminifers, two genera of perforate, trochoid foraminifers, and common brachiopod spines, echinoid spines, trilobite fragments, crinoid columnals, and abundant fusulinids.

Morrill limestone. The ostracod fauna of the Morrill is made up solely of Carbonita (?) tumida magna, and this species is found only rarely. This is the only appearance of Carbonita (?) tumida magna in the Wolfcamp Series. Other microfossils noted were pelecypod fragments and high-spired gastropods.

Hiss limestone. The ostracod fauna of the Hiss is composed of Amphissites centronotus, A. pinguis, Kirkbya canyonensis, and Knightina harltoni, all of which are rare. This is the last appearance of Kirkbya canyonensis in the Wolfcamp Series. Other microfossils noted in the Hiss were rare perforate, trochoid foraminifers, arenaceous foraminifers belonging to two genera, brachiopod spines, echinoid spines and plates, crinoid brachiols, and bryozoan fragments.

Middleburg limestone. The ostracod fauna of the Middleburg limestone is made up of Hollinella emaciata, H. gibbosa, and Paraparchites humerosus, which are rare, and Jonesina bolliiformis, which is abundant. This is the first appearance of both Hollinella emaciata and Paraparchites humerosus. Several specimens belonging to the genus Bairdia were noted, but these were all immature moults and could not be identified as to species. Other microfossils noted were gastropod fragments and crinoid columnals and brachials.

Grouse limestone. The ostracod fauna of the Grouse limestone consists of Bairdia reussiana and Knightina bassleri, which are rare, and Bairdia beedei, which is abundant. This is the first appearance of Bairdia reussiana, and the only appearance of Knightina bassleri. The remaining microfaunal assemblage is made up of common perforate, trochoid foraminifers, arenaceous foraminifers belonging to two genera, rare spinose brachiopods, brachiopod spines, crinoid brachials and columnals, echinoid spines, holothurian ossicles, bryozoan fragments, trilobite fragments, and pelecypod fragments.

Threemile limestone. The ostracod fauna of the Threemile limestone is composed of Amphisites centronotus and Ulrichia robusta, which are common, and Amphisites pinguis, Bairdia beedei, E. florenzensis, and Basslerella firma, which are rare. This is the last appearance of Basslerella firma in the Wolfcamp Series, and the first appearance of Ulrichia robusta. Other microfossils noted in the Threemile were common arenaceous foraminifers, bryozoan fragments, crinoid columnals, coral

fragments, brachiopods, and brachiopod spines.

Havensville shale. The ostracod fauna of the Havensville shale consists solely of Jonesina primitioides, and this species is rare. The only other microfossils noted were rare perforate, trochoid foraminifers.

Schroyer limestone. The ostracod fauna of the Schroyer limestone is made up of Bairdia beedei, which is abundant, Hollinella crassamarginata and Jonesina bolliiformis, which are common, and Bairdia marmorea, Cavellina edmistonae, Hollinella gibbosa, and Paraparchites humerosus, which are rare. This was the last occurrence of Paraparchites humerosus in the Wolfcamp Series. Other microfossils found were arenaceous foraminifers belonging to two genera, perforate, trochoid foraminifers belonging to two genera, brachiopod spines, and crinoid columnals and brachials.

Wymore shale. The ostracod fauna of the Wymore shale consists solely of Jonesina bolliiformis, which is common, and rare specimens of Jonesina primitioides, its last occurrence in the Wolfcamp Series. Other microfossils present are common arenaceous foraminifers and brachiopod spines.

Kinney limestone. The ostracod fauna of the Kinney limestone consists of Bairdia beedei, Cavellina edmistonae, and Jonesina bolliiformis, all of which are common. Other microfossils found were perforate, trochoid foraminifers belonging to two genera, holothurian ossicles, crinoid columnals and brachials, and brachiopod spines.

Florence limestone. The ostracod fauna of the Florence limestone is made up of Cavellina edwistonae, which is abundant, Bairdia beedei, Hollinella emaciata, and Monoceratina lewisi, which are common, and Bairdia florensaensis, B. marmorea, B. reussiana, Hollinella crassamarginata, and H. gibbosa, which are rare. This is the last occurrence of Hollinella crassamarginata and H. emaciata in the Wolfcamp Series. The remaining microfaunal assemblage consists of arenaceous foraminifers belonging to two genera, rare holothurina ossicles, rare pecten-like pelecypods, crinoid brachials and columnals, and brachiopod spines.

Oketo shale. The ostracod fauna of the Oketo shale consists of Bairdia beedei and Bythocypris pediformis, which are abundant, Bairdia marmorea and Knightina minuta, which are common, and Amphissites pinguis, Bairdia florensaensis, B. reussiana, Cornigella parva, Jonesina bolliiformis, Kirkbya wymani, Knightina harltoni, K. texana, Macrocypris garrisonensis, Monoceratina lewisi, and Ulrichia robusta, all of which are rare. This is the last occurrence of Amphissites pinguis, Bairdia florensaensis, B. reussiana, Bythocypris pediformis, Cornigella parva, Jonesina bolliiformis, Kirkbya wymani, Knightina harltoni, K. minuta, Macrocypris garrisonensis, Monoceratina lewisi, and Ulrichia robusta in the Wolfcamp Series. Other microfossils noted in the Oketo shale were arenaceous foraminifers belonging to two genera, perforate, trochoid foraminifers belonging to two genera, common fusulinids, common holothurian ossicles, rare perforate, non-trochoid foraminifers, crinoid columnals, brachiopod spines,

bryozoan fragments, pelecypod fragments, echinoid spines, gastropods, and trilobite fragments.

Oage shale. The ostracod fauna of the Oage shale is made up of Cavellina edmistonae, which is abundant, and Hollinella gibbosa and Kirkbya valida, both of which are rare. This is the only appearance of Kirkbya valida in the Wolfcamp Series. The remaining microfaunal assemblage consists of rare shark teeth, crinoid columnals and bractials, bryozoan fragments, brachiopod spines, and gastropod fragments.

Grant shale. The ostracod fauna of the Grant shale is composed of Pairdia beedei, Cavellina edmistonae, and Hollinella gibbosa, which are common, and Amplissites centronotus, Pairdia marmorea, Healdia winfieldensis, and Knightina texana, which are rare. Other microfossils noted in the Grant were rare arenaceous foraminifers, common perforate, trochoid foraminifers, common holothurian ossicles, crinoid columnals, brachiopod spines, and bryozoan fragments.

Recapitulation. The repeated occurrence and abundance of the species Pairdia beedei, E. florensaensis, and E. marmorea (Table 2) would seem to indicate that they dominate other species of the genus Pairdia in Wolfcamp strata. While this is probably the case, it should not be construed as being to the extent indicated. A large number of Pairdia fragments, other than the above named species, were found throughout the sampled strata, but were usually crushed or broken beyond the possibility of correct identification. Pairdia beedei, E. florensaensis, and

B. marmorea may owe much of their abundance to an unusually thick oarpace wall or to some less obvious factor which produces an excellent state of preservation.

It was understood that a study of ecology would be limited by the impossibility of sampling each distinct stratigraphic zone. The possibility of determining a relationship between a given species and its environment was further limited by the tendency of the faunas to occur only in limestones and calcareous zones in shales. A notable exception to this is the abundant fauna of the green, pyritiferous Stine shale. The species found in abundance in the Stine were Cavellina nebrascensis and Rythocypris pediformis. Both are smooth-shelled, long-ranged forms, and are thought to be more hardy than most of the highly ornamented ostracods, which usually exhibit a shorter geologic range. It is probable that ostracods, while they may exist in an adverse environment, thrive only under conditions which are conducive to the existence of other organisms.

The ostracod microfaunas studied include several which contain an abundant, distinctive, and easily identified fauna. It is probable that these, with care, could be used as horizon markers in subsurface correlation.

Ostracods should be more useful for purposes of correlation than the foraminifers of the Wolfcamp Series. They are more abundant than the foraminifers, appear to include a greater variety of forms, and are much more easily identified. Of the foraminifers that were noted, most were extremely small, and

the tests of these were frequently poorly preserved.

Although about a hundred samples were processed, and several thousand specimens were picked, sorted and identified, it is felt that this investigation is only started. Its continuation would define more exactly the stratigraphic ranges of the species of ostracods, and perhaps develop the details of their evolution during Wolfcamp times. Certainly the achievement of the former objective would be productive of precision in the correlation of cuttings from Wolfcamp strata brought to the surface in the drilling of wells.

ACKNOWLEDGMENTS

The writer wishes to express sincere appreciation to Dr. Frank Byrne, under whose supervision this work was conducted, for constant aid and suggestions.

Thanks are also extended to Mr. Melville R. Mudge for aid in collecting samples and for the use of measured stratigraphic sections of Riley County, to the United States Geological Survey office at Kansas State College for the use of the map in Fig. 2, and to Mr. M. E. Davis for aid in all phases of field and laboratory work.

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