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NON-MARINE OSTRACODA FROM THE LOWER PENNSYLVANIAN IN THE SOUTHERN APPALACHIANS, AND THEIR BEARING ON INTER-CONTINENTAL CORRELATION.[1]

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ABSTRACT.—A fresh-water ostracode fauna, consisting of five genera, is described. Two new genera *Pruvostina* and *Hilboldtina* are established. Many lamellibranchs also occur in the fauna. The fauna is compared with Pennsylvania fresh-water fossils in Europe and found to be remarkably similar. On the basis of the non-marine fauna the Kanawha is correlated in part with Westphalian B. The *Modiolaris* and *Similis-Pulchra* zones are recognized in the Kanawha.

IN the course of field work in 1939 in the Southern Appalachian coal field, H. R. Wanless noted the presence of several non-marine zones. These were called to the attention of C. H. Summerson who made collections for the purpose of studying the lamellibranch fauna. However, fresh-water ostracodes proved to be so numerous and of such great variety that they attracted our first attention. We gratefully acknowledge the assistance and enthusiastic aid of Doctor Wanless in the preparation of this paper.

PREVIOUS WORK.

The study of non-marine Pennsylvanian invertebrate faunas from North America is almost a virgin field. Certain faunas, especially the lamellibranchs, have been intensively studied in Europe, primarily in Belgium, northern France, the Donetz Basin, and the British Isles. In fact, most of the Coal Measures of those areas have been classified on the basis of non-marine faunas.

[1] A grant from the University of Illinois Graduate School Research Board made it possible to prepare the plates in this paper.

Ostracodes have not received as much attention by European workers as other invertebrates even though they often occur in great numbers. There has been a general tendency to lump all sorts of ostracodes in one genus, or even several genera within one species. The result, of course, is that some of them are said to possess a long stratigraphic range. Only three papers treating fresh-water ostracodes from the Carboniferous of North America have been written. Dawson (1853) described several species from the South Joggins (Pennsylvanian) formation of Nova Scotia. Holland (1935) described a Permian fauna from the Dunkard. Scott (1943) restudied the Dunkard fauna and added one new species from the Pennsylvanian of Illinois.

On the other hand, non-marine pelecypods from the Carboniferous of Europe have been extensively studied. The progress of study in North America is approximately equivalent to that of the ostracodes. Two species of *Carbonicola* McCoy, five of *Anthracomya* Salter, and eight of *Naiadites* Dawson have been reported. Newell (1940) has restudied some of Dawson's material. In North America there is a general tendency to belittle the value of non-marine invertebrates for stratigraphic correlation. Many of them have been considered to range through great thicknesses of strata and to show very little change. The experience of foreign workers has shown the fallacy of this contention. In fact, fresh-water animals live in an environment more susceptible to change than those in a marine habitat and we can expect these changes to be reflected to some extent in the animals.

Many geologists probably feel that fresh-water invertebrates would have at the most only local significance. However, they have proved of great value in correlating the Coal Measures between the British Isles, Belgium, and France. From our brief study of similar faunas from the Southern Appalachians we are impressed with their potential value for correlation on an inter-continental basis as well as between local areas.

WORLD DISTRIBUTION OF FRESH-WATER OSTRACODES.

Knowledge of the geographic distribution of ostracodes is incomplete, but sufficient information is available to show that many genera and species have a cosmopolitan distribution.

Hoff (1942) found that all the genera and many of the species of ostracodes now living in Illinois are distributed throughout the Holarctic. The relationship between European and North American faunas is remarkably close, many species being common to both continents. The following list indicates the extent of this widespread geographic distribution of living species;

World-wide except Australia—
Cyprinotus incongruens

Holarctic—
Ilyocypris gibba
I. bradyi
Cypricercus fuscatus
C. reticulatus
Notodromas monacha

Holarctic and South America—
Cypridopsis vidua
Cypria ophthalmica

Europe and North America—
Candona albicans
C. caudata
Potamocypris smaragdina
Cyprois marginata
Darwinula stevensoni

Such a distribution has been accomplished without the aid of land bridges. We must conclude therefore that a similar distribution could have taken place within any geological period of time.

Naturally, the question will be asked, how can fresh-water ostracodes migrate? Very little is known about the subject, but the manner of reproduction in ostracodes suggests some possibilities. Reproduction is usually syngamic but often parthenogenetic. With few exceptions the syngamic forms are oviparous; the eggs usually attached to plants, stones, or deposited in muds accumulating in a lake basin. These eggs are resistant to periods of drought and freezing temperature. They may remain dormant for many months while the pond is dry. It is possible, therefore, that the wind may be an agent of transportation. Any floating object could also carry the eggs.

ASSOCIATED FOSSILS.

Lamellibranchs, crustaceans, insects, worm tubes, fish remains, and plants are commonly found with fresh-water ostracodes. Of this group the lamellibranchs are the most common.

We have found several lamellibranchs which we believe to be conspecific with European species. If these forms had been river inhabitants it is doubtful whether specific identification would be possible because of the change in shape of a mollusc shell according to the longitudinal distribution, commonly expressed as Ortmann's law. However, the Pennsylvanian lamellibranchs under consideration lived in shallow, swampy water where the environment was more stable than that found in running streams. Furthermore, the swampy environment in the Pennsylvanian coal basins of Europe and America are believed to have been very similar. Even though considerable variation occurs in the individuals of a given species, this variation is not so great as to preclude the possibility of accurate identification. Poor preservation of thin shelled lamellibranchs is also a handicap in taxonomy.

ECOLOGY OF NON-MARINE FAUNAS.

The time of the formation of the Coal Measures was notable for its rhythmic changes in depth of water resulting in a variety of sedimentary types. Coal seams and the associated underclays seem to represent a time of very shallow water or subaerial condition during which plants flourished. The succeeding shales were deposited following subsidence which locally deepened the water, permitting more rapid sediment accumulation. In some areas the deepening permitted the entrance of marine water and calcareous shales and limestones were then deposited. In other areas, such as the Southern Appalachian coal fields, marine beds do not make up so much of the section. Here, as in Europe, depositional basins were often cut off from the sea and developed fresh-water faunas. Marine zones are present in this area but less frequent than the brackish water (Lingula) and fresh-water zones. The fresh-water areas were probably wide bodies of shallow water, swamps partially filled with vegetation, slow, sluggish streams, or lagoons that received most of their water from land drainage, having little if any communication with the open sea.

In a study of the fresh-water pelecypods of one small area, a large variety of forms will be found. The question of definition of variable forms into species results. Statistical studies by Professor Trueman show that in one species there is such an unusually extreme variation that opposite variation trends of a shell would be different enough to represent separate species. Thus specimens of different species are connected by innumerable transition stages. In the living Unionidae this condition may be found for a single species from a lake or stream. Rather than attempt to use such forms as index fossils, the zones set up in Europe are in terms of assemblages of forms typical of a certain interval of time.

In general the Carboniferous lamellibranchs belonging to the Cardiniidae may be compared to the modern Unionidae. They were not burrowing forms, but rather attached by a byssus to sunken objects or to floating timber. The abundance of the shells with *Spirorbis* attached to the outer surface, the lack of trails, and the fragile valves suggest that they were free in shallow water.

Fresh-water ostracodes are excellent indices to environmental conditions. The group lives in almost every conceivable aquatic habitat. They have been taken from permanent still waters such as lakes and swamps; from temporary still waters such as ponds, ditches, crayfish burrows; from pools in intermittent streams, and from permanent streams of all kinds. Hoff (1942) found that most species could be classified as living in temporary or permanent and still or running water. Independent environmental factors such as type of bottom or associated vegetation are only of secondary importance. This is well illustrated by four species, *Candona distincta* Furtos which lives only in temporary, still waters, *Darwinula stevensoni* (Brady and Robertson) which lives only in permanent still waters, *Candona acuta* Hoff which has been found only in temporary, running waters, and *Candona sigmoides* Sharpe which lives only in permanent running waters. Some species may live in all four environments, but occur more abundantly in one than the others.

The distribution of certain species and genera may be controlled by independent factors such as bottom, current, or hydrogen ion concentration. The Candoninae are essentially bottom crawlers and they prefer a mud bottom to a sand or gravel floor. The free swimming *Cypridopsis vidua* prefers to live in very shallow water among grass, alga, or aquatic vegetation; therefore, it is more or less independent of the bottom, but such vegetation will be supported by a bottom that will produce a shale or a calcareous shale.

Among the ostracodes described in this paper species of *Candona* and *Cypridopsis* are common. We believe that they lived in very shallow water, probably less than 10 feet in depth; in permanent still waters supporting a luxuriant aquatic flora. The ostracodes, then as now, were probably seasonal in occur-

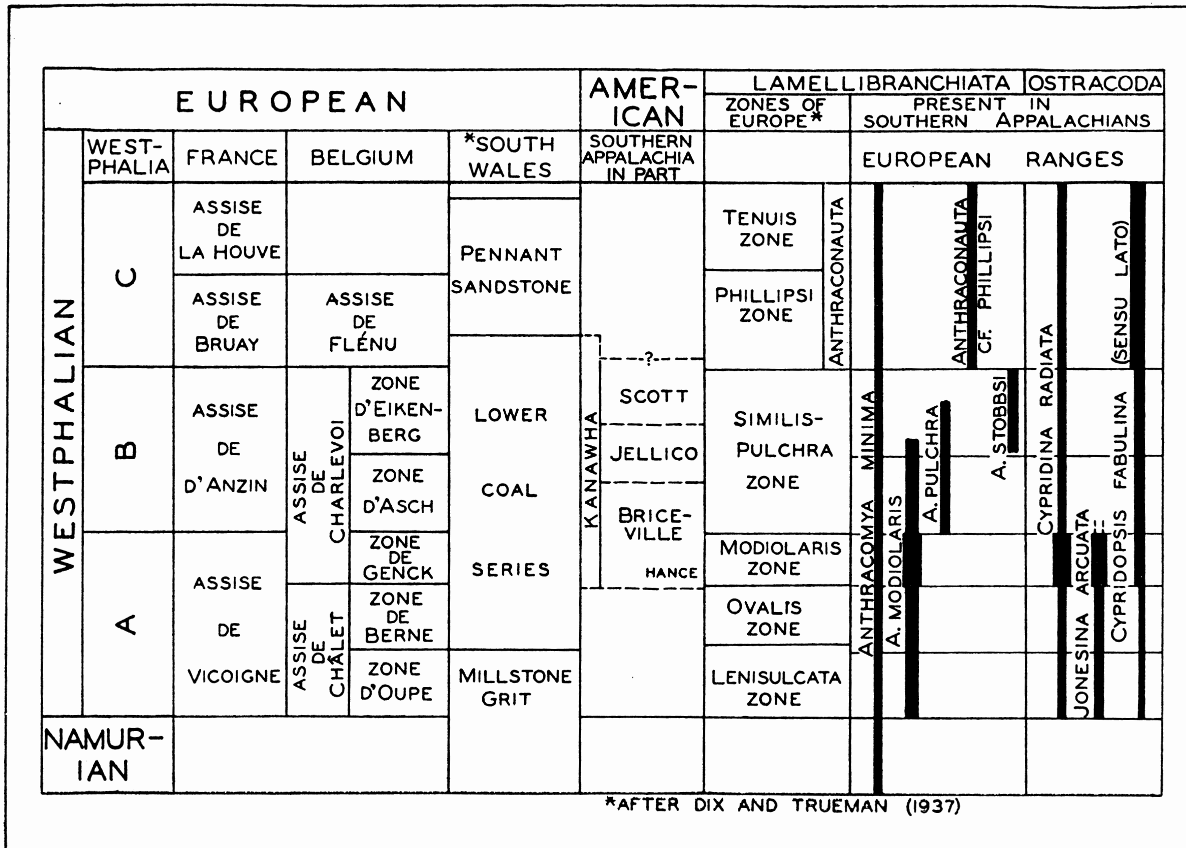

Fig. 1.—Correlation chart based on fresh-water invertebrates.

rence, living in great numbers during warm periods and passing through cold periods in the egg stage. This probably accounts for the great number of individual shells found on certain bedding planes as shown in Plate 2, Fig. 5. All the adults must have died as the water cooled in the aestival period.

An unusually complete ecological picture is obtained from the study of Collection No. N14, where the fresh-water assemblage is in the roof of a cannel coal. Cannel coals represent accumulation of spore and spore-like material in bodies of open water. In this case a cannel coal of three feet in thickness accumulated, then conditions changed so that the supply of spores gradually decreased resulting in a canneloid shale as a roof. In this roof material the fossils of a fresh-water assemblage are found.

The fossils are well-preserved in pyrite suggesting an abundance of sulphur, a condition characteristic of black shale environment. The canneloid shale shows fragments of leaves, stems, and fruiting bodies not found in the cannel below. Accompanying the plants are pelecypods, ostracodes, *Spirorbis*, and fish remains. A more careful study of greater volume of material will undoubtedly yield a greater faunal variety. This occurrence gives an example of a fresh-water, carbonaceous, black shale that is common in the Pennsylvanian, instead of the usual marine, black shale.

AMERICAN-EUROPEAN CORRELATION.

Though the ostracodes of Europe have not been classified and zoned with the precision that the lamellibranchs have, nevertheless, a sufficient number of diagnostic types is known to warrant tentative stratigraphic correlation. *Cypridina radiata* Jones, Kirkby, and Brady is one of the rarest and most unusual of all ostracodes. Its large size, unique radial pattern on the inner shell surface, and limited stratigraphic range make it of unusual value in correlation. Two complete specimens were recovered from a dark gray shale in the Hance formation near Molus, Kentucky, 125 feet above the top of the Naese sandstone. In Europe this form has been reported only from the Westphalian and primarily from the Zone de Genck in the top of Westphalian A. It is very rarely found in Westphalian B and C.

One of the most common ostracodes in the Hance is *Jonesina* *arcuata* (Bean). It has been collected in considerable numbers from the non-marine shale at Molus, Kentucky. It is also one of the common species in Europe and has been reported only from Westphalian A, being most abundant in the Zone de Genck.

Cypridopsis fabulina (Jones and Kirkby) is the most common of all ostracodes in the Briceville. It also occurs in the Jellico. The species is reported from all of the Westphalian, but has represented a group in which several distinct species and two or more separate genera have been included. As a consequence the stratigraphic limits of the species have not been defined.

Associated with the above three species of ostracodes are certain lamellibranchs. Two of them have been identified as *Anthracomya modiolaris* Sowerby and *Anthracomya minima* (Ludwig). The latter has a long range but the former is restricted to rather narrow stratigraphic limits. *A. modiolaris* is used in the British Isles to designate a zone in the Lower Coal Series called the *Modiolaris Zone.* In Belgium it ranges from the base of Westphalian A, Zone d'Oupeye, to the base of Westphalian B, Zone d'Asch. In France it ranges from the Faisceau de Modesta in the top of the Assise de Vicoigne through the Faisceau de Meuniere in the base of the Assise de Anzin.

The data furnished by the non-marine faunas support a correlation between the lower Briceville and the upper part of Westphalian A, probably Zone de Genck.

A few non-marine ostracodes have been found in the lower part of the Scott formation in northern Tennessee. They represent new species and cannot be used for precise correlation. However, very similar, if not identical, forms have been described from France from the Assise de Bruay, Westphalian B and C, and included with *Cypridopsis fabulina* (Jones and Kirkby). Pruvost (1919) pictures a specimen, Pl. 24, Figs. 6, 6a, from the Faisceau de Dusouich which appears to be conspecific with *Pruvostina wanlessi* n. sp. The ostracodes are associated with lamellibranchs, *Spirorbis*, and an occasional fish scale. The lamellibranchs are of exceptional value. One species has been identified as *Anthraconauta* cf. *phillipsi* (Williamson), another as *Anthacomya stobbsi* Dix and Trueman, and a third as *A. pulchra* Hind. The genus *Anthraconauta* does not extend lower than the base of Westphalian C which corresponds to the base of the *Phillipsia zone* in the upper part of the Lower Coal Series of South Wales. *A. stobbsi* and *A. pulchra* are restricted to the *Similis-Pulchra zone*.

The non-marine fauna found in the basal Scott formation of northern Tennessee strongly supports a correlation of the Scott with Westphalian B in part. The presence of *Anthraconauta* cf. *phillipsi* with *Anthracomya stobbsi* and *A. pulchra* suggests the upper part of the *Similis-Pulchra zone*. This correlation is only at slight variance with that proposed by Jongmans and Gothan (1933). Based on floras they correlated the Kanawha precisely with Westphalian B, whereas, based on non-marine invertebrates the top and bottom of the Kanawha are placed slightly above and below the Westphalian contacts.

CONCLUSIONS.

It is concluded that the zones of non-marine fossils in the Pennsylvanian of the Appalachian Province afford a means of correlating the rocks of this system with those of Europe. Though this is a preliminary report and all correlations herein proposed are tentative, sufficient material is at hand to show that some, if not most, of the European non-marine faunal zones are present. These faunas are apt to prove more valuable than marine faunas and will be sufficiently reliable to be of both local and inter-continental value.

FRESH-WATER ZONES AND LOCALITIES.

The collections are at the University of Illinois, and though all of those listed are from fresh-water zones and carry a non-marine fauna, ostracodes have not been recovered from all of them. Due to the difficulty experienced in finding the non-marine, fossil-bearing zones in the field, detailed descriptions of localities are given.

Collection No. N1, locality 39.—Along rural highway between Coalfield and Christmas, Morgan County, Tennessee, Briceville (TVA Petros) Quadrangle, on the south side of Little Emory River. Beds dip 14 degrees southwest at small mine entry south of road. The collection was made from a three-foot bed of gray to black, silty shale overlying the Hooper coal in the Briceville formation. Most of the specimens were collected from a six-inch interval above the coal.

The fossils are badly crushed and are chiefly iron stains on the bedding surfaces. They are very abundant throughout the shale and locally cover the bedding surfaces. This is the oldest collection studied and there are present at least two species of *Anthracomya*.

Collection No. N2, locality 7.—Beds along U. S. Route 119 just north of Molus, Harlan County, Harlan Quadrangle, Kentucky. The outcrop is on the north side of the road at base of the section about 125 feet above the Naese sandstone in the Hance

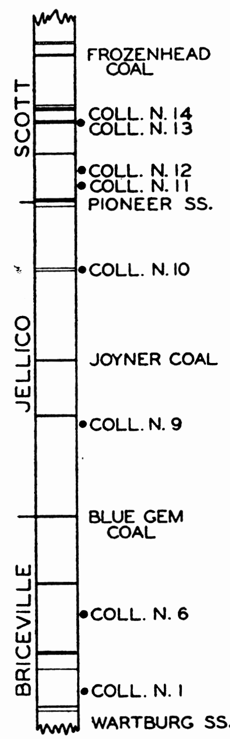

Fig. 2.—Partial section at Frozenhead Mountain, Petros, Morgan County, Tennessee, showing position of fresh-water zones. (From manuscript of H. R. Wanless.)

formation, dipping 22 degrees south and 10 degrees west away from Pine Mountain. The beds are gray, calcareous, somewhat silty, and micaceous shale rich in iron stains, about two feet thick.

The fossils are scattered throughout the shale, pelecypods found were of genera *Anthracomya*, and possibly *Carbonicola*.

This is the best preserved collection of non-marine pelecypods found. With the pelecypods is an unusual abundance of ostracodes that in places cover the surface. They are represented by several genera most of which are new species and one a new genus. The genera identified are *Candona*, *Pruvostina*, *Cypridina* and *Cypridopsis*.

Collection No. N3, locality 9.—Exposure on U. S. Route 25W near the head of Big Creek just north of Cumberland Mountain near an abandoned slope mine in the Rex coal about five miles northeast of Lafollette. Beds dip gently northwest away from Cumberland Mountain, Briceville (Lafollette TVA) Quadrangle, Campbell County, Tennessee.

The fossil zone is about 50 feet above the Rex coal in the lower part of the Briceville formation in a shale zone about 25 feet thick. The fossils occur at zones a foot or more in thickness. The material collected was in a zone of fine, blue shale.

The specimens are poorly preserved as iron stains on the bedding surfaces, and only identified by their outline. The pelecypods present were represented by two or three species of the genus, *Anthracomya*. Associated with these pelecypods are fish scales and teeth, fragments of plant stems, leaves and fruiting bodies.

Collection No. N4, locality 9.—Same road cut section as Collection No. N3. The collection was made in a zone about 220 feet above the N3 collection, about 30 feet above the Murray coal, and about 200 feet below the Kent coal in the Briceville formation. The fossils are in a gray, silty, micaceous, non-calcareous, heavily iron-stained shale. The zone is not related closely to any coal but is in the middle of a large thickness of shale. The shale is leached and the fossils are iron-stained casts and molds or impressions, often badly crushed.

In addition to a pelecypod fauna there are numerous freshwater ostracodes, primarily *Candona* and *Cypridopsis*. A short distance higher, *Lingula carbonaria* is present but there is no fresh-water fauna in the strata which contain *Lingula*. The *Lingula zone* is in a bleached blue, rather soft shale.

Collection No. N5, locality 40.—Exposure two miles north of Rockhold, Whitley County, Kentucky, Williamsburg Quadrangle, along U. S. Route 25W.

The fossil zone is in a canneloid coal and underlying ironimpregnated shale about 6 inches thick. The fossils are scattered in the lower part of the coal and the shale below. This zone lies in the Breathitt formation and was tentatively correlated by Wanless (1939) with the Bear Run coal of southern Ohio. From a small sample, specimens were identified as *Anthracomya*, species undetermined.

Collection No. N6, locality 41.—Exposure along Tennessee Route 62, between Stephens and Coalfield along the gorge of the Middle Fork of Little Emory River, Briceville (TVA Petros) Quadrangle, Morgan County, Tennessee.

Fossils occur in a black, silty shale about 50 feet below a massive sandstone and about 100 feet above the Poplar Creek coal in the Briceville formation. The shale is micaceous, noncalcareous and iron-stained. The fossils are stains of limonite and impressions of crushed fresh-water pelecypods. They are of several species of *Anthracomya.*

Collection No. N7, locality 42.—Section about one mile west of U. S. Route 25W along the road extending from small mines in the Kent coal to mines in the Jordan, Log Mountain and Rich Mountain coals, Briceville (TVA Lafollette) Quadrangle, Campbell County, Tennessee.

The fossils were found in the roof of the Rich Mountain at the base of the Jellico formation, 145 feet below the Log Mountain (Jellico) coal. The shale is black, canneloid, thin-bedded and about 1 foot thick. There are scattered pelecypods of *Anthracomya*, represented by several species. The sample was limited and a larger amount of material will yield a greater number of species. Included with the pelecypods are individuals of *Cypridopsis.* The pelecypod shells commonly have attached to their surfaces the annelid *Spirorbis.*

Collection No. N8, locality 43.—Roof of mine in so-called "Mason Coal" about 250 feet above the road pass of U. S. Route 25E between Clear Creek and Little Cannon Creek, Middlesboro quadrangle, Bell County, Kentucky.

The fossils occur in a medium to blackish gray, slightly silty shale, 6 to 8 feet thick, above the so-called "Mason Coal," in the Mingo formation. The lower part of the shale is nearly black carbonaceous shale. The fossils are common through the shale and especially on certain bedding surfaces where they cover the surface with broken shells. The pelecypods are represented by several forms of *Anthracomya* and *Anthraconauta*, and a species questionably referred to *Carbonicola*. These fossils are accompanied by plant fragments, *Spirorbis*, and fish remains consisting of teeth and scales. *Jonesina bispinosa* n. sp. was collected from these shales.

Collection No. N9, locality 25.—Exposure on Tennessee Route 116, at head of New River in the mining village of Fork Mountain along the railroad grade. Area formerly included in Anderson County on Briceville Quadrangle, but was transferred to Morgan County when state acquired its Brushy Mountain Prison property. Beds dip slightly southwest.

The shale with fossils is about 15 feet above the Jellico (State) coal in the Jellico formation. The shale is black, carbonaceous, hard, somewhat silty, and thin-bedded. Certain layers of the shale are covered with iron-stained pelecypod shells. The black shale is about four inches thick in a general shale interval several feet above the Jellico coal. The pelecypods present are several species of *Anthracomya*. Associated with these are plant and fish remains, *Spirorbis*, and ostracodes. Of the latter, *Candona* and *Cypridopsis* were identified.

Collection No. N10, locality 25.—Exposure on Tennessee Route 116 a little south of road pass at head of New River, two miles north of the railroad station at Petros, Morgan County, Tennessee, Briceville (TVA Petros) Quadrangle.

The fossils occur in a mottled, weathered, black shale with irregular patches of buff to yellow. The zone is about 4 feet thick, lies about 235 feet above the Joyner coal, and 150 feet below the Pioneer sandstone in the Jellico formation. The fossils are in the shale 5 feet above an underclay, the intervening shale containing chiefly plant remains. About 14 feet above the shale is a nodular, blue limestone. The specimens are iron-stained species of *Anthracomya*. Some traces of plants are present. The shells are numerous but poorly preserved.

Collection No. N11, locality 18.—Exposure on side road to Braden Mine in the Windrock coal about one-quarter mile south of Graves Gap, Briceville Quadrangle, Anderson County, Tennessee.

Fossils occur in a blue black, somewhat mottled shale about 2 feet thick. Shale contains mica and is badly leached. It is part of a general shale interval above an underclay. The zone lies 50 feet above the Pioneer sandstone, and 175 feet below the Windrock coal in the lower part of the Scott formation. The pelecypods are of the genus *Anthraconauta.* Included with these were *Spirorbis anthracosia,* and at least three genera of ostracodes. The latter were leached and crushed.

Collection No. N12, locality 14.—Section on forest road near the head of Flat Fork of Emory River about three miles east of CCC camp, Briceville (TVA Hogbell Gap) Quadrangle, Morgan County, Tennessee.

Fossil zone in a gray, silty shale about 35 feet above the Pioneer sandstone in the Scott formation. The fossils are pyritized and crushed, but very abundant. The pelecypods were identified as species of *Anthracomya* and *Anthraconauta.* Associated with these are plant stems and numerous *Spirorbis* attached to pelecypod shells. No ostracodes were observed.

Collection No. N13, locality 38.—Section at mine entry in Windrock coal at upper Windrock, Briceville (TVA Windrock) Quadrangle, Anderson County, Tennessee.

There are also numerous fresh-water zones along the mine incline between Upper Windrock and Windrock, below the Pioneer sandstone that have not been collected. The collection studied came from the roof of the Windrock coal in the Scott formation. The fossils are in a medium hard, gray shale about 2 feet thick above the coal. The specimens are leached till only impressions are present. Species of *Anthraconauta* were found with imprints of *Spirorbis* attached. Leached specimens of ostracodes are present but too poor for identification.

Collection No. N14, locality 44.—Section on WPA road northwest of Newcomb about one-fourth mile southeast of road pass between Burnt Pone and Hatfield branches, Williamsburg Quadrangle, Campbell County, Tennessee.

An unusually well-preserved zone of pyritized fossils in a hard, black canneloid shale. The shale lies in the roof of the Windrock Cannel, in the Scott formation, and is about 1 foot thick. The pelecypods present were identified as *Anthraconauta.* There are three well-preserved genera of ostracodes, *Candona, Cypridopsis, Pruvostina.* There are also *Spirorbis,* plants, and fish remains to make a very complete fresh-water fauna.

SYSTEMATIC DESCRIPTIONS.

Order Ostracoda Latreille 1802.

Family Cypridae Zenker.

Genus Cypridopsis Brady 1867.

Cypridopsis Brady, 1867, Intell. Observ. Vol. 12, pp. 110-130.
Carbonia (part) Jones, 1870, Geol. Mag., Vol. 7, p. 218, Pl. 9.—Jones, 1879, Ann. Mag. Nat. Hist. Ser. 5, Vol. 4, p. 30.
Carbonita (new name) Strand, 1926, Arch. für naturgeschichte, 92, pt. A, No. 8, p. 41.—Bassler and Kellett, 1934, Geol. Soc. Amer. Special Pub. No. 1, p. 237.

The genus *Carbonia* was proposed by Jones for certain ostracodes obtained from non-marine beds in the Pennsylvanian (Coal Measures) of South Wales. He described two species *C. evelinae* and *C. agnes* and two varieties under the latter species. No generic diagnosis was given and no genotype was designated. Bassler and Kellett (1934) designated *C. agnes*, the second species described in Jones' paper, as the genotype. Only a fragment of the exterior of the shell was preserved on this specimen, but Jones shows a few very small pits on it and in the specific description explains them by saying that "the casts have a faintly reticulated surface, due to the structure of the shell . . ." He also made a drawing showing a section of the surface and details of the reticulate pattern. Later, Jones (1879) gave a generic description and described several new species, but still included diverse generic types within the genus.

A study of our material and figures of Jones has convinced us that *C. agnes* does not possess the external striations present on the specimens described by Jones as *C. evelinae*, *C. agnes rugulosa*, and *C. agnes subrugulosa*. We are placing these striated forms in a new genus, herein called *Hilboldtina*.

We have made direct comparisons between the shells of *Cypridopsis vidua*, a modern species, and the Pennsylvanian forms which we have identified as *Carbonita fabulina* Jones. There are no differences of sufficient importance between the carapaces of *Cypridopsis* and *Carbonita* to warrant separate generic designations. This contention can be easily checked because *C. vidua* can be collected from almost any fresh-water body throughout the temperate belt of the world. When compared with Jones' (1879) figures of *C. fabulina*, Pl. 2, Figs. 1-6 the relationship is at once apparent.

Cypridopsis fabulina (Jones and Kirkby).

Plate 1, Figs. 6-11.

Plate 2, Fig. 5.

Cythere fabulina Jones and Kirkby, 1867, Geol. Soc. Glasgow, Tr. 2, p. 217.
Carbonia fabulina Jones, 1870, Geol. Mag., Vol. 7, p. 218.
Carbonia fabulina Jones and Kirkby, 1879, Ann. Mag. Nat. Hist. Ser. 5, Vol. 4, Pl. 2, Figs. 1-10.
Carbonia fabulina Pruvost, 1911, Soc. Geol. Nord, Ann. 40, Pl. 2, Figs. 1-6.

Carapace reniform, posterior and anterior extremities broadly and similarly rounded; dorsum broadly convex, continues with same curvature into postero-dorsal and antero-dorsal slopes; venter slightly concave in middle third; right valve overlaps left around free margin, overlap very slight around posterior and anterior ends, pronounced along venter. In dorsal view the valves are cuneate; greatest thickness posterior of mid-length; dorsal contact of valves slightly sinuate; hinge along medial third of dorsum, slightly impressed into a narrow groove; surface pitted to finely reticulate; muscle-scar round, situated immediately antero-ventral of mid-carapace. Length 0.80 mm.; height 0.55 mm.; thickness 0.47 mm.

Hypotype.—Univ. of Ill. Paleontology coll., No: x-1700, paratypes, x-1701, x-1702.

Localities.—No. 39, collection N1, Briceville; No. 7, collection N2, Hance formation; No. 9, collection N4, Briceville formation; No. 42, collection N7, Jellico formation; No. 25, col-

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EXPLANATION OF PLATE 1.

(All Figures X 33).

Figs. 1-5—*Pruvostina wanlessi* n. sp. 1, 2, 3, Venter, lateral of left valve, and dorsum of holotype, x-1705, overlap dextral. 4, Lateral view of a single valve, questionably included in this species. 5, Lateral view of right valve, paratype, x-1706, overlap sinistral. All figures of the exterior of pyritized forms.

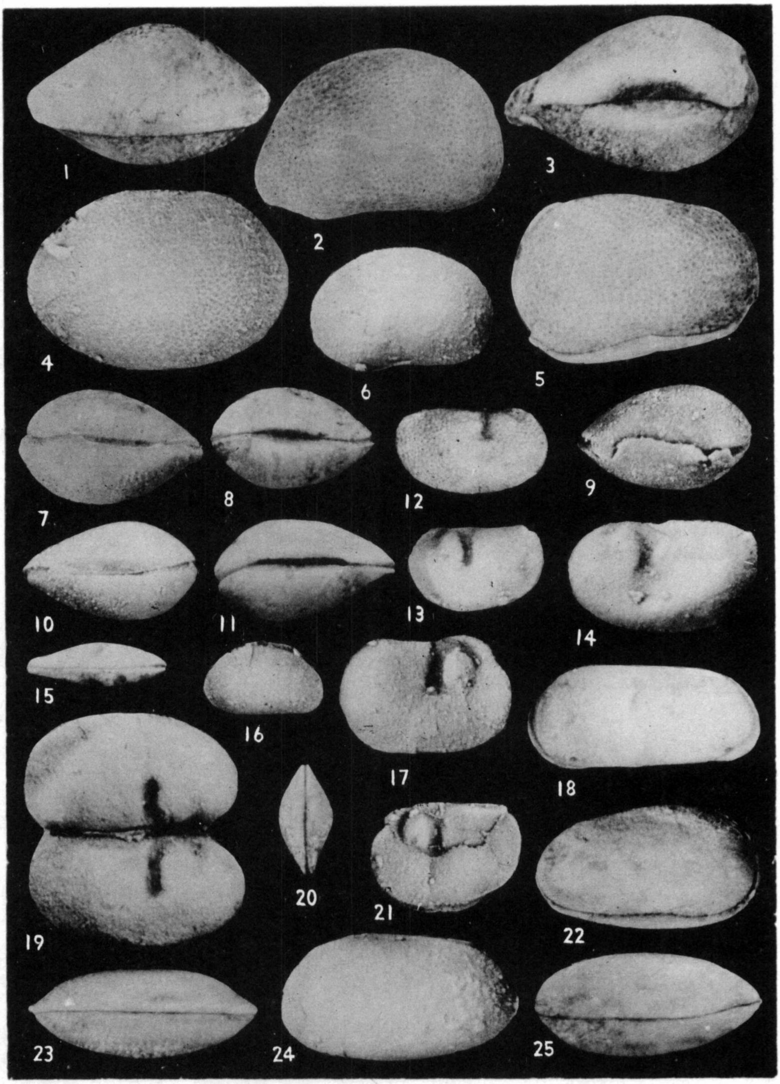
Figs. 6-11, 16, 20—*Cypridopsis fabulina* (Jones and Kirkby). 6, Left valve. 7-8, Dorsum of females. 9, Venter. 10-11, Dorsum of males. 16, Left valve of young molt; 20, dorsum of same. All figures of interior molds.

Figs. 12-15, 19, 21—*Jonesina? arcuata* (Bean), 12, Right valve, exterior. 13-14, 21, Left valves, interior molds. 15, Dorsum of male, interior mold. 19, Anterior end to the right, both valves hinged, but open.

Fig. 17—*Jonesina?* sp. Right valve. Specimen crushed along dorsum.

Fig. 18—*Candona kentuckyensis* n. sp. Right valve. Overlap on ends accentuated by slight crushing of left valve.

Figs. 22-25.—*Hilboldtina multiplicata* n. sp. 22, Left valve; 23, dorsum; 24, right valve; 25, venter. Holotype, x-1703, exterior of pyritized specimen.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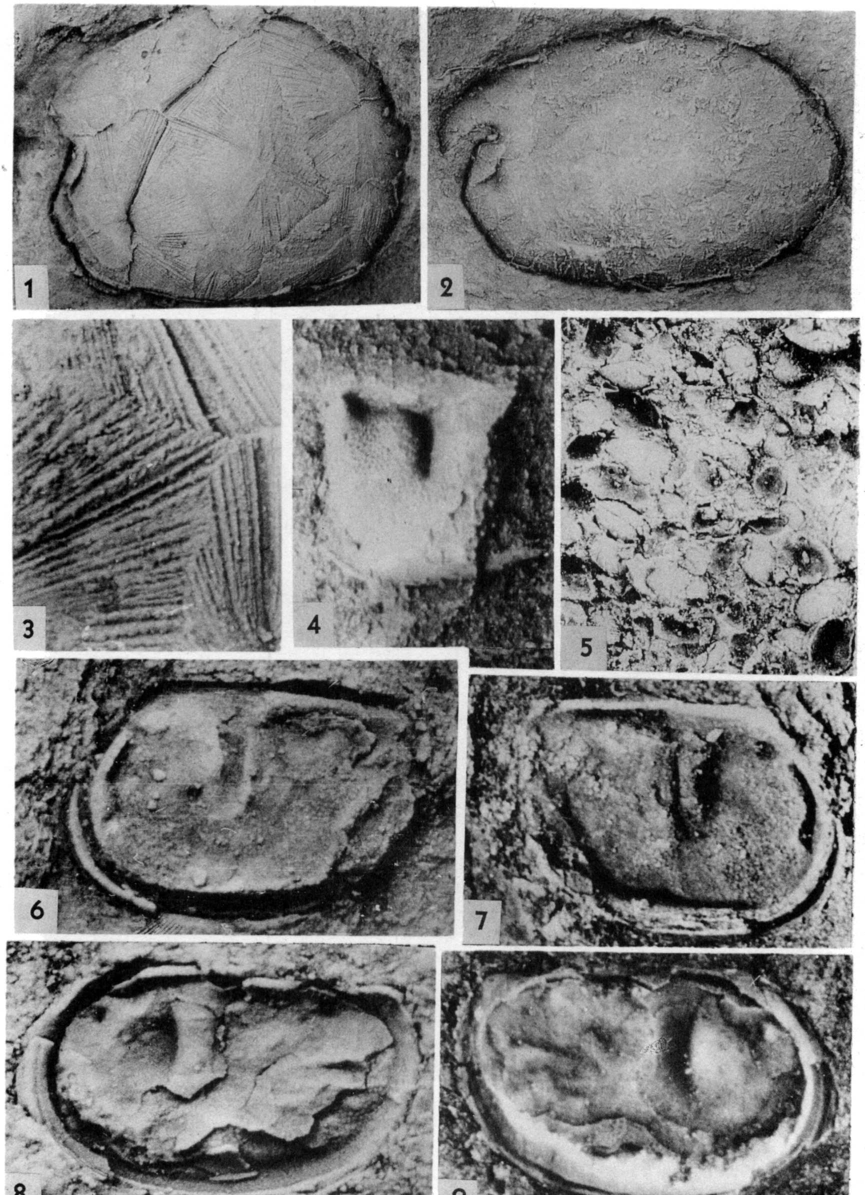
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lection N9, Jellico formation; No. 44, collection N14, Scott formation.

Remarks.—This is the most ubiquitous of all ostracodes in the fresh-water shales. Individuals are so numerous that some of the bedding planes of the shale are completely covered with several layers of shells. Unfortunately, the state of preservation is very poor, and a perfect specimen is seldom if ever found. The shell material appears to have been very thin and flexible, and the valves of most specimens have been pressed together. When occurring in great abundance they often are partially fused together and form a brown, slightly iridescent, resinous, mass.

C. fabulina is very similar to *Cypridopsis parvula* (Holland) from the Dunkard (Permian). The carapace of the former is slightly thicker, the groove along the hinge slightly wider, and the dorsum more convex than comparable characters in the latter.

There appear to have been distinct sexes in *C. fabulina.* We consider the thicker individuals such as those illustrated in Pl. 1, Fig. 7 as the females, and those in Figs. 9-11 as the males. This is the common thing in genera of this family as shown in the modern forms of *Cypridopsis vidua.*

All of the specimens in our material are molds of the interior. Surface features such as pits are, therefore, uncommon, but on a small portion of one shell a few faint and minute pits can be seen, Pl. 1, Fig. 7.

Genus *Hilboldtina* Scott and Summerson, n. gen.

Carapace elongate-ovate; dorsum broadly convex to almost straight; ends rounded; hingement by smooth contact of valves as seen from dorsal view, one valve may rise slightly higher

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EXPLANATION OF PLATE 2.

Figs. 1, 3.—*Cypridina aciculata* Scott and Summerson, n. sp. 1, Interior mold of left valve, x-10. Holotype, No. x-18. 3, Detail of juncture of three sets of radii, x-50.

Fig. 2.—*Cypridina radiata* Jones, Kirkby and Brady. Interior mold of left valve, x-10.

Fig. 5.—Coquina of *Cypridopsis fabulina* from collection N1, Briceville formation, x10.

Figs. 4, 6-9. Jonesina? spinosa Scott and Summerson, n. sp., x-48. 4, Fragment of anterior end, showing finely reticulated surface and antero-dorsal spine. Anterior margin broken off. 6-7, Positive and negative of same specimen. 8-9, Positive and negative of same specimen.

than other valve along hinge as seen in lateral view; slight overlap of one valve around free margin, right valve usually the largest; surface covered wholly or in part by fine longitudinal striations.

Genotype.—*Hilboldtina multiplicata* n. sp.

We can place only four forms with certainty in *Hilboldtina*, three described by Jones (1870) and one new species described in this paper.

Hilboldtina evelinae (Jones) Geol. Mag. 7, p. 218, Pl. 9, Figs. 4a, b, c.
Hilboldtina agnes rugulosa (Jones), idem. Pl. 9, Figs. 8, 9.
Hilboldtina agnes subrugulosa (Jones), idem. Pl. 9, Fig. 10.
Hilboldtina multiplicata Scott and Summerson, n. sp.

Hilboldtina multiplicata Scott and Summerson, n. sp.

Plate 1, Figs. 22-25.

Carapace ovate-oblong; greatest length below median line, greatest height median or in posterior half; dorsum broadly arched, almost straight along hinge line; venter broadly convex; anterior end more sharply rounded than posterior; dorsal view elongate ovate, greatest thickness medial to posterior; hinge long, about three-fourths total length of shell; right valve overlaps left around free margin, greatest overlap along venter just posterior of mid-length, least overlap around anterior end; left valve rises gently, almost imperceptibly above right along hinge; surface covered with numerous fine striations that lie parallel to each other and sub-parallel to the dorsum, striations fade away toward each end leaving smooth surfaces toward the extremities. About fifty striations occur on each valve, or at the rate of eighty per millimeter. They are slightly wavy and on first appearance seem to form an anastomosing network. However, only near each end of the striations can any true division be seen. The addition of new striations takes place by bifurcation. The muscle-scar is situated slightly anterior of mid-point. Length 1.07 mm.; height 0.60 mm.; thickness 0.42 mm.

Holotype.—Univ. of Ill. Paleontology coll., No. x-1703, paratype, x-1704.

Locality.—No. 44, collection N14, Scott formation.

Genus *Pruvostina* Scott and Summerson, n. gen.

Relatively large cyprids; dorsum convex, venter convex to slightly sinuate; valves strongly unequal, the largest overlapping the smallest around the free margin; hinge short, deeply impressed into wide canoe-shaped channel, hingement stops where overlap begins; surface strongly pitted to finely reticulate.

Genotype.—Pruvostina wanlessi n. sp.

Pruvostina can be easily confused with *Whipplella* Holland. We have the holotype and paratype of *W. cuneiformis* before us as well as the holotype and paratype of *C. wanlessi* n. sp. The outline of these two genera is about the same. The surface ornamentation of fine reticulae is almost identical, and the degree of overlap is approximately the same. However, the one character which is diagnostic is the hinge. In *Whipplella* the valves meet tightly along the hinge leaving at the most a knife-edge thin or almost imperceptible groove; whereas, in *Pruvostina* the hinge is longer and is strongly impressed in a prominent channel. The dorsal and outer edges of the channel are formed by rather sharp raised shoulders. The sides of the channel do not always have the same slope, one side may also be wider than the other.

Pruvostina differs from *Cyprodopsis* by the wide and deep channel along the hinge and the pronounced overlap around the free margin in the former.

Pruvostina wanlessi Scott and Summerson, n. sp.

Plate 1, Figs. 1-5.

Carapace large; dorsum broadly convex, venter almost straight; greatest height in posterior half; greatest extension of anterior end slightly above mid-line, greatest extension of posterior end at or slightly below mid-line, valves unequal, the larger overlapping the smaller around free margin, overlap very strong along venter; greatest thickness medial to posterior; dorsal contact of valves slightly sinuate; hinge about one-third of shell length, impressed in prominent canoe-shaped channel; overlap begins at ends of channel by the dorsal edge of the larger valve curving strongly over the smaller valve; entire surface of carapace covered with fine reticulae. Sinistral and dextral forms are in our collection. Other than reversal of overlap they are similar in all respects. Length 1.20 mm.; height 0.75 mm.; thickness 0.75 mm.; greatest length of hinge channel 0.50 mm.; maximum width of channel 0.20 mm.

Holotype.—Univ. of Ill. Paleontology coll. No. x-1705, paratype, x-1706.

Locality.—No. 44, collection N14, Scott formation.

Genus Candona Baird 1845

Candona kentuckyensis Scott and Summerson, n. sp.

Plate 1, Fig. 18.

Carapace subrectangular; dorsum and venter subparallel, ends rounded; the larger left valve overlaps right around ends; dorsal view elongate-elliptical; hinge long, contact of valves along hinge smooth, surface probably pitted, only a few large pits are preserved on the posterior half of some of the specimens at hand. Length 1.07 mm.; height 0.47 mm.; thickness 0.40 mm.

Holotype.—Univ. of Ill. Paleontology coll. No. x-1707.

Locality.—No. 7, collection N2.

Family Kloedenellidae.

Genus Jonesina Ulrich and Bassler.

There is considerable doubt as to the designation of certain species found in the Pennsylvanian of Europe and the southern Appalachians to the genus *Jonesina.* This uncertainty is primarily due to lack of knowledge concerning the true character of the genotype of *Jonesina.* Johnson (1936) examined certain specimens obtained from England and described the lateral view in detail, but was unable to determine all pertinent features relative to the hinge-line. Species of *Jonesina* (*sensu lato*) have often been listed from marine sediments and only rarely from fresh-water deposits.

Jonesina? arcuata (Bean).

Plate 1, Figs. 12-15, 19, 21.

Cypris arcuata Bean, 1836, Ann. Mag. Nat. Hist., Vol. 9, p. 377, Fig. 55.

Beyrichia arcuata Jones and Kirkby, 1886, Geol. Mag., Vol. 3, p. 438, Pl. 12, Figs. 12-14.

Jonesina arcuata Ulrich and Bassler, 1908, U. S. Nat. Mus. Proc. 35, Pl. 44, Figs. 17-19, p. 324. Pruvost, 1930, Mem. Musee Royal D'Histoire Naturelle de Belgique. No. 43, Pl. 10, Figs. 11-14, pp. 187-189.

Hypotype.—Univ. of Ill. Paleontology coll. No. x-1708.

Localities.—No. 39, collection N1, Briceville; No. 7, collection N2, Hance formation.

Jonesina? bispinosa Scott and Summerson, n. sp.

Plate 2, Figs. 4, 6-9.

Carapace subrhomboidal; dorsum straight, venter broadly convex; greatest extension of anterior end below median line; greatest extension of posterior end above median line; valves unequal, right overlaps left around free margin; prominent sinus extends from dorsum approximately half way to venter, situated slightly anterior of mid-length; surface finely reticulate; spine situated just below each cardinal point; hinge area unknown in dorsal view. No complete specimen showing all the external features has been found. Length 1.10 mm.; height 0.75 mm.

Holotype.—Univ. of Ill. Paleontology coll. No. x-1708, paratypes, No. x1709, x-1710.

Locality.—No. 43, collection N8, Mingo formation.

Family Cypridinidae Sars.

Genus Cypridina Milne-Edwards.

Cypridina radiata Jones, Kirkby, and Brady.

Plate 2, Fig. 2.

Cypridina radiata Jones, Kirkby, and Brady, 1874, Paleontogr. Soc., Vol. 28, Pt. 1, Pl. 5, Figs. 6a-f, p. 14.

Cypridina radiata Pruvost, 1911, Soc. Geol. Nord. Ann., Vol. XL, Pl. 2, Figs. 15a-b, p. 73.

Cypridina radiata Pruvost, 1919, La Faune Continentale du Terrain Hoviller du Nord de la France, Pl. 24, Figs. 14-19, pp. 46-50.

Carapace large, sub-oval; dorsum and venter strongly convex; postero-dorsal and postero-ventral slopes convex, both merging imperceptibly into convex posterior end. Anterior end extended ventrally into strong cypridinoid beak. Surface of valves evenly convex with greatest thickness in center. Internal surface of carapace marked by a system of acicular radii. Some sets of radii appear to form hexagons, others trapeziums, and still others appear circular; 15-22 aciculae in each set. About fifty to sixty sets occur on each valve. Length 5.0 mm.: height, 4.0 mm.

Hypotype.—Univ. of Ill. Paleontology coll. No. x1711, paratype, x-1712.

Locality.—No. 7, collection N2, Hance formation.

This is one of the most distinct species of described ostracodes. Its large size and unique radiate shell pattern are unusual. Its occurrence in the Pennsylvanian of the southern Appalachian mountains is of more than passing interest.

Only three specimens have been found, but they agree in every detail with those described from the European area. The shells are preserved as molds of the interior. The surface of the molds is marked with a system of acicular radii. Needle-like grooves and ridges radiate out from a central point. The radii are so terminated that each set roughly forms a hexagon, though the boundaries are often indistinct and irregular. This inner structure represents the zone of attachment between the carapace and the inner mantle.

Cypridina aciculata Scot and Summerson n. sp.

Plate 2, Figs. 1, 3.

Carapace very large, ovate to subcircular; dorsum strongly arched, venter gently convex; posterior end convex, extending with uniform curvature into dorsum; anterior end marked by typical cypridinoid beak. The entire inner surface of the shell is covered with a complex set of acicular radii, about nine on each valve. The radii consist of needle-like ridges with intervening grooves that are arranged in roughly designed trapeziums. Three large trapeziums are arranged obliquely from an antero-ventral point to the postero-dorsal slope. The centers of these three large irregular trapeziums can be connected with a straight line. As many as eighty radii occur around the perimeter of the central trapezium. They are added by intercolation. However, many of the radii are not simple, but are modified by minute cross-bars. Three smaller centers of radii occur in the antero-dorsal area and also in the postero-ventral area. Length 5.3 mm.; height 3.2 mm.

Holotype.—Univ. of Ill. Paleontology coll. No. x-1713, paratype, No. x-1712.

Locality.—No. 7, collection N2, Hance formation.

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