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NEOGENE (PLIO-PLEISTOCENE) FRESH-WATER OSTRACODES FROM THE CENTRAL HIGH PLAINS

By
Edwin D. Gutentag and Richard H. Benson

PREFACE

Water wells are drilled or dug in unconsolidated sand and clay, which differ in character from one location to the next to such an extent in some areas that mapping a water-producing zone solely on the basis of similarity of rock type is very difficult. Fossils can be very helpful in correlating water-bearing strata of the same age or strata formed in similar depositional environments. Microfossils (those too small to identify with the unaided eye) are particularly useful for this purpose, as undamaged specimens can be recovered from well cuttings. The most abundant microfossil in the surficial water-yielding strata of Kansas is the microscopic fresh-water relative of the lobster, the ostracode.

The ostracode abounds in almost every aquatic habitat but it is not commonly known to the layman. To the geologist the ostracode represents an important form of past life found in rocks of all ages, extending back from the Recent for more than 500 million years, and deposited in environments ranging from deep ocean to lakes and streams. The Germans call the ostracode "muschelkrebs" or mussel-shrimp, because it resembles a tiny shrimp contained in the shell of a fresh-water mussel. Illustrated within this report are ostracode shells, which are the sole remains of an otherwise very complicated form that has lived in the High Plains area from some time before the Ice Age to the present.

Richard H. Benson

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NEOGENE (PLIO-PLEISTOCENE) FRESH-WATER OSTRACODES FROM THE CENTRAL HIGH PLAINS

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ABSTRACT

Pleistocene deposits in southwestern and central Kansas, western Oklahoma, and northern Texas have yielded eleven species of fresh-water ostracodes. Pliocene and Recent deposits have each yielded one species. Genera represented are *Cypricercus, Eucypris, Cypridopsis, Potamocypris, Candona, Ilyocypris, Cyprideis,* and *Limnocythere*. Four species are new: *Eucypris meadensis, Candona nyensis, C. renoensis,* and *Limnocythere staplini*. Nine species described previously from living forms were found as fossils: *Cypricercus tuberculatus* (Sharpe), *Cypridopsis vidua* (O. F. Müller), *Potamocypris smaragdina* (Vávra), *Candona caudata* Kaufmann, *C. crogmaniana* Turner, *C. fluviatilis* Hoff, *Ilyocypris bradyi* Sars, *I. gibba* (Ramdohr), and *Cyprideis littoralis* Brady.

All genera represented and two of the new species (*Eucypris meadensis* and *Candona nyensis*) are living today. The existing classification of living ostracodes, based on appendages, is used for the Pleistocene forms, although the fossil ostracodes were necessarily described on the basis of their carapace features.

Candona nyensis n. sp. seems to be restricted to deposits of Pleistocene age, and can be used locally in southwestern Kansas to distinguish Pleistocene from Pliocene sediments.

Cyprideis littoralis Brady, which normally lives in brackish water, seems to have become adapted to the fresh-water environment of Pleistocene sinkholes.

INTRODUCTION

Pleistocene fresh-water ostracodes have been described from very few parts of the world and have never been previously studied from the central High Plains. The sinkhole country around Meade County, Kansas, (Fig. 1-2) affords a unique opportunity for study, inasmuch as ostracodes are found in several Pleistocene rock units exposed on the flanks of the stream-dissected sinkholes. Samples from these beds and additional samples from Pleistocene strata in Texas, Oklahoma, and Missouri and from Pliocene and Recent deposits in Meade County were studied in order to determine whether ostracodes could be used as guide-fossils for the Pleistocene Epoch or its stages and also to extend knowledge of this poorly known group of the Ostracoda.

Previous work.—Published taxonomic analyses of Recent living fresh-water ostracodes have been carefully examined during the study

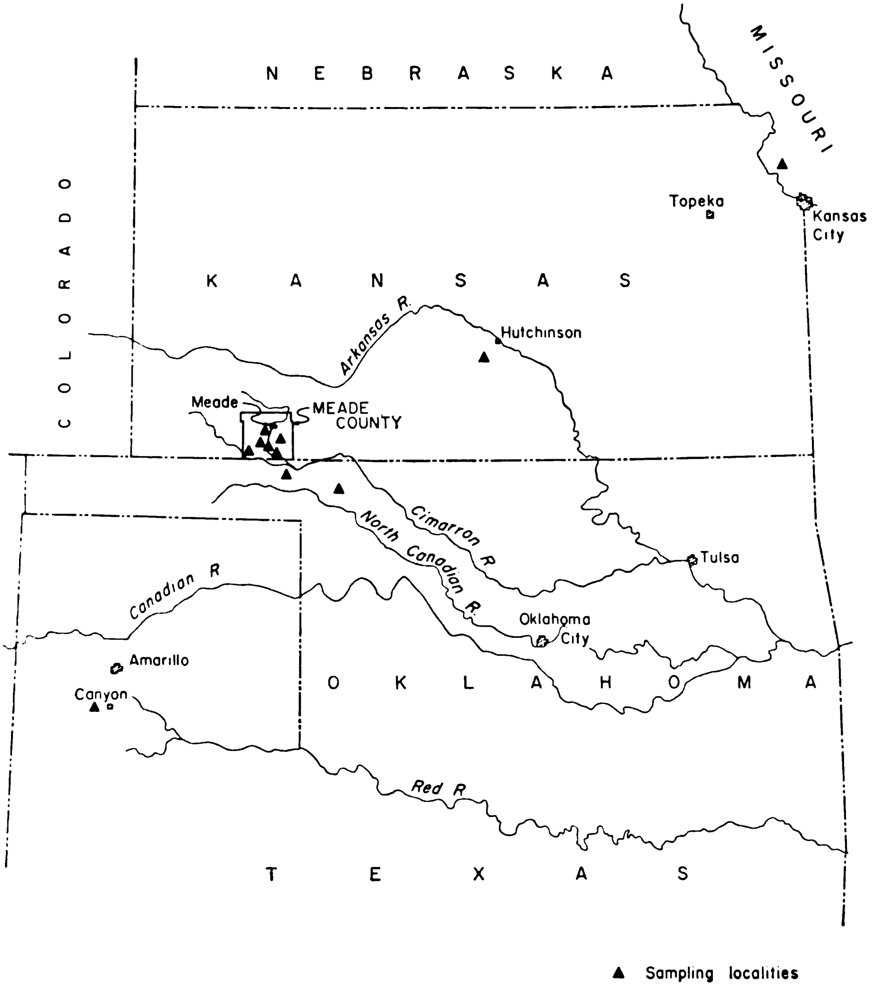

FIG. 1.—Generalized map of the High Plains area showing sample-collecting localities.

of Pleistocene and Pliocene ostracodes, as the fossil forms are similar to or identical with living species. These descriptions of living species from widely separated areas in the United States and from Europe are primarily concerned with the soft parts of the animal, which are not preserved as fossils. The lack of adequate descriptions of the carapaces of these forms has been a considerable handicap in the present study.

Turner (1895) published the first important study of living ostracodes in the United States. Later, Sharpe (1918) diagnosed the known North American species and formulated a key for their identification. Sars (1926) described a few Canadian species; Furtos (1933) de-

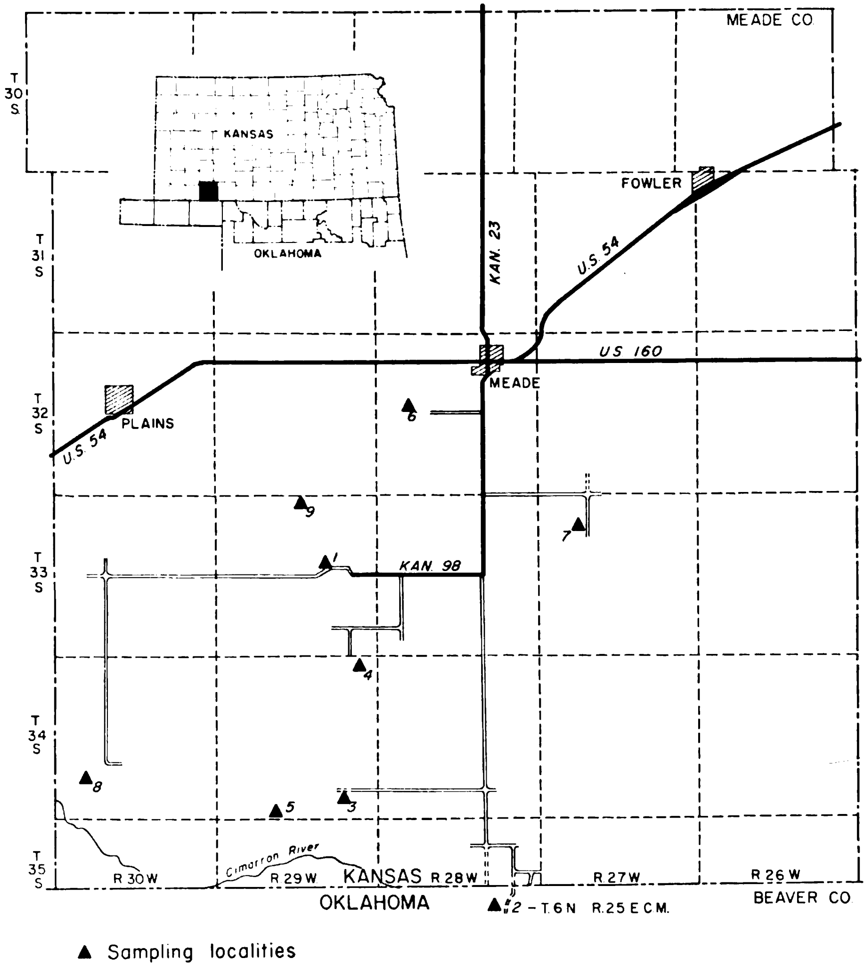

FIG. 2.—Map of Meade County, Kansas, showing localities sampled.

scribed ostracodes from Ohio; Dobbin (1941) described several species from Washington; and Hoff (1942) described the ostracodes of Illinois. Tressler (1947) compiled another checklist of known species of North American fresh-water ostracodes. Swain (1955) described the Recent fresh-water ostracodes living in the saline waters of San Antonio Bay, Texas, many of which have been found also in the Pleistocene fresh-water deposits of southwestern Kansas and the High Plains. Ferguson (1958) published a supplementary checklist for the period 1947-1957. Winkler (1960) described, from cave deposits in Michigan, an early Recent fauna that shows a similarity to the fauna described herein. Swain (1961) published the most recent revision of the classification of the cypridacean ostracodes, which is used in the present report, as part of Treatise on Invertebrate Paleontology, pt. Q, Arthropoda 3 (Moore, ed., 1961).

Relevant European studies referred to in this report include: Jones (1857), a study of the Tertiary and Pleistocene Ostracoda of England; Sars (1925), an extensive study of Recent Ostracoda from Norway and other parts of Europe; Klie (1938), a complete review of the Recent fresh-water ostracodes of Germany; Bronstein (1947), a study of fresh-water ostracodes of the Soviet Union, and Wagner (1957), a study of the ostracodes of the Pays-Bas region of Holland.

One of the first reports of ostracodes in Pleistocene deposits of North America was that by Baker in 1920. Staplin (1953) described the morphology and ecology of Pleistocene ostracodes from Illinois. Ostracodes were found in Meade County, Kansas, by Smith (1940) and by Frye and Hibbard (1941).

Methods.—Specimens from the Pleistocene deposits of the High Plains were collected during the summer of 1956 and during the spring and summer of 1957. At most localities, samples of sand, clay, and silt were obtained at 1- to 3-foot intervals from outcrops for which measured sections had been published. Particular attention was paid to strata containing noticeable aquatic sedimentary structures or aquatic gastropod faunas. In a few outcrops ostracodes could be seen with a hand lens, but generally the samples were collected "blind" from well-sorted sands and silts. Where ostracodes were present in these samples they were found to be very abundant.

In the laboratory the samples were dried thoroughly in an oven, placed in beakers of water containing a small quantity of liquid detergent, heated to boiling, and the suspension decanted through 35- and 60-mesh screens. Samples free of clay and coarse sand were not heated but were washed under a stream of running water and sieved through 18-, 35-, and 60-mesh screens.

Acknowledgments.—Gratitude is expressed to the following persons: Dr. C. W. Hibbard of the Museum of Paleontology of the University of Michigan for aid in the field and for obtaining some of the samples used in this study; Dr. A. B. Leonard of the Department of Zoology at the University of Kansas for a sample from Missouri used in this study; and to Professor J. Hughes of the Panhandle Plains Historical Museum for material from Texas used in this study. Gratitude is expressed to G. Lloyd Foster, former graduate student of the Department of Geology, the University of Kansas, who was helpful during the time of this study.

Repository.—All of the types have been retained in the collections of the Department of Geology, the University of Kansas.

STRATIGRAPHIC CLASSIFICATION

The names and classification of stratigraphic units as used in this report (Fig. 3) are those of Hibbard (1958) for Meade County, Kansas. Dr. Hibbard accompanied us on most of our collecting trips and pointed out the placement of beds from which our samples were obtained relative to his stratigraphic classification. The classification of the Pleistocene currently used by the State Geological Survey (Jewett, 1959), is also shown in Figure 3.

Hibbard (1955, p. 183), with reference to classification based on the vertebrate fauna, stated:

> "Only tentative correlation exists at the present time in North America between the glacial and interglacial deposits of the glacial region and the nonglacial deposits of the Ice Age (Pleistocene) outside of the glaciated regions. If only four major glaciations and three major interglacial intervals occurred in North America, then a direct correlation can be made between the nonglacial Pleistocene depcsits in southwestern Kansas, and the known glacial section, on the basis of cyclic erosion, deposition, and successive Pleistocene faunas. Until more work is done and a better correlation exists between these regions it is considered best to treat the assignment of Pleistocene faunas from southwestern Kansas to definite glacial or interglacial ages as only tentative."

This consideration is especially true for a relatively unknown fossil group such as the ostracodes of the Pleistocene.

The ostracodes from the Pleistocene stages of the unglaciated High Plains area cannot be adequately correlated with those of the glaciated region until more ostracode faunas have been described from the glacial type areas.

OSTRACODE-BEARING STRATA

Pliocene Series

Laverne Formation.—The Laverne Formation was described in an unpublished manuscript by V. V. Waite (Gould and Lonsdale, 1926) and named from a locality in Harper County, Oklahoma. In Meade County, Kansas, the formation generally consists of gray, fine to medium thin-bedded micaceous sandstone and gray to tan shale. A diagnostic unit in the Laverne is the tan-gray, friable, calcareous, silty fine sandstone locally used as building stone and named "sawrock" (Frye and Hibbard, 1941). The beds dip at angles as great as 15 degrees, which may indicate post-Laverne solution of underlying beds. The thickness exposed at the surface in Meade County does not exceed 80 feet, but in nearby Seward County, test holes (Byrne and McLaughlin, 1948) indicate greater thickness, which may be the result of basin filling during Early Pliocene time.

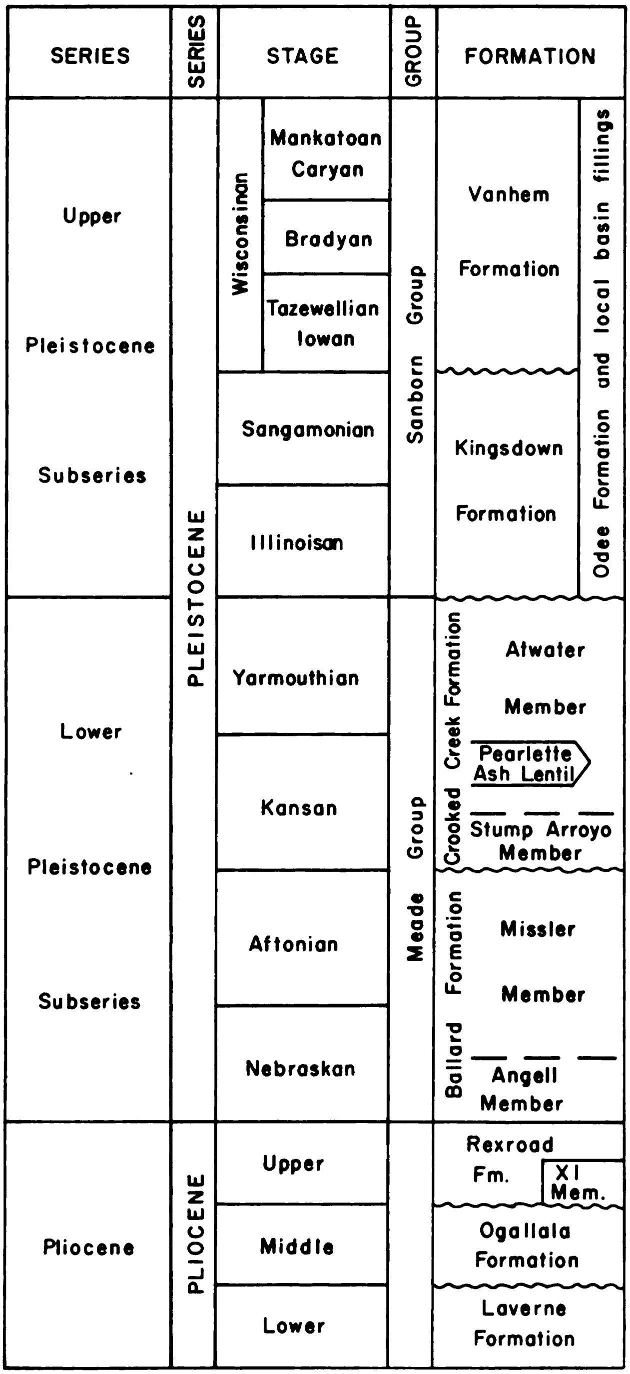

FIG. 3.—Southwest Kansas Pleistocene classification, modified after Hibbard (1958) and Jewett (1959).

At locality 8 (Fig. 2), the ostracodes were recovered from a limonitic sandstone bed at the top of the Laverne Formation.

Ogallala Formation.—No ostracodes were recovered.

Rexroad Formation.—Smith (1940) named the Rexroad Formation for the exposures on the Clarence Rexroad ranch, Meade County, Kansas. The lower beds are sand and fine gravel; the intermediate beds are sandy silt and include layers of organic matter; and the upper beds are clay, sandy silt, and caliche. The upper caliche zone occurs as nodules or as a massive bed of caliche. The Rexroad Formation is judged to represent Late Pliocene time on the basis of the contained vertebrate fauna (Hibbard, 1950, 1953; Woodburne, 1961). In the Meade County area the thickness ranges from 8 to 80 feet.

At locality 9 (Fig. 2), ostracodes were collected at the top of the Rexroad Formation, from a limonitic sandstone cemented with calcium carbonate.

Pleistocene Series

Lower Pleistocene Subseries

The Meade Group as defined by the Pleistocene Conference held in Lawrence, Kansas, in June of 1956 (Foley, 1956) has been revised to include the Ballard and Crooked Creek Formations. The term Lower Pleistocene Subseries is used by the State Geological Survey (Jewett, 1959) for the sediments equivalent to the Meade Group.

Ballard Formation.—Although ostracodes have not been recovered from the Ballard Formation, its stratigraphic position is important in the interpretation of overlying and underlying strata. The name Ballard Formation was proposed by Hibbard (1958) for the deposits that he had previously described as the Meade Formation (Hibbard, 1949b). In that earlier paper, Hibbard had restricted the Meade Formation to include Cragin's Meade gravels but to exclude the deposits at the section designated as type locality for the Meade Formation.

The basal part of the Ballard Formation contains stream-deposited arkosic (granitic) sand and gravel of Rocky Mountain source, which grades upward into sandy silt, clay, and caliche zones.

Crooked Creek Formation.—Hibbard (1949b) applied the name Crooked Creek Formation to the sediments laid down during the cycle of deposition that followed deposition of the Ballard Formation, and as type section cited the same one previously designated by Frye and Hibbard (1941) as the type section of the Meade Formation. The basal member of the Crooked Creek Formation, the Stump Arroyo Member, consists of tan sand and gravel, which are distinguishable from the basal members of the Ballard, Rexroad, and Ogallala Formations in the Meade County area. The Stump Arroyo Member is dated by its contained vertebrate fossils (Hibbard, 1951).

The Atwater Member of the Crooked Creek Formation overlies the Stump Arroyo Member. It consists of sand, silt, and clay both above and below the included Pearlette Ash lentil.

Seven Crooked Creek localities in Meade County were examined but no ostracodes were found. Ostracodes have been identified by Staplin (1953) from above the Pearlette Ash at the Cudahy fauna locality. Ostracodes were collected from Lower Pleistocene deposits above the Pearlette Ash in Reno County, Kansas, at locality 10. Ostracodes have also been identified from deposits below the Pearlette Ash at locality 11 near Canyon, Texas.

Upper Pleistocene Subseries

In southwestern Kansas the Sanborn Group as proposed by the 1956 Pleistocene Conference includes the Kingsdown and Vanhem Formations. The term Upper Pleistocene Subseries is used by the State Geological Survey (Jewett, 1959) for sediments equivalent to the Sanborn Group. The Odee Formation (Smith, 1940) and some local basin fillings are judged to be Upper Pleistocene.

Kingsdown Formation.—The Kingsdown Formation was described by Cragin in 1896, but he did not designate a type section. Hibbard (1949b) thought that the type locality was on Bluff Creek in Clark County, Kansas. Cragin (1896, p. 54) stated:

> ". . . the Kingsdown Marl consisted of yellowish-brown lacustrine or slack water marls, containing variously shaped concretions of calcium carbonate and silicate of lime. They are very rarely fossiliferous."

Hibbard (1944) believed that Cragin's description applies to the lower beds but not to the overlying beds, which he removed to the Vanhem Formation.

The Kingsdown as restricted by Hibbard (1944) consists of a lower gravel member, composed of abraded caliche fragments and gravel, and an upper part composed of thick-bedded buff silt that grades upward into sandy silt and fine sand. The thickness of the (revised) Kingsdown Formation at the type section is 25 feet.

The ostracodes at locality 6 (Fig. 2) were collected from the upper part of the Kingsdown Formation silts at the Cragin Quarry located on Big Springs Ranch, Meade County, Kansas.

Vanhem Formation.—The Vanhem Formation was named and described by Hibbard (1949b); the type section is the outcrop along the west bluff of a tributary of Bluff Creek in Clark County, Kansas. Smith (1940) regarded this section as the type section of Cragin's Kingsdown Formation.

The basal member of the Vanhem Formation consists of sand and gravel containing abundant calcareous pebbles and fragments of mortar-bed conglomerate, which were reworked from older formations. Contact with the middle silty layer, which contains small pebble layers, is indistinct. The upper member consists of silt which according to Hibbard (1949b) grades into loess at the top. The thickness of the Vanhem Formation at the type locality is 68 feet.

Ostracodes were recovered from the upper beds in the Jones Sink at locality 7 (Fig. 2), which Hibbard (1949b) judged to be Vanhem Formation on the basis of lithology and vertebrate fauna. We believe that the lower beds of the Jones Sink are Upper Pleistocene fluviatile deposits. A fossil soil is exposed 6 feet above the base of the section.

Odee Formation and local basin fillings.—The formation was named by Smith (1940) from exposures in Odee Township in southern Meade County. It consists of beds that are all probably younger than the Crooked Creek Formation. Many of the Pleistocene deposits younger than the Crooked Creek Formation are lower topographically than the older formations. The sinkholes seem to be filled with locally derived material. The Odee Formation consists of red mudstone, sand, and silt. Ostracodes were found in all samples collected from the Odee Formation at localities 3 and 4 (Fig. 2). At locality 3 a thin layer of limonitic sandstone cemented with calcium carbonate might be described as an "ostracode coquina".

An ostracode-bearing clay at locality 5 (Fig. 2) is part of a sink-fill deposit that Hibbard (personal communication) believed to be approximately the same age as the upper beds of the Odee.

Ostracodes are abundant in samples from the Nye Sink in Beaver County, Oklahoma, locality 2. According to Hibbard (personal communication), the Nye Sink beds are equivalent to the lower part of the Odee Formation, and the deposits were called Odee Formation by Smith (1940). Ostracodes are extremely abundant in bed 15 of Smith's measured section (1940, p. 103). He described this bed as "Marl, diatomaceous to sandy, gray to white, contains fossils." All beds except those at the top of the section show signs of collapse during formation of the sink.

The Odee Formation is 104 feet thick at locality 3 and 55 feet thick at locality 4.

Smith attributed the reddish colors to reworked material eroded from Permian or Triassic redbeds. The sand deposits were possibly derived from reworked Ogallala sediments.

Quaternary sand.—The ostracodes from locality 1 (Fig. 2) were collected alive from sands in a tributary of Crooked Creek that flows through Meade County State Park from an artesian spring. One species

(*Ilyocypris bradyi* Sars) found at this locality was also represented by fossils in the Odee Formation (Pleistocene).

Water from this stream was used by Dr. Hibbard to wash his samples for microvertebrate fossils. Because of possible contamination of older ostracodes that were recovered with microvertebrates, it was necessary to know which ostracodes were indigenous to the stream.

CONCLUSIONS

Use as stratigraphic guide fossils.—The ostracodes were examined in view of their potential use as stratigraphic indicators. Fossil fresh-water species of ostracodes are not well enough known to be used as stratigraphic indices for the subdivisions of the Pleistocene. Present knowledge indicates that the span of time since the beginning of the Pleistocene was inadequate for the selection and evolution of new forms. Hence the classic concept of appearance and extinction of species used to define a stratigraphic range may not be applicable in dividing the Pleistocene units. Changes in climate and corresponding geographic changes in environments and habitats of the ostracodes, however, have profound effect on the distribution of existing species. On the basis of comparison of modern distribution of ostracode species it is possible to distinguish some deposits associated with glacial stages as cold water in origin. No interglacial faunas were recognized.

For distinguishing Pleistocene faunas from Pliocene, at least in southwestern Kansas, we believe that *Eucandona nyensis* n. sp. is

TABLE 1.—*Ostracode species from localities sampled.*

Species	Locality number†												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Cypricercus tuberculatus (Sharpe)										X			
Cyprideis littoralis Brady		X	X	X	X		X	X	X				
Cypridopsis vidua (O. F. Müller)		X		X	X	X				X			
Candona caudata Kaufmann		X										X	
Candona crogmaniana Turner								X		X			
Candona fluviatilis Hoff										X		X	
Candona nyensis n. sp.		X	X	X	X		X			X	X		X
Candona renoensis n. sp.						X				X			
Eucypris meadensis n. sp.	X												
Ilyocypris bradyi Sars	X	X	X							X			
Ilyocypris gibba (Ramdohr)										X			
Limnocythere staplini n. sp.		X	X	X	X		X	?		X			
Potamocypris smaragdina (Vávra)		X			X		X			X			
*Age	A-a	A-e	A-e	A-e	A-d,c	A-d	A-b	D	C	B	B	A-b	A-f

*Age. A, Upper Pleistocene; a, Recent; b, Wisconsinan; c, Early Wisconsinan; d, Sangamonian; e, Illinoisan-Wisconsinan; f, Illinoisan; B, Lower Pleistocene (Kansan); C, Upper Pliocene (Rexroad Formation); D, Lower Pliocene (Laverne Formation).
†For description see Register of Localities.

diagnostic. Its earliest appearance is in the Crooked Creek Formation (Lower Pleistocene), and it is conspicuously absent from Pliocene sediments (Table 1).

Use as ecologic indicators.—Fresh-water ostracodes are found living in almost every modern stream, lake, pond, and spring. Generally ostracode species are geographically and seasonally distributed within the biomes or "life zones" affected by seasonal temperature changes and differences in latitude and altitude. Certain species, such as *Cypricercus tuberculatus,* are more common in warm-temperate or neotropical regions than in the colder near-artic or sub-alpine habitats. Nearctic forms adapted to cold waters are poorly known. Colder waters upwelling from artesian wells in Kansas contain what seem to be relic communities of microfaunas including *Potamocypris smaragdina* (Vávra) not found in surrounding warmer waters. The presence of southern or warm interglacial faunas and possible northern or near-glacial faunas in the same area but at different stratigraphic horizons may prove to be valuable in distinguishing sediments of interglacial from those of glacial stages.

Concerning more localized ecologic problems, Lohman (in Frye and Hibbard, 1941) stated that the diatoms found in the lower beds of the Laverne Formation suggest deposition under continental saline conditions. Leonard and Franzen (1944) postulated continental brackish-water conditions for these beds, citing the occurrence of spines on aqueous gastropods as well as the presence of the ostracode *Cyprideis littoralis* Brady identified by Tressler (in Frye and Hibbard, 1941, p. 401). They also pointed out that after deposition of the diatom-bearing marl, the water became fresh. Despite the postulated variety of these environments, *C. littoralis* Brady lived on the High Plains from Early Pliocene until Late Pleistocene time.

The occurrence of *Cyprideis littoralis* Brady, a common "brackish-water" form, in the Pleistocene sinkhole deposits of southwestern Kansas can be explained in two ways. (1) The sinkholes could have contained fresh water since the time of their origin; the implication is that *C. littoralis* Brady had to adapt itself to a fresh-water environment. (2) Some sinkholes contained fresh water while others contained brackish water, or some sinkholes contained brackish water at first but with the passage of time the water became fresh. The presence of *Cyprideis littoralis* Brady in multicycle sinks could not be cited as evidence for brackish water exclusively.

The sinkholes developed after the collapse of beds overlying Permian salt beds. Frye and Schoff (1942) show that the sinkholes are on the upthrown side of major faults. The evidence for a fresh-water environment is the abundant microvertebrate and gastropod fauna associated with the ostracodes in many sinkhole deposits. The other members of the fauna represent a fresh-water environment, therefore it is reasonable to assume that the ostracodes, including *Cyprideis littoralis* Brady, also lived in such a lake or pond environment during the Late Pliocene and Pleistocene. Klie (1938) mentioned the fresh-water occurrence of this species in Germany. It seems reasonable to assume that *C. littoralis* Brady is a euryhaline species capable of living successfully in various environments.

The evidence for changing environment is presented by the Meade Salt Sink (Merriam and Mann, 1957). This sinkhole, formed in Meade County in 1879, was first filled with saline water but now is almost filled with sediment. In periods of ample rainfall it contains fresh water, whereas during years of drought it remains dry. Perhaps this sequence was common during the Pleistocene, and many sinkholes that are now filled with sediment had such a history.

In San Antonio Bay, Texas, Swain (1955) found *Cyprideis littoralis* Brady in the brackish midbay subfacies of the river and prodelta facies, whereas *Candona caudata* Kaufmann and *Potamocypris smaragdina* (Vávra) were found in the brackish river and prodelta facies. These three species were found together in the Pleistocene sinkhole deposits of southwestern Kansas. Swain found that some fresh-water species are capable of living in brackish water at mouths of rivers, and that they do not necessarily represent a fresh-water environment.

In addition to the above conclusions, the authors of this report would stress the potential usefulness of ostracodes in the study of Pleistocene history but would also emphasize the need for further study of distribution and ecology of Recent forms. The living faunas of ostracodes in North America are inadequately known. Many species have been described from only one or two localities. Additional information about tropical, temperate, and arctic species living today will increase the significance of the fossil forms for interpreting past climates and environments.

One of the environmental parameters controlling distribution of most aquatic organisms is water temperature. Changes in temperature with changes in season, and differences in temperature due to differences in climate, altitude, latitude, depth, or other factors, presumably affect the distribution of fresh-water ostracodes, but the effects are almost totally unknown. Hoff (1942, p. 25) found that in his field experience in Illinois the small temperature range there had little effect on the distribution of ostracodes other than possibly on seasonal occurrence. Swain (1961, p. Q 211), in quoting Hoff, implied that temperature of water generally has little or no effect on distribution of ostracode species. In view of the lack of experimental or field data and our present knowledge of the effects of temperature on other organisms, perhaps Swain's conclusion is too strongly stated. The complex interrelationship of the several environmental factors depending ultimately on changes in temperature and their effect on ostracode distribution needs to be studied further.

REGISTER OF LOCALITIES

(Shown on locality map, Fig. 2)

1. Recent—Artesian spring, well, and drainage, wayside park in Meade County State Park, NW¼ SW¼ sec. 14, T. 33 S., R. 29 W., Meade County, Kansas.
2. Pleistocene (Illinoisan-Wisconsinan)—Nye Sink deposits, NW¼ SW¼ sec. 15, T. 6 N., R. 25 E. C. M., Beaver County, Oklahoma. Measured section (Smith, 1940, p. 103).
3. Pleistocene (Illinoisan-Wisconsinan)—Odee Formation, NE¼ sec. 35, T. 34 S., R. 29 W., Meade County, Kansas. Measured section (Smith, 1940, p. 101).
4. Pleistocene (Illinoisan-Wisconsinan)—Odee Formation, NW¼ SE¼ sec. 1, T. 34 S., R. 29 W., Meade County, Kansas. Measured section (Frye, 1942, p. 107).
5. Pleistocene (Sangamonian or Early Wisconsinan)—⅛ mile downstream from Hibbard's Dire Wolf locality, SW¼ sec. 33, T. 34 S., R. 29 W., Meade County, Kansas.
6. Pleistocene (Sangamonian)—Cragin Quarry locality, Big Springs Ranch, SW¼ sec. 17, T. 32 S., R. 28 W., Meade County, Kansas.
7. Upper Pleistocene (Wisconsinan)—Jones Ranch beds, NW¼ NE¼ sec. 8, T. 33 S., R. 27 W., Meade County, Kansas.
8. Lower Pliocene—Laverne Formation, W½ sec. 29, T. 34 S., R. 30 W., Meade County, Kansas.
9. Upper Pliocene—Rexroad Formation, NW¼ sec. 3, T. 33 S., R. 29 W., Meade County, Kansas.

Localities Outside Meade County Area

(Not shown on locality map, Fig. 2)

10. Lower Pleistocene (Late Kansan or Early Yarmouthian)—Above Pearlette Ash, SE¼ NE¼ sec. 1, T. 25 S., R. 7 W., Reno County, Kansas.
11. Pleistocene (Kansan)—Below Pearlette Ash, Canyon on U. S. Highway 87 just north of underpass, on east side of road before one reaches C. S. Highway 60 at Canyon, Texas. Collected by Jack Hughes.
12. Pleistocene (Wisconsinan)—Terrace deposit, SE¼ SW¼ sec. 8, T. 52 N., R. 36 W., Platte County, Missouri. Collected by A. B. Leonard.
13. Pleistocene (Illinoisan)—Doby Springs glacial fauna, SW¼ sec. 10, T. 27 N., R. 24 W., Harper County, Oklahoma. Collected by C. W. Hibbard.

TAXONOMIC PROBLEMS

Basis of Classification

All of the genera of this report are represented by previously described living species. At least two of the new species found in older Neogene strata are still living today. The existing generic and specific classifications of the living fresh-water ostracodes based on appendages are used in this report for most of the Pleistocene and older forms. Most ostracode neontologists do not regard variation in the features of the carapace as important in morphologic studies. The carapaces of living species and even of fossil species have not been sufficiently studied to justify a revised classification based on carapace morphology comparable to the one based on appendages. Both morphologic features are fundamental parts of the animal, hence separate classifications should be avoided if possible. Eventually the living species, which have been described and delineated on soft parts, should be re-evaluated in terms of present knowledge of carapace morphology to correlate with their fossil predecessors.

Significant Features of Carapace

Carapace features generally used by paleontologists to classify fossil fresh-water ostracodes include size and shape, adductor and mandibular muscle-scar patterns, normal pore canals, configuration of the duplicature, and ornamentation. The type of hinge is generally taxonomically significant in more advanced forms of Ostracoda, but the hinge of most forms of Cypridacea is adont, and differences are subtle and obscure. All members of the Cypridacea have some sort of bar and groove arrangement or are completely without a groove. The more complex merodont hinge, characteristic of a large group of predominantly brackish-water and marine Cytheracea is found only in *Cyprideis* among fresh-water inhabitants. The intermediate lophodont hinge is known from species of *Limnocythere* and perhaps from those of *Ilyocypris.*

The general shape, outline, and relative size of the valves are useful characters for delineation of some ostracode species and genera. Most species of the genus *Candona* are much larger and more reniform than those of the genus *Eucypris,* although within the genus *Candona* adults of the species range from 1 mm (*Candona renoensis* n. sp.) to 1.3 mm (*Candona nyensis* n. sp.) in length and from subreniform to subtrapezoidal. Much experience is needed to recognize the consistent difference in shape in these forms.

The muscle-scar pattern within the central area of the carapace is the most complex morphologic structure visible in many an otherwise simple cyprid carapace. Variation in shape and arrangement of the discrete scars that compose the mandibular and adductor muscle-scar patterns seems to be significant on the generic and even on the species level. For example, a rosette of five smaller scars and one elongate scar located dorsally tends to be distinctive of the genus *Candona*. The genus *Eucypris* can be recognized by its muscle-scar pattern of a subparallel group of five elongate scars whose long axes are oriented at an angle of about 45° with a tangent to the ventral margin.

The presence of sulci and lobes distinguishes a few genera from most of the unornamented fresh-water ostracode genera. The genus *Ilyocypris* is readily distinguishable from the genus *Limnocythere* by its more pronounced dorsolateral sulci. Although these forms belong to two different and widely separate families, on many specimens the diagnostic muscle-scar patterns cannot be seen.

The development of the marginal area and its associated structures (e.g., selvage, flange, vestibule, duplicature, list) is usually regarded as a generic character, although many genera have similar marginal areas. The genera *Cypridopsis* and *Eucypris* have similar marginal areas, but can be differentiated by size, shape, and muscle-scar pattern.

Character of minor ornamentation (e.g., nodes, reticulations, protrusions, and tuberculae) is generally used for distinguishing species. *Ilyocypris gibba* (Ramdohr) is distinguished from *I. bradyi* Sars by the presence of lateral protrusions and nodes on the former.

Sexual dimorphism is notable in some species of fresh-water ostracodes. The males of *Candona nyensis* n. sp. have a more arched dorsum and are more sinuate in lateral outline than are the females. Generally, the male eucandonids are larger and broader in the posterior region than are the females, which is quite the contrary of many species of marine ostracodes, in which the females are consistently broader. In some fresh-water species the males are absent, and some taxonomists have used presence or absence of males to distinguish genera. This criterion is difficult to impossible to apply to fossil forms unless all other species can be identified to the exclusion of a single maleless species.

The examination of normal pore canals, radial pore canals, and the marginal features is necessary for completeness in morphologic studies, but their taxonomic significance at the generic or specific level has not yet been demonstrated.

Ostracode Classification Used in This Study

(Modified after Treatise of Invertebrate Paleontology, Part Q, Arthropoda 3)

- Class CRUSTACEA Pennant, 1777
  - Subclass OSTRACODA Latreille, 1806
    - Order PODOCOPIDA Müller, 1894
      - Suborder PODOCOPINA Sars, 1866
        - Superfamily CYPRIDACEA Baird, 1845
          - Family CYPRIDIDAE Baird, 1845
            - Subfamily CYPRIDINAE Baird, 1845
              - Genus CYPRICERCUS Sars, 1895
              - Genus EUCYPRIS Vávra, 1891
            - Subfamily CYPRIDOPSINAE Kaufmann, 1900
              - Genus CYPRIDOPSIS Brady, 1868
              - Genus POTAMOCYPRIS Brady, 1870
          - Family CANDONIDAE Kaufmann, 1900
              - Genus CANDONA Baird, 1846
          - Family ILYOCYPRIDIDAE Kaufmann, 1900
            - Subfamily ILYOCYPRIDINAE Kaufmann, 1900
              - Genus ILYOCYPRIS Brady and Norman, 1889
        - Superfamily CYTHERACEA Baird, 1850
          - Family CYTHERIDEIDAE Sars, 1925
            - Subfamily CYTHERIDEINAE Sars, 1925
              - Genus CYPRIDEIS Jones, 1857
          - Family LIMNOCYTHERIDAE Klie, 1938
              - Genus LIMNOCYTHERE Brady, 1868

SYSTEMATIC DESCRIPTIONS

Superfamily CYPRIDACEA Baird, 1845
Family CYPRIDIDAE Baird, 1845
Subfamily CYPRIDINAE Baird, 1845
Genus CYPRICERCUS Sars, 1895

Cypricercus SARS, 1895, Vid. Selsk. Skr. I., Math. naturw. kl., (Christiana), no. 8, p. 37; SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 117, FURTOS, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p 445; HOFF, 1942, Illinois Biol. Mono., v. 19, p. 132-133.

Spirocypris SHARPE, 1903, Proc. U.S. Natl. Mus., v. 26, p. 981.

Type species—Cypricercus cuneatus SARS, 1895.

Diagnosis.—The oval somewhat elongate shape of the carapace and the slightly arched ventral margin distinguish this genus from the other members of the subfamily Cypridinae. *Pleistocene to Recent.*

Description.—The carapace as seen in lateral view is oval to subelliptical in outline. The dorsal margin is slightly arched anteriorly. The ventral margin is slightly sinuate in the central ventral region. The anterior margin is more broadly rounded than the posterior margin. The greatest height is anterior to the middle and is more than half the length. The surfaces of the valves in some species are pitted but in other species are covered by papillae or tubercles. The normal pore canals are simple and extend through the pits or papillae.

The carapace is ovate in dorsal view. The breadth is more than half the length. The anterior end is more narrowly rounded than the posterior. The left valve overreaches the right.

The line of concrescence and inner margin coincide only at the incurvature of the valve on the ventral margin. The duplicature is widest anteriorly, occurs posteriorly, and forms a vestibule. Radial pore canals are numerous, short and tubelike. The hingement on the right valve consists of a groove, which is formed by the hinge flange and the selvage. The hingement of the left valve consists of a bladelike extension of the dorsal flange, which fits the groove of the right valve. The free margin of the left valve projects inward and overreaches that of the right valve. The muscle scars consist of a central group of five oval scars and one or two small scars located posteroventrally.

Males are common and have the same carapace features as the female.

Remarks.—*Cypricercus* is distinguished by the character of the furca and coils of the testes. These important criteria, however, cannot be used for fossil forms. The carapace is generally more tumid than in *Eucypris*.

CYPRICERCUS TUBERCULATUS (Sharpe), 1908

Fig. 4. Pl. 2, fig. 11.

Spirocypris tuberculata SHARPE, 1908, Proc. U. S. Natl. Mus., v. 35, p. 406-408, pl. 50, fig. 1-2; pl. 55, fig. 1-6; ———, 1918, *in* Ward and Whipple, Fresh-water biology, p. 814, fig. 1267 a-c.

Cypricercus horridus SARS, 1926, Rept. Can. Arctic Exped. 1913-1918, v. 7, pt. 1, p. 6-7; pl. 3, fig. 1-7.

Cypricercus tuberculatus (Sharpe), HOFF, 1942, Illinois Biol. Mono., v. 19, p. 133-135, pl. 8, fig. 103-104.

Diagnosis.—The oval shape of the carapace and the papillose surface distinguish this species from the other described species.

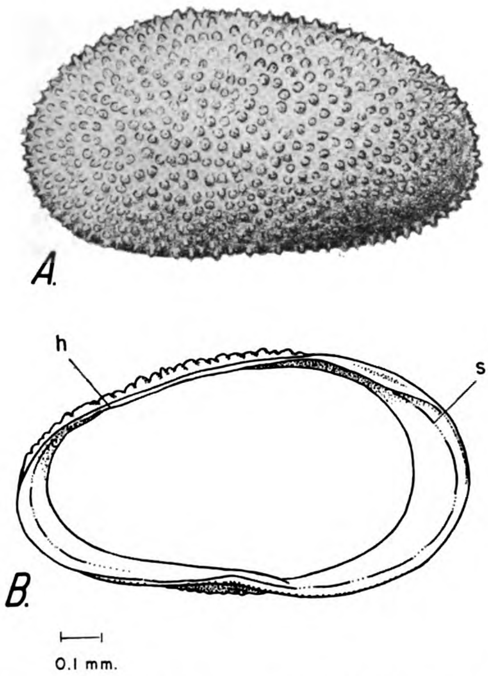

FIG. 4.—*Cypricercus tuberculatus* (Sharpe). **A.** Lateral view of exterior of left valve of adult carapace. **B.** Lateral view of interior of left valve of adult carapace (h, hinge; s, selvage).

Description.—In lateral view the carapace is subelliptical. The dorsal margin is broadly convex. The ventral margin is slightly sinuate in the central ventral region. The anterior margin is broadly rounded. The posterior margin is narrowly rounded. The greatest height is anterior to the middle and exceeds half the length. The surfaces of the valves are covered by numerous papillae. Normal pore canals are numerous and tubelike and extend through the papillae.

In dorsal view the carapace is ovate. The greatest breadth is at the middle and exceeds half the length. The anterior end is more narrowly rounded than the bluntly rounded posterior end. The left valve overlaps the right valve.

The line of concrescence and the inner margin do not coincide, thereby forming a vestibule. The duplicature is widest anteriorly. Radial pore canals are simple, short, numerous, and closely spaced. The marginal flange of the left valve is directed inward. The hingement of the left valve consists of a knifelike bar formed by the hinge flange. The interior surface is pitted; the pits reflect the papillae of the outer surface. The muscle scars could not be determined from the specimens examined.

Males have been recorded for this species, but they cannot be distinguished in fossil specimens.

Measurements.—Adult left valve; length 0.91 mm, width 0.48 mm, breadth of whole specimen 0.65 mm.

Remarks.—The description and plate diagram of Sars (1926, p. 6, Pl. 3) show that *Cypricercus horridus* is a synonym of *C. tuberculatus.* Sharpe (1903) regarded *Spirocypris* as very close to *Cypricercus,* differing only in shell shape and size of the furca, which are specific differences. Sharpe (1918) reported the species from springs and shallow weedy and swampy ponds.

Repository.—Specimens studied are reposited under catalogue no. 613571.

Genus EUCYPRIS Vávra, 1891

Cypris MULLER (part), 1776, Zoologiae Danicae Prodromus, Havniae; BRADY and NORMAN, 1889, Roy. Dublin Soc., Sci. Trans., ser. 2, v. 4, p. 73, 85; TURNER, 1895, Rept. Geol. Nat. Hist. Survey Minnesota, ser. 2, Zool., p. 319; SHARPE, 1898, Bull. Illinois State Lab. Nat. Hist., v. 4, p. 438.

Cypris (Eucypris) VAVRA, 1891, Arch. Landesdf. Böhmen, v. 8, pt. 3, p. 82, 84, 90; ALM, 1915, Zool. Bidrag Uppsala, v. 4, p. 46; FURTOS, 1933, Ohio Biol. Survey, v. 5 (Bull. 29), p. 450; DOBBIN, 1941, Univ. Washington Publ. in Biology, v. 4, no. 3, p. 189-194.

Eucypris MULLER, 1912, Das Tierreich, v. 31, p. 168; SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 113; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 102-106; MARTIN, 1940, Senckenbergiana, v. 22, no. 5-6, p. 356; LUTTIG, 1955, Palaeont. Zeitschr., v. 22, no. 5-6, p. 160.

Type species.—Monoculus virens JURINE, 1820.

Diagnosis.—This genus is differentiated from the other members of the subfamily Cypridinae by having a strongly arched dorsal margin and by having a sinuation on the central ventral margin. The ventral margin is slightly convex anteriorly. Only in rare individuals is the breadth more than half the length. *Upper Cretaceous to Recent.*

Description.—The carapace is subtriangular in lateral view. The dorsal margin is arched. The posterodorsal and anterodorsal margins form an obtuse angle in the central dorsal region. The ventral margin has a central ventral sinuation and exhibits a small convexity in the anteroventral region. The anterior margin is broadly rounded. The posterior margin is broadly rounded and forms a minor obtuse angle at its junction with the posterodorsal margin. The greatest height is more than half the length. The surface of the valves may be smooth or punctate. Normal pore canals are numerous and simple.

In dorsal view the carapace is ovoid. The greatest breadth equals approximately half the length, and is located posterior to the middle. The anterior end is parabolic. The posterior end is narrowly rounded. The left valve overreaches the right.

In the interior, the line of concrescence and inner margin coincide at the ventral incurvature of the valves. The duplicature is widest anteriorly; the vestibule is very shallow. The hingement is formed by a hinge flange of the left valve and the flange groove of the right valve. The muscle scars are elongate oval and consist of four large scars and one or two smaller scars in a subparallel position.

Remarks.—The generic differences in the subfamily Cypridinae have been determined by zoologists on the basis of such internal features as the length of the furcal ramus with respect to its width, features not preserved in fossil carapaces. *Eucypris* has also been distinguished from *Cypricercus* because *Eucypris* reproduces by parthenogensis and males are absent, whereas *Cypricercus* usually has males. The slightly arched dorsal margin of the carapace of *Cypricercus* and the more tumid dorsal outline usually differentiate it from *Eucypris*. The muscle-scar pattern of *Cypricercus* differs slightly from that of *Eucypris*. *Cyprinotus* differs from *Eucypris* by having tubercles on the margins of the valves.

EUCYPRIS MEADENSIS Gutentag and Benson, n. sp.

Fig. 5. Pl. 2, fig. 8-9.

Diagnosis.—The carapace of this species is more compressed and shorter than those of the other, previously described species of *Eucypris*. The obtuse angle at the junction of the anterodorsal and posterodorsal margins is sharper than in the other species.

Description.—Outline of the carapace is subtriangular when seen from lateral view. The dorsal margin is arched in the central dorsal region. The posterodorsal and anterodorsal margins form an obtuse angle in the central dorsal region. The ventral margin has a prominent sinuation in the central ventral region. The ventral margin is slightly convex anterior from the central ventral sinuation. The anterior margin is broadly rounded. The posterior margin is narrowly rounded and forms a small obtuse angle at its junction with the posterodorsal margin. The greatest height is measured from the central dorsal obtuse angle to the ventral margin and is more than half the length. The surface of the carapace is punctate. Normal pore canals are numerous and simple.

In dorsal view, the carapace is elliptical. The greatest breadth is less than half the length, and is located posterior to the middle. The left valve overreaches the right.

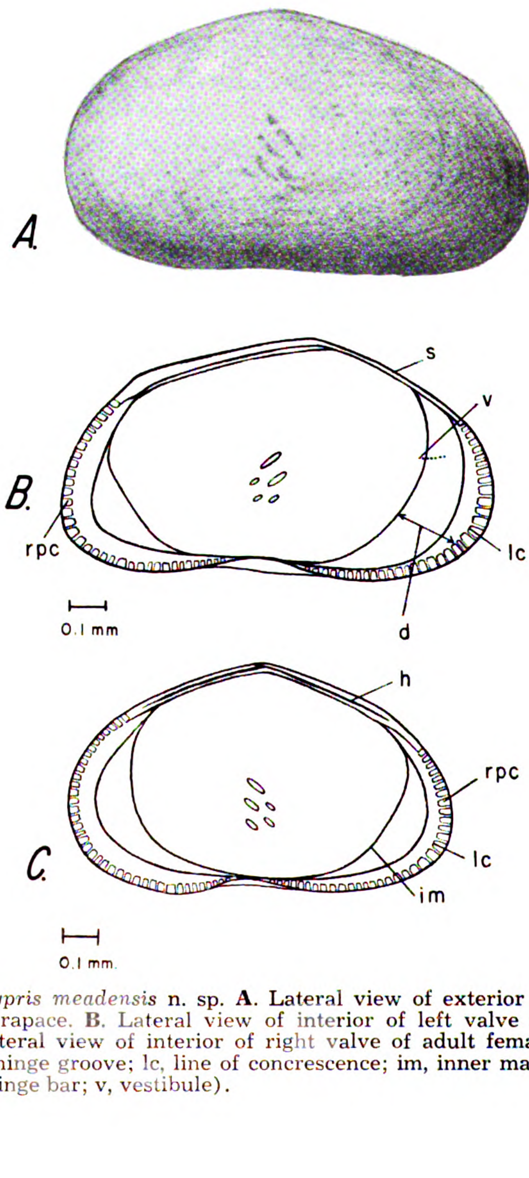

FIG. 5.—*Eucypris meadensis* n. sp. **A**. Lateral view of exterior of left valve of adult female carapace. **B**. Lateral view of interior of left valve of adult female carapace. **C**. Lateral view of interior of right valve of adult female carapace (d, duplicature; h, hinge groove; lc, line of concrescence; im, inner margin; rpc, radial pore canals; s, hinge bar; v, vestibule).

The line of concrescence and the inner margin coincide only at the central ventral incurvature of the valves. The duplicature is widest anteriorly, and present in the posterior; a very narrow vestibule is present. Radial pore canals are moderately long, numerous, and closely spaced. The hingement of the left valve is formed by a knifelike extension of the hinge flange. The posterodorsal hinge flange is directed toward the interior. The hingement of the right valve consists of a groove formed by the hinge flange and the selvage. The flange on the free margin of the left valve is projected inward. A prominent flange groove separates the flange from the slightly raised selvage. The selvage of the right valve is directed upward to fit into the flange groove of the left valve. The muscle scars consist of a subparallel group of five elongate scars whose axes make an angle of about 45° with a tangent to the ventral margin.

Measurements.—Holotype: female left valve; length 1.2 mm, height 0.68 mm. Paratype: female right valve; length 1.2 mm, height 0.68 mm, breadth of complete paratype 0.57 mm.

Remarks.—This species reproduces only by parthenogenesis. Immature specimens of *Eucypris meadensis* are more elongate posteriorly in lateral outline than the adults. *E. meadensis* is found living in an artesian-spring-fed stream in Meade County State Park. Inasmuch as adults were found in the winter as well as the late spring, probably more than one generation is produced each year. The species is associated with *Ilyocypris bradyi* Sars.

Repository.—Specimens studied are reposited under catalogue no. 616571.

Subfamily CYPRIDOPSINAE Kaufmann, 1900

Genus CYPRIDOPSIS Brady, 1868

Cypridopsis Brady, 1868, Intellectual Observer, v. 12, p. 117; Furtos, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 429-430; Dobbin, 1941, Univ. Washington Publ. in Biology, v. 4, p. 230; Swain, 1955, Jour. Paleontology, v. 29, p. 606; Wagner, 1957, The Hague, p. 25.

Pionocypris Brady and Norman, 1896, Roy. Dublin Soc., Sci. Trans., ser. 2, v. 5, p. 725.

Proteocypris Brady, 1906, Nat. Hist. Soc. Northumberland, Trans. ser. 2, v. 1, p. 335.

Pionocypris Sars, 1925, An account of the Crustacea of Norway, v. 9, p. 135.

Type species.—Cypris vidua (O. F. Muller), 1776.

Diagnosis.—The small size of carapace, distinctive subtriangular shape, and strongly tumid dorsal aspect differentiate *Cypridopsis* from other members of the subfamily Cypridopsinae. *Perm? Upper Cretaceous to Recent.*

Description.—The carapace is subovoid to subtriangular in lateral view. The dorsal margin is arched. The anterodorsal and posterodorsal margins form a sharp obtuse angle in the central dorsal region. The ventral margin of the right valve is sinuate in the central ventral region. The ventral margin of the left valve is slightly sinuate in some specimens and nearly straight in others. The anterior and posterior margins are broadly rounded. The greatest height, which is near midlength, is much more than half the length. The surfaces of the valves may be smooth or pitted. Normal pore canals are numerous and extend through pits.

In dorsal aspect the carapace is ovate and tumid. The anterior end is pointed; the posterior end is rounded. The breadth is more than half the length. Either valve may be the overreaching valve.

A duplicature with a vestibule is present in the anterior, posterior, and ventral marginal areas. Radial pore canals are not conspicuous. The hinge consists of a bladelike extension of the selvage on the overreaching valve and a flange groove on the overreached valve. The muscle scar pattern consists of a subcentral group of four large scars and two faint smaller scars. The smaller scars are anterior to the subcentral group.

Remarks.—Some workers have assigned species that have the left valve overreaching the right to *Pionocypris* and have restricted *Cypridopsis* to those species in which the right valve overreaches the left. The reversal of valve overreach or overlap has been described in other genera, i.e., ? *Cytheridea* (Alexander, 1933) and is not believed to be of taxonomic importance on the generic level.

CYPRIDOPSIS VIDUA (O. F. Müller), 1776

Fig. 6. Pl. 1, fig. 10.

Cypris vidua O. F. MULLER, 1776, Zool. Danicae Prodromus, Havniae, p. 199; HERRICK, Ann. Rep. Geol. Nat. Hist. Survey Minnesota, v. 7, p. 112, pl. 18, fig. 1.

Cypridopsis vidua (Müller), BRADY, 1868, Intellectual Observer, v. 12, p. 117; TURNER, 1892, Bull. Sci. Lab. Denison Univ., v. 6, p. 73; ———, 1895, Second Rept. Geol. Nat. Hist. Survey Minnesota, p. 312-314, pl. 72, fig. 1-19; pl. 75, fig. 5, 6, 8, 9; pl. 76, fig. 4, 7; SHARPE, 1918, *in* Ward and Whipple, Fresh-water Biology, p. 807, fig. 1235; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 132, fig. 438-441; HOFF, 1942, Illinois Biol. Mono., v. 19, no. 1-2, p. 151-153, pl. 8, fig. 115-117; BRONSTEIN, 1947, Inst. Zool. Acad. Sci. de l'URSS, new ser., no. 31, v. 2, no. 1, p. 160, pl. 9, fig. 8, 10, text fig. 80, 1-3; KESLING, 1951, Illinois Biol. Mono., v. 21, p. 2-116, pl. 1-96, text fig. 1-34; SWAIN, 1955, Jour. Paleontology, v. 29, p. 606, pl. 60, fig. 6a-c; WAGNER, 1957, The Hague, p. 26.

Pionocypris vidua (Müller), SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 135, pl. 63.

Cypridopsis vidua vidua FURTOS, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 430-431, pl. 6, fig. 1-4.

Cypridopsis vidua obesa FURTOS, 1933, (not BRADY and NORMAN, 1889), Ohio Biol. Survey, v. 5, (Bull. 29), p. 431.
Cypridopsis pustulosa FURTOS, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 431-432, pl. 6, fig. 5-9.

Diagnosis.—The small size, tumid dorsal appearance, obtuse-angled dorsal margin, and less sinuate ventral margin differentiate this species from the other species of *Cypridopsis*.

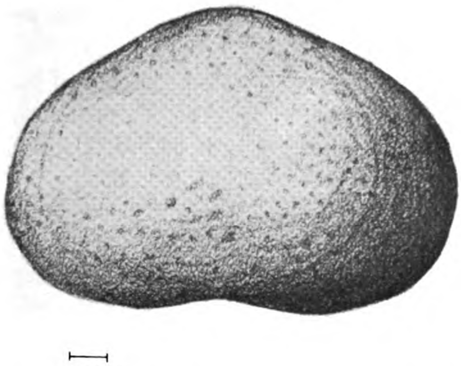

FIG. 6.—*Cypridopsis vidua* (O. F. Müller). Lateral view of exterior of right valve of adult carapace.

Description.—The carapace of the female is subtriangular in lateral view. The anterodorsal and posterodorsal margins form a sharp obtuse angle on the central dorsal margin. The ventral margin of the right valve is sinuate in the central ventral region. The ventral margin of the left valve is slightly sinuate in some specimens and is nearly straight in other specimens. The anterior margin is more broadly rounded than the posterior margin. The greatest height, which is near midlength, is more than half the length. The surfaces of the valves are pitted. Normal pore canals are numerous and extend through the pits.

In dorsal aspect the carapace is tumid. The anterior end is pointed, the posterior end is broadly rounded. The greatest breadth is in the middle and is much more than half the length. The left valve is slightly larger and overreaches the right valve.

The line of concrescence is slightly removed from the anterior, posterior, and ventral margins. The duplicature is prominent and is widest anteriorly; it is folded in the posteroventral corner in many specimens. Slight upward projection of the free margins of both valves produces left-over-right overlap in the central ventral sinuation. Radial pore canals are short, tubelike, and widely spaced. On most specimens the radial pore canals are inconspicuous. Minute tubercles are found on the anterior margin of the right valve. The hinge is formed by the bladelike extension of the selvage of the left valve into the flange groove of the right valve. At the highest point on the dorsum of the left valve the selvage has a few minute crenulate teeth. On the right valve the corresponding teeth are found outside the selvage, on the selvage groove. On the free margin of the right valve the selvage extends upward and forms a prominent flange groove with the inner margin. Muscle scars consist of a subcentral group of four large scars and two smaller, faint, slightly ventral adductor scars. Two large widely spaced scars are anteroventral to the groups.

Measurements.—Adult right valve; length 0.59-0.68 mm, height 0.38-0.44 mm. Adult left valve; length 0.61-0.72 mm, height 0.39-0.49 mm. Adult complete carapace; length 0.63-0.76 mm, breadth 0.47-0.51 mm.

Remarks.—*Cypridopsis vidua* is a multiform species, and recognition of specific differences in the genus is difficult. Probably the differences in the valve surfaces and slight differences in shape can be attributed to variations within the species. *C. vidua* is well represented in the Pleistocene deposits of Meade County, Kansas. It is also found living in St. Jacobs Well in Clark County, Kansas, where it is associated with other shallow-water genera.

Repository.—Specimens studied are reposited under catalogue no. 716561.

Genus POTAMOCYPRIS Brady, 1870

Potamocypris Brady, 1870b, Nat. Hist. Soc. Northumberland and Durham (1869), Trans., v. 3, p. 365; Sharpe, 1898, Bull. Illinois State Lab. Nat. Hist., v. 4, p. 471; Dobbin, 1941, Univ. Washington Publ. in Biology, v. 4, p. 231; Swain, 1955, Jour. Paleontology, v. 29, p. 605.

Candonella Claus, (part) 1891, Arb. Zool. Inst. (Wien), v. 9, p. 231; Vavra, 1898, Ergebn. Hamburg Magalhaensischen Sammelreise, v. 2, p. 12.

Paracypridopsis Kaufmann, 1900, Zool. Anzeiger, v. 23, p. 131.

Cypridopsis (Potamocypris) Alm, 1916, Zool. Bidrag fr. Uppsala, v. 4, p. 83; Furtos, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 432.

Cypridopsella Sars, 1925, An account of the Crustacea of Norway, v. 9, p. 142.

Type species.—*Bairdia fulva* Brady, 1868.

Diagnosis.—The arched dorsum, compressed dorsal aspect, and the overreaching right valve differentiate this genus from the other members of the subfamily Cypridopsinae. *Upper Cretaceous to Recent.*

Description.—The carapace is subreniform in lateral view. The dorsal margin is broadly arched. The ventral margin is sinuate in the central ventral region. The anterior margin of the left valve is more broadly rounded than that of the right valve. The posteroventral corner of the left valve in most species is slightly projected posteriorly, where it forms an acute angle. The posterior margin of the right valve is extremely truncate. The greatest height is near midlength and is more than half the length. The surfaces of the valves are smooth in some species but in others may be densely pitted. Normal pore canals are scattered but are most numerous ventrally.

The carapace is elliptical from the dorsal aspect. The anterior end is pointed; the posterior end is rounded. The greatest breadth is much less than half the length. The right valve overreaches the left valve.

In most species the duplicature is widest in the posteroventral corner of the left valve where a prominent flange groove is present. The duplicature of the right valve in most species is welded on the ventral margin. On the rest of the free margin the line of concrescence is removed from the margin and coincides with the inner margin. Radial pore canals are short, tubelike, and closely spaced. The hingement of the right valve consists of a thin groove on the dorsal flange. The hingement of the left valve consists of a bladelike extension of the selvage, which fits into the groove of the right valve. The muscle scars consist of a subcentral group of six oval scars.

Males have been reported for many of the species. Males are more elongate and higher than females.

Remarks.—*Potamocypris* is difficult to identify because of the extreme differences between left and right valves. The genus is common in shallow lakes. The thin valves are usually broken by burial.

POTAMOCYPRIS SMARAGDINA (Vávra), 1891
Fig. 7. Pl. 1, fig. 4-5.

Cypridopsis smaragdina VAVRA, 1891, Arch. naturw. Landesdf. Böhmen, v. 8, pt. 3, p. 80-81, fig. 26; SHARPE, 1898, Bull. Illinois Lab. Nat. Hist., v. 4, p. 470-471, pl. 48, fig. 11-12.

Potamocypris smaragdina (Vávra), DADAY, 1900, Ostracoda Hungariae (Budapest), p. 193; SHARPE, 1903, Proc. U. S. Natl. Mus., v. 26, p. 992, pl. 65, fig. 5-7; ———, 1918, *in* Ward and Whipple, Fresh-water Biology, p. 808, fig. 1245 a-c; HOFF, 1942, Illinois Biol. Mono., v. 19, p. 154-157, pl. 8, fig. 118-124; SWAIN, 1955, Jour. Paleontology, v. 29, p. 605-606.

Potamocypris smaragdina (Vávra), var. *compressa*, FURTOS, 1933, Ohio Biol. Survey, v. 5, p. 435-437, pl. 6, fig. 10-14; DOBBIN, 1941, Univ. Washington Publ. in Biology, v. 4, p. 231-232, pl. 2, fig. 1-6.

Candonella smaragdina VAVRA, 1898, Ergebn. Hamburg Megalhaensischen Sammelreise, v. 2, p. 12.

Diagnosis.—The shape of *P. smaragdina* closely approximates that of *P. fulva,* the type species, but the two species can be distinguished by differences in the adductor muscle-scar pattern. The uppermost scar of *P. smaragdina* is elongate and complete, whereas that of *P. fulva* is divided and consists of two separate scars. Other species differences are not distinguishable from examination of the carapace alone.

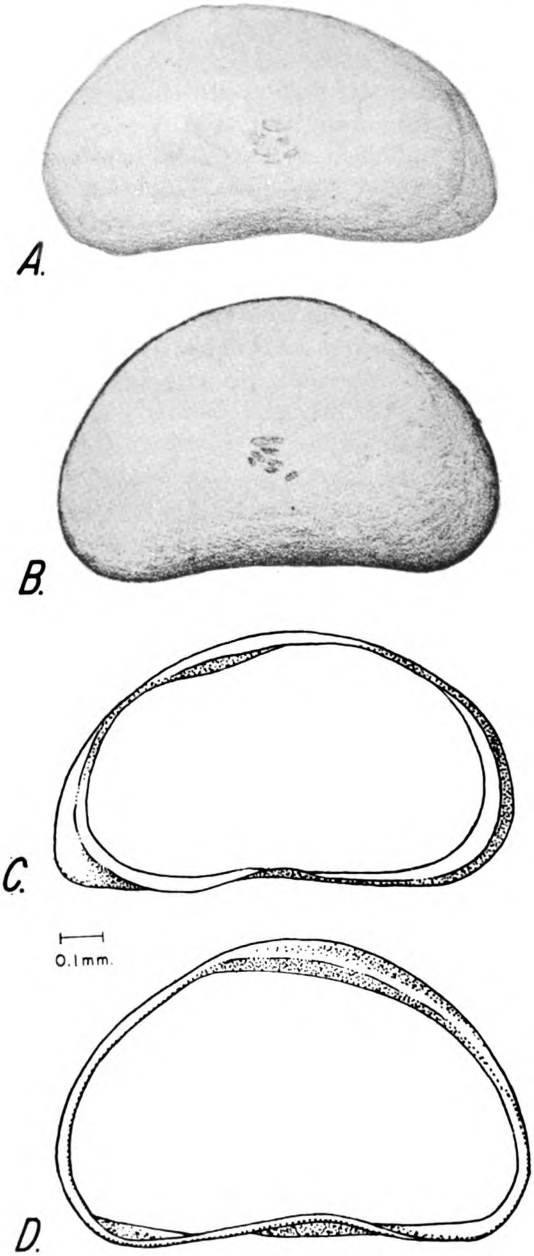

FIG. 7.—*Potamocypris smaragdina* (Vávra). **A**. Lateral view of exterior of left valve of adult carapace. **B**. Lateral view of exterior of right valve of adult carapace. **C**. Lateral view of interior of left valve of adult carapace. **D**. Lateral view of interior of right valve of adult carapace.

Description.—The adult carapace is elongate subtriangular in lateral view. The anterodorsal and central dorsal margins of the left valve form a rounded obtuse angle anterior to the middle. The dorsal margin of the right valve is broadly arched. The ventral margins of both valves are sinuate in the central ventral region. The anterior margin of the left valve is broadly rounded. The posterior margin of the left valve is extremely truncate and forms an acute angle in the posteroventral corner. The anterior margin of the right valve is more broadly rounded than the posterior margin. The greatest height on the left valve is anterior to the middle and is more than half the length. The greatest height on the right valve is located medially and is more than half to almost two-thirds the length. The valve surfaces are smooth but at high magnification appear slightly roughened. Normal pore canals are scattered over the surfaces of the valves, the greatest concentration being in the ventral half.

Only one complete specimen was available for study. The carapace is elliptical from the dorsal aspect. The posterior end is more bluntly pointed than the anterior end. The greatest width is less than half the length and is located medially. The right valve is larger and overreaches the left valve around the entire margin.

On the right valve the line of concrescence and the inner margin coincide along the free margin. The duplicature is narrow along the anterior margin and is broadest in the posteroventral corner of the left valve. The duplicature is welded along the ventral margin of the right valve but it is absent elsewhere. Radial pore canals are short, tubelike, and widely spaced. They are best observed in the posteroventral area of the left valve. The hinge of the left valve consists of a bladelike valve flange, which fits a groove in the right valve. The anterior and central dorsal valve flange of the right valve is folded toward the interior of the right valve. This is necessary because of the height difference of the valves. The selvage of the left valve along the free margin is projected upward. A prominent flange groove is present in the posteroventral corner of the left valve. The muscle-scar pattern consists of a subcentral group of six, four large scars and two smaller ventral scars.

Males have been reported but they are rare. Hoff (1942, p. 155) stated:

> "On the whole, the shell is much more elongate, the height little more than one-half the length; the peak of the dorsal margin more attenuated than in the female."

Measurements.—Adult female: left valve, length 0.69-0.74 mm, height 0.38-0.41 mm; right valve, length 0.67-0.72 mm, height 0.41-0.46 mm.

Remarks.—*Potamocypris smaragdina* is difficult to describe because of intraspecific variation in its size and shape. It is found in the Pleistocene deposits of Meade County. Hoff (p. 156) reports *P. smaragdina* as a common species of permanent waters.

Repository.—Specimens studied are reposited under catalogue no. 716561.

Family CANDONIDAE Kaufmann, 1900
Genus CANDONA Baird, 1846

Candona BAIRD, 1846a, p. 152; BRADY, 1868, Linnean Soc. London Trans., v. 26, p. 381; BRADY and NORMAN, 1889, Royal Dublin Soc., Sci. Trans., ser. 2, v. 4, p. 98; KAUFMANN, 1900, Revue Suisse Zool., v. 4, p. 379; MULLER, 1900, Zoologica, v. 30, p. 15; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 25-26; SWAIN, 1947, Jour. Paleontology, v. 21, p. 520-521; TRIEBEL, 1949, Senckenbergiana, v. 30, no. 4-6, p. 205-212; SWAIN, 1955, Jour. Paleontology, v. 29, p. 607-609; LUTTIG, 1955, Palaeont. Zeitschrift, v. 29, no. 3-4, p. 151; WAGNER, 1957, The Hague, p. 18.

Eucandona DADAY, 1900, Ostracoda Hungariae (Budapest), p. 242; SWAIN, 1961, Treatise on Invert. Paleontology, pt. Q, Arthropoda 3, p. Q 234-235.

Type species.—*Cypris candida* MULLER, O. F., 1776.

Diagnosis.—The reniform shape of the carapace and the muscle-scar pattern, a subcentral rosette of five scars and one dorsal elongate scar, are features that differentiate *Candona* from the other genera in the Family Candonidae. *Paleogene to Recent.*

Description.—In lateral view, the carapaces of both sexes are nearly reniform. The dorsal margin is approximately straight to broadly curved. The ventral margin is approximately straight to concave. The anterior margin is rounded; the posterior margin is rounded in the males, more truncate than the anterior margin in the female. The greatest height is in the middle or posterior to the middle. Surfaces of the valves are smooth or minutely punctate, and reticulate in some species. Normal pore canals are simple and scattered over the surfaces of the valves.

From the dorsal aspect the carapace is sub-elliptical. The anterior end is pointed, but the posterior end is rounded. The left valve overreaches the right valve.

The line of concrescence and the inner margin seem to coincide only at the central ventral incurvature of species that have sinuations. The duplicature is widest in the anterior end. Radial pore canals are numerous, simple, and closely spaced. A hinge flange on the selvage of the right valve fits into a groove on the selvage of the left valve. Muscle scar pattern consists of a subcentral rosette of five scars and one dorsal elongate scar.

Sexual dimorphism is pronounced in some species. The concave ventral margin of the male is distinctive, and in many species the anteroventral margin meets the ventral sinuation of a sharp acute angle. The males of many species are more inflated than the females.

Remarks.—Howe (1955) discussed the discovery of a paper by Baird (1846b) in which *Candona reptans* was designated as the type for *Candona. C. reptans* was designated by Brady and Norman in 1889 as the type species for *Erpetocypris,* and *C. candida* was designated as the type for *Candona*. Swain (1961) assigned all the forms that were previously placed in *Candona* to *Eucandona* and designated *C. balatonica* as the type species. According to the action taken by the International Commission of Zoological Nomenclature (1958, opinion 533), through application of its plenary powers, *Cypris candida* Müller was designated as the type species of *Candona; Eucandona* then became a junior subjective synonym.

Recent species inhabit fresh-water lakes and ponds and brackish bays. They are creepers and burrowers instead of swimmers. They are holarctic in distribution, and in this environment they are present in the largest number of species of any genus in the Cypridacea.

CANDONA CAUDATA Kaufmann, 1900
Fig. 8. Pl. 2, fig. 11.

Candona caudata KAUFMANN, 1900. Revue Suisse Zool., v. 8, p. 367-368, pl. 24, fig. 16-20; pl. 26, fig. 17-23; VAVRA, 1909, Die Süsswasser Fauna Deutsch., v. 2, p. 96, fig. 391-392; ALM, 1915, Zool. Bidrag. Uppsala, v. 4, p. 190; SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 76-77, pl. 35; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, p. 68, pl. 3, fig. 223-225; HOFF, 1942, Illinois Biol. Mono., v. 19, p. 80-82, pl. 3, fig. 33-35; SWAIN, 1955, Jour. Paleontology, v. 29, p. 608, pl. 29, fig. 5.

Candona elongata MULLER, 1912 (non HERRICK, 1879), Das Tierreich, v. 31, p. 140.

Diagnosis.—The posterior margin of the female left valve has a distinctive hook-shaped, acutely angled extension at the junction of the posterior and ventral margins. The right valve has a smaller extension in the posteroventral corner.

Description.—In lateral view, the carapace is elongate and reniform. The dorsal margins of both valves are arched, but the right valve has a small sinuation in the anterodorsal region. The ventral margin is sinuous in the central ventral region. The left valve is also slightly sinuous on the posteroventral margin. The anterior margins of both valves are bluntly rounded. The posterior margin of the right valve is sharply rounded and has a small extension in the posteroventral extremity. The posterior margin of the left valve has a sharply acute angled, hook-shaped posteroventral extension, which curves toward the right valve. The greatest height is posterior to the middle and is less than half the length. The surface of the valves is smooth and translucent; many specimens have been diagenetically bleached.

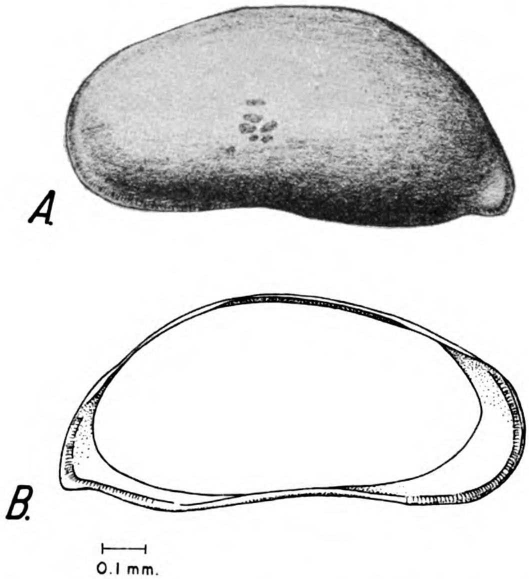

Fig. 8.—*Candona caudata* Kaufmann. **A**. Lateral view of exterior of left valve of adult female carapace. **B**. Lateral view of interior of left valve of adult female carapace.

Only separated valves were available for study, but the relative shape of the valves clearly shows that the left overreaches the right.

In the interior view, the line of concrescence and the inner margin are widely separated except at the central ventral infolding and the dorsal margin. The duplicature is widest anteriorly and in the postero-ventral areas. Radial pore canals are numerous, short, and closely spaced. The hinge consists of a groove on the dorsum of the left valve, which accommodates the bladelike edge of the right valve. The muscle scars are similar to those described for the genus.

Measurements.—Female left valve; length 1.17 mm, height 0.57 mm. Female right valve; length 1.12 mm, height 0.54 mm.

Remarks.—*Candona caudata* Kaufmann is distinguished from *C. crogmaniana* Turner by the hook-shaped extension on the left valve. *C. crogmaniana* is also larger and more truncate posteriorly than *C. caudata*.

Repository.—Material studied is reposited under catalogue no. 927567.

Candona crogmaniana Turner, 1894

Fig. 9. Pl. 2, fig. 10.

Candona crogmaniana Turner, 1894, Bull. Sci. Lab. Denison Univ., v. 8, p. 20-21, pl. 8, fig. 24-33; Furtos, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 476, pl. 8, fig. 1-3; pl. 9, fig. 17-18; pl. 12, fig. 9-10; Hoff, 1942, Illinois Biol. Mono., v. 19, p. 79-80, pl. 3, fig. 31-32.

Candona crogmani Turner, 1895, Rept. Geol. Nat. Hist. Survey Minnesota, ser. 2, Zool., p. 300-301, pl. 71, fig. 24-33, pl. 81, fig. 405; Sharpe, 1918, *in* Ward and Whipple, Freshwater Biology, p. 824, fig. 1295a-c.

Diagnosis.—The subtriangular carapace, the strongly arched dorsal margin, and the truncate posterior end distinguish this species from the other members of the genus.

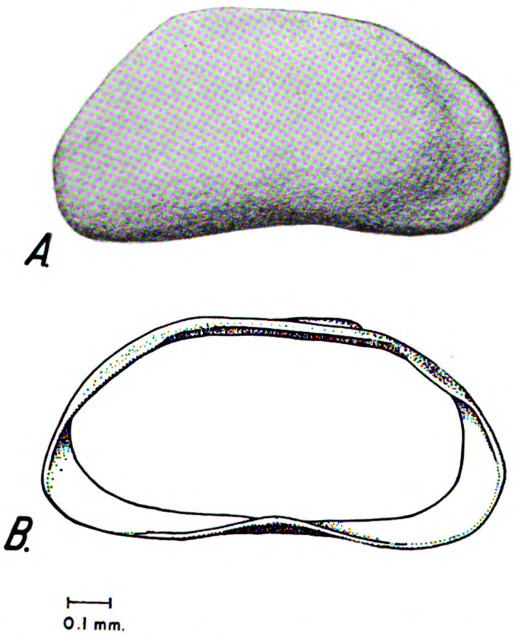

Fig. 9.—*Candona crogmaniana* Turner. **A.** Lateral view of exterior of right valve of adult female carapace. **B.** Lateral view of interior of left valve of adult female carapace.

Description.—In lateral view, the carapace is elongate and subtriangular. The dorsal margin is strongly arched posteriorly. The right valve has a small sinuation in the anterodorsal region. The central dorsal margin is straight; the ventral margin is concave. The anterior margin is narrowly rounded. The posterior margin is truncate forming an acute angle of about 53° with the venter. The greatest height, in the posterior end, is almost half the length. The surface of the valves is smooth. Normal pore canals are simple and scattered at random over the surface.

Only a few right valves of the female were available for study. The dorsal view (Furtos, 1933, p. 476) is as follows:

"Compressed, elliptical, over two and one-half times longer than broad; extremities pointed, the posterior the narrower; left valve longer than the right, projecting considerably beyond it at the posterior extremity."

In interior view, the line of concrescence is slightly removed from the ventral, posteroventral, and anterior margins. The duplicature is widest in the anterior end. The radial pore canals are short, closely spaced, and very numerous. The hinge consists of a groove on the dorsum of the left valve that accommodates a bar on the dorsum of the right valve. The muscle scars are similar to those described for the genus.

Measurements.—Female right valve; length 1.18 mm, height 0.65 mm.

Remarks.—The female of *Candona crogmaniana* Turner is similar to that of *C. caudata* Kaufmann but the former has a higher arch and a less pronounced posteroventral angle. The earliest occurrence of *C. crogmaniana* is from the Laverne Formation (Lower Pliocene). It is comparatively rare but its distinctive features make it readily identifiable when present.

Repository.—Specimens studied are reposited under catalogue no. 717562.

Candona fluviatilis Hoff, 1942

Pl. 1, fig. 13

Candona fluviatilis Hoff, 1942, Illinois Biol. Mono., v. 19, p. 60-62, pl. 1, fig. 7-9; pl. 2, fig. 10-11.

Diagnosis.—The reticulate surface and trapezoidal lateral outline distinguish this species from the other members of the genus.

Description.—The carapace of the female is trapezoidal in lateral view. The anterodorsal margin is slightly sinuous. The anterodorsal and central dorsal margins form a distinct obtuse angle. The central dorsal margin is nearly straight, only faintly concave. The central dorsal margin and the posterodorsal margin form a broadly rounded obtuse angle. The posterodorsal margin is broadly convex. The central ventral margin is sinuate, the greatest concavity being slightly anterior to the middle. The anterior margin is broadly rounded. The posterior margin is truncate and forms a narrowly rounded posteroventral corner. The greatest height is posterior to the middle and is slightly more than half the length. The surface of the valve is sub-reticulate. The reticulae are composed of interconnected ridges that surround small polygonal depressions. Normal pore canals are not visible.

Only a female left valve was available for identification; therefore, a description of the dorsal view is omitted. The structure of the hinge indicates that the left valve overreaches the right valve.

Inspection of the interior of the left valve discloses a fused duplicature widest at the anterior and present in the posterior. Radial pore canals are short, simple, and closely spaced. The hinge of the left valve consists of a groove in the dorsum formed by the hinge flange and a bladelike extension of the selvage. Muscle scars are the same as those described for the genus.

Measurements.—Adult female; length 0.88 mm, height 0.45 mm.

Remarks.—*Candona fluviatilis* Hoff is distinguished from *C. punctata* Furtos by its straight dorsal margin, reticulate surface, and smaller height. Hoff (1942, p. 62) collected this species from clear, shallow vernal streams flowing over muddy bottoms.

Repository.—Specimen studied is reposited under catalogue no. 927567.

CANDONA NYENSIS Gutentag and Benson, n. sp.

Fig. 10. Pl. 2, fig. 1-3.

Candona sp. aff. *Cypris pubera* O. F. Müller, SWAIN, 1947, Jour. Paleontology, v. 21, pl. 76, fig. 14-16.

Diagnosis.—The extremely truncate posterior margin of the female left valve and the obtuse anteroventral angle of the male carapace distinguish this species.

Description.—The female in lateral view is subreniform. The dorsal margin of the left valve is arched and there is a small sinuation in the posterodorsal region. The ventral margin is concave. The anterior margin is narrowly rounded. On the right valve, the posterior margin is bluntly rounded where the posterior and ventral margins form an obtuse angle. On the left valve, the posterior margin is extremely truncate. Above midheight, dorsal margin forms an obtuse angle with the posterior margin (posterior cardinal angle). The posterior margin is almost vertical as it slopes away from the posterodorsal angle, and it forms an obtuse angle with the ventral margin (posteroventral angle). The greatest height is posterior to the middle of the valve and is more than half the length. The surface of the valves is smooth and the shell material of many specimens is translucent. Many simple normal pore canals are scattered throughout, the greatest concentration being in the ventral region.

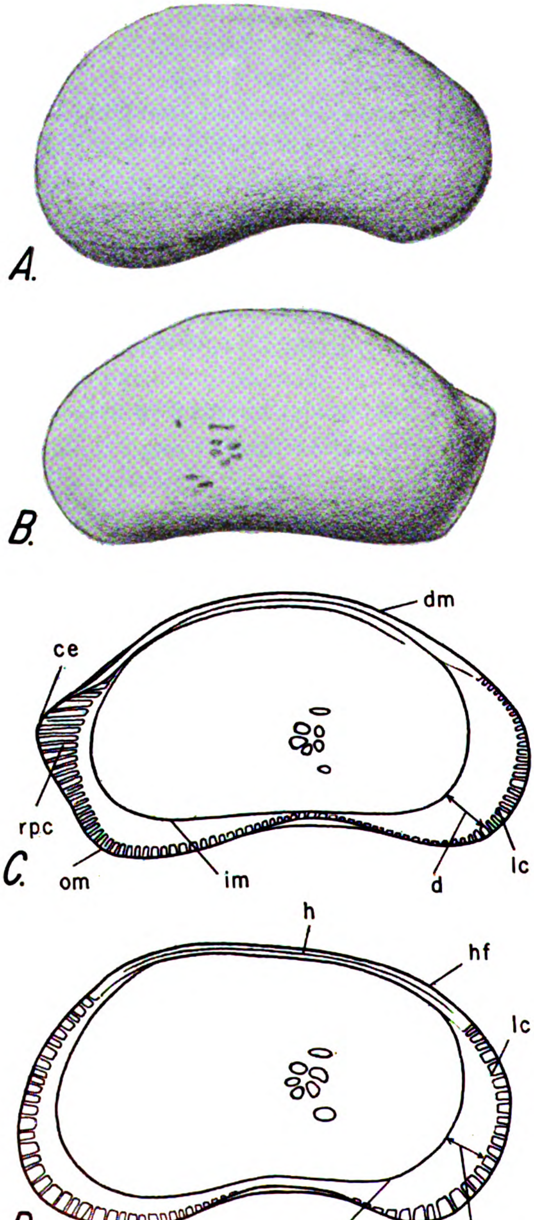

FIG. 10.—*Candona nyensis* n. sp. **A**. Lateral view of exterior of right valve of adult male carapace. **B**. Lateral view of exterior of left valve of adult female carapace. **C**. Lateral view of interior of left valve of adult female carapace. **D**. Lateral view of interior of left valve of adult male carapace (ce, caudal extension; d, duplicature; dm, dorsal margin; h, hinge groove; hf, hinge flange; im, inner margin; lc, line of concrescence; om, outer margin; rpc, radial pore canals).

In dorsal view, the female carapace is elliptical in outline. The anterior end is pointed, the posterior end is truncate, and the posterior margin of the left valve does not touch the right valve at the posteroventral angle. The left valve overreaches the right.

In the interior view, the line of concrescence is submarginal except at the incurvature on the ventral margin, where it is missing. The duplicature is widest anteriorly. Radial pore canals are simple, numerous, and closely spaced; they are not present at the infolding of the valves in the central ventral region. The hingement consists of a thin flange and grooved selvage on the left valve and a flange and thin selvage on the right valve. The muscle scars consist of a group of five scars as described for the genus.

Sexual dimorphism is pronounced in this species. The carapace of the male in lateral view is arched and larger than the female. The dorsal margin is strongly arched at the posterior termination of the hinge. The anterior is rounded; the posterior end is broadly rounded. The ventral margin is strongly sinuate, the greatest concavity being in the anterior end. The anteroventral angle is obtuse and is formed by the ventral sinuation and the anteroventral margin.

Measurements.—Holotype, female left valve; length 1.28 mm, height 0.74 mm. Paratype, female right valve; length 1.18 mm, height 0.65 mm. Allotype, male left valve; length 1.3 mm, height 0.80 mm. Allotype, male right valve; length 1.05 mm, height 0.85 mm.

Remarks.—This species was illustrated by Swain (1947, pl. 76, fig. 14-16 as *Candona* sp. aff. *Cypris pubera* O. F. Müller. Swain found *Candona nyensis* in the Recent deposits of Lake St. John, Colorado. *C. nyensis* was described by Staplin (1953, p. 162-166) as "*Candona swaini.*" This species seems to be a dominantly Pleistocene form, possible relics still living in cold-water stable habitats.

Repository.—Specimens studied are reposited under catalogue no. 716561.

CANDONA RENOENSIS Gutentag and Benson, n. sp.

Fig. 11. Pl. 1, fig. 12.

Diagnosis.—The subtrapezoidal lateral margin and the compressed female carapace clearly distinguish this species from those previously described. The male carapace has a distinctive pointed anterior end and is more strongly inflated than the female.

Description.—The carapace of the female is subtrapezoidal and reniform in lateral view. A slight sinuation is present on the anterodorsal margin. The central dorsal margin is nearly straight. A broadly rounded obtuse angle is formed by the central dorsal and posterodorsal margins. The ventral margin is slightly sinuous in the central ventral

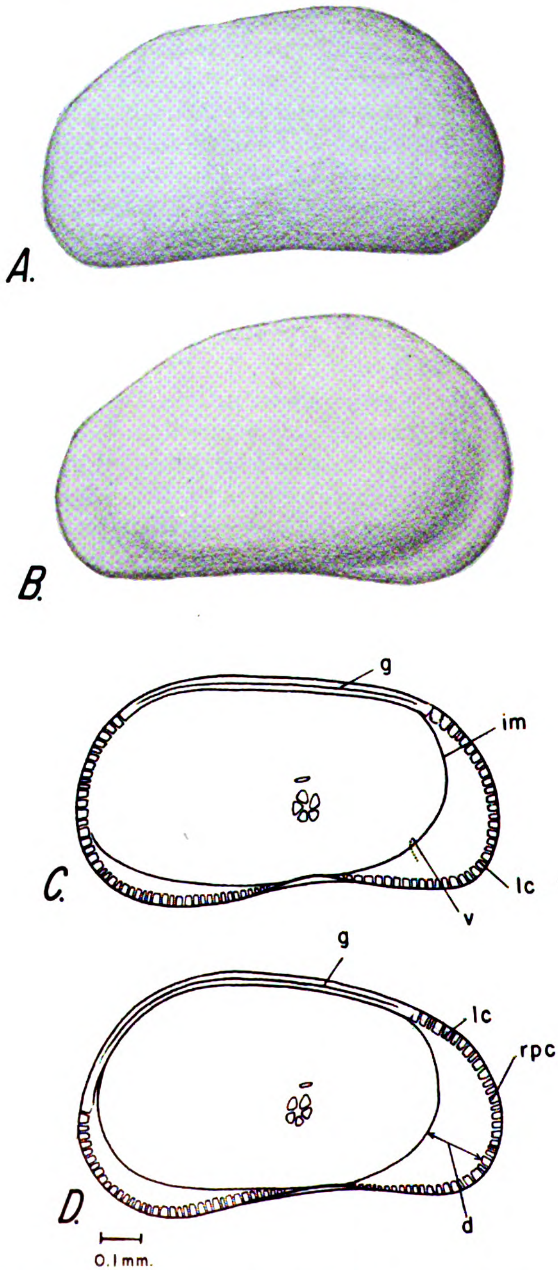

FIG. 11.—*Candona renoensis* n. sp. **A.** Lateral view of exterior of left valve of adult female carapace. **B.** Lateral view of exterior of left valve of adult male carapace. **C.** Lateral view of interior of left valve of adult female carapace. **D.** Lateral view of interior of left valve of adult male carapace (d, duplicature; g, hinge groove; lc, line of concrescence; im, inner margin; rpc, radial pore canals; v, vestibule).

area. The anterior margin is broadly rounded. The posterior margin is truncate. The posteroventral corner is a rounded obtuse angle. The greatest height is posterior to the middle and is slightly more than half the length. The surfaces of the valves are smooth, and the valves are translucent. Normal pore canals are simple and scattered over the surface, the greatest concentration being in the ventral area.

In dorsal view, the carapace of the female is narrow and elliptical. The anterior end is narrowly rounded. The posterior end is bluntly rounded. The left valve overreaches the right valve slightly, completely around the margin.

The marginal area is simple, composed of a wide anterior and narrower posteroventral duplicature forming a vestibule. The duplicature is absent or almost so from the posterior margin. Radial pore canals are numerous, short, and simple. The hingement consists of a hinge flange on the right valve that fits into the groove on the left valve. The groove on the left valve is formed by the hinge flange and a bladelike extension of the selvage. The muscle scar pattern is like that typical of the genus.

Sexual dimorphism is pronounced. The carapace of the male is more arched than the female; in dorsal view the anterior end is narrow and sharp because of the severe flattening of the anterior margin. The posterior end is broadly rounded. The breadth of the male is much greater than that of the female, which gives the male an inflated ovate shape. The marginal features of the male are the same as those of the female.

Measurements.—Holotype: left valve of female; length 0.99 mm, height 0.53 mm. Paratype: right valve of female; length 0.94 mm, height 0.51 mm. Breadth of female paratype 0.35 mm. Allotype: left valve of male; length 1.01 mm, height 0.61 mm; breadth of allotype 0.45 mm.

Remarks.—*Candona renoensis* differs from *Candona compressa* Koch by the more compressed breadth of the female. It differs from *Candona albicans* Brady by having a more rounded posterodorsal margin. The male of *C. renoensis* has a narrowly rounded anterior, which swells into an inflated carapace and it is therefore distinctive.

Repository.—Specimens studied are reposited under catalogue no. 613571.

Family ILYOCYPRIDIDAE Kaufmann, 1900

Subfamily ILYOCYPRIDINAE Kaufmann, 1900

Genus ILYOCYPRIS Brady and Norman, 1889

Ilyocypris BRADY and NORMAN, 1889, Roy. Dublin Soc., Sci. Trans. ser. 2, v. 4, p. 106; FURTOS, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 426; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 90; HOFF, 1942, Illinois Biol. Mono., v. 19,

p. 127-128; Triebel, 1941, Senckenbergiana, v. 23, no. 4-6, p. 298; Luttig, 1955, Palaeont. Zeitschr., v. 29, no. 3/4, p. 161.

Iliocyprella Daday, 1900, Ostracoda Hungariae, p. 237.

Type species.—Cypris gibba Ramdohr, 1808.

Diagnosis.—The carapace is nearly oblong but has a straight dorsal margin. One or two dorsal lateral sulci are present. Lateral protrusions occur in many species. *Triassic to Recent.*

Description.—The carapace is nearly oblong in the laterial view. The dorsal margin is almost straight. The ventral margin is sinuate in the central ventral region. The anterior margin is more broadly rounded than the posterior, and the anterior sulcus is larger than the posterior. The greatest height is anterior to the center. The surface of the valves is reticulate. Pits, nodes, and spines may be present. In most species spines are present along the entire anterior, ventral, and posterior margins. Larger spines are present in the posterior region.

As seen from the dorsal view most species have two or three lateral protrusions. The anterior end is narrower than the posterior, and the left valve is slightly larger than the right.

The line of concrescence in most forms is removed from the ventral, posteroventral, and anterior margins. The duplicature is widest anteriorly and in the posteroventral area. Radial pore canals are simple and very numerous but may be obscured by the ornamentation. The hinge consists of a groove in the left valve into which fits the bladelike dorsal edge of the right valve. A rosette of four muscle scars is situated in a subcentral depression.

Ilyocypris bradyi Sars, 1890

Fig. 12. Pl. 1, fig. 8-9.

Ilyocypris bradyi Sars, 1890, Oversigt af Norges Crustaceer, v. 2, p. 59-60; Sharpe, 1908, Proc. U. S. Natl. Mus., v. 26, p. 411-412, pl. 56, fig. 3-6; ———, 1918, *in* Ward and Whipple, Fresh-water Biology, p. 810, fig. 1258 a-d; Klie, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 93, fig. 329-332; Hoff, 1942, Illinois Biol. Mono., v. 19, p. 130-131, pl. 8, fig. 101-102.

Ilyocypris bradii Furtos, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 428, pl. 1, fig. 8-10.

Diagnosis.—Lack of lateral protrusions and the presence of two distinct dorsolateral sulci on *Ilyocypris bradyi* distinguish it from other species of the genus.

Description.—Carapace in lateral view is subquadrate in outline. The dorsal margin is approximately straight. The anterior sulcus is larger than the posterior sulcus. A median lobe separates the sulci. The ventral margin is sinuate in the central ventral region. The anterior margin is broadly rounded; the posterior margin is narrower but more bluntly rounded. The greatest height is anterior to the center. The sur-

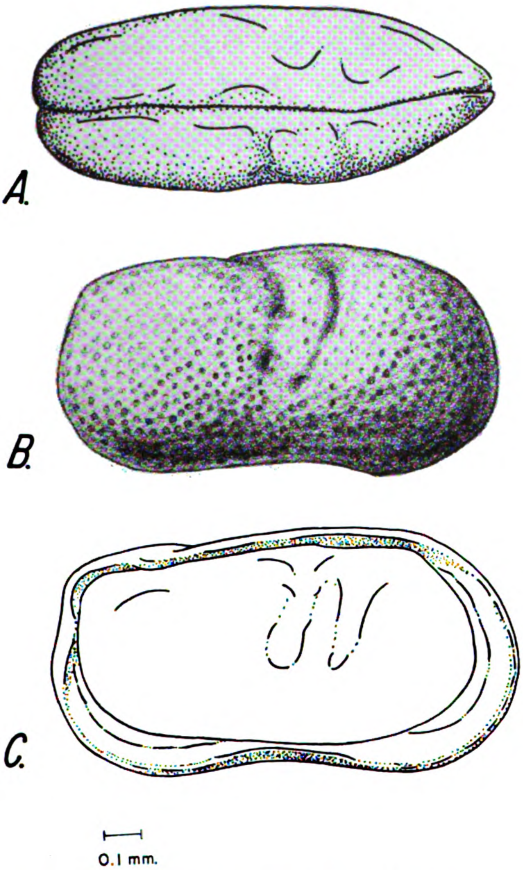

FIG. 12.—*Ilyocypris bradyi* Sars. **A**. Dorsal view of joined valves of adult carapace. **B**. Lateral view of exterior of right valve of adult carapace. **C**. Interior view of left valve of adult carapace.

face of the valves is reticulate; numerous spines project from anterior, posterior, and ventral margins. The spines along the posterior margin are larger than the others. In some specimens tubercles are present along all margins except the dorsal.

In dorsal view, the outline of the carapace is narrowly elliptical. The anterior end is pointed. The posterior end is narrowly rounded and slightly inflated. The dorsal surface is depressed at the point of contact of the valves between the median lobe and the posterior inflated area. The hinge flange of both valves projects slightly at the anterodorsal margin. The left valve overreaches the right.

The line of concrescence is removed from the ventral, postero-ventral, and anterior margins. The duplicature is widest anteriorly. Radial pore canals are simple and are not regularly spaced. On the left valve the hinge consists of a groove, which is best seen in the anterodorsal corner. On the right valve the hinge consists of a knife-like edge, which fits the groove on the left valve. The muscle-scar pattern consists of a group of four scars in a pit in the subcentral area.

Males are not known for this species.

Measurements.—Adult female: length 0.80-0.91 mm, height 0.42-0.47 mm, breadth 0.31-0.40 mm.

Remarks.—*Ilyocypris bradyi* lives in moving water where there is an abundance of algae and other vegetation. It was found living in association with *Eucypris meadensis* in the swift-flowing artesian-spring-fed stream in Meade County State Park, Kansas. *I. bradyi* does not compete with *E. meadensis,* as the former is a burrowing organism and the latter is a bottom crawler.

Repository.—Specimens studied are deposited under catalogue no. 927567.

ILYOCYPRIS GIBBA (Ramdohr), 1808

Fig. 13. Pl. 1, fig. 6-7.

Ilyocypris gibba (Ramdohr), BRADY and NORMAN, 1889, Roy. Dublin Soc., Sci. Trans., ser. 2, v. 4, p. 107, pl. 22, fig. 1-5; SHARPE, 1908, Proc. U. S. Natl. Mus., v. 35, p. 410-411, pl. 56, fig. 1-2. ———, 1918, *in* Ward and Whipple, Fresh-water Biology, p. 809, fig. 1257a,b; FURTOS, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 427, pl. 1, fig. 4-7; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 90, fig. 316; HOFF, 1942, Illinois Biol. Mono., v. 19, p. 128-130, pl. 7, fig. 99-100; BRONSTEIN, 1947, Inst. Zool. Acad. Sci. de l'URSS, new ser., no. 31, v. 2, no. 1, p. 88, pl. 1, fig. 5-6; LUTTIG, 1955, Palaeont. Zeitschr. v. 29, no. 3-4, p. 161, pl. 17, fig. 5-9.

Diagnosis.—The presence of two distinct dorsolateral sulci, three prominent lateral protrusions, and numerous nodes distinguish this species from the other members of the genus.

Description.—The adult female, in lateral view, is nearly oblong. The dorsal margin is nearly straight but is slightly arched over the sulci and it appears depressed posteriorly where the posterior lobe projects above the hinge line. The two sulci are broadest at the dorsal margin but they narrow considerably toward the venter and terminate in the dorsocentral area. The anterior sulcus is longer than the posterior sulcus. The ventral portion of the anterior sulcus is longer than the ventral portion of the posterior sulcus. The ventral margin is sinuate in the central ventral region. The anterior margin is more broadly rounded than the posterior margin. The greatest height is in the anterior and exceeds half the length. The surfaces of the valves are pitted. A median lobe separates the sulci and bears a small node. The anterior

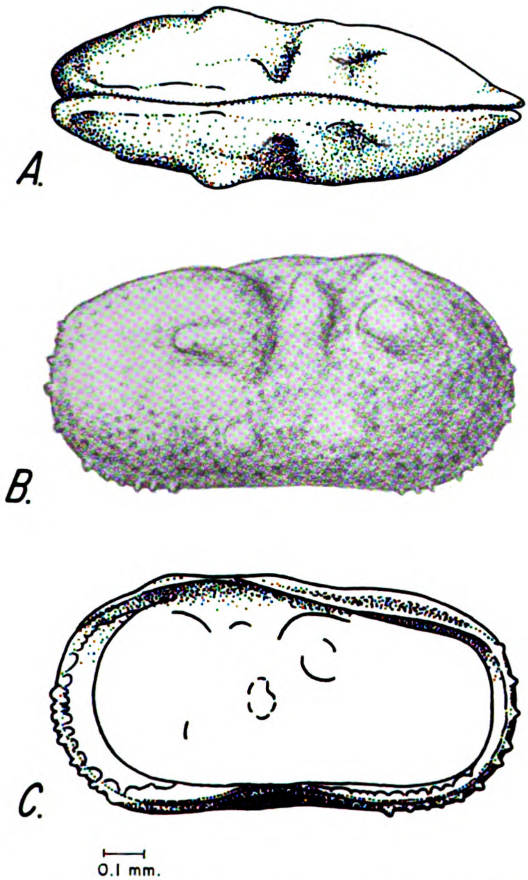

FIG. 13.—*Ilyocypris gibba* (Ramdohr). **A**. Dorsal view of joined valves of adult carapace. **B**. Lateral view of exterior of right valve of adult carapace. **C**. Lateral view of interior of right valve of adult carapace.

lobe bears a small node just anterior to the sulcus. A large node in the dorsocentral region is posterior to the termination of the posterior sulcus. Many small spines and tubercles are scattered along the submarginal and marginal areas. Normal pore canals are inconspicuous because of the ornamentation.

The carapace outline is elliptical in dorsal view. The anterior end is pointed. The posterior end is narrowly rounded. The contact margin appears depressed along the posterior half where the two posterior lobes bulge dorsally. The breadth is less than half the length. The left valve is larger and overreaches the right valve.

The duplicature is widest anteriorly and has a small groove along the anterior part and a slight fold near the inner margin. Radial pore canals are simple and numerous. On the left valve the hinge consists of a groove, which is more pronounced in the anterodorsal and posterodorsal corners. On the right valve the hinge consists of a simple bladelike edge, which fits the groove in the left valve. The muscle-scar pattern consists of four scars in a subcentral pit below the posterior sulcus.

Measurements.—Adult female; left valves, length 0.80-0.95 mm, height 0.44-0.52 mm; right valves, length 0.80-0.96 mm, height 0.43-0.53 mm. Breadth of complete carapace 0.35 mm, length 0.84 mm.

Remarks.—*Ilyocypris gibba* is very common in running water but is also found in ponds and lakes containing algae and other vegetation. Lüttig (1955) reports that *I. gibba* is found in the Recent of Europe, North Africa, and North America, and in the Quaternary of Great Britain. Klie (1938) states that *I. gibba* does not live in water colder than 50°F.

Repository.—Specimens studied are reposited under catalogue no. 61357.

Superfamily CYTHERACEA Baird, 1850
Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus CYPRIDEIS Jones, 1856

Cyprideis JONES, 1857, Palaeontographical Soc. London (1856), v. 4, p. 21; SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 154; BRONSTEIN, 1947, Inst. Zool. Sci. de l'URSS, new ser., no. 31, v. 2, no. 1, p. 295; GOERLICH, 1952, Senckenbergiana, v. 33, no. 1-3, p. 185-186; SWAIN, 1955, Jour. Paleontology, v. 29, p. 614.
Anomocytheridea STEPHENSON, 1938, Jour. Paleontology, v. 12, p. 141.
Type species.—*Candona torosa* JONES, 1850.

Diagnosis.—This genus differs from the other members of the subfamily Cytherideinae by its reniform to trapezoidal outline and by the occurrence of pits and occasional tubercles on the surface. Sexual dimorphism is pronounced in the genus. *Miocene to Recent.*

Description.—The female carapace, in the lateral view, is reniform to trapezoidal. The whole dorsal margin in some species is nearly straight or slightly convex, but it may slope toward the posterior. The ventral margin is slightly sinuate in most species but may be nearly straight in others. The anterior margin is broadly rounded. The posterior margin is truncate and in most species meets the venter in a rounded or sharp acute angle. The greatest height is anterior to the middle and is equal to or more than half the length. Normal pore canals are located in the pits. The surfaces of the valves are pitted; tubercles may be present on some species. Within some species, nodes are present or absent in the younger instars. Many species have a dorsal lateral depression.

The carapace in dorsal view is subelliptical. The anterior end is narrowly rounded, the posterior bluntly rounded. The left valve overreaches the right.

The line of concrescence coincides with the inner margin on the anterior and posterior margins. The duplicature is normally welded, but in some species a thin free duplicature is found inside the ventral margin. Numerous radial pore canals are present. They are tubelike and some may bifurcate near the outer margin. They form groups of two or three, and the groups are slightly separated from one another. The hinge of the right valve consists of an anterior crenulated tooth, a tooth socket, and a posterior tooth separated from the anterior tooth socket by a thin crenulated groove. The left valve is in antithesis to the right valve. The muscle scars consist of a row of four closely spaced adductor scars anterior to the middle but in the central area, and two widely spaced anterior scars.

Sexual dimorphism is pronounced; the posteroventer is generally extended in males. The males are larger than the females in all described species.

Remarks.—Goerlich (1952, p. 186) shows that the hinge structure of *Anomocytheridea* as described by Stephenson is the same as that of *Cyprideis;* therefore *Anomocytheridea* is a synonym of *Cyprideis. Cyprideis* has been reported from Miocene to Recent and it is euryhaline, occurring in marine, brackish, and fresh water.

CYPRIDEIS LITTORALIS Brady, 1870
Fig. 14. Pl. 2, fig. 4-7.

Cyprideis littoralis BRADY, 1870a, Nat. Hist. Soc. Northumberland and Durham, Trans., v. 3, p. 125; SARS, 1925, An account of the Crustacea of Norway, v. 9, p. 155, pl. 71, pl. 72, fig. 1; KLIE, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 156, fig. 516-517; BRONSTEIN, 1947, Inst. Zool. Acad. Sci. de l'URSS, new ser., no. 31, v. 2, no. 1, p. 296-297, pl. 14, fig. 6-7; SWAIN, 1955, Jour. Paleontology, v. 29, p. 615-616, pl. 59, fig. 11 a-c, text-fig. 38, 5 a, b.

Cytheridea torosa littoralis (Brady) MULLER, 1912, Das Tierreich, v. 31, Ostracoda, p. 326.

Cytheridea torosa var. *teres* BRADY and NORMAN, 1889, Royal Dublin Soc., Sci. Trans., v. 4, ser. 2, p. 175.

Diagnosis.—The extremely truncate posterior margin of the female, the muscle-scar pattern (a row of four small round adductor scars), and the dorsolateral sulcus distinguish this species from other members of the genus.

Description.—Female carapace is subovate in lateral view. The dorsal margin of the right valve is slightly more convex than that of the left valve. The anterodorsal margin is slightly sinuate. A slightly rounded obtuse angle is formed at the junction of the ventral and

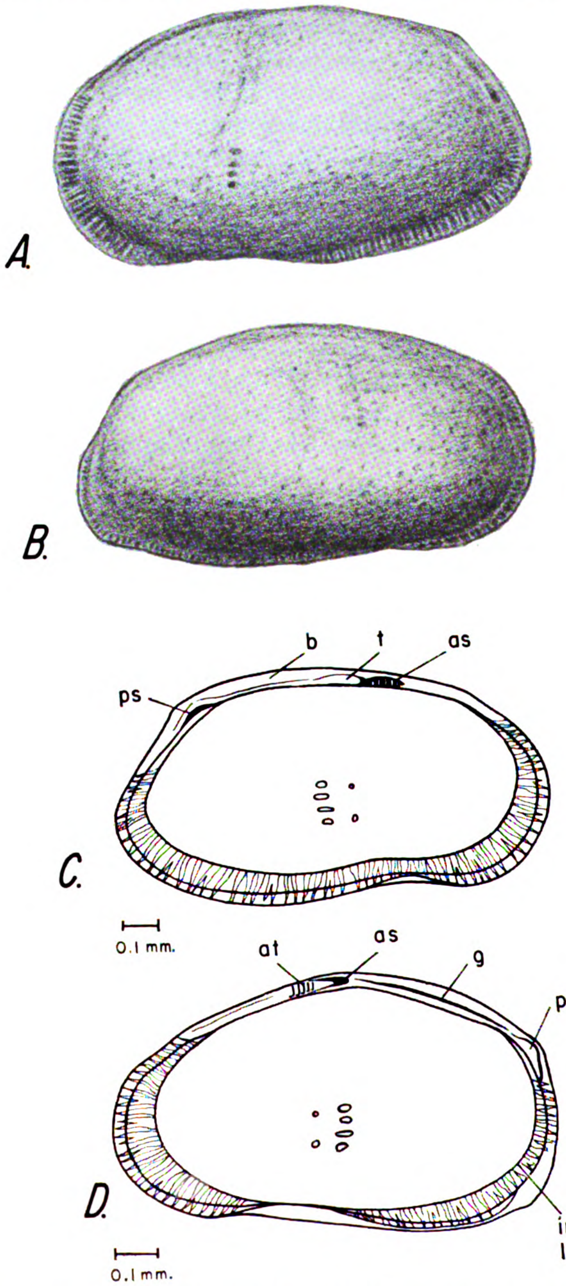

FIG. 14.—*Cyprideis littoralis* Brady. **A**. Lateral view of exterior of left valve of adult male carapace. **B**. Lateral view of exterior of right valve of adult male carapace. **C**. Lateral view of interior of left valve of adult male carapace. **D**. Lateral view of right valve of adult female carapace (as, anterior tooth socket; at, anterior tooth; b, bar; g, groove; im, inner margin; lc, line of concrescence; ps, posterior hinge socket; pt, posterior hinge tooth; t, anterior hinge tooth).

posterior margins. The anterior margin is broadly rounded. On the right valve a submarginal extension of the selvage is exposed along the anterior margin. The posterior margin is extremely truncate—almost vertical. The greatest height is located medially and is more than half the length. The surfaces of the valves are pitted. A shallow elongate dorsal sulcus is located anterior to the middle. Normal pore canals are numerous and extend from the interior through the pits.

In dorsal view the female carapace is subelliptical. The anterior is pointed; the posterior is bluntly rounded. The dorsal lateral sulci are slightly anterior to the middle. The hinge flange and the selvage flange project upward along the dorsal margin and have an exposed groove. The left valve is slightly larger and overreaches the right valve.

The line of concrescence coincides with the inner margin along the anterior and posterior margins of the valves. A narrow duplicature is present along the ventral margin posterior to the middle and extending to the posteroventral corner. Radial pore canals are numerous long tubes, which may show some bifurcation, and most are found in separate pairs. The hinge of the right valve consists of a raised crenulate dental element on the raised selvage extension anterior to the middle on the dorsal margin. An intermediate groove posterior to the raised crenulate anterior dental element is followed by a triangular tooth socket. Posterior to the tooth socket a crenulate groove is formed by the selvage and the valve edge. This thin groove extends from the tooth socket to the posterodorsal corner, where the valve edge is raised to form a crenulate posterior tooth. The hinge of the left valve is in antithesis to that of the right valve. The blade-like selvage of the free margin of the right valve fits the thin groove formed by the selvage and valve edge on the left valve. The muscle-scar pattern consists of a row of four small round adductor scars anterior to the middle but in the central region. Two widely spaced antennal and mandibular scars are located anterior to the row of adductor scars.

Sexual dimorphism is pronounced in this species. The carapace of the male is larger and more elongate than that of the female. The dorsal margin is evenly arched. The posterior margin is broadly rounded. The posteroventral acute angle is sharper than in the female. The features of the interior of the male valve are the same as those in the female.

Measurements.—Adult female: left and right valves; length 0.99-1.03 mm, height 0.63 mm, breadth 0.99-1.0 mm. Adult male: left valve; length 1.18-1.22 mm, height 0.67-0.69 mm; right valve; length 1.19-1.23 mm, height 0.65-0.67 mm.

Remarks.—*Cyprideis littoralis* is found in the Laverne Formation (Pliocene) and in fresh-water Pleistocene sink deposits in Meade County, Kansas. *C. littoralis* seems to be euryhaline. Swain (1955, p.

616) reports this species from the middle and lower parts of San Antonio Bay, Texas, and in nearshore or brackish waters in Europe, Asia, and northern Africa. The measurements of *C. littoralis* from the Pleistocene of Meade County compare closely to those given by Sars (1925, p. 155). On the Pleistocene specimens the dorsal margin seems slightly more arched than that on the European specimens.

Repository.—Specimens studied are reposited under catalogue no. 716561.

Family LIMNOCYTHERIDAE Klie, 1938
Genus LIMNOCYTHERE Brady, 1868

Limnocythere Brady, 1868, Intellectual Observer, v. 12, p. 121; Klie, 1938, Die Tierwelt Deutschlands, v. 34, pt. 3, p. 150; Luttig, 1955, Palaeont. Zeitschrift, v. 29, no. 3-4, p. 162; Swain, 1955, Jour. Paleontology, vol. 29, p. 612.

Limnicythere Brady, 1868, Linnean Soc., Trans., (London), v. 26, p. 419; Sars, 1925, An account of the Crustacea of Norway, v. 9, p. 149; Furtos, 1933, Ohio Biol. Survey, v. 5, (Bull. 29), p. 422; Dobbin, 1941, Univ. Washington Publ. in Biology, v. 4, no. 3, p. 185.

Type species.—Cythere inopinata Baird, 1843.

Diagnosis.—The subrectangular shape of the carapace and the distinctive surface ornamentation and hingement of both sexes differentiate this genus from the other members of the family Limnocytheridae. *Jurassic to Recent.*

Description.—Carapace is subreniform to subrectangular in lateral view. In most species the dorsal margin is straight, but it may be slightly arched in some species. The ventral margin is sinuate; in most species the greatest concavity is in the central ventral region. The anterior margin is broadly rounded. The posterior margin is narrowly rounded. The greatest height is anterior to the middle in most species, and is approximately half the length. The surfaces of the valves are pitted or reticulate in most species. One or two transverse sulci, prominent along the dorsal margin, fade ventrally and disappear above the ventral margin. Nodes occur in many species. The marginal areas are flattened and may have small tubercles or spines.

In dorsal view, the carapace is compressed. The anterior is sharply pointed; the posterior is narrowly rounded. The dorsal valve flanges project upward. The sulci are very distinct. Valves of most species are inflated in the middle. Slight alate lateral protuberances are present, the posterior one being larger than the others. Valves are approximately equal in size.

The line of concrescence and the inner margin coincide interiorly around the marginal area of the valves. The numerous radial pore canals are best seen along the flattened margins. The hingement is lophodont. The hinge of the left valve is formed by weak anterodorsal and posterodorsal sockets separated by a thin bar. The hinge of the right valve consists of weak anterodorsal and posterodorsal teeth separated by a thin groove. On some species the hingement is very poorly developed and seems to be adont. The muscle scars are located in a subventral depression; the pattern consists of a row of small oval scars whose long axes are parallel to the length of the valve.

Remarks.—The spelling of *Limnocythere* as "*Limnicythere*" has led to some confusion. This mistake was perpetuated until 1941. The confusion dates from 1868, when Brady changed the spelling. The original and therefore correct spelling is *Limnocythere*. Members of this genus generally live in mud-bottomed lakes, although some species may inhabit other environments.

LIMNOCYTHERE STAPLINI Gutentag and Benson, n. sp.
Fig. 15. Pl. 1, fig. 1-3.

Diagnosis.—The species differs from the other described species of *Limnocythere* by its small size, subquadrate shape, and the arched dorsal margin of the female. The lack of prominent alae is also distinctive.

Description.—The female carapace is subquadrate in lateral view. The dorsal margin of the left valve is arched but the carapace exhibits a slight sinuation in the central dorsal region posterior to the middle. The arched dorsal margin of the right valve is sinuate at the junction of the valves along the central dorsal margin. The sulcus fades ventrally to the subcentral pit. The ventral margins of both valves are sinuate in the central ventral region. The anterior margins of both valves are more broadly rounded than the posterior margins. The greatest height is located anterior to the middle and is more than half the length. Nodes are common although not as pronounced as in other species. On each valve a small node is situated anterior to the sulcus in the dorsocentral region. On each valve a swelling is present posterodorsally from the sulcus. A prominent elongate longitudinal swelling is present above the sinuation in the central ventral region. The greatest breadth of the carapace is less than half the length.

The carapace of the female from the dorsal view is elliptical. The anterior end is pointed because of a flattening of the hinge margins. The sulcus is present at mid-length. The hinge flanges of both valves are projected upward to form sharp edges. The valves appear equal in size.

The duplicature is welded to the outer lamella and is widest anteriorly. Radial pore canals are small, inconspicuous, and widely spaced. The internal expression of the reticulations is clearly seen. The hinge-

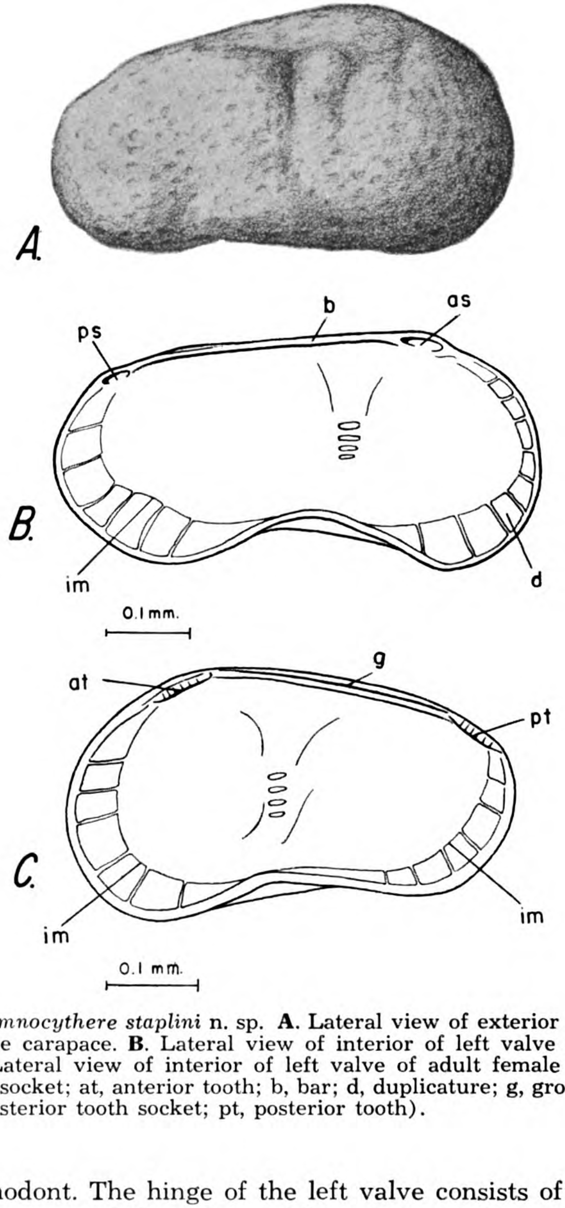

FIG. 15.—*Limnocythere staplini* n. sp. **A**. Lateral view of exterior of right valve of adult female carapace. **B**. Lateral view of interior of left valve of adult male carapace. **C**. Lateral view of interior of left valve of adult female carapace (as, anterior tooth socket; at, anterior tooth; b, bar; d, duplicature; g, groove; im, inner margin; ps, posterior tooth socket; pt, posterior tooth).

ment is lophodont. The hinge of the left valve consists of an anterior tooth socket, a central dorsal curved bar, and a posterior tooth socket. The bar is formed by the knifelike extension of the hinge flange. The hinge of the right valve consists of an anterior crenulate hinge tooth, a central dorsal curved groove, and a posterior crenulate hinge tooth. The groove is formed by the hinge flange and the selvage. The muscle scars are situated on a raised platform, which is the internal expression of the external pit. The muscle-scar pattern consists of a subcentral row of four oval scars whose long axes are parallel to the length of the valves.

Sexual dimorphism is pronounced, and the male is more elongate than the female. The central dorsal margin is straight. The ventral sinuation is deeper than in the female. The central ventral elongate swelling is more pronounced than in the female. Other features are the same in both sexes.

Measurements.—Adult female: holotype, left valve, length 0.52 mm, height 0.31 mm; paratype, right valve, length 0.49 mm, height 0.30 mm. Breadth of complete female paratype, 0.20 mm, length of complete paratype 0.56 mm. Adult male: allotype, left valve, length 0.63 mm, height 0.32 mm; allotype, right valve, length 0.55 mm, height 0.29 mm.

Remarks.—Specimens of *Limnocythere staplini* are not abundant in the Pleistocene deposits of Meade County, Kansas. This species closely resembles *L. sanctipatricii* Brady and Robertson but does not have the prominent alae of the latter species. In Meade County, *L. staplini* is associated with *Candona nyensis* n. sp. and *Cyprideis littoralis* Brady. It seems to have lived in a permanent lake. The recrystallized specimens of *Limnocythere* found in the Pliocene deposits resemble *L. staplini* but they have lost many of their original features.

Repository.—Specimens studied are reposited under catalogue no. 717563.

Explanation for Plate 1
(All figures ×60)

Fig. 1-3.—***Limnocythere staplini*** n. sp. 1, male left valve (allotype). 2, female left valve (holotype). 3, female right valve (paratype).
Fig. 4-5.—***Potamocypris smaragdina*** (Vávra), 1891. 4, left valve of adult. 5, right valve of adult.
Fig. 6-7.—***Ilyocypris gibba*** (Ramdohr), 1808. 6, right valve of adult. 7, left valve of adult.
Fig. 8-9.—***Ilyocypris bradyi*** Sars, 1890. 8, left valve of adult. 9, right valve of adult.
Fig. 10—***Cypridopsis vidua*** (O. F. Müller), 1776, right valve of adult.
Fig. 11—***Cypricercus tuberculatus*** (Sharpe), 1908, adult left valve.
Fig. 12.—***Candona renoensis*** n. sp., female left valve (holotype).
Fig. 13.—***Candona fluviatilis*** Hoff, 1942, adult left valve.

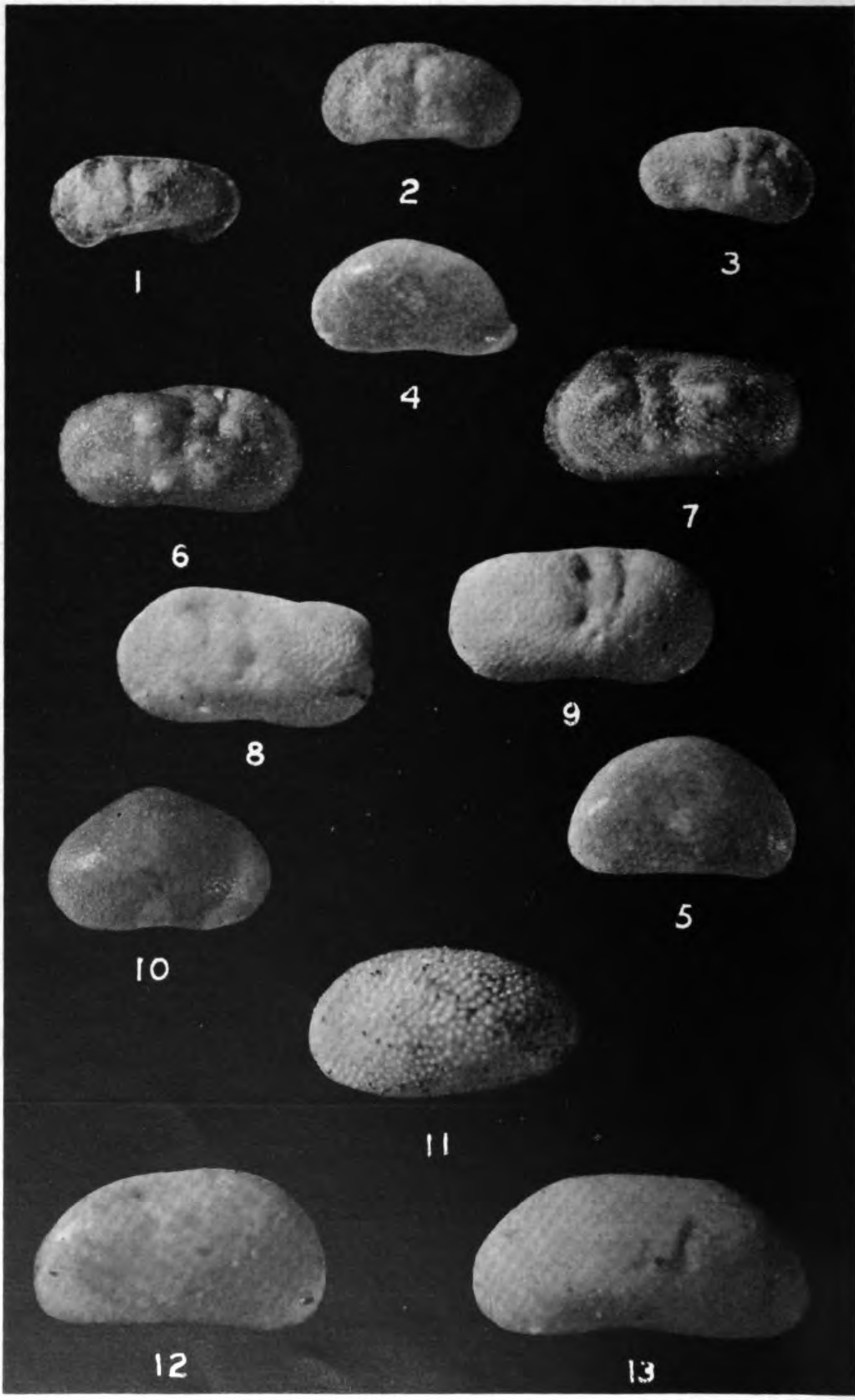

PLATE 1.

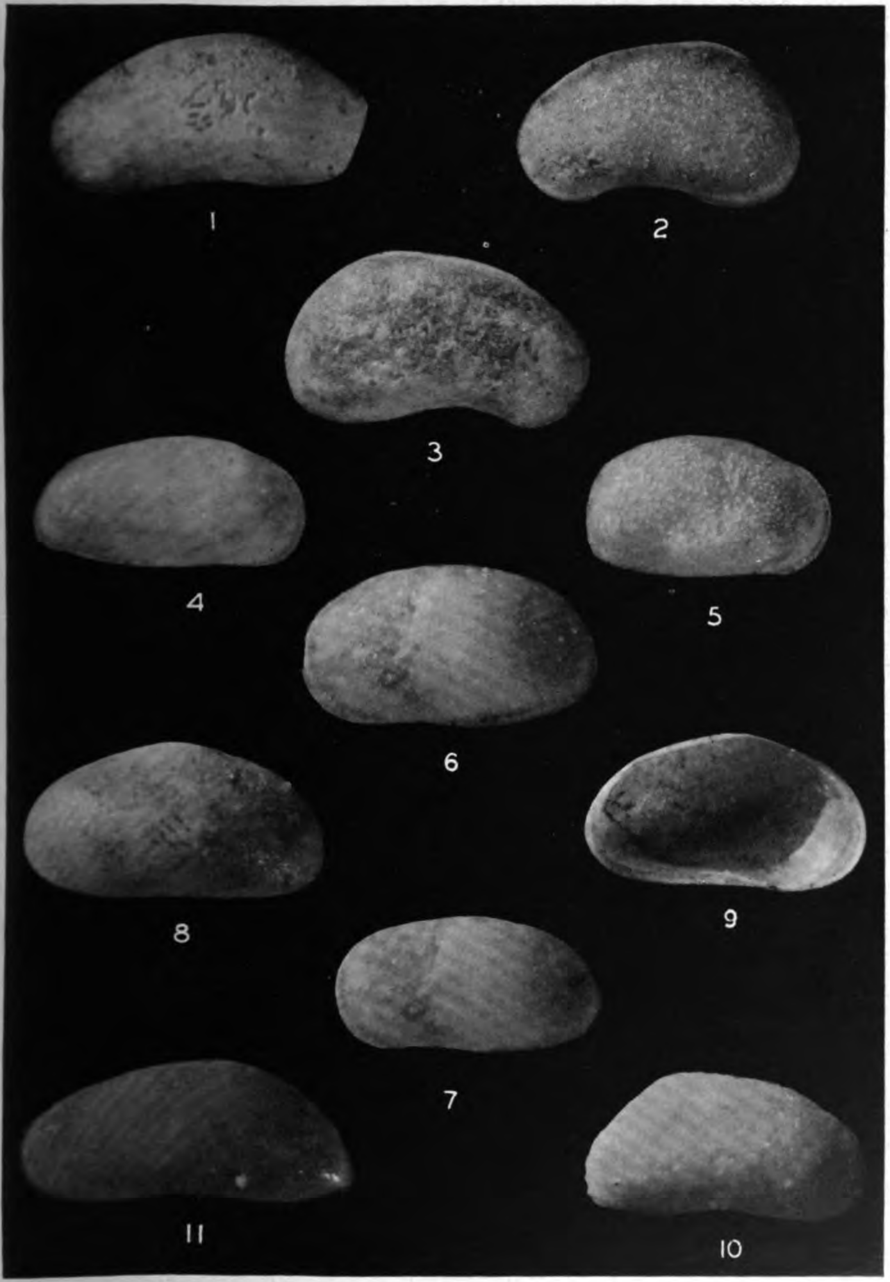

PLATE 2.—(All figures ×50).

Fig. 1–3.—*Candona nyensis* n. sp. 1, female left valve (holotype). 2, male left valve (allotype). 3, male right valve (allotype).

Fig. 4–7.—*Cyprideis littoralis* Brady, 1889. 4, right valve of male. 5, right valve of female. 6, left valve of large male. 7, left valve of male of average size.

Fig. 8–9.—*Eucypris meadensis* n. sp. 8, female left valve (holotype). 9, interior view of holotype.

Fig. 10.—*Candona crogmaniana* Turner, 1894, female left valve.

Fig. 11.—*Candona caudata* Kaufmann, 1900, female left valve.

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