



Reassignment of the Jurassic Todilto Limestone Ostocodite *Metacypris Todiltoensis* Swain 1946, to *Cytheridella*, with notes on the phylogeny and environmental implications of this Ostracodite

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REASSIGNMENT OF THE JURASSIC TODILTO LIMESTONE OSTRACODE *METACYPRIS TODILTOENSIS* SWAIN, 1946, TO *CYTHERIDELLA*, WITH NOTES ON THE PHYLOGENY AND ENVIRONMENTAL IMPLICATIONS OF THIS OSTRACODE

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Abstract—*Metacypris todiltoensis* Swain, 1946, should be reassigned to the genus *Cytheridella* Daday, 1905, to accommodate it better in the current organization of the Limnocytheridae. This placement is based on muscle scar structure, the single sulcus and close similarity of surface ornamentation. This species represents an important link between the ancestral *Lutkevichinella* faunas of the Triassic and the extant genus *Cytheridella*. The occurrence of this ostracode in the saline to hypersaline Todilto environments can be understood in terms of readaptation of a brackish-water ostracode group and perhaps in the possible parthenogenic nature of this species.

INTRODUCTION

The ostracode *Metacypris todiltoensis* was named by Swain (1946) on the basis of specimens from the Todilto Formation north of Thoreau, New Mexico (Fig. 1). The status of this important ostracode requires clarification on several points. The original description was very brief and did not cover such important features as biometrics and ontogeny; thus, redescription is needed. The illustrations, while good for their time, do not show many details of the shell that are revealed using the scanning electron microscope (SEM). Further, the generic name *Metacypris* was used originally for any Mesozoic or Cenozoic ornamented freshwater ostracode and included several different taxa. The Todilto species can now be moved from *Metacypris* to a more reasonable assignment in the genus *Cytheridella* Daday, 1905. The original descrip-

tion of this ostracode included no stratigraphic column and only a brief topographic description of the type locality. Clarification of the stratigraphic position of this ostracode can now be given and helps greatly with the paleoecologic interpretation of the habitat of this species.

Cytheridella todiltoensis is significant because it is the earliest described species of Jurassic nonmarine ostracode in North America. It is also the oldest representative of this genus reported worldwide. It represents an important bridge between the *Darwinula*-dominated faunas of the Triassic and the *Cypridea*- and *Bisulcocypis*-dominated faunas of the Late Jurassic and Early Cretaceous. Additionally, the environment of the Todilto Formation has long been controversial and this ostracode aids in the interpretation of this environment.

SYSTEMATICS

The redescription of *Metacypris todiltoensis* within the genus *Cytheridella* is the first part of this paper. The higher order taxonomy follows Colin and Danielopol (1980), but some modifications are suggested below. Certainly the Limnocytheridae are currently well enough known to allow a comprehensive revision, but such a revision is beyond the scope of this paper and only some suggestions for revision are presented here.

Subclass **Ostracoda** Latreille, 1806
Order **Podocopida** Muller, 1894
Suborder **Podocopa** Sars, 1866
Superfamily **Cytheracea** Baird, 1850
Family **Limnocytheridae** Klie, 1938
Subfamily **Limnocytherinae** Klie, 1938
Genus ***Cytheridella*** Daday, 1905

Diagnosis—Valves highly inflated posteriorly, having a single well-developed sulcus, marginal rim, and ornamentation similar to *Limnocythere* Brady, 1868. Type species: *Cytheridella ilosvayi* Daday, 1905.

Cytheridella todiltoensis (Swain), 1946
Figs. 2–5

Metacypris todiltoensis Swain, 1946, p. 553, pl. 84, figs. 20–22; Hoare, 1953, p. 62–63, pl. II, figs. 24–26.

Specimens—NMMNH P-14829–P-14847.

Description—Elongate, subrectangular; dorsal margin straight; ventral margin parallel to dorsal margin, slightly concave at center; anterior and posterior margins rounded; carapace with a prominent lip on both valves along anterior and posterior margins, which lack punctae; valves with prominent sulcus in area of muscle scar field, forming a constriction or offset of the single sulcus; valves inflated in dorsal aspect, width approximately equal to height, posterior more so than anterior; sides rounded with indentation at location of sulcus; right valve overlaps left valve slightly, most prominently along anterior and posterior margins;

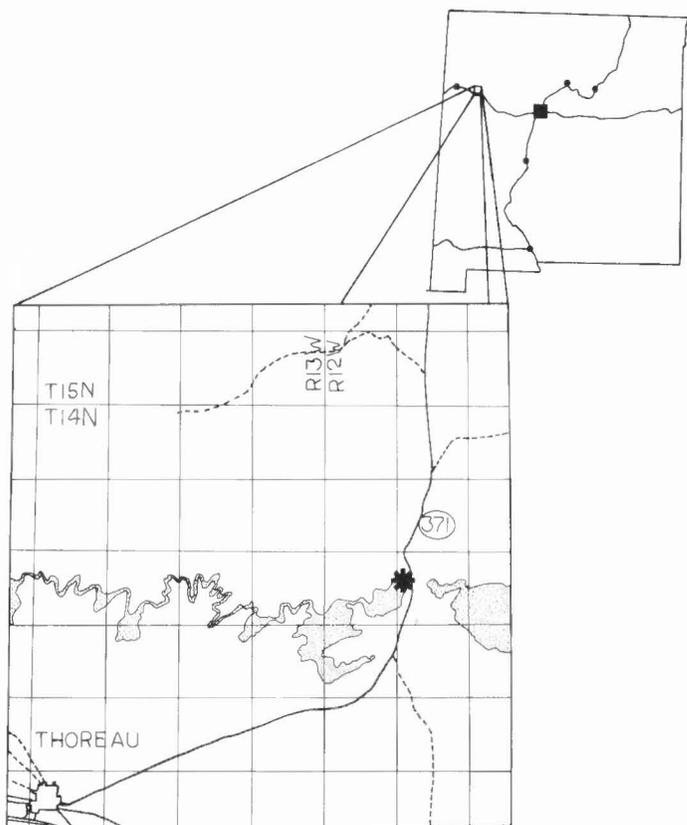


FIGURE 1. Type locality of *Cytheridella todiltoensis* (starred); Todilto Limestone outcrop stippled.

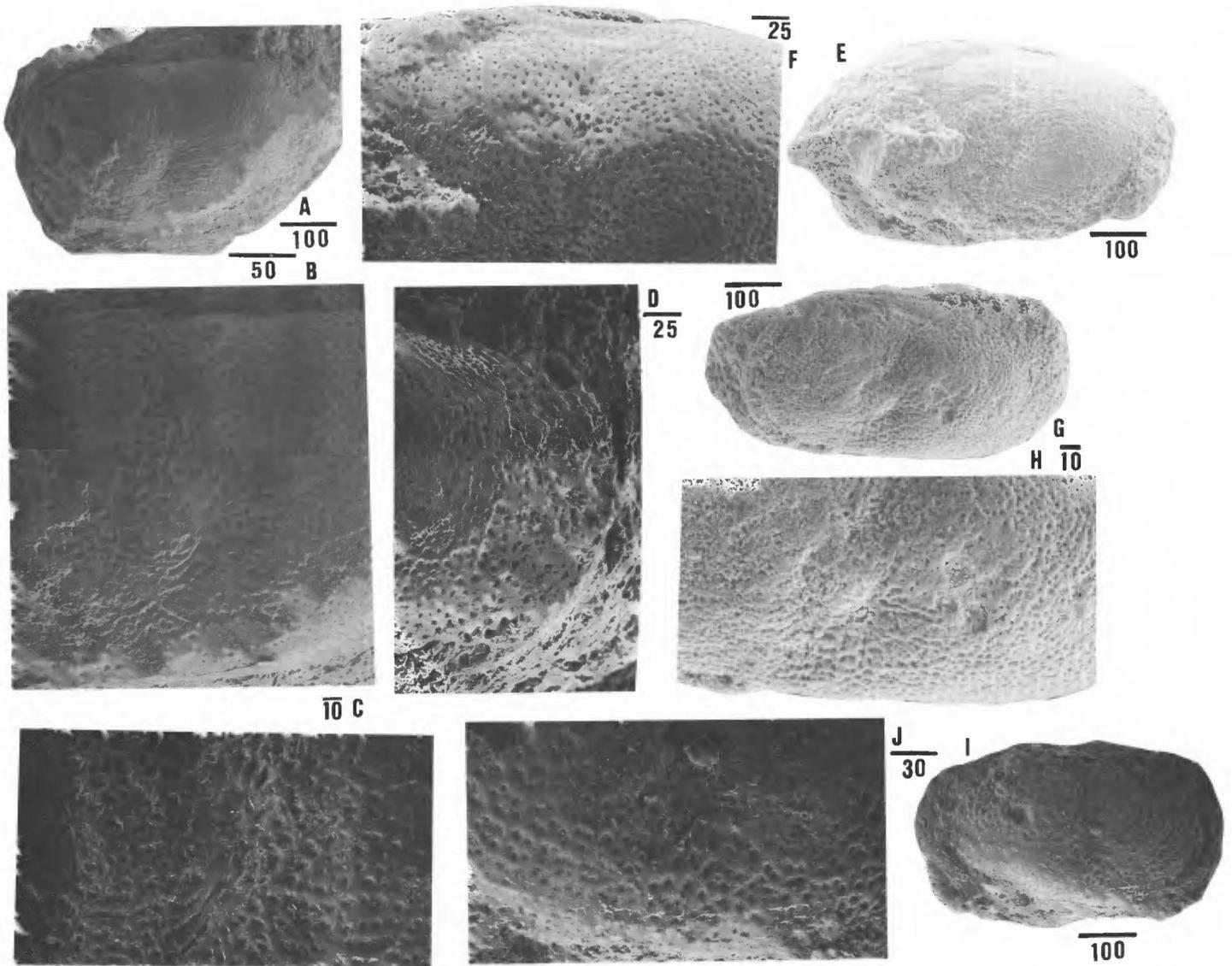


FIGURE 2. *Cytheridella todiltoensis*. A, Adult, right valve, NMMNH P-14835; B, Same, closer view of sulcus and surface ornamentation; C, Same, close view of adductor region showing characteristic folding; D, Same, anterior area close view; E, Adult valve, NMMNH P-14841; F, Same, close view of sulcus region; G, Adult valve, NMMNH P-14842; H, Same, closer view of sulcus region; I, Adult right valve, NMMNH P-14847; J, Same, close view of sulcus region. Bar scales in microns.

valve surface marked with very faint reticulation arranged roughly parallel to the valve outline and containing numerous punctae; punctae converge in sulcus region at location of internal muscle scars.

Discussion—The central muscle scar is similar to that of recent *Cytheridella*, consisting of four adductor scars arranged in a roughly vertical arc. This pattern of adductor scar arrangement also characterizes species of *Lutkevichinella* from which muscle scars have been described (Kozur, 1968). A small, irregular area anterior to the sulcus lacks punctae on some valves; ventral edges have punctae arranged in parallel rows separated by slightly raised ridges.

Measurements and statistical analysis of *Cytheridella todiltoensis* are presented in Fig. 6 and the Appendix; ontogeny is illustrated in Fig. 7. The relatively wide scatter of the size measurements can be attributed in part to the difficulties of measuring specimens not completely removed from the limestone matrix. This is particularly true of width measurements; total width was estimated at twice the width of a single valve.

Swain (1946) first compared this species with *Metacypris* [= ?*Bisulcocypris*] *whitei* Jones, 1886, based largely on the supposed unisulcate nature of the latter species. Hoare (1953, p. 62–63) observed, “In

reference to Swain’s remarks on *M. whitei* it might be well to state that all of the specimens of *M. whitei* that the writer has observed contain two sulci. The more anterior one is small and indistinct in some cases. There were no unisulcate specimens of *M. whitei* found in the samples from the Morrison Formation and the writer knows of no record in the literature where unisulcate specimens of *M. whitei* are described or illustrated [other than Jones’ original figures].”

In dorsal view, *Cytheridella todiltoensis* most resembles the males of *Cytheridella ilosvayi* Daday, 1905. Clearly defined sexual dimorphism in *Cytheridella todiltoensis* is not obvious. Whether this reflects a sorting or preservational bias, evidence of parthenogenesis, or simple lack of obvious dimorphism remains uncertain. *Cytheridella todiltoensis* is similar to *Gomphocythere ?linyngensis* Meizhen, 1984, from the Lower Jurassic of southern China. It differs in having much better developed anterior and posterior rims and in being shorter and narrower.

Occurrence—Swain (1946, p. 553) gave the type locality of this species as “Todilto Limestone Member of the Morrison Formation, about six miles north of Thoreau, New Mexico, on highway 56 [currently NM Highway 371]; collected by R. H. Wilpolt and J. B. Reeside, Jr.”

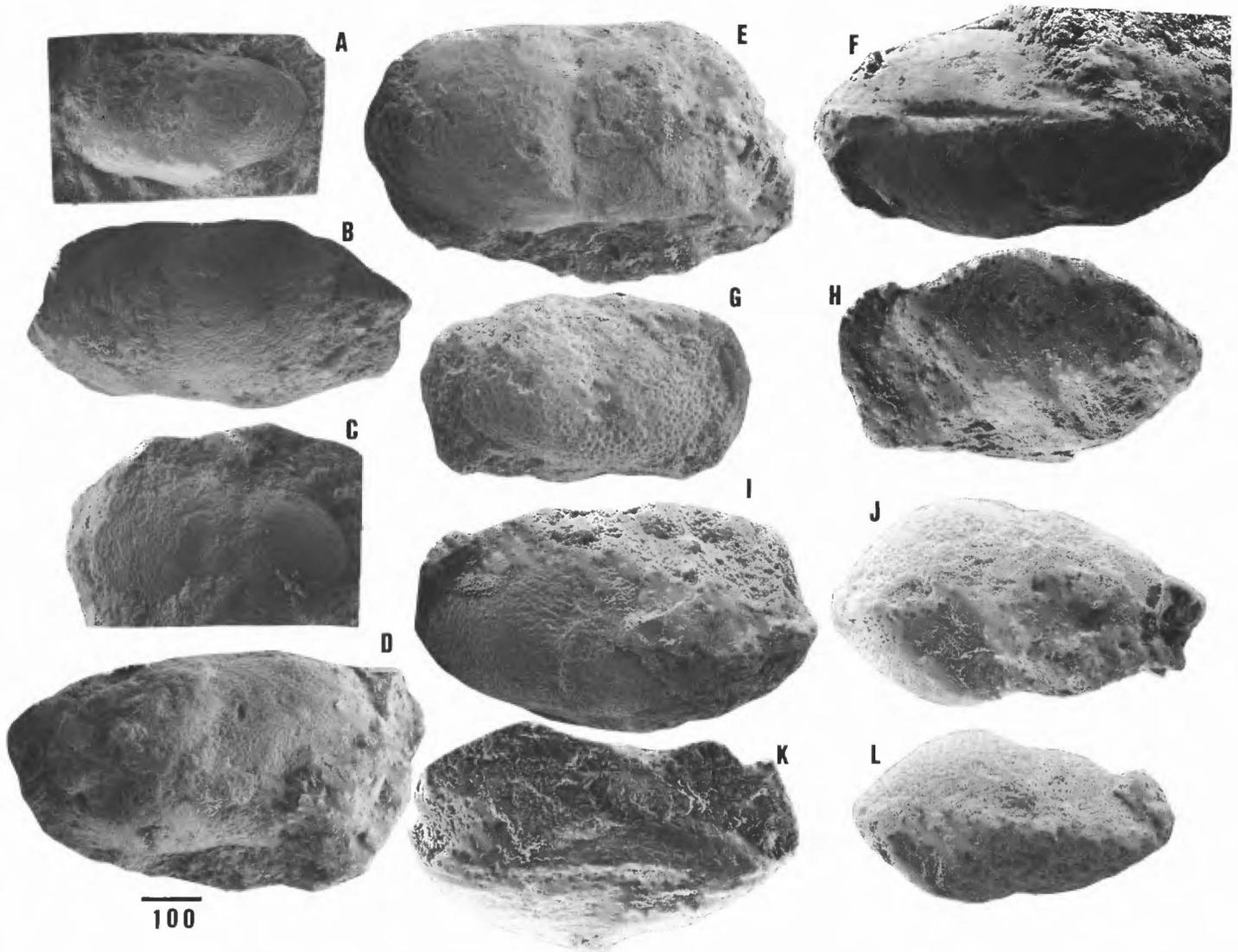


FIGURE 3. *Cytheridella todiltoensis*. A, Immature instar, left valve, NMMNH P-14831; B, Adult, left valve, NMMNH P-14844; C, Immature instar, left valve, NMMNH P-14830; D, Adult, left valve, NMMNH P-14845; E, Adult, right internal mold, NMMNH P-14846; F, Same, dorsal view; G, Adult, right valve, NMMNH P-14829; H, Adult, dorsal view, NMMNH P-14839; I, Adult, right valve, NMMNH P-14838; J, Adult, dorsal view, NMMNH P-14837; K, Adult, ventral view, NMMNH P-14840; L, Adult, dorsal view, NMMNH P-14834. Bar scales in microns.

Fortunately the Todilto Limestone Member of the Wanakah Formation is a relatively thin unit where it intersects the highway [NM-371] at San Antonio Spring, 6 mi north of Thoreau, New Mexico, near the San Antonio Mission. Large numbers of ostracodes forming the basis of this report were collected in a small, abandoned quarry immediately west of the highway (Fig. 8). Clearly this is at or within a few yards of the described type locality according to Swain's brief description. The ostracodes studied for this paper were found in the uppermost ledge of the Todilto Limestone exposed at this locality (Fig. 9). They are from the east end of the quarry.

PHYLOGENETIC RELATIONSHIPS

Correct assignment of *Cytheridella todiltoensis* requires a brief review of *Lutkevitchinella*, a Triassic genus; *Stenestoemia*, a Mesozoic genus along the lineage to the recent genus *Limnocythere*; and the *Bisulcocypris-Theriosynoecum* group that is related to the recent genus *Metacypris* and others. Clearly, *Cytheridella todiltoensis* differs from *Metacypris* as originally described by Brady and Robertson (1870) in several critical aspects. In *Cytheridella*, marginal rims are present, the posterior is tapered to rounded, the dorsal margin is straight, a sulcus

is present, and length is greater than width. In *Metacypris*, marginal rims are absent, the posterior is rounded, the dorsal margin is convex, the sulcus is weak or absent, and width is only slightly greater than length. *Cytheridella* appears to be the correct genus for the Todilto species based on the following similarities: offset of single sulcus, position and shape of the muscle scars, reticulated structure of valve ornamentation, and structure of anterior and posterior marginal rims.

The genus *Cytheridella* is very similar to the recent genus *Gomphocythere* Sars, 1924 and, as observed by Pinto and Sanguinetti (1962), several modern species of *Cytheridella* have been incorrectly referred to *Gomphocythere*. It differs in being much wider in the posterior area. The Jurassic species discussed here could well be a new genus ancestral to both of these modern genera, which are separated largely on the basis of soft part anatomy.

Pinto and Sanguinetti (1958, 1962) considered the genus *Cytheridella* to be without known fossil representatives. These authors would assign fossil members of this genus to either one of various marine genera (e.g., *Archicythereis*) or to new undescribed genera. The following is a summary of these reassignments from Pinto and Sanguinetti (1962): *Cytheridella mediterranea* Zalanýi, 1913 was referred to "genus in-

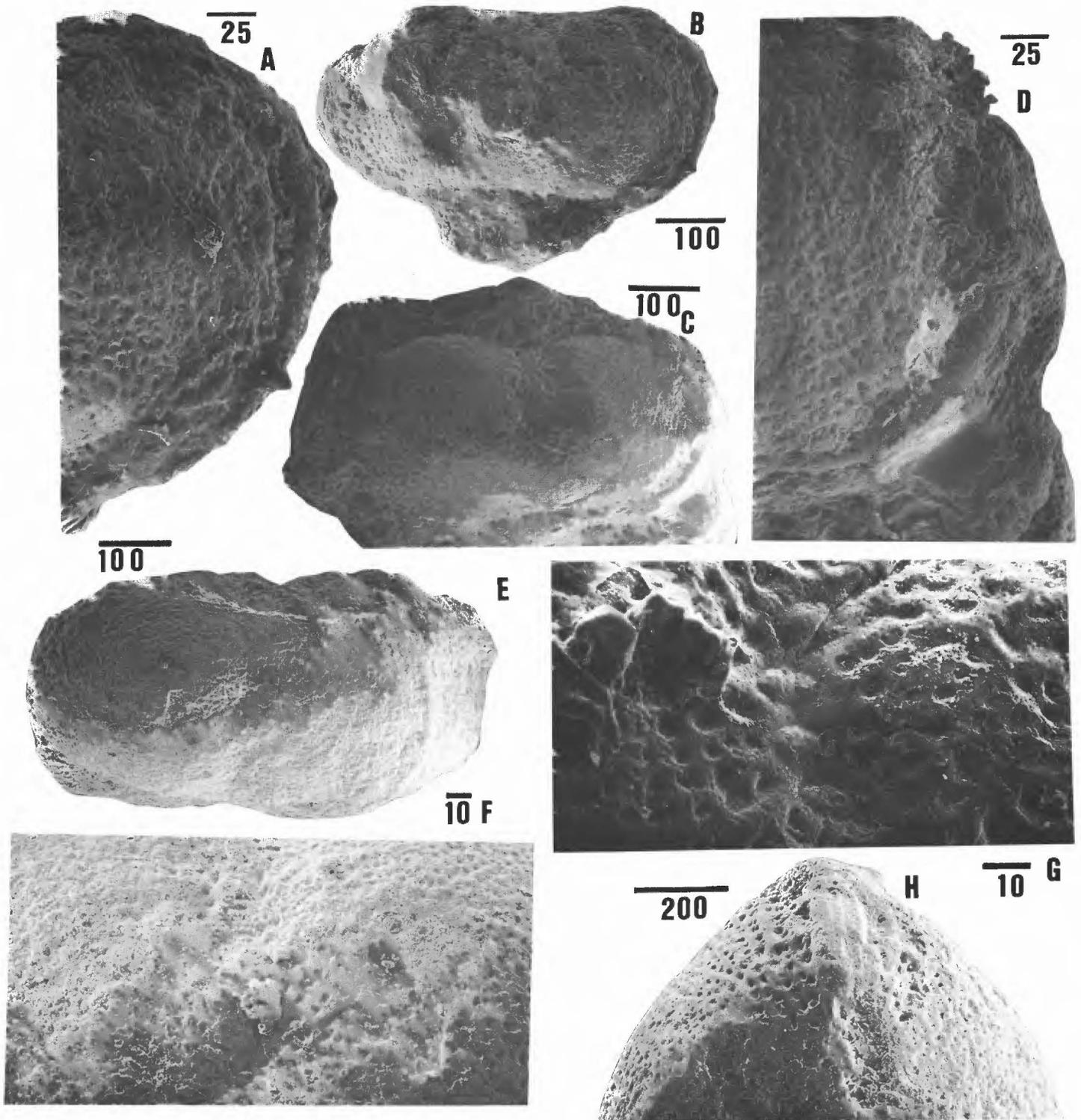


FIGURE 4. *Cytheridella todiltoensis*. A, Adult, right valve, close view of anterior margin, NMMNH P-14836; B, Same, right valve; C, Adult, right valve, NMMNH P-14832; D, Same, close view of anterior margin; E, Adult, left valve, NMMNH P-14833; F, Same, close view of sulcus area; G, Adult, close view of sulcus area showing adductor scar arrangement, NMMNH P-14843; H, Adult, dorsal view, close view of posterior margin, NMMNH P-14837. Bar scales in microns.

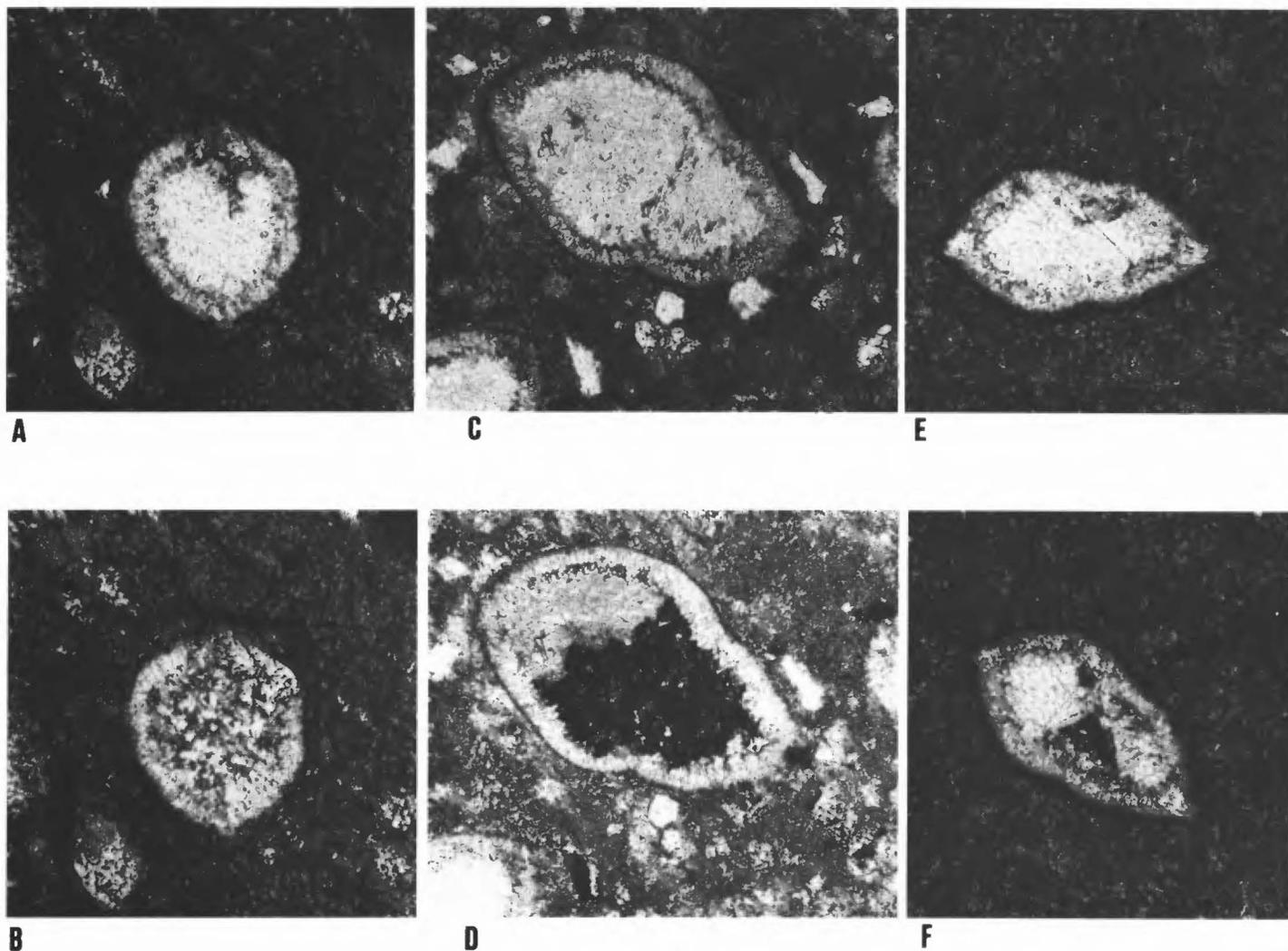


FIGURE 5. Thin section views of *Cytheridella todiltoensis* (Swain). A, Transverse profile, normal light; B, Same, crossed nicols; C, Longitudinal view, normal light; D, Same, crossed nicols; E, Longitudinal view, normal light; F, Same, crossed nicols.

certus"; *C. chambersi* Howe, 1935, *C. lienenklausi* Veen, 1936, *C. bosqueti* Veen, 1936, *C. binkhorsti* Veen, 1936, and *C. tuberculifera* Veen, 1936 were all referred to *Archicythereis*; *C. lyelli* Veen, 1936 to *Phacorabdodus pergensi*; *C. darwini* Veen, 1936 to *Cythereis horridulior*, *C. ubaghsi* Veen, 1936 to *Spongicythere koninckiana*, and *C. barnstorffensis* Martin, 1957 to "new genus."

Colin and Danielopol (1980) indicated two possible fossil members of the genus *Cytheridella*, *Cytheridella? strangulata* from the Eocene of India, and *C.? ritzkowskiana* Carbonnel and Ritzkowski, 1969, from the Oligocene of Europe. Additionally, the following recent species of *Cytheridella* were listed by Colin and Danielopol (1980): *C. ilosvayi* Daday, 1905, *C. boldi* Purper, 1974, *C. allosa* (Tressler) 1939 (synonymized with *C. ilosvayi* by Teeter, 1980), *C. monodi* Klie, 1936, *C. damasi* Klie, 1944, *C. chariessa* Rome, 1977, and *C. sp. 5*. The genus *Cytheridella* has been extensively reviewed by Purper (1974) and Victor (1987), with descriptions of new species. Victor (1987) named *C. tepida* and Swain (1987) added an Oligocene species, *C. alpinensis*.

It is important in this discussion that the evolutionary path of the Limnocytheridae be understood. I follow the reasoning of Colin and Danielopol (1980, p. 7) in placing this genus in the subfamily Limnocytherinae, based on characters of the sulcus, ornamentation and dimorphism. Various similarities of soft anatomy considered by these authors are not relevant to the assignment of the Jurassic species under consideration here, but are very important in validating the position of the recent species in a phylogenetic framework.

Lutkevitchinella Schneider, 1956 was originally described from the Lower Triassic of the USSR, but there is much variation in the ostracodes included in the genus. It has also been reported from the Rot and Muschelkalk of Germany (Diebel, 1965; Kozur, 1968) and possibly from the Triassic of China (Xu, 1988; Qiqing, 1989). Some of the Chinese species resemble more closely the Timiriaseviinae group than the Limnocytherinae. *Lutkevitchinella* is similar in shape to *Limnocythere*. Major groups are those with numerous elongate surface ridges (i.e., *L. tsharigini* Shleifer, 1966), those lacking this ornamentation pattern (e.g., *L. simplex* Kozur, 1968) and resembling *Limnocythere* in general outline, particularly in dorsal view, and those that are shorter and wider posteriorly, resembling such ostracodes as *Cytheridella* and the Timiriaseviinae (i.e., *Lutkevitchinella yimaensis* Qiqing, 1989). The first group likely gave rise to *Stenestroemia decipiens* (Andersen); the second group probably gave rise to other recognized species of *Stenestroemia* and *Limnocythere*; the last group was probably ancestral to *Cytheridella* and *Gomphocythere* and perhaps to the Timiriaseviinae. This suggests that *Stenestroemia* as currently recognized is polyphyletic and hence an artificial grouping. An ostracode described in open nomenclature (Kietzke, 1987) from the Upper Triassic of New Mexico (USA) may also belong to the *Stenestroemia-Limnocythere* group of *Lutkevitchinella*.

During the Jurassic, the Limnocytherinae and the Timiriaseviinae were well differentiated. This had obviously occurred prior to the Bathonian because the faunas described by Bate (1965) from England and

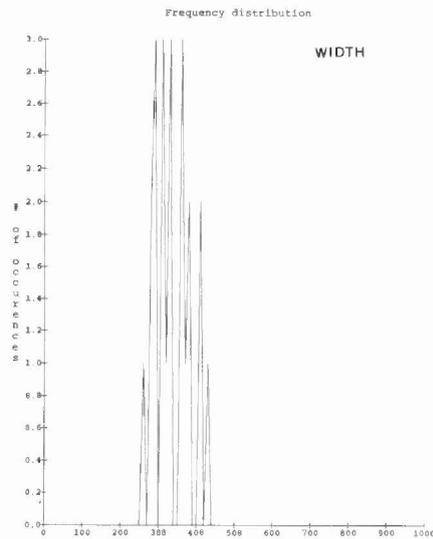
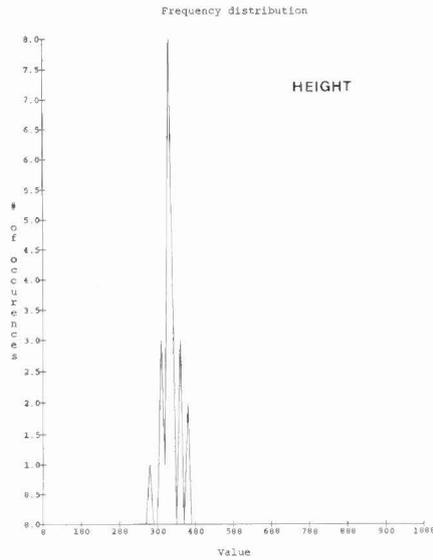
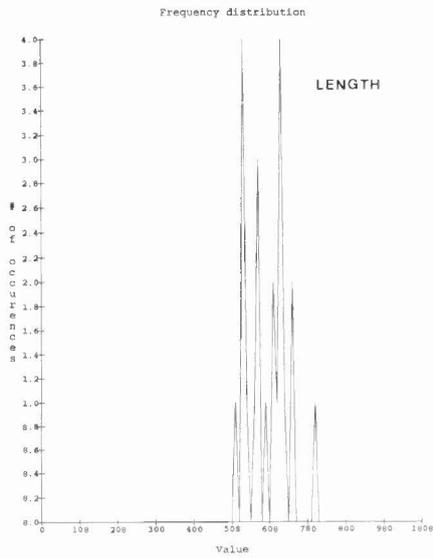


FIGURE 6. Frequency diagrams of length, height and width of *Cytheridella todiltoensis*. Measurements in microns.

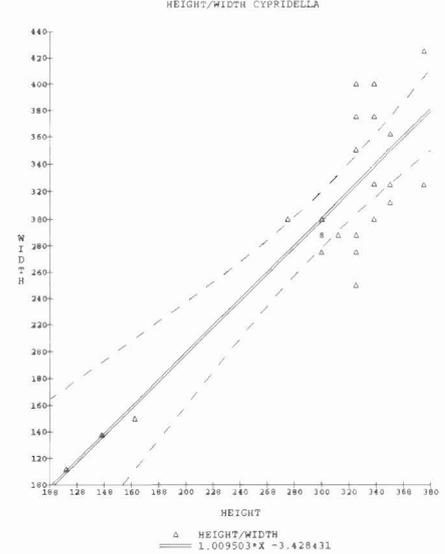
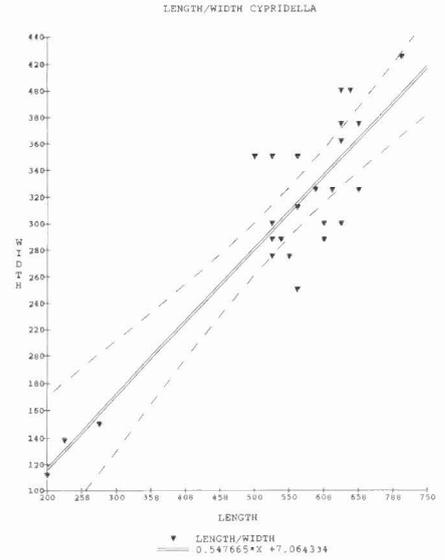
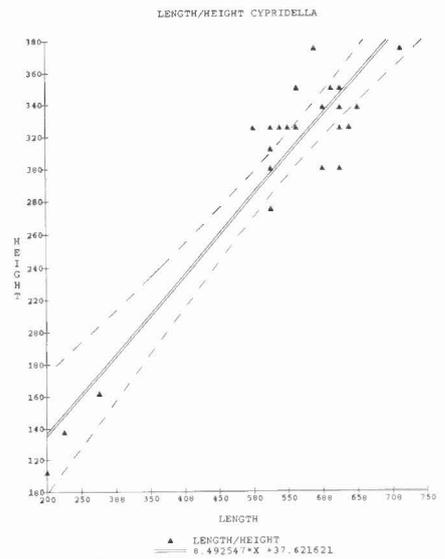
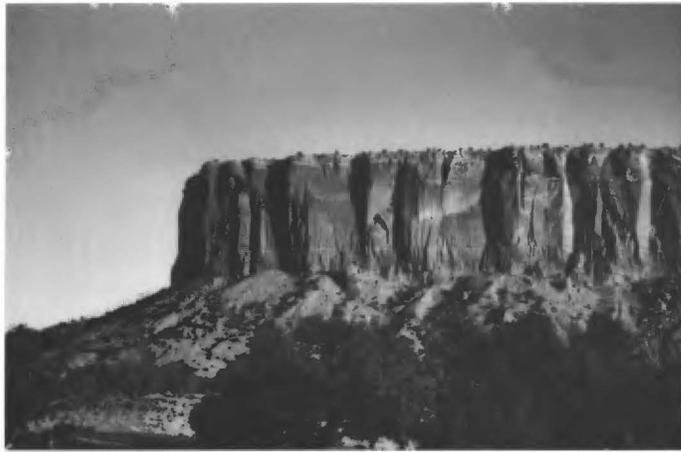


FIGURE 7. Ontogeny of *Cytheridella todiltoensis*, shown in length:height, length:width and height:width. Measurements shown in microns.



A



B



C



D

FIGURE 8. View of the Todilto Limestone capping a ridge near the type locality of *Cytheridella todiltoensis*; B, The abandoned quarry that is here designated the type locality of *Cytheridella todiltoensis*; C, Closer view of the upper ostracode-bearing unit of the Todilto Limestone at the east end of the quarry; D, Closer view of the ostracode-bearing upper unit of the Todilto Limestone at the west end of the quarry.

by Govindan (1975) from India include representatives of both subfamilies. Colin and Danielopol (1980) suggested that this separation occurred during the Triassic. The evidence from China (Qiqing, 1989) suggests this may have occurred early in the Triassic. The Timiriaseviinae were diverse on the generic and especially the specific level during the Late Jurassic and Early Cretaceous. The Limnocytherinae, on the other hand, were less diverse, with only a few genera, some probably synonymous. *Stenestroemia*, from the European Upper Jurassic, and the Chinese genus *Naevicythere* from the Lower Jurassic appear to be synonymous, although the latter genus tends to have a less well defined dorsal margin and to be less tapered in dorsal view. Several Lower Jurassic species from China described as *Gomphocythere* (e.g., *G. longa* Fang and Xu, 1981) may belong in *Stenestroemia* as well. Most other species included in *Gomphocythere* by Chinese workers appear to be correctly assigned, based on their narrow posterior width, but they could also belong to a *Cytheridella-Gomphocythere* stem group.

SURFACE ORNAMENTATION

The details of the surface ornamentation of ostracodes has received increased attention since the advent of the SEM as an illustration tool. The surface of *Cytheridella todiltoensis* has a pattern of low, coarse reticulation with pitting (= microreticulation, microfossae). This is nearly identical to that seen in modern *Cytheridella* and *Limnocythere*, termed

protoreticulation and microreticulation by Liebau (1977). Liebau (1977, p. 107–108) observed that this early level of ornamentation represents a primitive stage of ornament genetics where the components show intraspecific variation in number and arrangement of single elements. This means the single elements may not have any taxonomic validity in separation of species. However, Hou and Zhao (1988) noted that while the single elements may vary, the general type of ornamentation is usually consistent and of taxonomic utility. Carbonel (1968) suggested that the type of ornamentation is genetically controlled, while the degree of ornamentation development is environmentally controlled.

Hou and Zhao (1988) observed Mesozoic and Cenozoic ostracode ultrastructure and emphasized that type of surface ornamentation provides evidence of evolutionary affinity and may have value in classification. The similarity of *Cytheridella* ornamentation to that of *Stenestroemia* and *Limnocythere* further confirms that these genera are closely related.

The only genus in the Timiriaseviinae with protoreticulation, according to Colin and Danielopol (1980), is *Theriosynoecum*, and only some members of that genus, as broadly defined by these authors, are protoreticulated. I believe the narrower definition of this genus given by Sohn (1982) is correct. *Dryelba* Sohn, 1982 is valid, and an undescribed genus with a large node anterior of the sulcus (e.g., *Metacypris persulcata* of Peck 1941), is also present and related to *Dryelba*. The classification within the subfamily of Colin and Danielopol (1980) is more likely to be correct than that proposed by Sohn (1982).

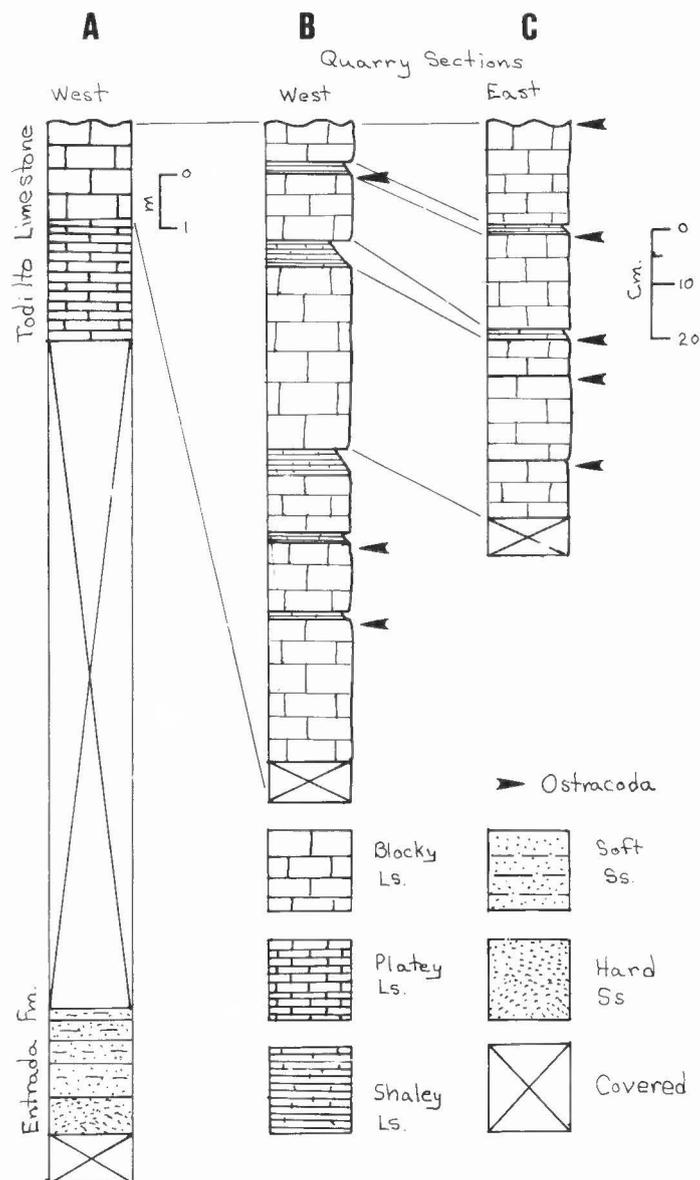


FIGURE 9. Stratigraphic column of the Todilto Formation in the area of the *Cytheridella todiltoensis* locality. A, Section to the quarry from the Entrada Formation near the west end of the quarry; B, Section of the uppermost ostracode-bearing limestone at the west end of the quarry; C, Section of the upper ostracode-bearing interval at the east end of the quarry, where the ostracodes described in this paper were obtained.

BIOSTRATIGRAPHIC POSITION

The Todilto Limestone is generally considered to be Jurassic (Callovian) in age based on its fossil fish fauna (Schaeffer and Patterson, 1984) and correlations with the Sundance Formation. *Cytheridella todiltoensis* can shed very little direct information on the refinement of this age, owing to a lack of nonmarine faunas of the same age and the unusual, restricted saline environment of the Todilto Limestone as deduced from other evidence.

An earlier Jurassic ostracode fauna from the Kayenta Formation (Jurassic, ?Sinemurian), currently under study by the author, lacks any ostracodes related to this species and is dominated by *Darwinula*.

PALEOECOLOGY

The depositional environment of the Todilto Formation has long been a matter of conjecture. Three major environmental models have been proposed:

1. Evaporitic lake model, used by Rapaport et al. (1952), Anderson and Kirkland (1960), Tanner (1965, 1970, 1974), Vincelette and Chittum (1981), and Kocurek and Dott (1983). It envisions a lake or playa lake that became more evaporitic, going from a clastic to carbonate to gypsum evaporitic phase.

2. Marine embayment model, proposed by Harshbarger et al. (1957), Ridgley and Goldhaber (1983), Shaeffer and Patterson (1984), and Armstrong (1991). It envisions the Todilto as a hypersaline marine embayment of the Curtis sea.

3. Salina model, proposed by Lucas et al. (1985), which suggests that the Todilto was deposited in an isolated basin filled with marine water from the Curtis sea through the Entrada sand dunes, but never directly connected to the Curtis sea.

Isotopic evidence supports a marine origin for the waters depositing the Todilto evaporites (Ridgley and Goldhaber, 1983). Lucas et al. (1985) argued that this isotopic evidence is equally consistent with the salina model, but the paleontologic evidence supports the salina rather than the embayment model. The lack of a demonstrated connection to the Curtis sea also supports the salina model.

The ostracodes are scattered through several tens of centimeters of limestone. This makes it unlikely that they are a fauna associated with the Wanakah beds above the Todilto. Also they are somewhat more common in some silty beds but are not restricted to these beds, suggesting they were transported into this environment or at least sorted by sedimentary processes. This is strongly implied by the presence of only two instars. Current or wave action is suggested by the undulatory nature of the upper limestone beds.

Thin sections of the ostracode-bearing intervals (Fig. 10) show an extremely fine-grained, wavy bedded limestone alternating with beds of similar limestone containing abundant, angular, fine-grained, quartz sand and silt, sometimes with secondary iron oxide replacement in voids and along grain boundaries. The quartz is dominantly undulatory, but some microgranular grains are also present, together with microcline and rounded calcite grains. Mica is rare. The ostracodes are by far the largest grains and are almost always complete valves containing authigenic sparry calcite. Some crushed or partially open valves are filled with material similar to the groundmass. The interior of the valves appears to have been recrystallized, with crystals pointing toward the sparry interior. Details of valve ultrastructure are not obvious in thin section and are probably obscured by the diagenetic alteration of the valves.

Modern members of the genus *Cytheridella* live in fresh water. *Cytheridella alosa* from Florida is strictly limnic to very low-level oligohaline if washed-in carapaces are included (Keyser, 1977). This species also has a temperature range of 20–30°C and a preference for sandy bottoms or occasionally organic debris (Keyser, 1977).

The presence of a typically freshwater ostracode genus in the Todilto Formation is further evidence supporting the salina model, particularly when combined with the absence of any demonstrable marine Ostracoda in the Todilto Formation anywhere in the basin, including the northern end near the supposed Curtis sea connection. The occurrence of ostracodes only along the basin margins at Satan Pass, near Thoreau, New Mexico (Swain, 1946), near Durango, Colorado (Reeside, in Bush et al., 1959), and from Bull Canyon, east of Santa Rosa, New Mexico (Lucas et al., 1985) is evidence that the typical basin environments of the Todilto Formation were inhospitable to *Cytheridella todiltoensis*. Possibly, only areas with some freshwater influx were inhabited by this species. Another factor is the apparent lack of the fish known from lower in the Todilto. The evaporitic stage of the Todilto might have eliminated potential predation from this source. The presence of *C. todiltoensis* even at the margins of the Todilto Basin suggests that it was tolerant of saline to hypersaline conditions. The absence of this genus, however, in known Jurassic marine faunas indicates that it is not a typical marine genus.

The occurrence of *Cytheridella todiltoensis* on the upper surface of the Todilto Limestone, presumably equivalent to or slightly preceding the evaporitic phase, also indicates the species was tolerant of evaporitic, presumably hypersaline environments. Armstrong (1991, p. 61)

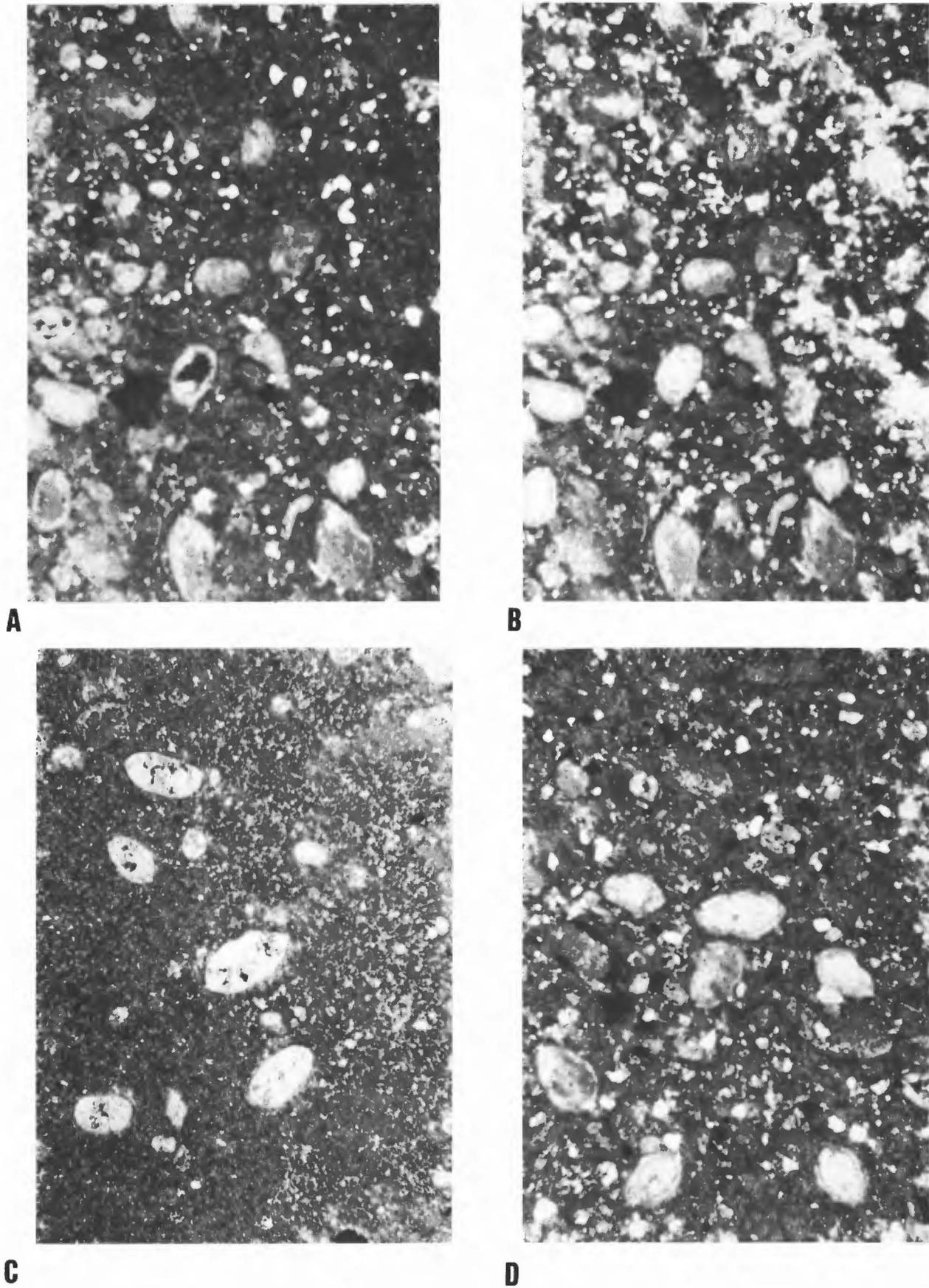


FIGURE 10. Thin section views of Todilto Limestone sediments. A, Typical nonsilty, wavy limestone with scattered ostracodes, perpendicular to bedding; B, Same lithology, parallel to bedding; C, Typical silty limestone perpendicular to bedding; D, Same lithology, parallel to bedding.

considered these ostracodes to live in "ephemeral gypsiferous ponds." Explanations for this habitat choice include the possibility that the ostracode was preadapted to fluctuating salinity, that the ostracode occupied the environment only during brief periods when the environment was fresher than typical, or the ostracodes were redeposited from another environment. The lack of instars suggests that the species might not have lived in the Todilto environments in which it is now found or that mechanical sorting selectively removed some instars. Thin sections, however, show that the species is not restricted to the siltier intervals but is also found in the silt-free zones. Concerning preadaptation, the descendant members of this subfamily are largely limnic, freshwater forms, whereas the ancestral members are usually associated with more marine ostracodes, which probably indicate marginal marine or brackish-water environments.

Cytheridella todiltoensis is not obviously sexually dimorphic and therefore might be parthenogenic. The slightly bimodal height of this ostracode might suggest sexual dimorphism, but the normal distribution of the width and length argues against it. Whatley (1983) observed that both sexual and asexual reproduction have advantages; the former in developing a more vigorous stock and the latter in expansion of geographic range. Colin and Danielopol (1979) suggested that slow diversification of the Timiriaseviinae during the Cenozoic in Europe might be due to a change in reproductive pattern from heterosexual to parthenogenetic. If the Limnocytherinae retained syngamic reproduction, then these diversification constraints might not have applied. In *Candona*, another nonmarine ostracode, parthenogenic species tend to a "dispersal fringe . . . in its bid to re-occupy former habitats" (McKenzie, 1986, p. 269). The hypersaline margins of the Todilto would represent such a "dispersal fringe" environment. There is no obvious evidence of sexual dimorphism in *Cytheridella todiltoensis*. Whether this indicates parthenogenic reproduction remains speculative.

Colin and Danielopol (1979) also suggested that the ecologic restriction of the Timiriaseviinae by the concurrent expansion and diversification of the Cyprididae during the Late Jurassic and Early Cretaceous might have further restricted this group from diversification in the Cenozoic. The influence of these factors on the Limnocytherinae appears to have been similar but more pronounced, with a relatively conservative group arising from the *Lutkevichinella* stock in the Middle to Late Triassic continuing during the Mesozoic and Cenozoic to give rise to *Limnocythere* and *Cytheridella*, respectively. A clear radiation of this group during the Mesozoic might have been restricted not only by the explosive radiation of the Cyprididae but also by the slightly earlier radiation of its sister group, the Timiriaseviinae.

CONCLUSIONS

Cytheridella todiltoensis (Swain), 1946 is the correct taxonomic designation of *Metacypris todiltoensis* Swain, 1946, and is the oldest member of the genus reported. Paleocological interpretations based on *Cytheridella* indicate a freshwater habitat for this ostracode. This ostracode might have occupied marginal areas of the Todilto basin during periods of freshwater influx. The ultrastructure of surface ornamentation in *Cytheridella* can already be differentiated in the Jurassic species, *C. todiltoensis*. The usefulness of *C. todiltoensis* as a stratigraphic and paleoecologic tool is greatly hampered by the lack of other Callovian nonmarine ostracodes and the obviously unusual nature of the Todilto Limestone environment.

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REFERENCES

- Anderson, F. W., 1941, Ostracodes from the Portland and Purbeck beds at Swindon: Proceedings of the Geological Association [London], v. 51, p. 373–384.
- Anderson, R. Y. and Kirkland, D. W., 1960, Origin, varves, and cycles of Jurassic Todilto Formation, New Mexico: American Association of Petroleum Geologists Bulletin, v. 44, p. 37–52.
- Armstrong, A. K., 1991, Jurassic Todilto Limestone—facies, diagenesis and mineralogy, Grants District, McKinley and Cibola Counties, New Mexico: New Mexico Geology, v. 13, p. 61.
- Bate, R. H., 1965, Freshwater ostracodes from the Bathonian of Oxfordshire: Paleontology, v. 8, p. 749–759.
- Bernard, F., Bizan, J.-J. and Oertli, H.-J., 1957, Ostracodes lacustres du Bathonian du Poitou (Bassin de Paris): Bulletin de la Societe geologique de France, v. 6, p. 753–770.
- Brady, G. S. and Robertson, D., 1870, The Ostracoda and Foraminifera of Tidal Rivers. Part I. Ostracoda: Annals, Magazine of Natural History, ser. 4, no. 31, v. 6, p. 1–33.
- Bush, A. L., Bromfield, C. S. and Pierson, C. T., 1959, Areal geology of the Placerville Quadrangle, San Miguel County, Colorado: U.S. Geological Survey, Bulletin 1072-E, p. 299–384.
- Colin, J.-P. and Danielopol, D. L., 1979, Why most of the Timiriaseviinae (Ostracoda, Crustacea) became extinct: Geobios, v. 12, p. 745–749.
- Colin, J.-P. and Danielopol, D. L., 1980, Sur la morphologie, la systematique, la biogeographie et l'evolution des ostracodes *Trimiriaseviinae* (Limnocytheridae): Paleobiologie continentale, v. 11, p. 1–51.
- Daday, E., 1905, Untersuchungen über die Süsswassermikrofauna Paraguays. IV. Ostracoda: Zoologica, v. 44, p. 234–270.
- Diebel, L., 1965, Neue ostracodeen aus dem mittleren Muschalkalk von Gotha (Thur.): Abhandlungen Zurnal Geologisches Institute, v. 1, p. 223–255.
- Fang, J. T. and Xu, M. Y., 1981, Fossils from the Mesozoic coal-bearing strata of Hunan and Jiangxi, part I: Ostracodes: Coal Industry Press, Beijing, p. 30–37.
- Govindan, A., 1975, Jurassic freshwater ostracodes from the Kota Limestone of India: Paleontology, v. 10, p. 207–216.
- Harshbarger, J. W., Repenning, C. D. and Irwin, J. H., 1957, Stratigraphy of the uppermost Triassic and the Jurassic rocks of the Navajo Country: U.S. Geological Survey, Professional Paper 291, 73 p.
- Hoare, R. D., 1953, The ostracode genus *Metacypris* in North America [M.S. thesis]: Columbia, University of Missouri, 76 p.
- Hou, You Yang and Zhao, Yu-hong, 1988, A preliminary study on ornamentation and ultrastructure of Mesozoic and Cenozoic Ostracoda in China; in Hanai, T., Ikeya, N. and Iohizaki, K., eds., Evolutionary Biology of Ostracoda: New York, Elsevier, p. 235–242.
- Keyser, D., 1977, Ecology and zoogeography of recent brackish water Ostracoda (Crustacea) from southwest Florida; in Löffler, H. and Danielopol, D., eds., Aspects of ecology and zoogeography of recent and fossil Ostracoda: New York, D. W. Junk, p. 207–222.
- Kietzke, K. K., 1987, Calcareous microfossils from the Upper Triassic of north-eastern New Mexico: New Mexico Geological Society, Guidebook 38, p. 119–126.
- Kozur, H., 1968, Neue ostracodeen aus dem Rot und Muschelkalk des germanischen Binnenbeckens: Akademie der Wissenschaften (Berlin), Monatsberichte der Deutschen Akademie der Wissenschaften zur Berlin, v. 10, p. 498–519.
- Kocurek, G. and Dott, R. H., Jr., 1983, Jurassic paleogeography and paleoclimate of the central and southern Rocky Mountain region; in Reynolds, M. W. and Dolly, E. D., eds., Mesozoic paleogeography of west-central United States: Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, Denver, Colorado, p. 101–116.
- Liebau, A., 1977, Carapace ornamentation of the ostracode Cytheracea: principles of evolution and functional significance; in Löffler, H. and Danielopol, D. L., eds., Aspects of ecology and zoogeography of recent and fossil Ostracoda: New York, D. W. Junk, p. 107–120.
- Lucas, S. G., Kietzke, K. K. and Hunt, A. P., 1985, The Jurassic System in east-central New Mexico: New Mexico Geological Society, Guidebook 36, p. 213–242.
- McKenzie, K. G., 1986, Ostracoda: new aspects of their biogeography; in Gore, R. H. and Heck, K. L., Crustacean biogeography: Boston, A. A. Balkema, p. 257–277.
- Neale, J. W., 1988, Ostracodes and palaeosalinity reconstruction; in DeDecker, P., Colin, P. and Peyouquet, J.-P., Ostracoda in the earth sciences: New York, Elsevier, p. 125–155.
- Peck, R. E., 1941, Lower Cretaceous Rocky Mountain nonmarine microfossils: Journal of Paleontology, v. 15, p. 285–304.

- Pinto, I. D. and Sanguinetti, Y. T., 1958, *Bisulcoypris* a new Mesozoic genus and preliminary note about its relation with *Metacypris* and allied forms: Boletim da Sociedade Brasileira de Geologia, v. 7, no. 1, p. 75-90.
- Pinto, I. D. and Sanguinetti, Y. T., 1962, A complete revision of the Genera *Bisulcoypris* and *Theriosynoecum* (Ostracoda) with the world geographical and stratigraphical distribution (including *Metacypris*, *Elpidium*, *Gomphocythere*, and *Cytheridella*): Escola de Geologia de Porto Alegre, special publication no. 4, p. 1-165.
- Purper, I., 1974, *Cytheridella boldi* Purper, sp. nov. (Ostracoda) from Venezuela and a revision of the genus *Cytheridella* Daday, 1905: Ann. Acad. Brasil Ciencia, v. 46, p. 635-662.
- Qiqing, P., 1989, The Early-Middle Triassic stratigraphy and Ostracoda from Yima Area in Henan Province: Journal of Hebei College of Geology, v. 12, no. 3, p. 325-346 [in Chinese, English summary].
- Rapaport, I., Hadfield, J. P. and Olson, R. H., 1952, Jurassic rocks of the Zuni Uplift, New Mexico, USA: United States Atomic Energy Commission, RMO-642, p. 1-33.
- Ridgley, J. L. and Goldhaber, M., 1983, Isotopic evidence for a marine origin of the Todilto Limestone, north-central New Mexico: Geological Society of America, Abstracts with Programs, v. 15, p. 414.
- Schaeffer, B. and Patterson, C., 1984, Jurassic fishes from the western United States, with notes on Jurassic fish distribution: American Museum Novitates, no. 2796, 86 p.
- Schleifer, A. G., 1966, Ostracodes of the Lower Triassic Baskunchak Series of the Caspian Lowland and their stratigraphic importance: Moskova Institut Neftekhim: Gazovai Promyslemosti im Akademii I. M. Gubkiva, Trudy, no. 61, p. 112-139 [in Russian].
- Sohn, I. G., 1982, Dryelbidae n. fam. from continental Upper Jurassic and Lower Cretaceous rocks; in Bate, R. H., Robinson, E. and Sheppard, L. M., eds., Fossil and recent ostracodes: Ellis Harwood Ltd. and British Micropaleontological Society, p. 305-325.
- Swain, F. M., 1946, Middle Mesozoic nonmarine Ostracoda from Brazil and New Mexico: Journal of Paleontology, v. 20, p. 543-555.
- Swain, F. M., 1955, Ostracoda of San Antonio Bay, Texas: Journal of Paleontology, v. 29, p. 562-646.
- Swain, F. M., 1987, Some Oligocene and Miocene freshwater Ostracoda from central and southern Nevada and southwestern Texas: Revista Espanola de Micropaleontologia, v. 19, p. 413-448.
- Tanner, W. F., 1965, Upper Jurassic paleogeography of the Four Corners Region: Journal of Sedimentary Petrology, v. 35, p. 564-574.
- Tanner, W. F., 1970, Triassic-Jurassic lakes in New Mexico: Mountain Geologist, v. 7, p. 281-289.
- Tanner, W. F., 1974, History of Mesozoic lakes of northern New Mexico: New Mexico Geological Society, Guidebook 25, p. 219-223.
- Teeter, J. W., 1980, Ostracoda of the Lake Flint Formation (Pleistocene) of southern Florida: Micropaleontology, v. 26, p. 337-355.
- Victor, R., 1987, A new species of the genus *Cytheridella* (Crustacea, Ostracoda) from Nigeria, West Africa: Journal of Natural History, v. 2, p. 893-902.
- Vincelette, R. R. and Chittum, W. E., 1981, Exploration for oil accumulations in Entrada Sandstone, San Juan Basin, New Mexico: American Association of Petroleum Geologists Bulletin, v. 65, p. 2546-2570.
- Whatley, R. C., 1983, The application of Ostracoda to palaeoenvironmental analysis; in Maddocks, R. F., ed., Applications of Ostracoda, Proceedings of the eighth international symposium on Ostracoda, July 26-29, 1982: University of Houston, Texas, p. 51-77.
- Xu, Mao-Yu, 1988, Ostracodes from the Mesozoic coal-bearing strata of northern Shaanxi, China; in Hanai et al., eds., Evolutionary biology of Ostracoda: Elsevier, p. 1283-1291.

APPENDIX
MEASUREMENTS OF *CYTHERIDELLA TODILTOENSIS*
IN MICRONS

| Length | Height | Width | |
|--------|--------|-------|--------------------|
| 650 | 300 | — | Holotype* |
| 650 | — | 350 | Paratype* |
| 588 | 775 | 325 | Paratype* |
| 588 | 775 | 325 | |
| 525 | 275 | 300 | |
| 612 | 350 | 325 | |
| 500 | 325 | 350 | |
| 625 | 300 | 300 | |
| 625 | 338 | 400 | |
| 625 | 350 | 362 | |
| 712 | 375 | 425 | |
| 525 | 300 | 275 | |
| 562 | 325 | 250 | |
| 650 | 338 | 325 | |
| 538 | 325 | 288 | |
| 525 | 325 | 350 | |
| 550 | 325 | 275 | |
| 525 | 312 | 288 | |
| 600 | 300 | 288 | |
| 562 | 350 | 312 | |
| 638 | 325 | 400 | |
| 650 | 338 | 375 | |
| 200 | 112 | 112 | |
| 562 | 325 | 350 | |
| 625 | 325 | 375 | |
| 275 | 162 | 150 | |
| 225 | 138 | 138 | |
| 600 | 338 | 300 | |
| 545 | 306 | 305 | Mean |
| 128 | 68 | 78 | Standard Deviation |

Total Population

| | Length | Height | Width |
|--------------------|----------|---------|---------|
| Count | 25 | 25 | 25 |
| Sum | 13626 | 7651 | 7638 |
| Mean | 544.96 | 306.04 | 305.52 |
| Sem | 25.67 | 13.54 | 15.69 |
| Median | 562 | 325 | 312 |
| Variance | 16477.79 | 4583.96 | 6156.09 |
| Standard Deviation | 128.37 | 67.70 | 78.40 |
| Maximum | 712 | 375 | 425 |
| Minimum | 200 | 112 | 112 |
| Range | 512 | 263 | 313 |
| Skewness | -1.778 | -2.039 | -1.071 |
| Kurtosis | 2.747 | 3.483 | 1.131 |

Adults Only

| | Length | Height | Width |
|--------------------|---------|--------|---------|
| Count | 22 | 22 | 22 |
| Sum | 12924 | 7239 | 7238 |
| Mean | 587.45 | 329.04 | 329.00 |
| Sem | 11.54 | 5.04 | 9.97 |
| Median | 594 | 325 | 325 |
| Variance | 2928.07 | 558.81 | 2186.57 |
| Standard Deviation | 54.11 | 23.64 | 46.76 |
| Maximum | 712 | 375 | 425 |
| Minimum | 500 | 275 | 250 |
| Range | 212 | 100 | 175 |
| Skewness | 0.302 | -0.649 | 0.392 |
| Kurtosis | -0.415 | 0.636 | -0.655 |

*From Swain, 1946, not included in the statistical calculations.



Table Mesa southeast of Shiprock in morning light. The Upper Cretaceous Mancos Shale slopes are capped here by Point Lookout Sandstone. Photograph taken the morning of 12 April 1992. Copyright © Paul L. Sealey, 1992.