UPPER CRETACEOUS OSTRACODS FROM CALIFORNIA

by JOHN C. HOLDEN

ABSTRACT. A limited exposure of Upper Cretaceous marine siltstones and claystones near the coastal town of Carlsbad, California, contains a remarkably well-preserved microfauna.

Twenty-six species of ostracods including twenty-three new species and one new trachyleberid genus occur in the upper part of the section. This faunule possesses distinct Cenozoic affinities expressed by the presence of the genera *Trachyleberis*, *Actinocythereis*, and *Idiocythere*, all of which have previously been reported from rocks not older than Lower Tertiary. Generic affinities with European forms are also indicated by new species of *Idiocythere*, previously recorded only from the Eocene of Germany and *Isocythereis*, previously known only from the Cretaceous of Germany. Three species which also occur in Upper Cretaceous rocks of the U.S. Gulf Coast are present: *Brachycythere darensis* Swain 1952, *Krithe cushmani* Alexander 1929, and *Cytheropteron coryelli* Schmidt 1948.

AN extremely well-preserved Upper Cretaceous ostracod faunule occurs in the Rosario Formation as exposed about three miles east of Carlsbad, California. Ostracods, usually *Cytherella*, are sparse in most of the Rosario Formation but at Carlsbad are abundant with a wide diversity of species. A study of the foraminifera from this area was published by Bandy (1951), in which the fauna was correlated with Cretaceous faunas of the American Gulf Coast and with those of the Campanian stage of Europe.

The exposures near Carlsbad are only a small part of widespread coastal deposits of late Cretaceous age extending from below the type area near El Rosario, Baja California, 230 miles south of Carlsbad, to the Simi Hills, 113 miles north of Carlsbad. These rocks range through the Campanian and Maestrichtian stages, as used by Matsumoto (1959, p. 130; 1960, p. 69). At Point Loma about 1,800 feet of strata are exposed containing, in addition to ammonoids, a faunule having similarities to that of the upper part of the Rosario Formation at El Rosario and that of the upper parts of the Cretaceous sequence in the Santa Ana Mountains (Milow, pers. comm.). Matsumoto (1960, p. 69), on the basis of the included ammonoids, assigned an Upper Campanian to possible Lower Maestrichtian age to the Cretaceous sequence in the Simi Hills. There, as at Point Loma, faunistic similarities to the more southern exposures of the Rosario Formation are noted.

About 200 feet of unmetamorphosed sediments of Upper Cretaceous age overlying granitic rocks and dipping 3° north-west are exposed near Carlsbad. Near the base of the exposure directly overlying the granites, the Rosario Formation is composed of sandy siltstones and sandy claystones. Near the top, the lithology becomes progressively more clayey.

Lithologic character is an important factor in the preservation of the microfossils. The fauna with which this work is concerned was collected from the finer sediments near the top of the section, near the contact of the Rosario Formation with the overlying Lower Tertiary sedimentary rocks (text-fig. 2). From the middle to the base of the section, only a few leached foraminifera are evident.

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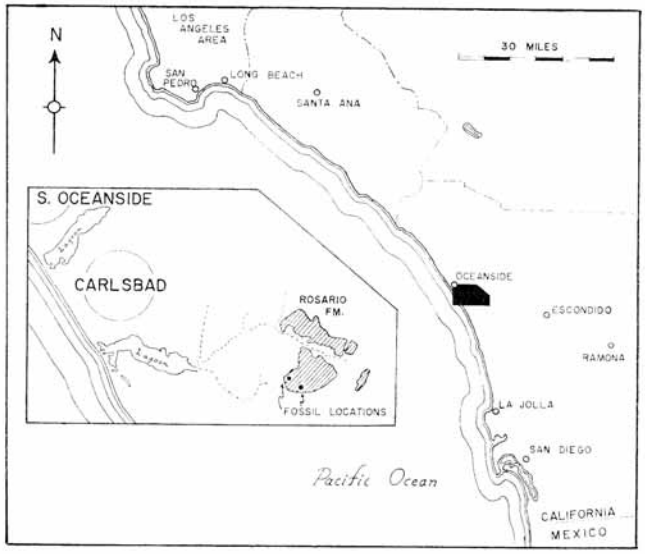
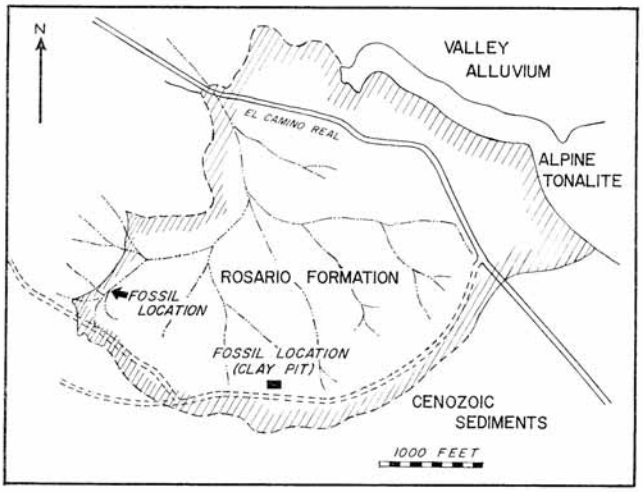


TEXT-FIG. 1. Distribution of the exposed Rosario Formation near Carlsbad, California. The coordinates of the fossil localities are 117° 20′ W. and 33° 07′ 08″ N.



TEXT-FIG. 2. Map showing locations of the two ostracod fossil localities. Edges of exposed Rosario Formation lined.

Ostracods were collected from two areas. The easternmost, a large clay pit about 100 feet square and 10 to 15 feet deep, is the most fossiliferous. Within the clay pit, a sequence 8 feet thick consisting of beds of brown silty claystone 1 to 3 feet thick, was sampled. A detailed stratigraphic analysis of the faunules represented in the individual beds of this exposure reveals no significant differences except in the abundance of fossils. The westernmost area is a deeply incised dry stream gully in which the rock types are the same as those of the clay pit. Several concretionary beds form ledges beneath which are found relatively unweathered and richly fossiliferous silty claystones. Because of their proximity, faunal similarities, and stratigraphic equivalence, these two areas are not dealt with independently.

Physiographically it appears that the sediments might have been deposited in a small coastal basin. Bordering on the east and north-east are topographically higher exposures of the Alpine (Green Valley) tonalite. A linear high of Lower Cretaceous metasediments (the Alisitos Formation) occurs to the north-west and south-west.

PALAEOECOLOGY

Tenuous palaeoecologic interpretations for the Cretaceous of the Carlsbad area were advanced by Bandy (1951, p. 490), based on the high relative abundances of rotaloid and planktonic foraminifera. With reservations, he suggested that the site of deposition may have been in the upper neritic zone.

The paucity of information concerning the ecologic requirements of living ostracods severely limits the evaluation of fossil assemblages, especially of those as ancient as the Rosario Formation. The meagre data that has been published in this realm involves mostly shallow water lagoonal and estuarine environments (e.g. Elofson 1941, Benson 1959, and Swain 1955), with the exception of the work by Curtis (1960) on ostracod biofacies in the Mississippi delta area, where faunas occurring to depths of 100 fathoms were studied.

Curtis recognized the following genera among others as characteristic of the 'open shelf, middle to outer neritic' zone: *Cytherella*, *Cytherelloidea*, *Paracypris*, *Argilloecia*, *Xestoleberis*, *Krithe*, *Cytheropteron*, and *Trachyleberis*. This group is well represented in the Rosario Formation with individuals of the following species composing about 70 per cent. of the entire assemblages: *Cytherella terminopunctata* sp. nov., *Cytherelloidea milowi* sp. nov., *Trachyleberis acuminata* sp. nov., *Actinocythereis allisoni* sp. nov. (considered here to be closely related to *Trachyleberis*), and *Xestoleberis minuta* sp. nov. Representatives of the other genera, though not abundant, are present.

This general similarity of Rosario and extant Gulf of Mexico faunas suggests that the ostracod-bearing rocks of the Carlsbad area were deposited in a middle or outer neritic environment. This environment in the Gulf of Mexico (Curtis 1960, p. 473) occurs at depths exceeding 15 fathoms, where the sediments are generally clays, rates of deposition are low, chlorinity is normal marine (19–20‰), and monthly temperature averages vary from 22° C. (at 30 fathoms) to 20° C. (at 50 fathoms). In relation to shallower areas, ostracod abundances are greater and the faunas contain more species.

Three genera, previously unreported from Cretaceous rocks, are present. These are: *Trachyleberis*, *Actinocythereis*, and *Idiocythere*. Species of *Idiocythere* have previously been recorded only from the Eocene of Europe. *Trachyleberis* and *Actinocythereis* are

known elsewhere to range from the Paleocene to Recent and Eocene to Recent respectively (Moore 1961, p. Q334).

Acknowledgements. The writer wishes to extend thanks to Messrs. Edwin C. Allison and E. Dean Milow (Geology Department, San Diego State College) for their guidance in various aspects of this study, and Mr. Edward Gooken, who also collected from the Carlsbad area and generously donated specimens. Thanks also are due to Dr. Erich Triebel (Natur-Museum of Senckenberg, Frankfurt) for information concerning the genera *Idiocythere* and *Platycosta*. The writer is greatly indebted to Dr. Richard S. Boardman (U.S. National Museum, Washington, D.C.), who generously loaned type specimens in his care, and Dr. Gregory I. Sohn (U.S. Geological Survey) for his co-operation. Professor Frederick M. Swain (Department of Geology, University of Minnesota) and Mr. Bruce Cameron (a graduate student at Stanford University) read the manuscript and offered many helpful suggestions.

The primary types are deposited at San Diego State College, San Diego, California, and are designated here by the prefix SDSC. Some secondary types are deposited at the U.S. National Museum, Washington, D.C., designated here by the prefix USNM.

SYSTEMATIC DESCRIPTIONS

Subclass OSTRACODA Latreille 1806
Order PODOCOPIDA G. W. Müller 1894
Suborder PLATYCOPINA Sars 1866
Family CYTHERELLIDAE Sars 1866
Genus CYTHERELLA Jones 1849

Cytherella terminopunctata sp. nov.

Text-fig. 3*a–d*

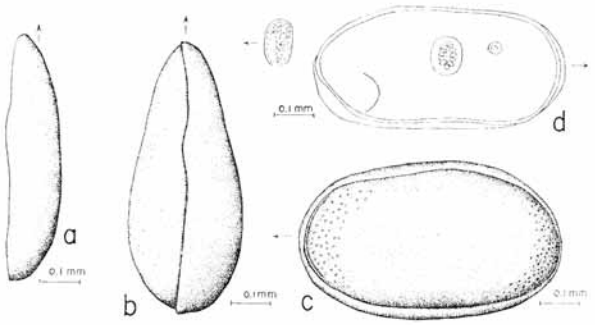
Diagnosis. Cytherella, terminally punctate with flattened or inwardly depressed postero-ventral margin in left valve, and ovate profile.

Description. Carapace massive; in profile highest just posterior to mid-length; right valve larger, completely overlapping left valve; right valve margins slightly convex giving carapace ovate shape; ventral and dorsal margins of left valve straight and almost parallel; postero-ventral margin of left valve flattened or depressed inwards. Dimorphism expressed in dorsal view by lenticular, shorter males, and anteriorly acuminate, posteriorly inflated females. Ornamentation, distinct when stained, of small pits on posterior and anterior parts of both valves.

Muscle scar pattern typical of genus but with prominent antero-dorsal doughnut-shaped mandibular(?) scar.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Paratype, SDSC 1 (right valve ♂)	0·64	0·36	0·15
Holotype, SDSC 2 (entire ♀)	0·65	0·40	0·27
Paratype, SDSC 3 (left valve ♀)	0·65	0·32	0·12
Paratype, USNM 131791 (entire ♀)	0·69	0·39	0·29

Discussion. C. terminopunctata is comparable with *C. fredericksburgensis* Alexander 1932 from the Albian of Texas but differs in having a pitted carapace and more evenly rounded dorsal margin. From a dorsal view this species closely resembles *C. ovoidea* Alexander 1929, although in lateral view the Rosario species is much more elongate. Next to *C. milowi* sp. nov., this species is most abundant at the Carlsbad locality.

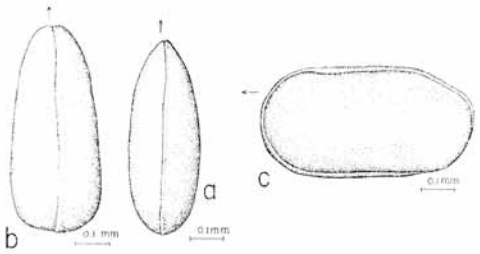


TEXT-FIG. 3. *Cytherella terminopunctata* sp. nov. *a*, Paratype, SDSC 1, dorsal view of male right valve. *b*, Paratype, USNM 131791, dorsal view of entire female carapace. *c*, Holotype, SDSC 2, external view of female left valve showing overreach of right valve. *d*, Paratype, SDSC 3, internal view of female left valve.

Cytherella elliotti sp. nov.

Text-fig. 4*a–c*

Diagnosis. Elongate, smooth *Cytherella*, with straight and parallel dorsal and ventral margins, obliquely sloping postero-dorsal margin, and nearly equal valves.



TEXT-FIG. 4. *Cytherella elliotti* sp. nov. *a*, Paratype, USNM 131792, dorsal view of entire male carapace. *b*, *c*, Holotype, SDSC 4; *b*, dorsal view of entire female carapace; *c*, lateral view of left valve showing overlap of right valve.

Description (based on two well-preserved entire carapaces, one male, one female). Carapace elongate in profile with length almost twice height; dorsal and ventral margins parallel, straight. Anterior margin of both sexes semicircular in outline; posterior margin evenly rounded ventrally, sloping about 30° antero-dorsally, giving carapace posterior sag. In dorsal view: male carapace lenticular, more pointed toward anterior; female carapace gently wedge-shaped toward anterior, thickest in rear. Valves nearly equal, thin, right valve narrowly overlapping left valve around entire margin; carapace smooth.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 4 (entire ♀)	0·59	0·32	0·21
Paratype, USNM 131792 (entire ♂)	0·64	0·33	0·26

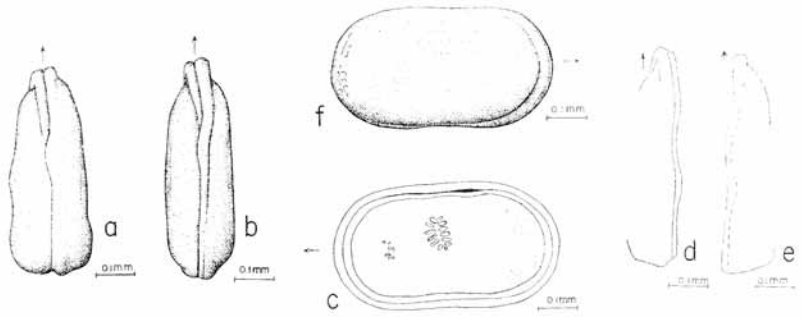
Discussion. This species is very similar to *C. ubaghsi* van Veen 1932, from the Maestrichtian of South Limburg, but the male of *C. ubaghsi* in dorsal view is more lenticular and less wedge-shaped, the inflations of the female do not extend beyond the posterior margin, and in lateral view the postero-dorsal slope is more pronounced than in *C. elliotti* sp. nov.

Genus CYTHERELLOIDEA Alexander 1929

Cytherelloidea milowi sp. nov.

Text-fig. 5*a–f*

Diagnosis. A *Cytherelloidea* characterized by pronounced marginal ridge, best developed anteriorly, subtle surface undulations, and large flange-like tooth in left valve with corresponding 'socket' in right valve.



TEXT-FIG. 5. *Cytherelloidea milowi* sp. nov. *a*, Holotype, SDSC 5, dorsal view of entire female carapace. *b*, Paratype, SDSC 6, dorsal view of entire male carapace. *c*, Paratype, SDSC 7, internal view of female right valve. *d*, *e*, Paratype, SDSC 8; *d*, dorsal hinge view of female left valve; *e*, dorsal hinge view of right valve. *f*, Paratype, USNM 131793, side view female right valve.

Description. In profile: dorsal margin straight, ventral margin slightly concave, posterior and anterior margins evenly rounded; wide longitudinal ridges faintly discernible on lateral surfaces—expressed as low undulations; some specimens finely pitted on posterior inflations; fine ornamentation of longitudinal lines also occasionally present; prominent smooth marginal ridge best developed anteriorly, present on both valves. Strong sexual dimorphism; females wedged-shaped, in dorsal view, due to two distinct posterior swellings in each valve; male carapace thinner, sides parallel.

Right valve overlapping left valve around entire margin; in dorsal view: left valve with projecting flange-like tooth just posterior to centre; right valve with accommodating 'socket'.

Muscle scar pattern typical for genus: adductor muscle scar field of about thirteen smaller scars, sometimes divided.

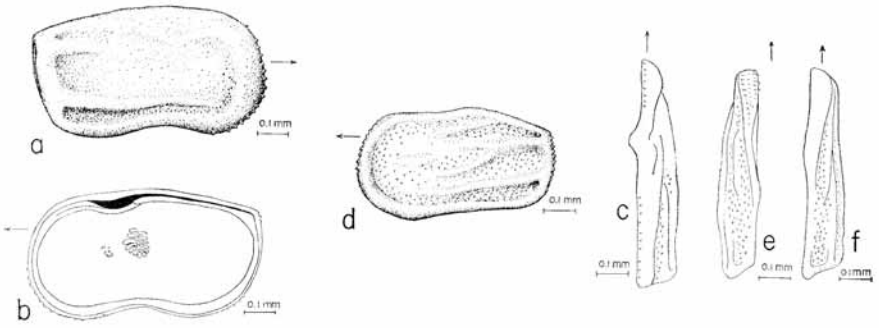
Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 5 (entire ♀)	0·57	0·32	0·22
Paratype, SDSC 6 (entire ♂)	0·57	0·32	0·17
Paratype, SDSC 7 (right valve ♀)	0·57	0·32	0·17
Paratype, SDSC 8 (left valve ♀)	0·55	0·31	0·13
Paratype, SDSC 8 (right valve ♀)	0·55	0·32	0·13
Paratype, USNM 131793 (right valve ♀)	0·57	0·32	0·12

Discussion. This species is a unique Cretaceous form, differing from most by the lack of well-developed ornamentation, yet having a conspicuous marginal ridge. *C. milowi* sp. nov. is very abundant in the Carlsbad area.

Cytherelloidea directiangula sp. nov.

Text-fig. 6*a–f*

Diagnosis. A *Cytherelloidea* with broadly rounded, wide-rimmed anterior margin and evenly spaced small marginal denticulations; ventrally trending longitudinal ridge arising from vertical posterior ridge, and fairly deeply concave ventral margin.



TEXT-FIG. 6. *Cytherelloidea directiangula* sp. nov. *a–c*, Holotype, SDSC 9; *a*, exterior view of adult right valve; *b*, internal view; *c*, dorsal view. *d*, *e*, Paratype, SDSC 10; *d*, exterior view of penultimate left valve; *e*, dorsal view. *f*, Paratype, USNM 131794, dorsal view of penultimate right valve.

Description. Right valve overlaps left around entire margin; dorsal margin broadly arched, ventral margin deeply concave; broad continual marginal ridge best developed posteriorly, joined posteriorly to two anteriorly attenuated longitudinal ridges; posterior cardinal angle sharply angled at about 90°. Adductor muscle scar depression virtually lacking except in younger instars where it may well be developed; surface densely pitted; ridges well developed. In penultimate instars surface less ridged; pits scarcer, larger than in adults.

Hingement of simple overlap except in mature individuals, in which part of right valve dorsum strongly projects with subjacent socket-like depression for reception of left valve.

Muscle scar pattern typical for genus: about thirteen smaller scars in two rows curving postero-ventrally. Additional scars located just anterior to adductor scar pattern.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 9 (right valve)	0·80	0·46	0·11
Paratype, SDSC 10 (left valve, young)	0·70	0·40	0·11
Paratype, USNM 131794 (right valve, young)	0·71	0·41	0·11

Discussion. This species resembles *C. biloculata* van Veen 1932, from the Maestrichtian of South Limburg, in the basic ornamentation of two longitudinal ridges arising from a vertical posterior ridge, the presence of an entire peripheral rim, and concave ventral margin. Strong, almost tooth-like antero-dorsal overlap by the right valve is also common to both. *C. biloculata*, however, lacks the sharp dorsal angle and large size of *C. directiangula*.

C. denticulata (Bosquet 1854), also from the Maestrichtian of South Limburg, resembles both the above species in their noted similarities and, like *C. directiangula*, has a 90° antero-dorsal margin and greater size. The Rosario Formation species differs from *C. denticulata* in the former's aberrant left valve and more sharply angled antero-ventral margin.

C. hieroglyphica (Bosquet 1852), from the Lower and Middle Eocene of France and Belgium (Keij 1957, pp. 47, 48), is apparently related to the Carlsbad species, as evidenced by the heavy antero-marginal rim, posterior truncation, pitted surface, and basically similar pattern of three lateral ridges. *C. directiangula* has a more arched dorsum and poorly developed lateral ridges in the anterior areas.

Suborder PODOCOPINA Sars 1866
Superfamily BAIRDIACEA Sars 1888
Family BAIRDIIDAE Sars 1888
Genus BAIRDOPPILATA Coryell, Sample and Jennings 1935

Bairdoppilata cretacea sp. nov.

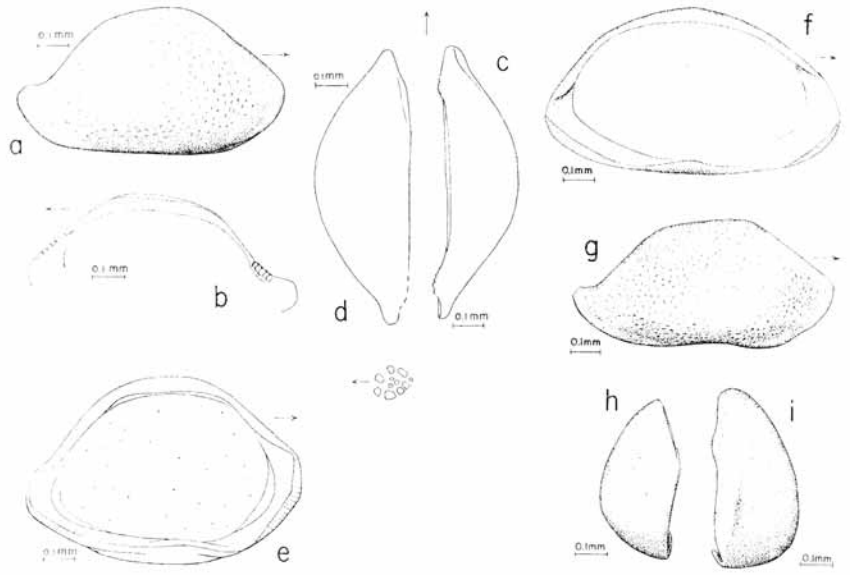
Text-fig. 7*a–i*

Diagnosis. A *Bairdoppilata* with relatively small, pitted, highly dimorphic carapace, and antero-ventral flange.

Description. Carapace relatively small, elongate; smaller right valve with long straight dorsal margin sloping posteriorly at about 10°, antero-dorsal and postero-dorsal margins equally long; pronounced upturned caudal process; straight to convex ventral margin curving up evenly at both ends; valve with conspicuous antero-ventral flange. Larger left valve with gently rounded dorsal margin and evenly convex ventral margin; strongly overlapping right valve along entire dorsal margin and at ventral inturned area. Greatest inflation in ventral area; laterally compressed at both ends in dorsal view; surfaces finely pitted.

Hingement typical for genus: terminal elements of right valve of five to six smaller teeth. Radial pore canals numerous, anterior and posterior vestibules present; normal

pores small, abundant. Adductor muscle scar pattern composed of circular pattern of eight smaller scars with three scars inside.



TEXT-FIG. 7. *Bairdoppilata cretacea* sp. nov. *a–c*, Holotype, SDSC 11; *a*, external view of male right valve; *b*, internal hinge view; *c*, dorsal view of right valve. *d*, *e*, Paratype, USNM 131796; *d*, dorsal view of male left valve; *e*, internal view of left valve. *f*, Paratype, SDSC 12, internal view of female left valve. *g*, Paratype, SDSC 13, external view of male right valve. *h*, Paratype, SDSC 14, anterior view of male right valve. *i*, Paratype, SDSC 15, anterior view of male left valve.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 11 (right valve ♂)	0·88	0·50	0·21
Paratype, SDSC 12 (left valve ♀)	0·92	0·56	0·27
Paratype, SDSC 13 (right valve ♂)	0·82	0·45	0·22
Paratype, SDSC 14 (right valve ♂)	0·87	0·45	0·24
Paratype, SDSC 15 (left valve ♂)	0·89	0·57	0·27
Paratype, USNM 131796 (left valve ♂)	0·92	0·65	0·31

Discussion. The shape in profile of this species is much like that of *B. magna* (Alexander 1927), from the Maestrichtian Navarro Formation of Texas, and *B. pondera* Jennings 1936, from the Maestrichtian(?) of New Jersey. *B. cretacea* differs from the former by being much smaller (0·92 mm. long as opposed to 1·40–1·50 mm.) and having a more posteriorly extended ventral margin. It differs from the latter by having a smaller, relatively longer carapace and a more elongate, flatter dorsal margin.

In shape this species is almost identical to *B. cretacea* van Veen 1936, differing only by having a pitted surface and somewhat flatter dorsal margin to the left valve.

Superfamily CYPRIDACEA Baird 1845
Family PARACYPRIDIDAE Sars 1923
Genus PARACYPRIS Sars 1866

Paracypris fragilis sp. nov.

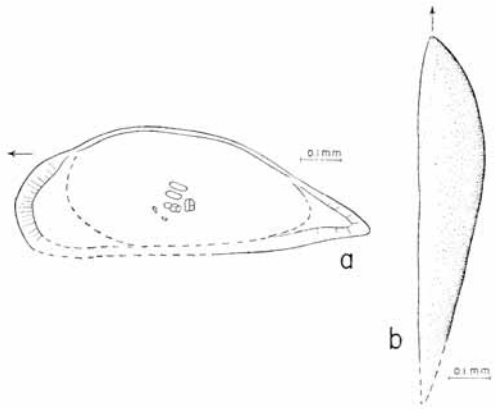
Text-fig. 8*a–b*

Diagnosis. A *Paracypris* with straight ventral margin, broadly arched dorsal margin, and posteriorly tapering carapace with slight concavity in antero-dorsal margin.

Description. Greatest width and height in anterior one-third of carapace; anterior margin broadly rounded and protruding, with depression in antero-dorsal margin; ventral margin straight to slightly concave; posterior sharply pointed both from side and dorsal view. Left valve overlapping right valve at antero-dorsal concavity, overlapping not pronounced.

Duplicature wide; vestibules well developed; radial pore canals numerous, short.

Adductor muscle scar pattern an almost perpendicular row of three scars: bottom scar faintly divided into three or four smaller scars, scar posterior to lowest scar also faintly divided; two small obliquely arranged antennal(?) scars located antero-ventral to adductor scar group.



TEXT-FIG. 8. *Paracypris fragilis* sp. nov. *a*, Holotype, SDSC 16, internal view of right valve. *b*, Paratype, USNM 131795, dorsal view of right valve.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 16 (right valve)	0·84	0·34	0·12
Paratype, USNM 131795 (right valve)	0·85	0·36	0·14

Discussion. The Rosario species is comparable in general shape to *P. goodlandensis* Howe and Laurencich 1958, from the Albian(?) of Texas and *P. acuta* (Cornuel 1848), from the Hauterivian to Aptian of France, but the latter is more slender. The description of the profile of the dorsal margin and position of greatest width of *P. goodlandensis* in Howe

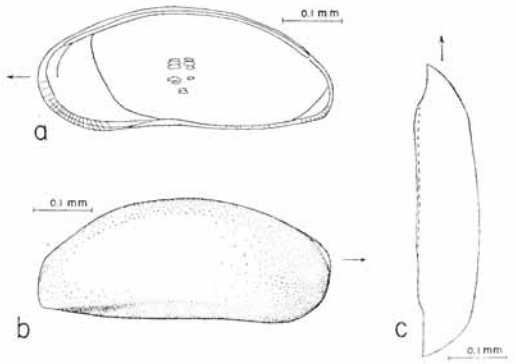
and Laurencich (1958, p. 448) also applies to *P. fragilis*, but the concave ventral margin, larger size, and slightly upturned posterior of *P. goodlandensis* distinguish it from the present species.

Family PONTOCYPRIDIDAE G. W. Müller 1894
Genus ARGILLOECIA Sars 1866

Argilloecia constricta sp. nov.

Text-fig. 9*a–c*

Diagnosis. An *Argilloecia* with conspicuously laterally flattened carapace, small antero-dorsal flange, large anterior vestibule, and adductor muscle scar boss of nine scars in two rows, with two ventrally adjacent mandibular scars.



TEXT-FIG. 9. *Argilloecia constricta* sp. nov. *a–c*, Holotype, SDSC 17; *a*, internal view of right valve; *b*, external view of right valve; *c*, dorsal view of right valve.

Description. Carapace small, smooth; shape distinctive of genus: mid-portion of valves conspicuously flattened; posterior margin truncated, ventral margin straight; dorsum arched; small flange developed at antero-dorsal angle.

Anterior vestibule large, posterior vestibule apparently small; duplicature narrow; radial pore canals fairly numerous, simple.

Hinge adont: dorsum of right valve modified to elongate smooth bar fitting into, and partially over, left valve.

Dimensions. Holotype, SDSC 17: length 0·50 mm.; height 0·21 mm.; width 0·1 mm. (single valve).

Discussion. An exact description of muscle scar pattern, vestibule, and the variability of this species is wanting for the lack of a sufficient number of specimens. No satisfactory comparisons can be made with known Cretaceous species of this genus. Unlike this and the type species, all recorded Cretaceous species lack the flattened mid-portions and are more tapered posteriorly.

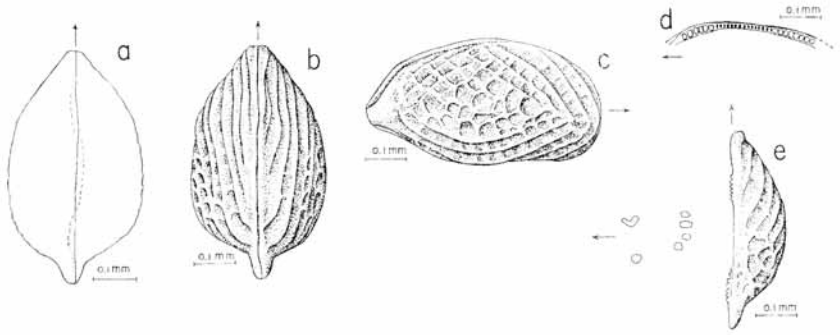
Superfamily CYTHERACEA Baird 1850
Family PROGNOCYTHERIDAE Sylvester-Bradley 1948
Genus NEOCYTHERE Mertens 1956
Subgenus PHYSOCYTHERE Kaye 1963

Neocythere (*Physocythere*) *fornicata* sp. nov.

Text-fig. 10*a–e*

Diagnosis. A *Neocythere* (*Physocythere*) with an arched dorsum; about five or six pronounced, anteriorly acutely-angled concentric lateral ridges; coarse reticulations, especially in middle regions of valves; and non-parallel, posteriorly convergent ventro-lateral ridges.

Description. The description is based on one entire adult specimen and several young. The hinge of the adult was observed with the aid of transmitted light (text-fig. 10*d*).



TEXT-FIG. 10. *Neocythere* (*Physocythere*) *fornicata* sp. nov. *a–c*, Holotype, SDSC 18; *a*, dorsal view showing dentition; *b*, ventral view; *c*, lateral view of right valve. *d*, Paratype, SDSC 19, hinge view. *e*, Paratype SDSC 20, dorsal view of right valve and muscle scar pattern; muscle scars not drawn to scale.

In profile: dorsal margin broadly arched; ventral margin straight; venter and dorsum convergent posteriorly to well-developed, low, caudal process. Surface deeply sculptured with five or six sub-concentric ridges that acutely converge in anterior; median two-thirds of valve coarsely reticulated. Left valve larger, overlapping right valve in cardinal areas and at caudal process, right valve overlapping left valve at ventral inturned area.

Hinge antimerodont: terminal cusps of right valve deeply notched with five or six teeth; median bar of right valve strongly crenulate; with supra-adjacent accommodation groove.

Adductor muscle scar pattern of four equal scars in curved line; V-shaped antennal scar anterior to top two adductor scars; single mandibular scar ventral to antennal scar. Duplicature narrow; small vestibules present.

Dimensions. Holotype, SDSC 18 (entire): length 0·57 mm.; height 0·30 mm.; width 0·32 mm.

Discussion. Kaye (1963) has clarified the *Neocythere* problem considerably by erecting three subgenera based on vagaries in dentition. The present species belongs to the subgenus *Physocythere* Kaye, because of its merodont hinge.

Kaye notes only one species of this subgenus with an arched dorsum, namely *Neocythere* (*Physocythere*) *semilaeva* Kaye 1963, from the Upper Albian of England. This feature is shared by the present species; however, *N.* (*P.*) *semilaeva* has weak ornamentation whereas in the Californian species it is strong. *N.* (*N.*) *sculpta* (Cornuel 1846), from the Barremian and Aptian of France and *N.* (*N.*) *vanveeni* Mertens 1956, from the Upper Albian of Germany, also have arched dorsa.

Unlike other neocytherids, the ridge pattern in the antero-lateral part of the carapace of this species is acutely angled, not rounded.

Family BRACHYCYTHERIDAE Puri 1954
Genus BRACHYCYTHERE Alexander 1933

Brachycythere darensis Swain 1952

Text-fig. 11*a–e*

1952 *Brachycythere darensis* Swain, p. 80, pl. 8, figs. 40, 41.
1957 *Brachycythere sphenoides* (Reuss); Butler and Jones, p. 27, pl. 3, fig. 1.
1958 *Brachycythere darensis* Swain; Howe and Laurencich, p. 86.

Diagnosis. A *Brachycythere* with heavily keeled and relatively posteriorly rounded carapace.

Description. In profile, dorsal margin of right valve highly and evenly arched above left valve; dorsal margin of left valve straight, sloping gently posteriorly and then more abruptly past the posterior cardinal angle; surface smooth, with small depressions coinciding with conspicuous normal pores. Long massive keel present, extending at lowest point to or below ventral margin, coincident with row of normal pores.

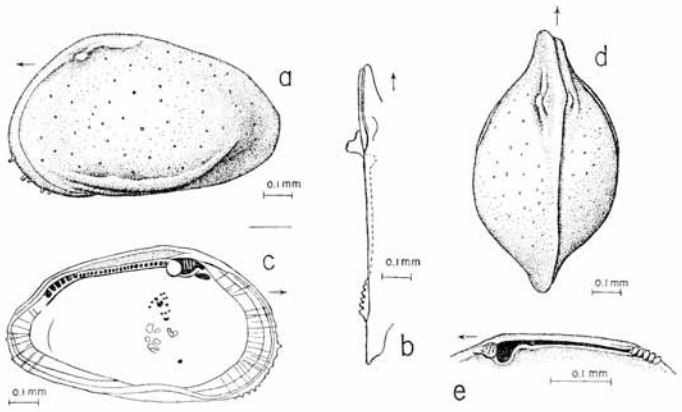
Hinge essentially hemiamphidont: anterior tooth of right valve stepped, posterior part faintly grooved into four ridges; posterior element of right valve coarsely grooved into five or six smaller teeth.

Adductor muscle scar pattern basically of four in a row; top two scars divided into four, bottom two scars fused into one; V-shaped antennal scar immediately anterior to highest adductor scars; many small mandibular scars above adductor group; single mandibular scar antero-ventral to adductor group. Marginal areas without vestibules; radial pore canals abundant, wavy, with tendency to be paired in posterior area.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Plesiotype, SDSC 21 (entire)	0·92	0·59	0·50
Plesiotype, SDSC 22 (right valve)	1·00	0·55	0·35
Plesiotype, SDSC 23 (left valve)	0·93	0·57	0·30
Plesiotype, SDSC 24 (right valve)	0·91	0·53	0·29
Plesiotype, USNM 131797 (entire)	0·92	0·57	0·54

Discussion. The description of the species by Swain (1952, p. 80) does not include a consideration of the internal features. The preservation of those from Carlsbad is excellent, and allows scrutiny of the finest internal details.

Slight differences exist between *B. darensis* from the Upper Cretaceous of North Carolina and individuals from Carlsbad, California. Of the sixteen specimens collected from the Carlsbad area none were as large as the holotype (length 1·04 mm., height 0·72 mm., width 0·61 mm.); also, the carapace is slightly more pointed posteriorly than in the holotype, though not as much as *B. sphenoides* (Reuss 1854).



TEXT-FIG. 11. *Brachycythere darensis* Swain 1952. *a*, Plesiotype, SDSC 21, left valve of entire specimen. *b*, Plesiotype, SDSC 22, dorsal hinge view of right valve. *c*, Plesiotype, SDSC 23, internal view of left valve, adductor and antennal scars in white. *d*, Plesiotype, USNM 131797, dorsal view of entire carapace. *e*, Plesiotype, SDSC 24, internal hinge view of right valve.

B. sphenoides (Reuss) of Butler and Jones (1957), from the Lower Maestrichtian(?) of Louisiana, is also included in the synonomy on the basis of their illustration. It appears more like *B. darensis*, as described by Swain and those from Carlsbad, than *B. sphenoides* (Reuss).

Family CYTHERIDEIDAE Sars 1925
Subfamily KRITHINAE Mandelstam *in* Bubikan 1958
Genus KRITHE Brady, Crosskey, and Robertson 1874

Krithe cushmani carlsbadensis subsp. nov.

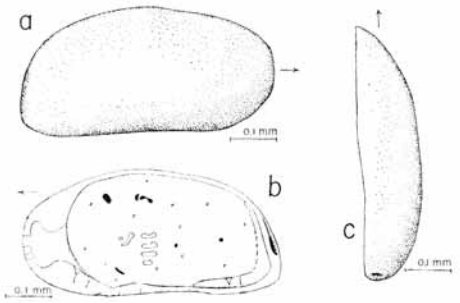
Text-fig. 12*a–c*

Diagnosis. Like *Krithe cushmani* Alexander 1929, from the Campanian-Santonian of Texas, but with blunter postero-ventral margin, more oblique antero-ventral margin, straighter slightly concave ventral margin, and smaller carapace.

Description (based on an excellently preserved right valve and one broken specimen). In profile: dorsal margin broadly arched, ventral margin evenly and gently concave, anterior margin sharply truncated, in dorsal view mid-portion of carapace somewhat flattened, evenly inflated; surface smooth; normal pores few and large.

Dentition typical for genus. Adductor muscle scar pattern a vertical row of four large elongate scars; irregular pair of antennal scars anterior to top two adductor scars; elongate mandibular scar below antennal scars near ventral margin; three irregular mandibular scars in dorsal region.

Anterior vestibule large, radial pore canals fairly sparse; normal pores sparse, large.



TEXT-FIG. 12. *Krithe cushmani carlsbadensis* subsp. nov. *a–c*, Holotype, SDSC 25; *a*, external view of female right valve; *b*, internal view, antennal and adductor scars white, posterior vestibule broken; *c*, dorsal view.

Dimensions. Holotype, SDSC 25 (right valve): length 0·53 mm.; height 0·28 mm.; width 0·13 mm.

Discussion. K. bartonensis (Jones 1857, p. 85) from the Upper Eocene (Bartonian) of the Netherlands, Belgium, and England, has a less truncated posterior, concave venter, and single antennal scar. Otherwise it is similar to *K. cushmani carlsbadensis*. This species is rare in the Carlsbad area.

Family CYTHERURIDAE G. W. Müller 1894
Genus CYTHERURA Sars 1866

Cytherura(?) *divaricata* sp. nov.

Text-fig. 13*a–e*

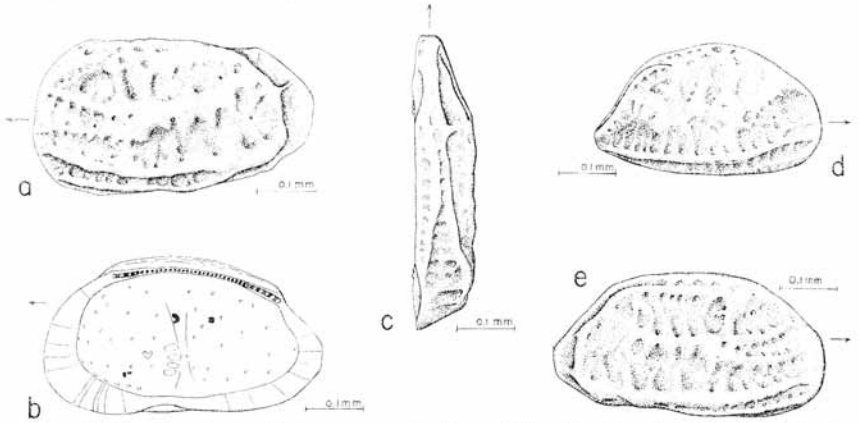
Diagnosis. A *Cytherura*(?) with heavy central lateral ridge dividing into three smaller ridges at weak sub-central tubercle; weak dentition, and pronounced inequivalved carapace.

Description. Adult shell heavy: valves unequal, right valve much higher and overlapping left along mid-dorsum; left valve strongly overlapping right at antero-dorsal and postero-dorsal margins, and at sharply inturned ventral area; dorsal margin of left valve straight; left valve subquadrate in profile, right valve sloping sharply at antero-dorsal and postero-dorsal margins; heavy marginal ridges along dorsum and venter and around posterior. Ventral lateral ridge bifurcating: topmost ridge largest—especially apparent in penultimate instars; median ridge continuous from marginal ridge at postero-dorsal area, running obliquely to fairly well-defined sub-central tubercle and

there dividing into three smaller outwardly radiating ridges; large externally conspicuous normal pores in deep depressions along ridges.

Hinge weak antimerodont: left valve with terminal tooth plates grading into more finely crenulate groove; teeth barely projecting from valve in dorsal view; no vestibules present; radial pore canals sparse, wavy; normal pores large, sparse.

Four sub-rectangular adductor muscle scars located on edge of faint vertical ridge, upward opened V-shaped antennal scar anterior to adductor scars; mandibular scars above, and antero-ventral to, adductor scars.



TEXT-FIG. 13. *Cytherura* (?) *divaricata* sp. nov. *a*, Holotype, SDSC 26, external view of adult left valve. *b*, Paratype, SDSC 27, interior view of adult right valve, adductor and 'V'-shaped antennal scars white. *c*, Paratype, USNM 131798, dorsal view of adult right valve showing weak antimerodont dentition. *d*, Paratype, USNM 131799, external view of probable penultimate right valve showing well-developed caudal process. *e*, Paratype, SDSC 28, external view of adult right valve.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 26 (left valve)	0·47	0·26	0·15
Paratype, SDSC 27 (right valve)	0·52	0·27	0·11
Paratype, SDSC 28 (right valve)	0·47	0·26	0·12
Paratype, USNM 131799 (young right valve)	0·37	0·22	0·09
Paratype, USNM 131798 (right valve)	0·48	0·27	0·10

Discussion. Though the basic pattern of ornamentation is the same, as are the muscle scar patterns and hinge, the presumably penultimate instars have a much more posteriorly pointed carapace than the adults. They are considered young because of their fragile shell, lack of well-developed duplicature, and smaller size.

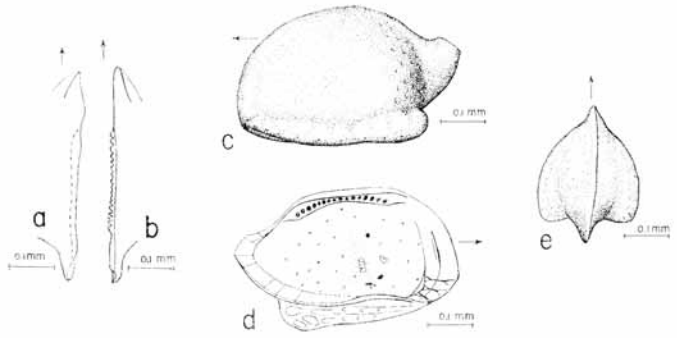
This species is apparently a member of the '*Cytherura*(?)' group as recognized by Howe and Laurencich (1958, pp. 309–16), including *C.*(?) *astriata*, *C.*(?) *bemelenensis*, *C.*(?) *crassistriata*, and *C.*(?) *tenuistriata*, all of van Veen 1936, from the Maestrichtian of South Limburg. Shape, ornamentation, and lack of a well-developed caudal process indicate the need for a new generic name for these species. Of the above group the Rosario Formation species most closely resembles *C.*(?) *bemelenensis*. The others differ in the nature of their lateral ridge complexes in the posterior region.

Genus CYTHEROPTERON Sars 1866

Cytheropteron coryelli carlsbadensis subsp. nov.

Text-fig. 14*a–e*

Diagnosis. This subspecies is distinguished from *Cytheropteron coryelli* Schmidt 1948 by its smaller size, faintly pitted posterior, and more pronounced, less differentiated median bar in the right valve.



TEXT-FIG. 14. *Cytheropteron coryelli carlsbadensis* subsp. nov. *a*, *c*, *d*, Holotype, SDSC 29; *a*, dorsal hinge view of adult left valve; *c*, external view showing pitted posterior; *d*, internal view, adductor and antennal scars in white. *b*, Paratype, SDSC 30, dorsal hinge view of adult right valve. *e*, Paratype, SDSC 31, dorsal view of entire young form.

Description. Schmidt (1948, p. 413) states: 'in dorsal view resembles triangular arrowhead. . . . Posterior margin narrow, tapering, with dorsally curving caudal process in center. . . . faint suggestion of median sulcus. Ventral wings strongly developed, with compressed outer margins. . . .'

Hinge weak holomerodont, almost prionodont; posterior surface faintly punctate; four closely spaced adductor muscle scars located on slight vertical median ridge; V-shaped antennal scar posterior to top adductor scars; mandibular scars also on median ridge above and below adductor scars; anterior duplicature wide with small low vestibule and few large bifurcating radial pore canals; sparse, simple, posterior radial pore canals.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 29 (left valve, adult)	0·56	0·24	0·22
Paratype, SDSC 30 (right valve, broken)	0·56	—	—
Paratype, SDSC 31 (entire, young)	0·35	0·22	0·25

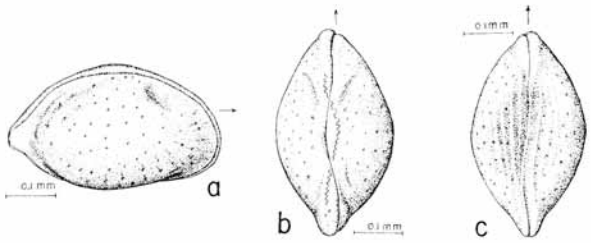
Discussion. The Carlsbad specimens, in shape and sulcation, more nearly resemble *C. coryelli* than *C. navarroense*, which are treated as synonyms by Howe and Laurencich (1958, p. 303). Alexander (1929, p. 105) mentions no sulcus in the description of *C. navarroense*, and his figures do not show the pronounced posteriorly projecting alae of *C. coryelli* Schmidt (1948, p. 413) and those dealt with here. These appear to be two distinct species.

Genus EOCYTHEROPTERON Alexander 1933

Eocytheropteron turgidulum sp. nov.

Text-fig. 15*a–c*

Diagnosis. An *Eocytheropteron* with short, central caudal process; strong left valve dorsal overlap; oblique, short antero-dorsal sulcus; thickened margins.



TEXT-FIG. 15. *Eocytheropteron turgidulum* sp. nov. *a–c*, Holotype, SDSC 32; *a*, external view of right valve showing overlap of left valve; *b*, dorsal view of entire carapace showing hinge structure; *c*, ventral view of entire carapace.

Description. In dorsal view carapace relatively compressed for genus, tapering equally anteriorly and posteriorly; left valve overlapping right valve around entire margin, best developed dorsally and postero-dorsally; caudal process of left valve short, straight, medially located, completely overlapped around margins by left valve; anterior and posterior margins with poorly developed, massive, peripheral rims; postero-dorsal area sculptured with few discontinuous concentric ridges; venter with about four narrow, parallel ridges in each valve; deep, short, oblique, antero-dorsal sulcus present.

Hinge antimerodont: terminal elements with about five or six equal sized crenulations, median bar coarsely crenulate.

Dimensions. Holotype, SDSC 32 (entire): length 0·42 mm.; height 0·25 mm.; width 0·24 mm.

Discussion. Though only one specimen was found, almost perfect preservation allows specific description.

This species is undoubtedly related to the smooth, dorsally sulcated eocytheropterids of Alexander (1933) and Swain (1952) from the Aptian and Albian of the Gulf Coast. Of this group *E. semiconstrictum* Alexander 1933 appears most similar to this species, but differs in having a higher left valve in relation to the right, a more upturned caudal process, and a larger carapace.

Genus EUCYTHERURA G. W. Müller 1894

Eucytherura versabilis sp. nov.

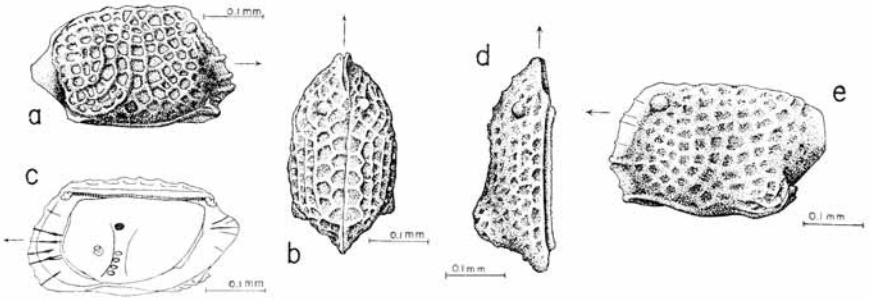
Text-fig. 16*a–e*

Diagnosis. A small inflated *Eucytherura* with about eight to ten reticulations from venter to dorsum; well-developed, medially located caudal process; very weak dentition; convex dorsal margin.

Description. Carapace inflated in dorsal view; small alae usually present. In profile: dorsal margin slightly convex; anterior margin obliquely sloping towards antero-ventral area, transected by four to five short horizontal ridges; posterior margin with medially located unornamented caudal process; surface sculptured with deep reticulations; median sulcus faint, eye tubercles prominent, ocular sinus large.

Dentition antimerodont: small terminal teeth of right valve faintly divided into three smaller teeth; narrow median groove crenulate, irregular.

Duplicature moderately wide: radial pore canals enlarged, sometimes bifurcating, sparse; very shallow posterior and anterior vestibules present. Muscle scar pattern of four ventrally located adductor scars on edge of median ridge; two antennal scars anterior to the uppermost adductor scar, large mandibular scar located on median ridge above adductor scars.



TEXT-FIG. 16. *Eucytherura versabilis* sp. nov. *a*, Paratype, USNM 131800, external view of female right valve. *b*, Holotype, SDSC 33, dorsal view of entire female. *c*, Paratype, SDSC 34, internal view of female right valve, showing adductor and mandibular scars in white. *d*, *e*, Paratype, SDSC 35; *d*, dorsal view of male(?) left valve; *e*, side view of left valve.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 33 (entire ♀?)	0·35	0·21	0·20
Paratype, USNM 131800 (right valve ♀?)	0·34	0·21	0·11
Paratype, SDSC 34 (right valve ♀?)	0·35	0·21	0·11
Paratype, SDSC 35 (left valve ♂?)	0·36	0·22	0·14

Discussion. In both dorsal view and profile this species is similar to *E. cretacea* van Veen 1936, from the Maestrichtian of South Limburg, Netherlands. Also as in that species the dentition is tending towards amphidont in some specimens as a result of thickening of the anterior end of the median bar; however, the dorsal margin is not straight and the carapace is only slightly sulcate.

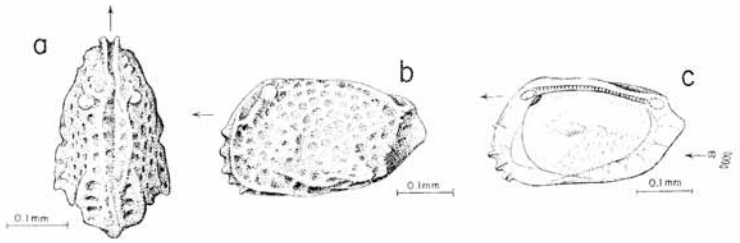
Of the North American species of *Eucytherura*, *E. stephensoni* Weingeist 1949 is most similar in general shape, but as with other Cretaceous species of this genus, its dorsal margin is straighter than that of the new species.

Sexual dimorphism: in both forms the carapace is greatly inflated; however, in a very few specimens, in lieu of the small postero-ventral alae, the carapace is extended by a conspicuous knob.

Eucytherura planolata sp. nov.

Text-fig. 17*a–c*

Diagnosis. An *Eucytherura* with flat sides broadening ventrally; wide postero-dorsal area; very faint anterior muscle scar tubercle; and narrow ventral ridge continuing up the anterior margin.



TEXT-FIG. 17. *Eucytherura planolata* sp. nov. *a*, *b*, Holotype, SDSC 36; *a*, dorsal view of entire male (?) carapace; *b*, side view of left valve. *c*, Paratype, SDSC 37; internal view of female(?) right valve.

Description. Carapace flattened on sides, broadening ventrally. In profile: anterior margin blunt, with maximum of five heavy denticulations confined to ventral-most part; dorsal margin slightly convex, sub-parallel with slightly convex ventral margin; posterior compressed (beneath broad postero-dorsum); narrow ventral ridge from mid-venter, along ventral margin, part way up anterior margin; pointed alae of two short, oblique ridges. Surface reticulate; eye tubercles present, with heavy, ventrally connected short ridges; carapace faintly sulcate; indistinct muscle tubercle present; dimorphism not observed.

Dentition antimerodont; terminal elements faintly divided, small, sub-hemispherical; median bar of left valve crenulate, wavy.

Adductor muscle scar pattern of four equal oblong scars; two equal antennal scars anterior to uppermost adductor scars. Anterior vestibule deep in ventral part of anterior margin, posterior vestibule shallow; radial pore canals diverging, coarse in antero-ventral region.

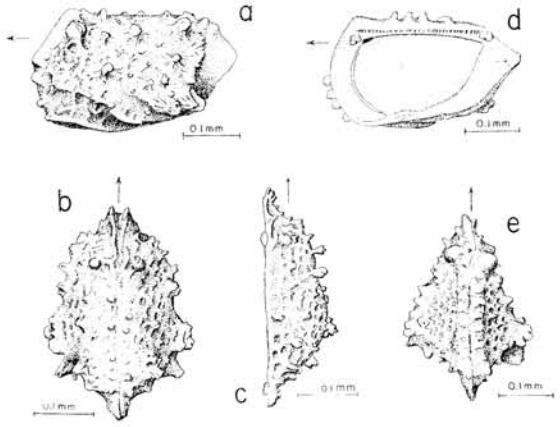
Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 36 (entire ♂?)	0·37	0·19	0·11
Paratype, SDSC 37 (right valve ♀?)	0·35	0·20	0·10

Discussion. E. planolata sp. nov. bears no affinities with known Gulf Coast or European Eocene—Cretaceous eucytherurids, differing from all especially by the presence of the flattened postero-dorsal region, the oblique ventral ridges, and the antero-ventral marginal ridge. *E. bakeri* Hornibrook 1953, from the Middle and Upper Oligocene of New Zealand, exhibits perfectly the antero-ventral marginal ridge and is very similar to, though not conspecific with, this species.

Eucytherura spinata sp. nov.

Text-fig. 18*a–e*

Diagnosis. A highly dimorphic *Eucytherura* with postero-ventral alae of two complex spines, and combined reticulate and heavily spinose ornamentation.



TEXT-FIG. 18. *Eucytherura spinata* sp. nov. *a*, *b*, Holotype, SDSC 38; *a*, side view of the left valve of entire female carapace; *b*, dorsal view of carapace. *c*, Paratype, SDSC 39, dorsal view of female right valve. *d*, Paratype, SDSC 40, internal view of female right valve. *e*, Paratype, SDSC 41, dorsal view of entire male carapace.

Description. Carapace subquadrate. In profile: dorsal margin straight, appearing denticulate with several high spines; ventral margin straight to slightly convex; anterior margin blunt with four or five moderately heavy denticulations in ventral half; posterior margin with high caudal process; surfaces heavily spinose and reticulate, postero-ventral alae usually terminating in two large, often complex, spines; narrow sinuous ventral ridge from lowermost anterior denticulation to mid-venter; poorly developed, irregular ventro-lateral ridge from mid-anterior spine to postero-venter. Dimorphism pronounced. In dorsal view: more abundant females highly inflated (with rounded dorsum); males thin, flat sided, with narrow dorsum, inequivalved, with eye tubercle and alae of right valve more posterior than in left valve; same postero-ventral width as females.

Hinge antimerodont: small terminal elements of right valve faintly divided into three; median bar of left valve crenulate. Anterior vestibule narrow; radial pore canals indistinct owing to obscuring heavy exterior ornamentation; normal pores grouped within reticulations.

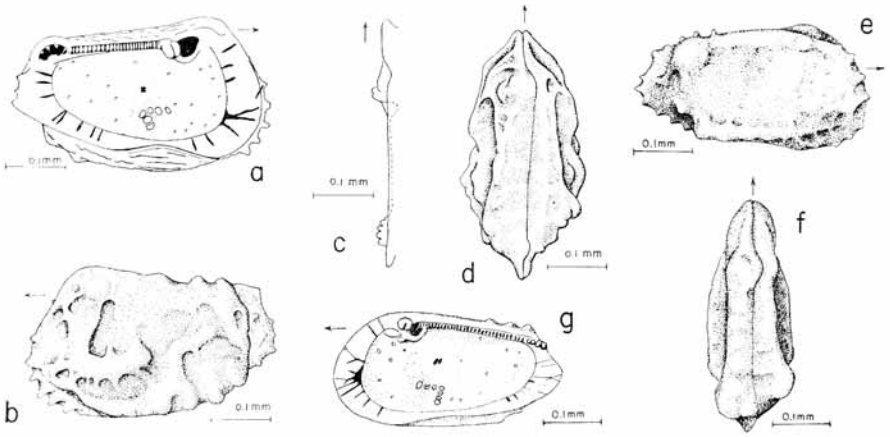
Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 38 (entire ♀)	0·38	0·22	0·26
Paratype, SDSC 39 (right valve ♀)	0·38	0·21	0·15
Paratype, SDSC 40 (right valve ♀)	0·36	0·21	0·13
Paratype, SDSC 41 (entire ♂)	0·34	0·20	0·24

Discussion. In profile this species is best compared with *E. cretacea* van Veen 1936, from the Maestrichtian of South Limburg, which also has a straight dorsum, denticulate truncate anterior margin, subquadrate shape in profile, and sharp pronounced alae. *E. cretacea*, however, is not spinose.

Family SCHIZOCYTHERIDAE Howe 1961
Genus AMPHICYTHERURA Butler and Jones 1957

Amphicytherura iniqua sp. nov.

Text-fig. 19*a–g*



TEXT-FIG. 19. *Amphicytherura iniqua* sp. nov. *a*, Holotype, SDSC 44, internal view of adult left valve. *b*, *d*, Paratype, USNM 131802; *b*, external view of left valve of entire adult; *d*, dorsal view showing unequal valves. *c*, Paratype, SDSC 45, dorsal hinge view of adult female right valve. *e*, *f*, Paratype, SDSC 46; *e*, external view of right valve of adult entire male carapace; *f*, dorsal view of entire carapace. *g*, Paratype, SDSC 47, internal view of adult male right valve, mandibular scars black.

Diagnosis. A highly dimorphic *Amphicytherura* with pronounced postero-dorsal swelling in right valve, medially interrupted centro-lateral ridge upturning abruptly near anterior margin; carapace small.

Description. Female carapace wedge-shaped in profile: dorsal margin straight to slightly concave upward; ventral margin dominated by massive, discontinuous ridge extending around posterior up to broad dorsal ridge; median ridge usually discontinuous in middle of shell owing to development of inconspicuous sulcus, but well-developed anteriorly where it turns up about 45° beneath low eye tubercle; posterior caudal-like process laterally compressed. Valves unequal: right valve with knob-like outward extension of posterior portion of dorsal ridge, left valve overlapping right valve at sockets and inturned portion on venter; ocular sinuses large, eye tubercles broad. Male carapace much lower in height; considerably less ornamented in lateral regions, median ridge completely lacking except toward far anterior; dorsal ridge more pronounced; carapace laterally compressed.

Hinge schizodont: anterior tooth bifid, bar of left valve coarsely crenulate with anterior bifid tooth, posterior tooth of right valve notched forming four or five smaller teeth, dentition somewhat weaker in males.

Small confined anterior vestibule present with several large radial pore canals emanating from it; thin bifurcating radial pore canals also present. Normal pores large but sparse. Adductor muscle scars four in row on edge of slight ridge, top scar situated just anterior and dorsal to next lowest scar; two mandibular scars just ventral to top adductor scar; two oval antennal scars located directly dorsal to adductor scars.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 44 (left valve ♀)	0·40	0·25	0·13
Paratype, SDSC 45 (right valve ♀)	0·39	0·22	0·12
Paratype, USNM 131802 (entire ♀)	0·41	0·24	0·21
Paratype, SDSC 46 (entire ♂)	0·40	0·21	0·15
Paratype, SDSC 47 (right valve ♂)	0·37	0·18	0·09
Paratype, SDSC 47 (left valve ♂)	0·38	0·19	0·07

Discussion. Penultimate instars have the same proportions and diagnostic features as adults, save for a well-developed antimerodont hinge. Both male and female pre-adult instars found.

The female of this species is very similar in many external respects to *A. limburgensis* Howe and Laurencich 1958, from the Maestrichtian of South Limburg, Netherlands. It differs in having its greatest height at the far anterior end, typically shows an external sulcus, and has a well-developed schizodont hinge.

Genus PAIJENBORCHELLA Kingma 1948

Paijenborchella pseudotrigona sp. nov.

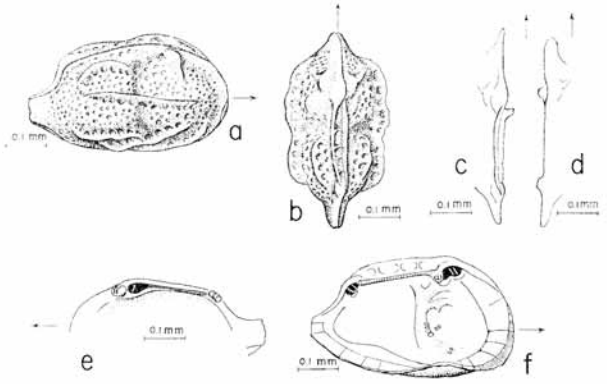
Text-fig. 20*a–f*

Diagnosis. A *Paijenborchella* with stout subquadrate carapace; three narrow ridges in ventral area, one medially and one short ridge dorsally on posterior lobe.

Description. Carapace stout, subquadrate in profile and dorsal view; caudal process located slightly below middle, surface ornamented with deep, variously sized pits, and sharp narrow ridges. Three longitudinal ridges lie in the ventral area, an additional one medially, and a fifth dorsally on posterior lobe. Left valve higher than right valve, with narrow dorsal ridge connected to eye tubercle; left valve overlapping right valve in cardinal areas and mid-ventrally; carapace divided by deep vertical sulcus; eye tubercles with an oblique short ridge pointing antero-ventrally.

Hinge schizodont: anterior element of right valve sometimes more than once divided; posterior tooth trilobed; left valve with crenulate bar and projecting, narrow, bifid anterior tooth.

Muscle scar pattern of four adductors in row on side of median ridge with two mandibular scars medially and anterior to them; two antennal scars low in antero-ventral area. No vestibules present; radial pore canals sparse.



TEXT-FIG. 20. *Paijenborchella pseudotrigona* sp. nov. *a*, *b*, Holotype, SDSC 48; *a*, external view of right valve showing overlap by left valve; *b*, dorsal view of entire carapace. *c*, *f*, Paratype, USNM 131803; *c*, dorsal hinge view of adult left valve; *f*, internal view, mandibular scars in black. *d*, Paratype, SDSC 49, dorsal hinge view of adult right valve. *e*, Paratype, SDSC 50, internal hinge of adult right valve.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 48 (entire ♀?)	0·50	0·30	0·25
Paratype, USNM 131803 (left valve ♀?)	0·50	0·30	0·15
Paratype, SDSC 49 (right valve ♀?)	0·47	0·25	0·13
Paratype, SDSC 50 (right valve ♀?)	0·49	0·29	0·14

Discussion. This is the second recorded species of *Paijenborchella* collected from Cretaceous rocks. The other, *P. marssoni* Treibel 1949, from the Senonian of Rügen, Germany, differs from this species in having a longer caudal process, poorly developed median ridge, no short dorsal ridge, smooth carapace, and an elongate posterior tooth.

P. trigona Marianos and Valentine 1958, from the Eocene of Marysville Buttes, California, closely resembles this species in robust shape, ornamentation, placement of the lateral ridges, and marked dimorphism. Here, as in Marianos and Valentine's work, the much more abundant short form is illustrated (text-fig. 20).

Family TRACHYLEBERIDIDAE Sylvester-Bradley 1948
Genus TRACHYLEBERIS Brady 1898

Trachyleberis acuminata sp. nov.

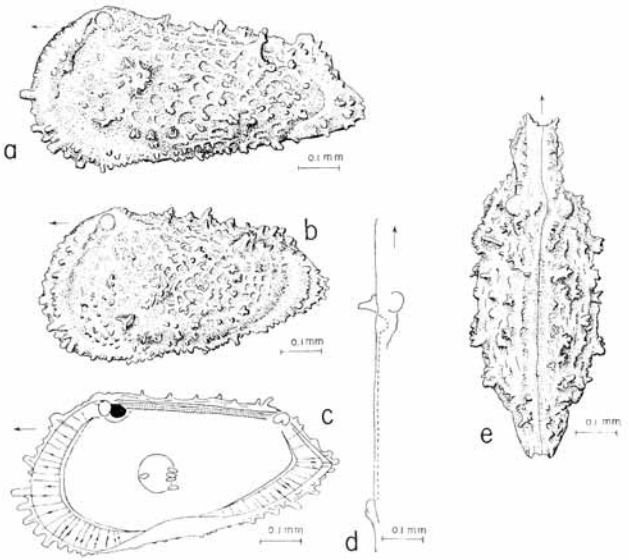
Text-fig. 21*a–e*

Diagnosis. A *Trachyleberis* with acuminate carapace; ornamentation of dense reticulations and spines; ventrally notched posterior tooth in right valve.

Description. Ventral and dorsal margins straight, tapering posteriorly giving carapace pronounced wedge shape; left valve overlapping right at antero-dorsal angle and in ventral inturned area; otherwise, valves equal; eye tubercle glassy, conspicuous; combination of reticulation and spines gives sugary texture.

Dentition holamphidont: right valve with narrow stepped projecting anterior tooth with postjacent socket and crenulate groove; posterior terminal tooth blunt, ventrally notched; left valve with complementary dentition including small knob beneath posterior socket to accommodate notched tooth of right valve.

Radial pore canals numerous, commonly with small median enlargements. Adductor muscle scar pattern on edge of internal pit, lowermost scar separated from other three; anterior heart-shaped antennal scar deep within pit. Dimorphism reflected in longer male carapaces.



TEXT-FIG. 21. *Trachyleberis acuminata* sp. nov. *a*, Holotype, SDSC 51, external view of male left valve. *b*, Paratype, SDSC 52, external view of female left valve. *c*, *d*, Paratype, SDSC 53; *c*, internal view of female right valve; *d*, dorsal hinge view. *e*, Paratype, USNM 131806, dorsal view of entire male carapace.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 51 (left valve ♂)	0·88	0·43	0·18
Paratype, SDSC 52 (left valve ♀)	0·75	0·41	0·19
Paratype, SDSC 53 (right valve ♀)	0·78	0·38	0·20
Paratype, USNM 131806 (entire ♂)	0·88	0·44	0·34

Discussion. The genus *Trachyleberis* has not previously been reported from rocks earlier than Lower Tertiary. In its pronounced wedge shape and pointed posterior the species differs markedly from the majority of other Cretaceous and Eocene trachyleberids. One might expect to find related forms in the Eocene of the West Coast of North America; but the four species of *Trachyleberis* described by Marianos and Valentine (1958) from the Eocene of Marysville Buttes, California, although spinose and reticulate, are all more quadrate in outline and more rounded posteriorly.

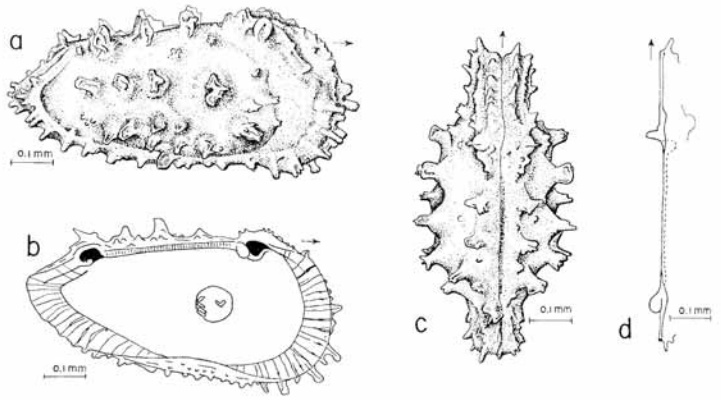
T. washburni (Stephenson 1946) (Blake 1950, pp. 180–1) resembles the new species in ornamentation and shape except for its more parallel ventral and dorsal margins, and resulting blunter posterior. The ventral margin of *T. acuminata* sp. nov. is continuous in both sexes and does not turn up abruptly towards the posterior as in *T. washburni*. In shape, ornamentation, and dimorphic characteristics, this species is in many ways comparable to the type species of the genus, *T. scabrocuneata* (G. S. Brady 1880).

Genus ACTINOCYTHEREIS Puri 1953

Actinocythereis allisoni sp. nov.

Text-fig. 22*a–d*

Diagnosis. An *Actinocythereis* characterized by ornamentation of four rows of large spines with blade-like terminations on a smooth surface; acuminate posterior.



TEXT-FIG. 22. *Actinocythereis allisoni* sp. nov. *a*, Holotype, SDSC 54, exterior view of right valve of entire female carapace showing overreach of left valve. *b*, Paratype, SDSC 55, internal view of female left valve. *c*, Paratype, USNM 131804, dorsal view of entire female carapace. *d*, Paratype, USNM 131805, dorsal hinge view of female right valve.

Description. Carapace wedge-shaped: anterior margin broadly rounded; dorsal margin straight to slightly concave; ventral margin straight in males, convex in females; posterior usually sharply acuminate; surface smooth with the exception of spines with blade-like terminations arranged in four longitudinal rows: dorsal row with three, often recurving spines, median row with four spines, the most anterior terminating as sub-central tubercle spine; two ventral rows contain, from dorsal to ventral, three and four spines respectively; other prominent spines are often located in front of and below the sub-central tubercle. Eye tubercle glassy, prominent; surmounted by a short vertical flange, and with another larger oblique flange to anterior margin. Sexually dimorphic: males longer.

Hinge holamphidont: anterior tooth of right valve inconspicuously stepped and strongly projecting; in dorsal view, median bar of left valve finely crenulate, posterior socket underlain by small knob for notched terminal element of right valve.

Adductor muscle scar pattern a row of four scars on side of sub-central depression, topmost scar somewhat displaced; V-shaped antennal scar within pit. No vestibules present; irregular radial pore canals abundant, paired, often medially enlarged.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 54 (entire ♀)	0·80	0·38	0·34
Paratype, SDSC 55 (left valve ♀)	0·78	0·40	0·17
Paratype, USNM 131804 (entire ♀)	0·78	0·38	0·30
Paratype, USNM 131805 (right valve ♀)	0·90	0·39	0·16

Discussion. This species resembles *Trachyleberis acuminata* sp. nov. in every respect except in ornamentation. Undoubtedly these species are closely related, but no explanation can be offered why both occur together abundantly.

Actinocythereis davidwhitei (Stadnichenko 1927), from the Lower and Middle Eocene of North Carolina and the Middle Eocene of Texas (Swain 1951, pp. 33, 34), is similar to the *Actinocythereis* from the Upper Cretaceous of Carlsbad. Some consistent differences are present. The dorsal row of spines consists of only four spines, not five as in *A. davidwhitei*; the spines are wide and extremely complex, the carapace is enlarged at their bases; the ventral row of spines is doubled. Blake (1950, p. 180) equates *A. davidwhitei* to *A. gibsonensis* (Howe and Chambers 1935), to which the above differences still apply.

Genus CYTHEREIS Jones 1849

Cythereis brooksi sp. nov.

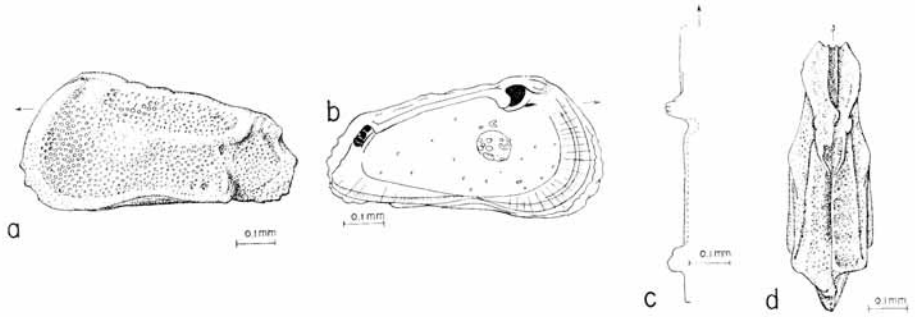
Text-fig. 23*a–d*

Diagnosis. A *Cythereis* with laterally compressed carapace, much divided antennal and adductor muscle scars, obliquely furrowed anterior element in right valve, and massive duplicature area.

Description. Carapace wedge-shaped; dorsal margin straight, ventral margin straight in females, concave in longer males giving antero-ventral area a characteristic sag; anterior margin smooth, a few subtle knobs on antero-ventral part; from dorsal view two anterior marginal ridges present an outer thicker ridge, and a straight inner narrow ridge; glassy deeply set eye tubercles present; exterior sculptured with low continuous ridge beginning in postero-ventral area, continuing around anterior margin, along dorsum (including eye tubercle), curving sharply at postero-dorsal area just above its starting point and terminating with broad sub-central tubercle; small dense pits cover areas between ridges.

Hinge paramphidont: anterior element of right valve large, divided diagonally into four narrow ridges, the anterior-most one short, giving element a stepped appearance, intermediate socket and groove smooth; posterior element heavy, elongate, notched ventrally to form four teeth, left valve with complementary dentition; sockets notched accordingly.

Adductor and antennal muscle scars much divided: adductor scars with basic pattern of four in a row, but upper two split into five, lower two fused into one; anteriorly adjacent antennal scar V-shaped with two scars above; one mandibular scar near inner margin in antero-ventral sector; other mandibular scars dorsal to pit. Area of duplicature extremely heavy; details difficult to ascertain due to thickness, even in transparent individuals; radial pore canals sparse, vestibules lacking; ocular sinus small.



TEXT-FIG. 23. *Cythereis brooksi* sp. nov. *a*, *b*, Holotype, SDSC 56; *a*, exterior view of female left valve; *b*, internal view. *c*, Paratype, SDSC 57, dorsal hinge view of female right valve. *d*, Paratype, USNM 131808, dorsal view of entire female carapace.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 56 (left valve ♀)	0·69	0·34	0·14
Paratype, SDSC 57 (right valve ♀)	0·69	0·36	0·14
Paratype, USNM 131808 (entire ♀)	0·67	0·35	0·21

Discussion. The paramphidont hinge indicates that this species belongs to the genus *Cythereis*, but the divided adductor muscle scars are atypical of that genus.

In shape and placement of the lateral and marginal ridges *C. subgracilis* Morrow, from the Coniacian(?) of Kansas, can be compared with this species though it is more quadrate and not as heavily pitted. Perhaps the best comparison can be made with *C. sp.* aff. *C. fredericksburgensis* Alexander, of Swain 1951. Externally it appears very similar to a male of this species. *C. fredericksburgensis* Alexander, conversely, is too inflated.

The species is named in honour of Professor Baylor Brooks, San Diego State College, California.

Genus PLATYCOSTA gen. nov.

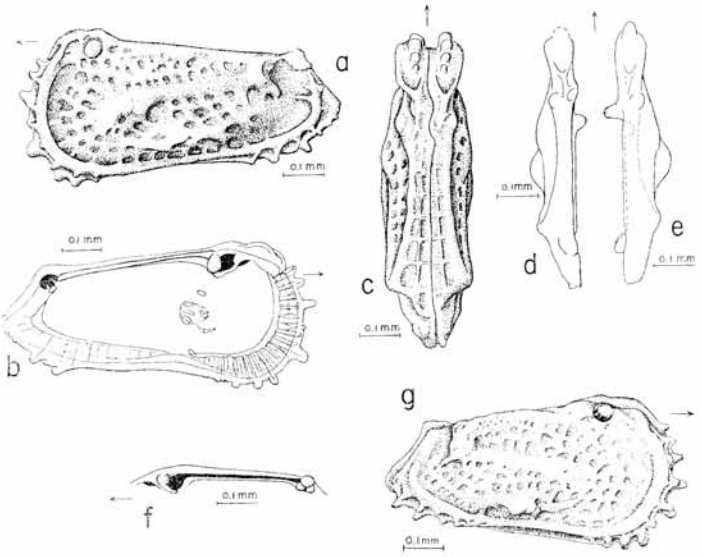
Description. Carapace laterally compressed, subquadrate in profile, slightly narrowing posteriorly; ornamentation of heavy marginal ridge with tendency to be doubled (like *Platycythereis*), extending from antero-dorsal angle around ventral margin to postero-dorsal angle, dorsal ridge connecting posteriorly with oblique lateral ridge from low sub-central tubercle, and poorly developed ventral lateral ridge, in some specimens only a knob; carapace reticulate, valves unequal in antero-dorsal area, left valve higher and overlapping right valve much as in *Idiocythere*; eye spots and large ocular sinuses present.

Dentition hemiamphidont with holamphidont tendency, posterior tooth of right valve trilobed. Duplicature moderately and evenly wide, shallow posterior and anterior vestibules present; radial pore canals numerous, with tendency to bifurcate. Muscle scar pattern vertical row of four adductor scars and anterior V-shaped antennal scar.

Type species. Platycosta oena gen. et sp. nov.

Age. Campanian.

Discussion. Similarities in shape and details of the double marginal ridge strongly suggest a phylogenetic relationship to *Platycythereis.* However, development of the ventral lateral ridge with a corresponding reduction of the marginal ridge would give characteristics like *Costa.*



TEXT-FIG. 24. *Platycosta oena* gen. et sp. nov. *a–c*, Lost specimen; *a*, external view of male left valve; *b*, internal view; *c*, dorsal view of both valves. *d*, Paratype, SDSC 60, dorsal view of female left valve. *e*, *f*, Paratype, SDSC 61; *e*, dorsal view of female right valve; *f*, internal hinge view. *g*, Holotype, SDSC 58, side view of entire female carapace showing overreach by left valve.

Platycosta oena gen. et sp. nov.

Text-fig. 24*a–g*

Description. Carapace wedge-shaped; laterally compressed; dorsal margin straight, ventral margin straight to slightly concave, anterior margin blunt, broadly rounded, with eight or nine well-developed spines; left valve overlapping right valve in antero-dorsal area; exterior ornamented with large deep reticulations; dorsal ridge connected posteriorly by oblique median ridge going to low, broad, sub-central tubercle; poorly defined isolated ventral ridge present in males, a broad tubercle in females; posterior and

anterior twin ridges continuous along ventral, anterior, and posterior margins; glassy eye tubercle present. Strongly dimorphic: males longer.

Hinge essentially hemiamphidont: anterior element of right valve with extended tooth; posterior element trilobed with two smaller teeth beneath a larger one; median element of left valve smooth.

Adductor muscle scar pattern of four in a vertical row on side of small deep pit; upturned V-shaped antennal scar well within pit, anterior to adductor scars; single mandibular scars dorsal and ventral to pit. Posterior and anterior vestibules present; radial pore canals abundant with tendency to group into twos and threes. Normal pores small, sparse.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 58 (entire ♀)	0·71	0·38	0·25
Paratype, SDSC 59 (right valve ♂)	0·79	0·35	0·15
Paratype, SDSC 60 (left valve ♀)	0·65	0·36	0·14
Paratype, SDSC 61 (right valve ♀)	0·67	0·33	0·12
Paratype, USNM 131809 (entire ♀)	0·65	0·32	0·22

Genus IDIOCYTHERE Triebel 1958

Idiocythere triebeli sp. nov.

Text-fig. 25*a–f*

Diagnosis. An *Idiocythere* with narrow curved adductor muscle scars, large posteriorly pointing alae, and narrow vestibules.

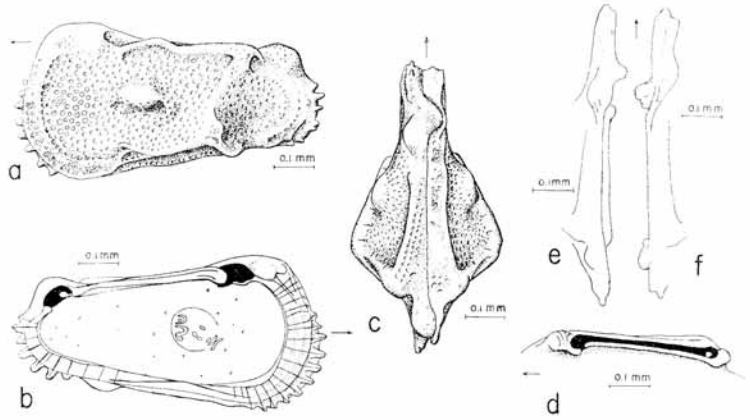
Description. In dorsal view carapace wedge-shaped, laterally compressed at both ends; narrow at dorsal margin but widening ventrally to pronounced, posteriorly pointing alae, highest point near anterior margin in left valve; surface covered with small closely spaced pits, poorly developed on ridges; valves unequal: left valve longer, higher, overlapping right valve ventrally at inturned area, at postero-dorsal angle and antero-dorsal angle by tooth-like projection. Eye tubercles absent; tubercles corresponding to tooth sockets present on both valves, especially well-developed on left valve.

Hinge 'modified holamphidont' (Sylvester-Bradley, p. Q339), i.e. 'with additional strongly projecting conical-pessular tooth in front . . . (of) socket' of left valve; median bar smooth; anterior tooth of right valve massive, faintly crenulate.

Adductor muscle scar complex: of two narrow posteriorly opened, U-shaped scars and subjacent divided scar; two antennal scars anterior to adductor scar pattern, the lower one bifid; elongate mandibular scars antero-ventral to muscle scar pit. Shallow anterior and posterior vestibules present. Radial pore canals fairly abundant, irregular, tending to bifurcate within marginal spines. Normal pores small, not abundant; five or six aligned and corresponding to edge of alae.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 62 (left valve ♂)	0·77	0·40	0·25
Paratype, SDSC 63 (entire ♀)	0·72	0·38	0·38
Paratype, USNM 131807 (left valve ♀)	0·71	0·25	0·24
Paratype, USNM 131807 (right valve ♀)	0·70	0·38	0·22

Discussion. *I. triebeli* sp. nov. is very similar to the type species, *I. lutetiana* Triebel 1940, from the Eocene (Lutetian) of France; however, the Californian species is more widely alate, is ornamented with more equal sized pits, has a blunter anterior margin, and has simple radial pore canals, not arranged in fan-shaped groups.



TEXT-FIG. 25. *Idiocythere triebeli* sp. nov. *a*, *b*, Holotype, SDSC 62; *a*, external view of male left valve; *b*, internal view of left valve. *c*, Paratype, SDSC 63, dorsal view of entire female carapace. *d–f*, Paratype, USNM 131807; *d*, internal hinge view of female right valve; *e*, dorsal hinge view of left valve; *f*, dorsal hinge view of right valve.

Cythereis kewi Le Roy 1943, from the Santa Barbara Formation of California, though not an *Idiocythere* owing to the presence of eye spots and ocular sinuses, markedly resembles that genus in many respects.

Genus ISOCYTHEREIS Triebel 1940

Isocythereis carlsbadensis sp. nov.

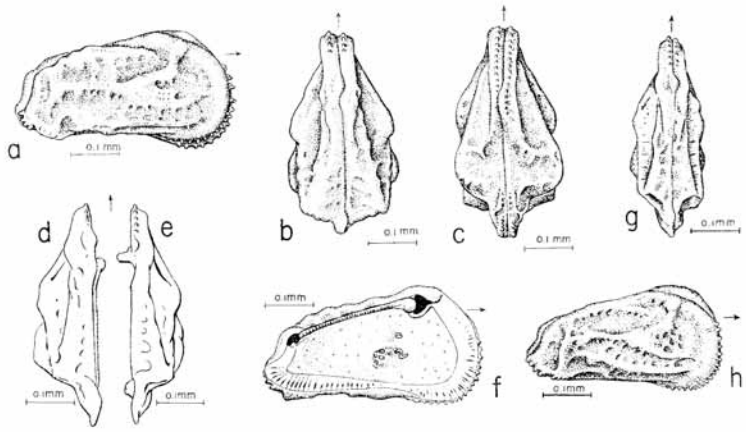
Text-fig. 26*a–h*

Diagnosis. An *Isocythereis* with finely denticulate anterior margin, strong overlap of left valve in antero-dorsal area, narrow duplicature with abundant radial pore canals and pronounced wedge-shaped carapace.

Description. Carapace wedge-shaped in profile; dorsal margin straight (in left valves) to slightly convex (in right valves), ventral margin concave. Carapace ornamented with sub-parallel longitudinal ridges: middle ridge bifurcating at well-developed sub-centric tubercle, with one ridge extending to low, well-developed eye tubercle, other extending almost to anterior margin; irregular dorsal and ventral ridges present; various sized reticulations, horizontal and vertical ridges present; anterior margin heavily rimmed, finely denticulate. Sexually dimorphic: females broader and longer than males.

Adductor muscle scars divided into six or seven smaller scars within deep pit, lower scars elongate and parallel; antennal scar shaped like reversed S, conspicuous mandibular scars above it. Area of duplicature moderate in width; no vestibules present; radial pore canals abundant, single, straight, each with medial enlargements; normal pores small, abundant.

Dentition paramphidont, heavy: median element crenulate, anterior tooth of right valve elongate, stepped.



TEXT-FIG. 26. *Isocythereis carlsbadensis* sp. nov. *a–c*, Holotype, SDSC 64; *a*, external view of adult female right valve showing overreach by left valve; *b*, dorsal view of entire carapace; *c*, ventral view of entire carapace. *d–f*, Paratype, SDSC 65; *d*, dorsal view of female left valve; *e*, dorsal view of right valve; *f*, internal view of left valve. *g*, *h*, Paratype, USNM 131810; *g*, dorsal view of entire male carapace; *h*, external view of right valve showing overreach by left valve.

Dimensions (in mm.).	*Length*	*Height*	*Width*
Holotype, SDSC 64 (entire ♀)	0·47	0·26	0·24
Paratype, SDSC 65 (right valve ♀)	0·47	0·24	0·14
Paratype, SDSC 66 (left valve ♀)	0·48	0·26	0·15
Paratype, USNM 131810 (entire ♂)	0·43	0·24	0·15

Discussion. This species is placed in the genus *Isocythereis* on the basis of the divided adductor muscle scars, small size, and general ornamentation. The genus previously contained only two species, both Albian in age, from wells in Germany. The type species, *I. fissicostis* Triebel 1940, possessing a reticulate carapace with three well-defined lateral ridges, and sub-marginal eyespot, is more like *I. carlsbadensis* sp. nov. than *I. fortinoides* Triebel 1940.

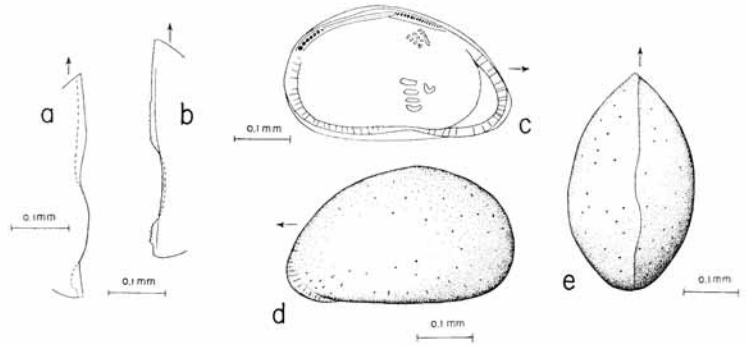
I. carlsbadensis sp. nov. varies from the generic description in that the area of duplicature is not wide, the radial pore canals are abundant, not scarce, and the hingement is paramphidont, not hemiamphidont, though it is tending to be hemiamphidont (see text-fig. 26*e*). It is possible that this species represents a new genus which should belong in the family Hemicytheridae.

Family XESTOLEBERIDIDAE Sars 1928
Genus XESTOLEBERIS Sars 1866

Xestoleberis minuta sp. nov.

Text-fig. 27*a–e*

Diagnosis. A *Xestoleberis* with a sharply pointed, ventrally located anterior margin; long, oblique, antero-dorsal margin; and long, straight ventral margin.



TEXT-FIG. 27. *Xestoleberis minuta* sp. nov. *a–c*, Holotype, SDSC 67; *a*, dorsal hinge view of left valve; *b*, dorsal hinge view of right valve; *c*, internal view of left valve. *d–e*, Paratype, USNM 131811; *d*, external view of left valve; *e*, dorsal view of entire carapace.

Description. Carapace smooth, fragile: shape much like type species; highest point just posterior to middle; widest point also just posterior to middle; ventral margin straight, dorsal margin, as seen in profile, broadly arched, angled at highest spot; acuminate anterior margin located in antero-ventral area. In dorsal view carapace sub-evenly inflated: posterior rounded, anterior more pointed; carapace about as high as wide; not dimorphic.

Hinge antimerodont: right valve with elongate terminal cusps, posterior element with about six crenulations, anterior element finely crenulate, intermediate element finely crenulate, arcuate. Anterior vestibule present; fused portion of duplicature narrow, everywhere with many radial pore canals; normal pores large, more abundant ventrally where they tend to form in rows.

Adductor muscle scar pattern composed of inclined row of four rectangular scars; V-shaped antennal scar just anterior to top two adductor scars; complex of many small mandibular scars in dorsal area.

Dimensions (in mm.)	*Length*	*Height*	*Width*
Holotype, SDSC 67 (left valve)	0·39	0·24	0·11
Holotype, SDSC 67 (right valve)	0·40	0·22	0·11
Paratype, USNM 131811 (entire)	0·37	0·21	0·21
Paratype, SDSC 68 (entire)	0·36	0·21	0·21
Paratype, SDSC 69 (entire)	0·37	0·21	0·21
Paratype, SDSC 70 (right valve)	0·37	0·22	0·11
Paratype, SDSC 71 (right valve)	0·37	0·22	0·12
Paratype, SDSC 72 (entire)	0·38	0·22	0·22

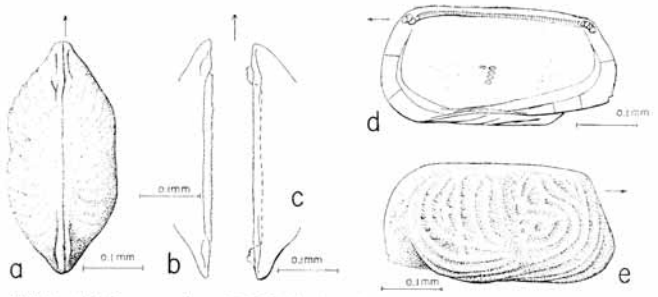
Discussion. The Rosario Formation species is closely similar to *X. marssoni* Bonnema 1941 except that the posterior regions are higher in profile. Also, *X. minuta* sp. nov. is apparently not dimorphic and is very small.

Sexual dimorphism, common in the genus, was not observed in any of the twenty-three specimens from Carlsbad.

Unidentified ostracod

Text-fig. 28 *a–e*

Description. Shape distinctive: dorsal and ventral margins straight, converging slightly towards posterior, anterior margin obliquely truncated in antero-dorsal area, posterior margin broadly rounded but sharply angled in postero-ventral area; ventral regions



TEXT-FIG. 28. Unidentified ostracod. *a*, SDSC 42, dorsal view of entire adult. *b*, SDSC 43, dorsal hinge view of adult left valve. *c-e*, USNM 131801; *c*, dorsal hinge view of adult right valve; *d*, internal view showing grouped normal pores; *e*, external view.

moderately inflated, shallow median sulcus present. Equivalved: right valve inconspicuously overlapping median element of left valve along dorsum. Surface ornamentation dominated by about fifteen to twenty narrow vertical ridges in dorsal area, curving around ends of the shell in concentric pattern forming sub-horizontal parallel ridges in ventral area; subordinate reticulations best developed in posterior regions.

Hinge antimerodont; terminal elements of right valve composed of three or four tightly grouped smaller teeth; median bar of left valve long, straight, very finely crenulate, running almost entire length of dorsum.

Adductor muscle scar pattern of four small equal-sized scars on median ridge; two small antennal scars anterior to uppermost adductor scar, narrow anterior and posterior vestibules present; area of duplicature moderately wide with very few, straight simple radial pore canals; normal pores tiny, very dense, grouped within depressions of reticulations, ridges imperforate.

Dimensions (in mm.).	*Length*	*Height*	*Width*
SDSC 42 (entire ♀)	0·39	0·19	0·18+
SDSC 43 (left valve ♂)	0·41	0·20	0·08
USNM 131801 (right valve ♀)	0·39	0·19	0·10

Discussion. The ornamentation consisting of ridges is much like that in *Prognocythere heiroglyphica* Swain and Peterson from the Upper Jurassic of South Dakota, as is the shape in both dorsal and lateral views. The ridges on this species, however, are more pronounced.

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