

# PLIO-PLEISTOCENE OSTRACODS FROM THE UPPER AMAZON OF COLOMBIA AND PERU

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**ABSTRACT.** An unnamed formation from near La Tagua, Colombia, and the Pebas Beds of Peru contains rich ostracod faunas that provide new information on the environment of deposition and the probable age of the sediments. The ostracods are a mixture of freshwater, brackish, and marine species, from what was essentially a brackish-water environment. Fifteen species, of which nine are new, are described, together with two new subspecies. Three genera—*Botulocyprideis*, *Otarocyprideis*, and *Rhadinocytherura*—are new.

FROM a collection of South American molluscs being examined by C. P. Nuttall three samples of marl were processed for ostracods. The ostracods proved to be an undescribed fauna, and give information concerning the environment of deposition and the possible age of the sediments.

Text-fig. 1 shows the sample localities. The one Peruvian sample, chocolate-brown marl of the Pebas Beds from northern Peru, was extracted from matrix in molluscs collected by Mr. Hauxwell in 1870 from Pichua, just west of Cochaquinás, approximately 30 miles (48 km) down the Marañon River from Pebas (approx. lat. 3° 23' N., long. 72° 10' W.). The two Colombian samples were shelly grey clays from an unnamed sequence collected in 1977 by Michael Eden during the Colombian Amazonas Expedition, Proyecto Radargrametrico dell Amazonas, from the Caqueta Basin area of southern Colombia—lat. 0° 05' N., long. 74° 40' W.: sample CAE/GEO/54 from the river bank just downstream of La Tagua and sample CAE/GEO/33 from a well about ½ km from the Caqueta River at a depth of 480–560 cm from the surface. The age of the Peru sample is considered by some to be Pliocene (Gardner 1927) although Simpson (1961) regarded the so-called Pebas Beds of the Porto Peter on the Juruá River, Brazil, as being Pleistocene in age or even younger. There are, however, no molluscan genera or species common to the Pebas Beds of Peru and Simpson's locality so it is unlikely that they represent the same formation or are of the same age (pers. comm. C. P. Nuttall). The presence of marine ostracods in the Pebas Beds of Peru makes it unlikely that these beds could be younger than Pleistocene if introduced via a marine transgression.

Gardner (1927) considered the mollusc fauna to be Pliocene in age, and referred to the presence of freshwater ostracods, as *Cypris* sp. associated with the molluscs. Little detailed work has been undertaken on the ostracods of the Upper Amazon—either fossil or Recent—and considerable scope exists for taxonomic studies on the ostracod faunas and their application to the elucidation of the environment of deposition and the correlation of the sediments. The most important published work is that of Purper (1977) who figures ostracods of Pliocene or younger age from the Upper Amazon of Brazil.

All the ostracods described in this paper have been deposited in the British Museum (Natural History), London. All measurements are in mm.



TEXT-FIG. 1. Location map of Peruvian and Colombian samples.

## SYSTEMATIC DESCRIPTIONS

Superfamily CYTHERACEA Baird, 1850

Family CYTHERIDEIDAE Sars, 1925

Subfamily CYTHERIDEINAE Sars, 1925

Genus CYPRIDEIS Jones, 1857

*Cyprideis purperi* sp. nov.*Derivation of name.* After Ivone Purper of Universidade Rio Grande do Sul.*Diagnosis.* Sulcate species of *Cyprideis* with surface ornamentation of small pits. Seven to nine short anterior marginal spines on free margin of both valves.*Description.* Carapace subquadrate in lateral outline, tapering slightly to the posterior, especially in the male dimorph, and with a shallow but distinct dorso-median sulcus. Shell parallel-sided in dorsal view with variously developed anterior marginal borders. Ventral margin convex in juvenile instars, becoming straight with incurvature anterior of the mid-point in adults. Dorsal margin convex with distinct anterior cardinal angle. Surface ornamented with small rounded pits which decrease in size towards valve edges. Anterior margin bears short terminal spines; postero-ventral margin may or may not have terminal spines. Left valve larger than the right. Normal pore canals are of sieve type; hinge and muscle scars as for genus (Pl. 7, figs. 2, 6; Pl. 8, figs. 1, 2). Marginal pore canals, some of which bifurcate, long and numerous. Inner margin and line of concrescence coincide.*Remarks.* Two subspecies of *C. purperi* are recognized: *C. purperi purperi* subsp. nov. having a broad, well-pronounced anterior marginal border and *C. purperi colombianaensis* subsp. nov. where there is a less well-pronounced marginal border, the surface pits extending to the valve edge.*C. purperi* resembles both *C. locketti* (Stephenson 1935), described from the Miocene of Louisiana, and *C. salebrosa* Bold, 1963 from the Pliocene and Pleistocene of N. America and the Recent coasts of S. America (Sandberg 1964). *C. locketti* is distinguished by its strong postero-ventral flange tab on the right valve and the unique flange tab on the antero-ventral corner of the male dimorph. *C. salebrosa* has a very narrow anterior marginal zone, is distinctly convex in ventral outline, and is considerably wider in the posterior half when viewed dorsally. No noded forms of *C. purperi* have been found. *C. purperi* is placed in the genus *Cyprideis* rather than the allied genus *Cytheridea* on the absence of a vestibule, the ventral margin being incurved anterior of the mid-point (in *Cyprideis* the incurvature is in the posterior portion) and the generally more quadrate shape with pronounced sexual dimorphism. In *Cyprideis* the carapace is more strongly tapered to the posterior and dimorphism is not very pronounced. *C. purperi* resembles the genus *Heterocyprideis* Elofson, 1941 in the presence of anterior marginal teeth and a postero-ventral spine but unlike *Heterocyprideis* does not have an anterior vestibule, and is sulcate.*Cyprideis purperi purperi* subsp. nov.

Plate 7, figs. 1-13; Plate 8, figs. 1, 2; text-fig. 2

1977 *Cytheridea* sp. nov. C Purper, pl. 3, figs. 1-4.1977 *Cytheridea* sp. nov. D Purper, pl. 3, figs. 5-6.?1977 *Cytheridea* sp. nov. E Purper, pl. 3, fig. 7.*Localities and horizon.* Type locality, Pichua, Marañon River, Peru, from the Pebas Beds, Plio-Pleistocene. Other occurrences described by Purper 1977, from the Upper Amazon Basin, Brazil.*Material.* Holotype, OS 10992, female right valve, and numerous valves and carapaces.

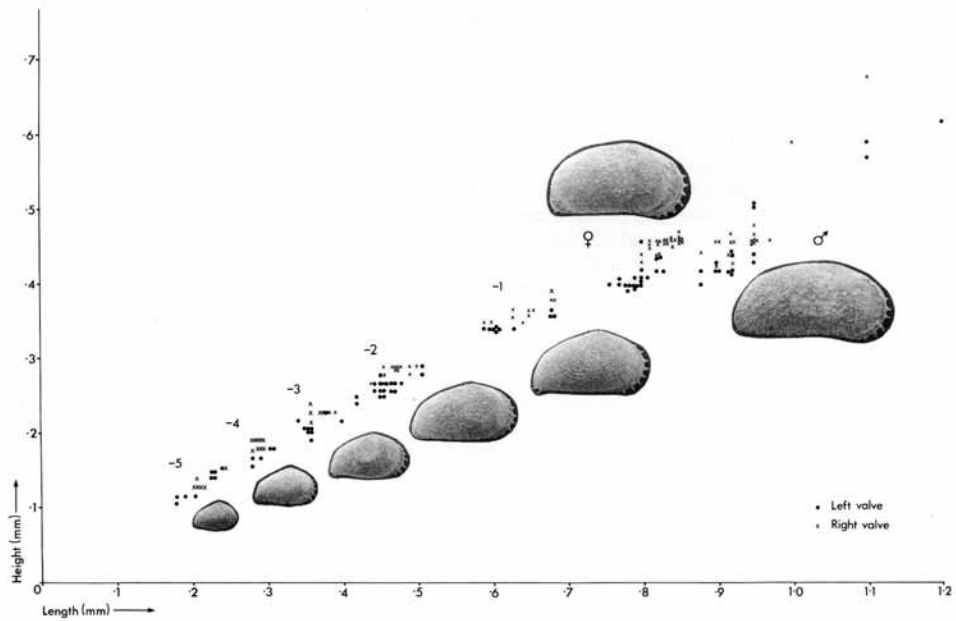
Dimensions

	L	H	W		L	H	W
Holotype:				Paratypes:			
OS 10992 ♀ RV	0.81	0.44		OS 11001 ♂ car.	0.95	0.46	0.40
Paratypes:				OS 11002 ♂ RV	0.98	0.43	
OS 10993 ♀ LV	0.83	0.44		OS 11004 juv. RV	0.24	0.16	
OS 10994 ♀ LV	0.84	0.45		OS 11005 juv. RV	0.47	0.28	
OS 10995 ♀ car.	0.84	0.45	0.40	OS 11006 juv. RV	0.63	0.35	
OS 10996 ♀ car.	0.85	0.46	0.41	OS 11007 juv. RV	0.70	0.37	
OS 10997 ♀ LV	0.85	0.46		OS 11008 ♂ p.m. RV	1.25	0.64	
OS 10998 ♀ RV	0.83	0.43		OS 11009 ♀ p.m. LV	1.15	0.68	
OS 10999 ♂ RV	0.97	0.46		OS 11010 juv. RV	0.37	0.23	
OS 11000 ♂ LV	0.97	0.48					

**Diagnosis.** Subspecies of *Cyprideis purperi* with relatively broad anterior marginal zone with pronounced smooth marginal groove.

**Description.** Subquadrate carapace ornamented with circular pits which cover valve surfaces apart from smooth anterior marginal zone. Hinge well-developed entomodont type which consists, in the left valve, of a posterior loculate socket with six to seven loculi, a median bar having a denticulate postero-median element, and a dentate antero-median element, and an anterior loculate socket with nine to ten loculi. Muscle scars: vertical row of four adductors, a V-shaped frontal scar, an oval mandibular scar, and a prominent fulcral point between the most dorsal adductor scar and the frontal scar. Marginal pore canals numerous and long, some bifurcate. Sexual dimorphism pronounced, females being shorter and more rounded posteriorly and wider in the posterior half than males.

**Remarks:** Text-fig. 2 shows an instar diagram of *C. purperi purperi* where an almost complete population of this subspecies is present in the Pichua sample, with five juvenile stages being represented. We found four specimens much larger in size than the normal adult but otherwise similar,



TEXT-FIG. 2. Instar diagram for *Cyprideis purperi purperi* subsp. nov.

although the anterior marginal spines are rather poorly developed. Purper (1977) figured a similar specimen as *Cytheridea* sp. nov. E. No juveniles are recognizable of this form. We propose that these large specimens are post-maturation moults of *Cyprideis purperi purperi*.

*Cyprideis purperi colombiaensis* subsp. nov.

Plate 8, figs. 3-9

*Locality and horizon.* Only from La Tagua, S. Colombia. Locality CAE/GEO/33, Plio-Pleistocene.

*Material.* Holotype, OS 11011, male left valve. Several single valves, mainly adult.

*Dimensions.* Holotype: OS 11011 ♂ LV L 0.80, H 0.40; Paratypes: OS 11003 ♂ RV L 0.88, H 0.42; OS 11012 ♂ RV L 0.88, H 0.40; OS 11013 ♂ RV L 0.90, H 0.42; OS 11014 ♀ RV L 0.79, H 0.42; OS 11015 ♀ LV L 0.79, H 0.42.

*Diagnosis.* Subspecies of *C. purperi* with surface ornamentation of subparallel rows of pits extending laterally to the free margins of the valves.

*Description.* The carapace is subquadrate in outline with a narrow anterior marginal border into which the ornamentation extends. All internal features are as for *C. purperi purperi* subsp. nov.

*Remarks.* *C. purperi colombiaensis* differs from *C. purperi purperi* by having a narrower anterior marginal border and having the ornamentation extended on to it; it is also somewhat thinner shelled. The duplicature is narrower and consequently the marginal pore canals are shorter, although in number and appearance are alike in the two subspecies. Juveniles indistinguishable.

Genus OTAROCYPRIDEIS gen. nov.

*Derivation of name.* Greek, *otos* meaning 'ear' referring to valve shape. Gender, feminine.

*Type species.* *Otarocyprideis elegans* sp. nov.

*Diagnosis.* A large, subrectangular ear-shaped genus of the Cytherideinae having rounded anterior margin and truncated posterior margin. Strong vestibules anteriorly and posteriorly; numerous dendritically branched marginal pore canals with ampullae. Marginal areas compressed. Hinge entomodont. Muscle scars with four vertically disposed adductors, heart-shaped frontal scar, oval mandibular scar, and pronounced fulcral point. Sexual dimorphism not obvious.

*Remarks.* The similarity of this genus to *Cyprideis* is obvious both in shape and hinge-type. Its generic status resides on the well-developed vestibules and the particularly well-branched dendritic marginal pore canals. *Cyprideis* has no vestibules and while the pore canals do exhibit branching the fine network of branches developed in *Otarocyprideis* is never seen in *Cyprideis*. The muscle scar pattern in the two genera is basically the same except that in *Cyprideis* the frontal scar is more open, obviously V-shaped and the position of the fulcral point is somewhat higher than in *Otarocyprideis*. Marginal teeth or spines are absent in this genus. Its close association with *Cyprideis* species suggests that this is a brackish water genus. *Otarocyprideis* is at present monotypic.

*Otarocyprideis elegans* sp. nov.

Plate 8, figs. 10-12; Plate 9, figs. 1-5, 7

1978 Ostracod B n.g.; n. sp. Purper, pl. 1, figs. 9-14.

*Locality and horizon.* Only from Pichua, Marañon River, Peru. Pebas Beds, Plio-Pleistocene.

*Material.* Holotype, OS 11028, right valve. Several additional valves and carapaces.

*Dimensions*

	L	H		L	H	W
Holotype:			Paratypes:			
OS 11028 RV	1.07	0.48	OS 11032 car.	0.97	0.49	0.41
Paratypes:			OS 11033 RV	0.79	0.36	
OS 11029 LV	1.07	0.51	OS 11034 LV	0.97	0.48	
OS 11030 LV	1.00	0.51	OS 11035 LV	1.00	0.49	
OS 11031 RV	1.07	0.51	OS 11036 juv. RV	0.61	0.31	

*Diagnosis.* Smooth species of *Otarocyprideis* with broadly flattened anterior marginal area. Internal details as for genus.

*Description.* Carapace large (0.97–1.07 mm in length), smooth and featureless, apart from a shallow ridge along the anterior margin. Anterior margin broadly rounded, posterior obliquely truncate. Ventral margin broadly convex apart from just anterior to mid-point, where it is strongly incurved. Maximum height and length occurs medially. In dorsal view carapace parallel sided. Left valve larger than right, which it overlaps dorsally and overreaches anteriorly. Eye spots absent. In left valve hinge with posterior loculate socket, a denticulate median bar and an anterior loculate socket. Inner marginal areas very broad, with a well-developed vestibule anteriorly and a less prominent one posteriorly. Marginal pore canals numerous, long, and branch repeatedly, many of them having ampullae. Simple normal pore canals small, scattered evenly over the shell surface.

Juveniles of *O. elegans* are more quadrate with a more rounded posterior margin and straight ventral margin.

*Remarks.* *O. elegans* is quite distinct with respect to shape and dendritic marginal pore canals from all other species of cytherideid genera. It is common in the Pichua sample, with good preservation of adults and juveniles.

Genus *BOTULOCYPRIDEIS* gen. nov.

*Derivation of name.* Latin *botulus*, meaning 'sausage', referring to the carapace shape. Gender, feminine.

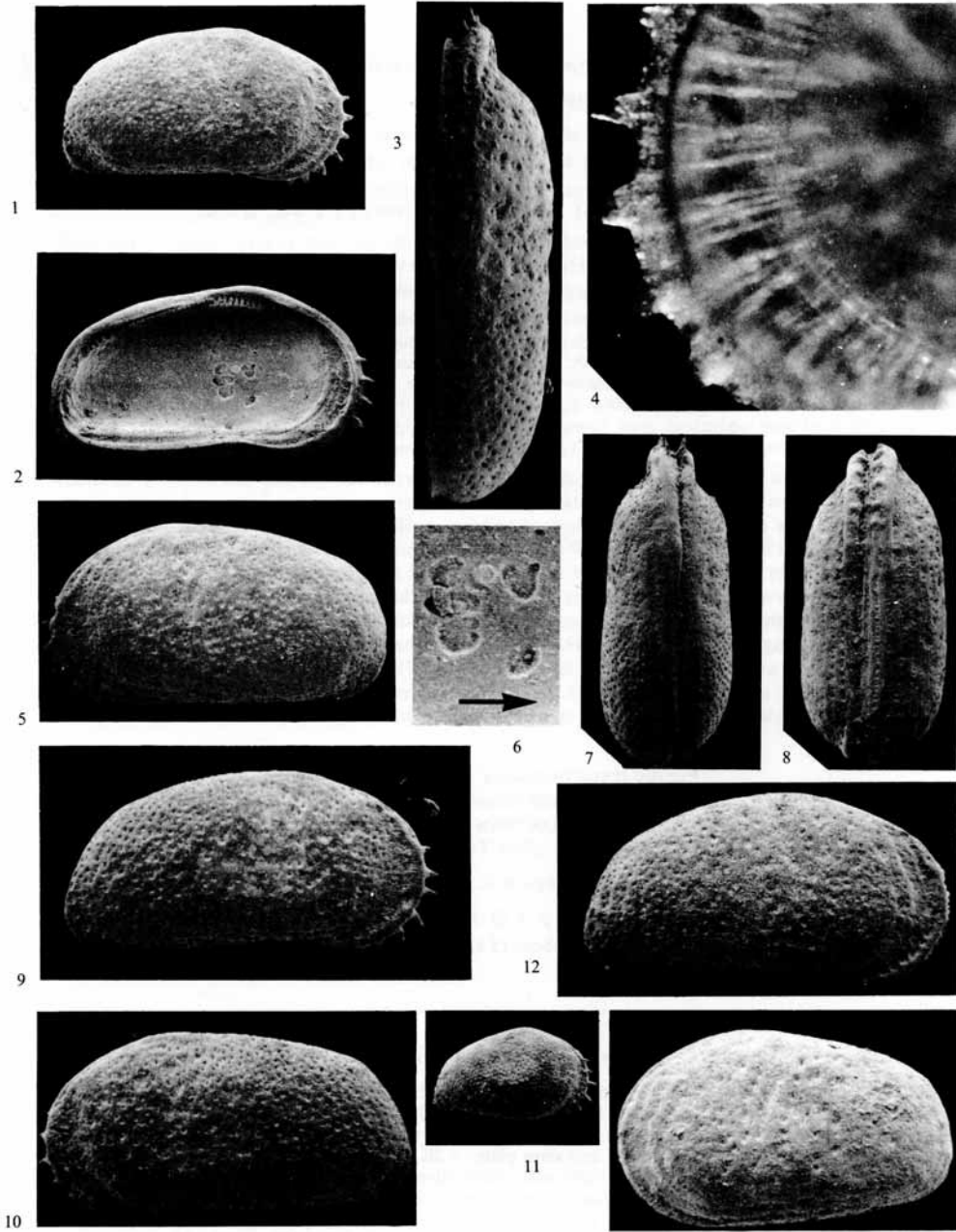
*Type species.* *Botulocyprideis simplex* sp. nov.

*Diagnosis.* Oval to subrectangular genus of Cytherideinae with rounded anterior and posterior margins. Hinge entomodont. Marginal pore canals short, numerous, some of which bifurcate. Inner margin and line of concrescence coincide. Non-dimorphic.

*Remarks.* This genus is distinguished from others of the Cytherideinae by its distinctive sausage-shaped carapace outline and the positive hinge elements occurring in the left valve. *Eucytheridea* Bronstein (see Bold 1961) has a similar external appearance to *Botulocyprideis* but differs internally by the possession of a large anterior vestibule and simple marginal pore canals. *Neocyprideis* Apostolescu, 1956 grows to a larger size, is more subrectangular in shape due to the pronounced posterior cardinal angle, and tends to have a more strongly developed hinge, with narrower duplication than *Botulocyprideis*.

## EXPLANATION OF PLATE 7

Figs. 1–13. *Cyprideis purperi purperi* subsp. nov., Pebas Beds, Peru. 1, external view, female right valve, holotype, OS 10992, × 62. 2, 6, internal view, female left valve, × 62, and muscle scars, × 169. 3, dorsal view to show hinge teeth, female right valve, paratype, OS 10998, × 98. 4, anterior marginal pore canals, by transmitted light, seen from the inside, male right valve, paratype, OS 11002, × 292. 5, external view, female left valve, paratype, OS 10997, × 62. 7, dorsal view, female carapace, paratype, OS 10996, × 65. 8, ventral view, female carapace, paratype, OS 10995, × 64. 9, external view, male right valve, paratype, OS 10999, × 63. 10, external view, male left valve, paratype, OS 11000, × 62. 11, external view, juv. right valve, paratype, OS 11005, × 62. 12, external view, right valve, post-maturation moult, male paratype, OS 11008, × 48. 13, external view, left valve, post-maturation moult, female paratype, OS 11009, × 48.



*Botulocyprideis simplex* sp. nov.

Plate 9, figs. 6, 8-13

*Locality and horizon.* Only from Pichua, Marañon River, Peru. Pebas Beds, Plio-Pleistocene.*Material.* Holotype, OS 11077, right valve. A few additional single valves.*Dimensions.* Holotype: L 0.61, H 0.29; Paratypes: OS 11078 RV L 0.61, H 0.31; OS 11079 LV L 0.60, H 0.28; OS 11080 RV L 0.61, H 0.29; OS 11081 LV L 0.61, H 0.29; OS 11082 LV L 0.62, H 0.30.*Diagnosis.* Smooth species of *Botulocyprideis* with parallel dorsal and ventral margins and well-rounded anterior and posterior margins. Hinge is a reversed version of *Cyprideis*-type with positive terminal elements in left valve. Inner margin and line of concrescence coincide.*Description.* Carapace ovoid with straight, parallel dorsal and ventral margins, parallel-sided in dorsal view. Greatest length and height both pass through mid-point. Valve surface completely smooth and featureless. Internally, marginal areas of moderate width; marginal pore canals numerous, evenly spaced with some bifurcating. Hinge weakly developed and consists, in the left valve, of an elongated anterior dentate tooth, a median locellate groove, and a short posterior dentate tooth. Muscle scars of *Cyprideis*-type, with vertical row of four equal-sized oval adductors, oval frontal scar which is slightly indented at the top giving a heart-shaped appearance, oval mandibular scar, and a pronounced fulcral point.*Remarks.* *B. simplex* resembles Ostracod A.n.g., n. sp. (Purper 1977) from the Tertiary of Brazil but differs chiefly on marginal pore canals. Those of Purper's species are long and branch many times, and from her illustrations there appears to be a vestibule anteriorly at least. *Eucytheridea bradii* (Norman, 1865) (see Bold 1961, p. 287) has a similar though not identical external appearance and internally differs by the possession of a well-developed anterior vestibule. *B. simplex* may be confused with the juveniles of *O. elegans* as they are about the same size and shape, from the same locality. The inner marginal area in *O. elegans* is much wider, vestibules are developed, and the positive terminal hinge elements occur in the right valve rather than the left. *Neocyprideis parallela* (Lienenklaus, 1905) an Oligocene form as figured by Malz (1973a) is similar in outline but is somewhat larger (length about 0.75 mm) with laterally compressed anterior, posterior, and ventral margins, and short, widely spaced simple marginal pore canals.

Family ILYOCYPRIDIDAE Kaufmann, 1900  
 Subfamily ILYOCYPRIDINAE Kaufmann, 1900  
 Genus PELOCYPRIS Klie, 1939  
*Pelocypris zilchi* Triebel, 1953

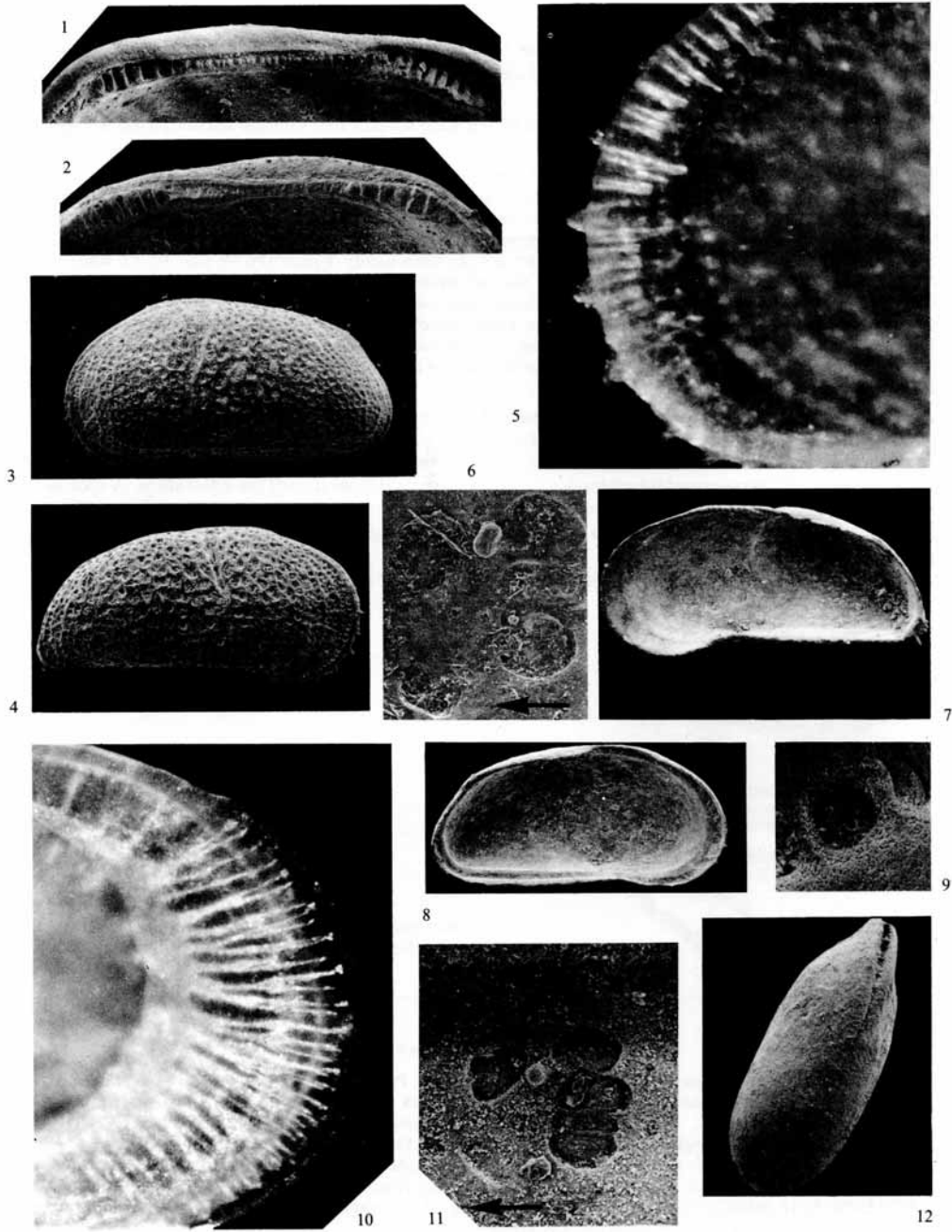
Plate 10, figs. 8-13; text-fig. 3

1953 *Pelocypris zilchi* n. sp.; E. Triebel, p. 2, pl. 1, figs. 1-8.*Type locality and horizon.* Barranca El Sisimico, about 15 km north-east of Vulkan San Vicente (El Salvador). Pleistocene.

## EXPLANATION OF PLATE 8

Figs. 1, 2. *Cyprideis purperi purperi* subsp. nov., Pebas Beds, Peru. 1, hinge, left valve, female paratype, OS 10993,  $\times 152$ . 2, hinge, right valve, female holotype, OS 10992,  $\times 145$ .  
 Figs. 3-9. *Cyprideis purperi colombianaensis* subsp. nov., locality CAE/GEO/33, Colombia. 3, 8, 9, external and internal view, male left valve,  $\times 62$ , and sieve plate,  $\times 2K$ , holotype, OS 11011. 4, 6, 7, external and internal views,  $\times 62$ , and muscle scars,  $\times 500$ , male right valve, paratype, OS 11012. 5, anterior marginal pore canals, by transmitted light, seen from the inside, male right valve, paratype, OS 11003,  $\times 209$ .  
 Figs. 10-12. *Otarocyprideis elegans* gen. et sp. nov., Pebas Beds, Peru. 10, branching anterior marginal pore canals, by transmitted light, seen from the inside, left valve, paratype, OS 11035,  $\times 198$ . 11, muscle scars, right valve, paratype, OS 11033,  $\times 500$ . 12, dorsal view, carapace, paratype, OS 11032,  $\times 51$ .





SHEPPARD and BATE, Plio-Pleistocene ostracods

*New material.* A few adult and juvenile valves only from locality CAE/GEO/33, La Tagua, S. Colombia.

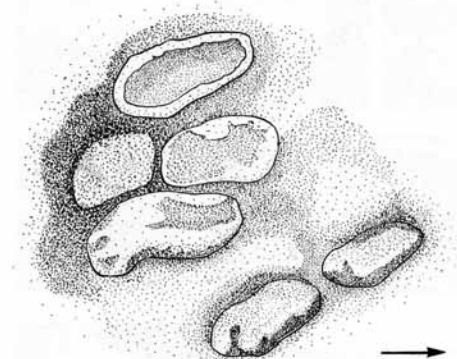
*Dimensions.* OS 11066 LV L 1.33, H 0.82; OS 11067 RV L 1.18, H 0.64; OS 11068 RV L 1.05, H 0.60; OS 11069 LV L 0.60, H 0.32.

*Diagnosis.* Bisulcate species of *Pelocypris* with pitted shell surface and dentate valve margin in right valve only.

*Description.* Carapace is subquadrate in shape with high anterior shoulder from which extend two short dorso-medial sulci. Anterior and posterior margins are broadly rounded; ventral margin almost straight, dorsal margin is sinuous. Greatest height of shell occurs anterior to mid-point, greatest width is in posterior half. Surface ornamentation of rounded pits which decrease in size towards valve edges; small tubercles around anterior and posterior margins. Entire valve margin in right valve evenly dentate (Pl. 10, figs. 10, 12) whereas that of left valve is smooth. Duplicature narrow. Narrow vestibules are developed anteriorly and posteriorly. Marginal pore canals have not been observed. Muscle scars consist of a subvertical row of three irregularly sized oval adductors situated on a vertical ridge which corresponds to the position of the external sulci. Behind the adductor scars, situated in a depression, a rather inconspicuous scar may be observed. Two elongate (mandibular?) scars are situated below and to the front of this group of scars (text-fig. 3). The hinge is of a simple adont form.

*Remarks.* The juveniles of *P. zilchi* differ markedly from the adult specimens by being distinctly ovoid with maximum width medially, and by lacking the sulci and associated high flattened shoulder. The ornamentation and internal features are, however, recognizable. The diagnostic dentate right valve margin and the marginal tubercles do not appear to be developed until the adult stage. A species which is geographically not very far removed from this Colombian species is *P. lenzi* Klie, 1939b, a Recent form from Brazil, but this has eight or nine long heavy spines on the anterior and posterior borders of both valves.

Species of *Pelocypris* are considered to inhabit fresh water environments.

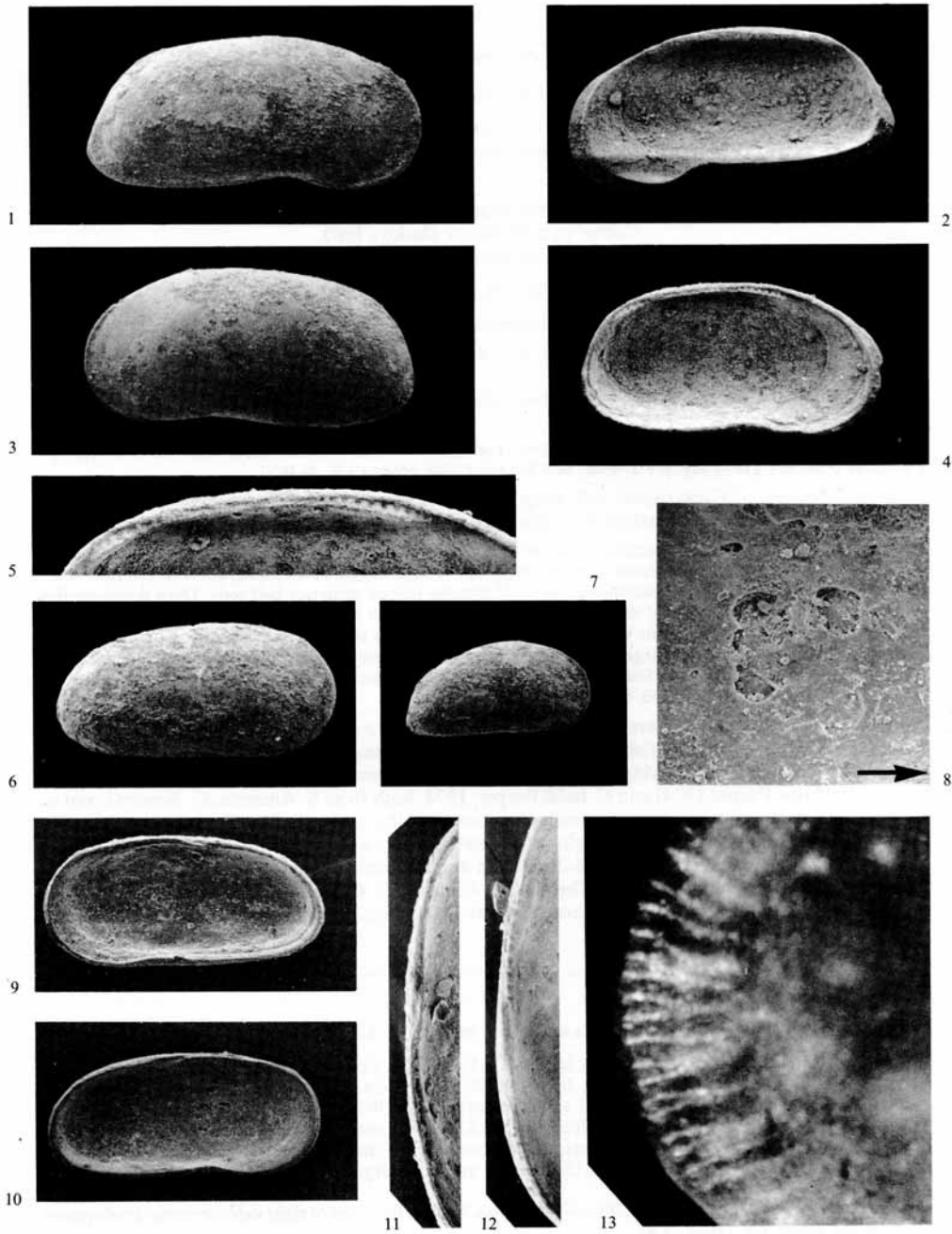


TEXT-FIG. 3. Muscle scars of *Pelocypris zilchi* Triebel, left valve, OS 11066  $\times$  605.

#### EXPLANATION OF PLATE 9

Figs. 1-5, 7. *Otarocyprideis elegans* gen. et sp. nov., Pebas Beds, Peru. 1, external view, right valve, holotype, OS 11028,  $\times$  51. 2, internal view, right valve, paratype, OS 11031,  $\times$  51. 3, external view, left valve, paratype, OS 11029,  $\times$  51. 4, 5, internal view,  $\times$  51, and hinge,  $\times$  100, left valve, paratype, OS 11034. 7, external view, juvenile right valve, paratype, OS 11036,  $\times$  51.

Figs. 6, 8-13. *Botulocyprideis simplex* gen. et sp. nov., Pebas Beds, Peru. 6, external view, right valve, holotype, OS 11077,  $\times$  76. 8, 10, 12, muscle scars,  $\times$  500, internal view,  $\times$  76, hinge,  $\times$  200, left valve, paratype, OS 11079. 9, 11, internal view,  $\times$  76, hinge,  $\times$  200, right valve, paratype, OS 11078. 13, anterior marginal pore canals,  $\times$  180, right valve, paratype, OS 11080.



SHEPPARD and BATE, Plio-Pleistocene ostracods

*Pelocypris* sp.

Plate 10, fig. 14

*Remarks.* One broken specimen (OS 11071) of a noded species of *Pelocypris* was found in sample CAE/GEO/33. It is left under open nomenclature.

Family LIMNOCYTHERIDAE Klie, 1938

Genus CYTHERIDELLA Daday, 1905

*Cytheridella postornata* sp. nov.

Plate 10, figs. 1-7

*Derivation of name.* From the Latin, ornamented posterior.

*Locality and horizon.* Type locality, La Tagua, S. Colombia. Locality CAE/GEO/54, Plio-Pleistocene, and locality CAE/GEO/33, Colombia.

*Material.* Holotype, OS 11072, left valve. Two adult valves and several juvenile valves from locality CAE/GEO/54.

*Dimensions.* Holotype: OS 11072 LV L 1.10, H 0.60; Paratypes: OS 11073 RV L 1.08, H 0.60; OS 11074 juv. LV L 0.62, H 0.34; OS 11075 juv. LV L 0.68, H 0.38; OS 11076 broken LV, H 0.50.

*Diagnosis.* Species of *Cytheridella* with deep dorso-medial sulcus dividing carapace into smooth anterior portion and swollen pitted posterior. Broad, compressed, anterior margin.

*Description.* Dorsal and ventral margins of carapace parallel, anterior and posterior broadly rounded. Posterior half greatly swollen and postero-ventral portion overhangs ventral margin so that carapace is an inverted heart-shape when viewed dorsally. Ornamentation of small circular pits on posterior half only. Deep dorso-medial sulcus extends about two-thirds of the way down the valves. Smooth anterior margin broad and compressed. Hinge a simple adont development where selvage of right valve fits into flange groove of left valve. Selvage developed equally round valve margins. Duplicature narrow and there is a narrow posterior vestibule. Muscle scars consist of a vertical row of four adductors on a ridge corresponding to the outside sulcus dividing the carapace into two parts (see Pl. 10, figs. 4, 5).

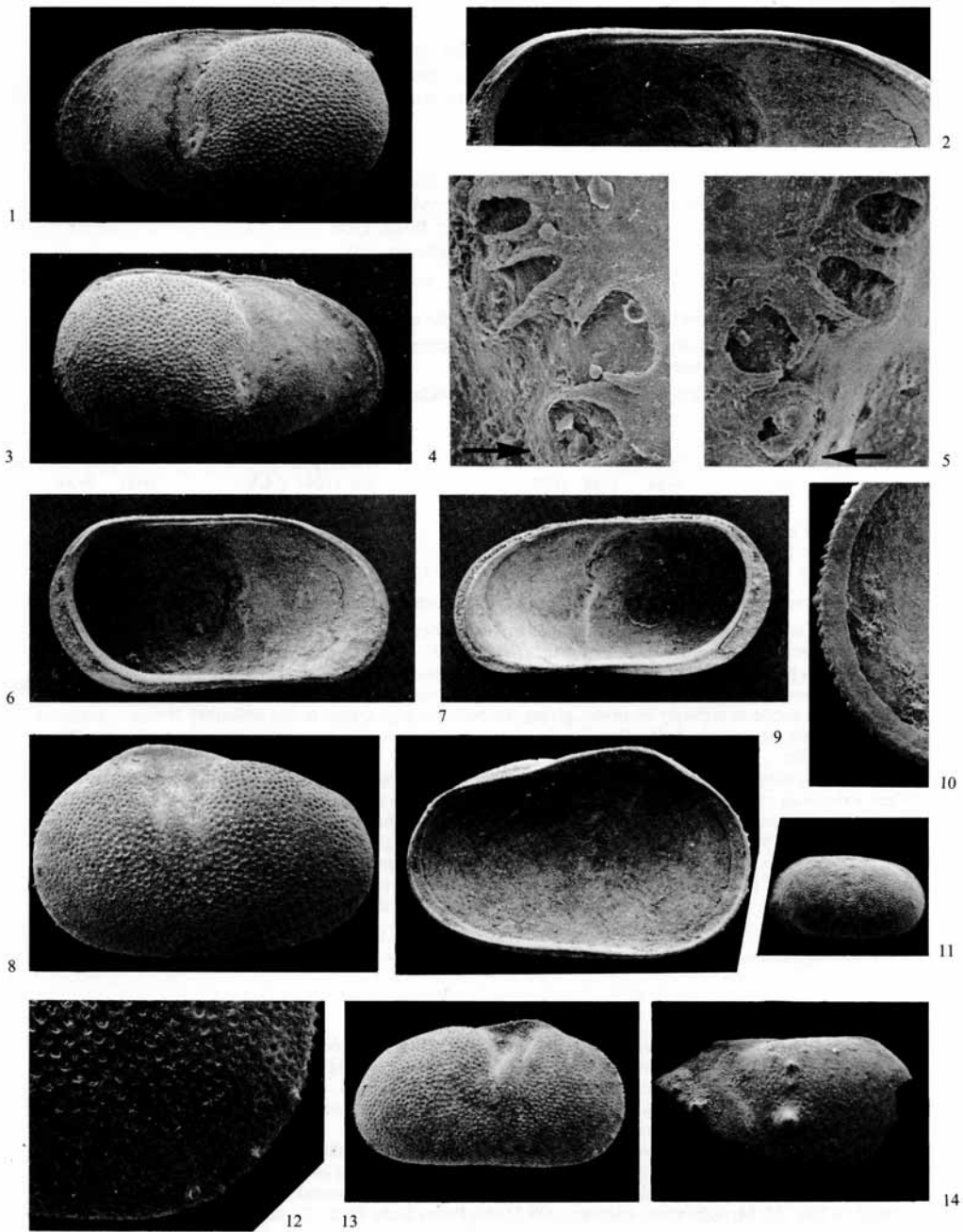
*Remarks.* *Cytheridella* species are strongly dimorphic. The two adult specimens observed in sample CAE/GEO/54 are considered females because of the pronounced posterior swelling. *C. postornata* sp. nov. is most similar to living species of the genus. It resembles the type species *C. ilosvayi* Daday, 1905 (see Purper 1974) and *C. boldi* Purper, 1974, both from S. America. *C. ilosvayi* is not so strongly sulcate as *C. postornata* externally, has pits over the entire shell surface, a rather sinuous dorsal margin, and the anterior margin is somewhat narrower. Internally the major difference between the two species lies in the well-developed anterior vestibule in *C. ilosvayi*. *C. boldi* is also pitted over the entire shell surface. The female dimorph of *C. boldi* is not so strongly swollen posteriorly as *C. postornata*, and the ventro-lateral part of the shell does not overhang the ventral

## EXPLANATION OF PLATE 10

Figs. 1-7. *Cytheridella postornata* sp. nov., locality CAE/GEO/54, Colombia. 1, 2, 4, 6, left valve, holotype, OS 11072. 1, external view,  $\times 51$ . 2, hinge,  $\times 100$ . 4, muscle scars,  $\times 1K$ . 6, internal view,  $\times 51$ . 3, 5, 7, external and internal views, right valve, paratype, OS 11073,  $\times 51$ . 5, muscle scars,  $\times 1K$ .

Figs. 8-13. *Pelocypris zilchi* Triebel, 1953, locality CAE/GEO/33, Colombia. 8, 9, external and internal views, left valve, OS 11066,  $\times 42$ . 10, duplicature, and dentate anterior shell margin, right valve, OS 11068,  $\times 71$ . 11, juv. left valve, OS 11069,  $\times 42$ . 12, 13, enlarged anterior margin,  $\times 71$ , and external view,  $\times 42$ , right valve, OS 11067.

Fig. 14. *Pelocypris* sp., locality CAE/GEO/33, Colombia, broken fragment of right valve showing development of surface nodes, OS 11071,  $\times 42$ .



SHEPPARD and BATE, Plio-Pleistocene ostracods

margin so far. *C. monodi* Klie, 1936, another Recent species, differs from *C. postornata* in having its greatest width in the median part of the carapace and tapering posteriorly. The Eocene species *C. strangulata* (Jones, 1860) is obliquely rounded anteriorly, irregularly ovoid in dorsal view, and triangular in posterior view.

Family CYTHERIDAE Baird, 1850  
 Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948  
 Genus AMBOCYTHERE Bold, 1958  
*Ambocythere campana* sp. nov.

Plate 11, figs. 1-9

*Derivation of name.* Latin, bell, referring to the shape of the posterior.

*Locality and horizon.* Only from La Tagua, S. Colombia, locality CAE/GEO/33. Plio-Pleistocene. Known only from the type locality and horizon.

*Material.* Holotype, OS 11037, female carapace. Several additional single valves and carapaces.

*Dimensions*

	L	H	W		L	H
Holotype:				Paratypes:		
OS 11037 ♀ car.	0.54	0.34	0.29	OS 11041 ♀ LV	0.60	0.34
Paratypes:				OS 11042 juv. LV	0.47	0.26
OS 11038 ♀ car.	0.57	0.34	0.26	OS 11043 broken ♀ LV	0.48	—
OS 11039 ♂ RV	0.63	0.33		OS 11045 juv. LV	0.37	0.24
OS 11040 ♂ LV	0.61	0.34		OS 11046 juv. LV	0.47	0.29

*Diagnosis.* Species of *Ambocythere* with reticulate ornamentation and bell-shaped posterior margin.

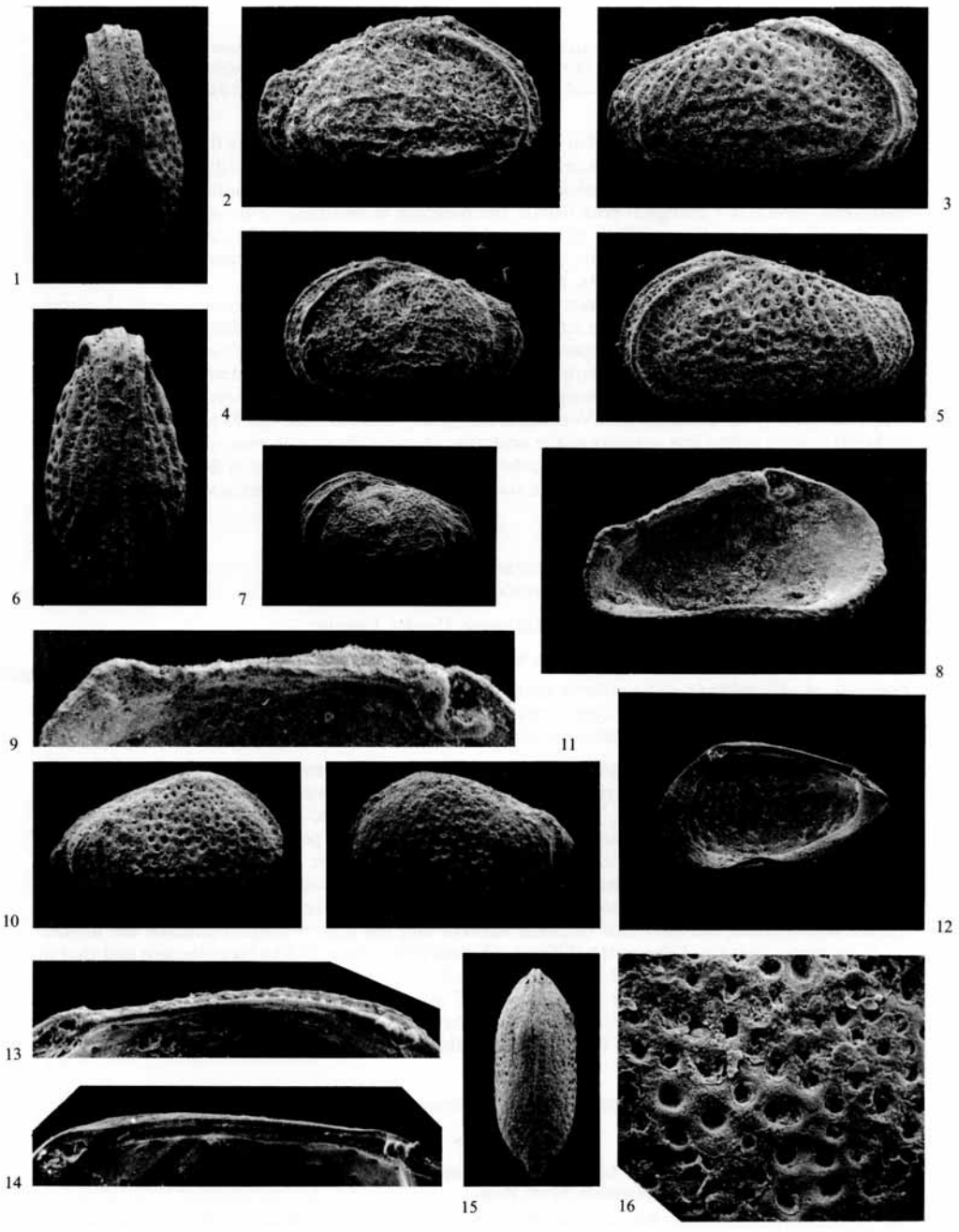
*Description.* Carapace pyriform to subquadrate in lateral view with greatest height in anterior third passing through anterior cardinal angle, and greatest length medially. Anterior margin broadly rounded, with strong carina-like rim parallel to it and extending dorsally to mid-point of dorsal margin and ventrally to about two-thirds along ventral margin. Dorsal margin short, straight, and slopes steeply just before the posterior cardinal angle where it becomes strongly incurved, giving the bell-end appearance to the obliquely truncate posterior. Carapace widest posteriorly. Left valve slightly larger than right, which it overlaps dorsally in the central part of dorsal margin.

Shell surface covered with reticulation of irregularly shaped pits which develop into several shallow lateral ridges, extending on to ventro-lateral and ventral surfaces, some of which curve up and follow the posterior margin. Near anterior marginal area, just behind marginal rim, the pits decrease in size and become arranged in parallel rows. These pits are also present in front of the rim, right up to the valve edge. Hinge-line straight. In left valve hinge consists of a deep anterior socket with a postadjacent knob-like process, which curves round beneath the socket, forming an anterior expansion of the median bar. Median bar itself is narrow and smooth and terminates just prior to the posterior smooth socket. It is the up-turning of the dorsal margin in the

EXPLANATION OF PLATE 11

Figs. 1-9. *Ambocythere campana* sp. nov., locality CAE/GEO/33, Colombia. 1, 6, female carapace, holotype, OS 11037, dorsal and ventral views,  $\times 76$  and  $\times 103$ . 2, right side, female carapace, paratype, OS 11038,  $\times 83$ . 3, right valve, male paratype, OS 11039,  $\times 83$ . 4, juv. left valve, paratype, OS 11046,  $\times 85$ . 5, male left valve, paratype, OS 11040,  $\times 83$ . 7, juv. left valve, paratype, OS 11045,  $\times 83$ . 8, 9, internal view,  $\times 83$ , and hinge,  $\times 143$ , female left valve, paratype, OS 11041.

Figs. 10-16. *Rhadinocytherura amazonensis* gen. et sp. nov. 10, 16, right valve, holotype, OS 11047, locality CAE/GEO/33, Colombia. 10, external view,  $\times 150$ . 16, enlargement of surface pitting,  $\times 1K$ . 11, 13, left valve, paratype, OS 11052, locality CAE/GEO/33, Colombia. 11, external view,  $\times 150$ . 13, enlargement of hinge,  $\times 288$ . 12, 14, right valve, paratype, OS 11048, Pebas Beds, Peru. 12, internal view,  $\times 150$ . 14, hinge,  $\times 288$ . 15, dorsal view, carapace, paratype, OS 11050, Pebas Beds, Peru,  $\times 150$ .



SHEPPARD and BATE, Plio-Pleistocene ostracods

region of the posterior cardinal angle which accommodates this posterior socket. Internally marginal area very broad anteriorly; inner margin and line of concrescence coincide; marginal pore canals long, numerous, and evenly spaced. Muscle scars not seen. Sexual dimorphism pronounced, females shorter and rather subquadrate, males more triangular laterally.

*Remarks.* This species has been placed in the genus *Ambocythere* despite lacking the usual denticulate, laterally projecting flange on the postero-ventral margin. Two morphologically similar genera are *Munseyella* Bold, 1957, and *Phacorhabdotus* Howe and Laurencich, 1958. Characteristic features of *Munseyella* include few marginal pore canals, the presence of vestibules anteriorly and posteriorly, and generally quadrate shape. None of these are shown on our material. *Phacorhabdotus* typically has subcentral tubercles on both valves, an eye node and prominent lateral ridges, broad compressed posterior and anterior marginal areas, and a holamphidont hinge.

Of the described *Ambocythere* species the closest to *A. campana* is *A. bodjonegoroensis* (Kingma, 1948) from the Pliocene of Java. The reticulate ornamentation here is very similar but the anterior marginal zone either side of the marginal rim is smooth. The dorsal margin slopes very steeply to the posterior which is much more obliquely truncate than in *A. campana*. A species which is possibly more closely allied to the present species has been described as *A. aff. bodjonegoroensis* Bold, 1965, a Miocene form from Trinidad and Venezuela where the reticulation extends further forward and the dorsal margin slopes less strongly to the posterior. *A. campana* is, however, distinguishable from both these species by its distinctly shaped posterior margin and the presence of the lateral ridges. All other described species of *Ambocythere* have surface ornamentation of ridges in various number and arrangement.

Family CYTHERURIDAE Müller, 1894

Genus RHADINOCYTHERURA gen. nov.

*Derivation of name.* Latin *Rhadinós*, slender + *Cytherura*. Gender, feminine.

*Type species.* *Rhadinocytherura amazonensis* sp. nov.

*Diagnosis.* A subovate to subquadrate genus of the Cytheruridae; rounded anterior and small triangular posterior with caudal process; smooth eye swelling. Well-developed vestibules at anterior and posterior ends. Hinge is modified peratodont with anterior terminal element lacking.

*Remarks.* The hinge of *Rhadinocytherura* is quite unique, being essentially peratodont in which the expansion of the median element is more pronounced anteriorly and where the anterior terminal element is absent in both valves. The hinge therefore comprises, in the left valve, a posterior loculate socket, a smooth median bar which expands slightly postero-medially and which is developed into a dentate anterior tooth. There is no anterior socket. An accommodation groove is present. The corresponding elements in the right valve are a posterior dentate tooth with an adjacent deep postero-median groove which narrows anteriorly where it is connected to a deeper loculate socket. Both the posterior terminal element and the antero-median element are divided into three parts. Text-fig. 4 shows the difference between the hinge of *Rhadinocytherura* and that of *Semicytherura* which has a typical Peratodont type hinge.

The carapace shape, size, and the presence of a caudal process place this genus into the Cytheruridae. The hinge, however, is obviously different and it may be necessary at a later date to erect a different taxonomic group based solely on this feature.

*Rhadinocytherura amazonensis* sp. nov.

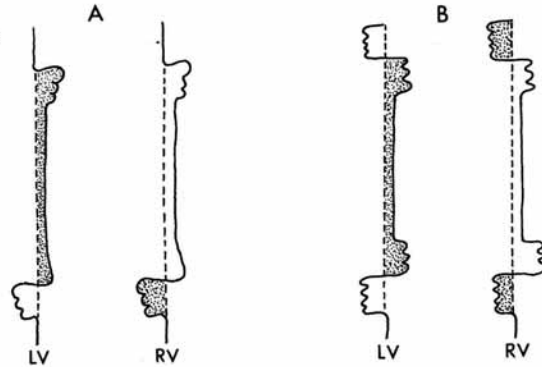
Plate 11, figs. 10-16

*Locality and horizon.* Type locality, La Tagua, S. Colombia, locality CAE/GEO/33, Plio-Pleistocene; also from the Pebas Beds at Pichua, Marañon River, Peru.

*Material.* Holotype, OS 11047, RV, from locality CAE/GEO/33; several additional valves and carapaces.



TEXT-FIG. 4. Diagrammatic reconstruction of *Rhadinocytherura* hinge (A) in comparison with typical Peratodont hinge as in *Semicytherura* (B).



*Dimensions*

	L	H	W
Holotype:			
OS 11047 RV	0.26	0.15	
Paratypes:			
OS 11048 RV	0.26	0.15	
OS 11049 RV	0.26	0.15	

	L	H	W
Paratypes:			
OS 11050 car.	0.24	0.13	0.09
OS 11052 LV	0.26	0.15	
OS 11053 LV	0.27	0.15	
OS 11054 RV	0.25	0.15	

*Diagnosis.* Species of *Rhadinocytherura* with surface ornamentation of subcircular pits.

*Description.* Carapace small (0.24–0.26 mm in length), subovate to subquadrate, highest anteriorly and with greatest length medially. Dorsal margin strongly arched with apex at anterior cardinal angle; ventral margin convex. Anterior broadly rounded and slightly compressed at extreme valve edges; posterior triangular, with distinct caudal process. Posterior margin broadly flattened and extends ventrally for about one-third of ventral margin. In dorsal view the valves are perfectly parallel-sided. Surface with small subcircular pits arranged roughly in rows parallel to ventral margin and bend up to follow the anterior and posterior margins. The slight eye swelling in the region of the anterior cardinal angle is smooth; so too is the compressed postero-ventral border. Pore canals simple, irregularly scattered over the shell surface. Inner marginal areas are broad with well-developed vestibules both anteriorly and posteriorly. Muscle scars consist of a vertical row of four connected adductor scars of unequal size; the frontal scar has not been observed. The hinge has already been discussed in detail for the genus. Sexual dimorphism has not been observed in this species.

*Remarks.* Ostracod D n.g., n. sp. Purper, 1977, is very close to *R. amazonensis* in valve outline, ornamentation, and presence of a caudal process and an eye swelling. The muscle scars, however, consist of four separate vertical adductors, an elongate frontal scar, and a distinct mandibular scar. The figured hinge shows a weakly denticulate median bar which is swollen more or less equally at both ends; this is clearly distinguishable from that of *R. amazonensis*. There is no other record of any similar species.

*R. amazonensis* is considered a marine to brackish-water form.

Family CYTHERIDAE Baird, 1850  
 Subfamily PERISSOCYTHERIDEINAE Bold, 1963  
 Genus PERISSOCYTHERIDEA Stephenson, 1938  
*Perissocytheridea formosa* sp. nov.

Plate 12, figs. 1–6, 8, 10–12

*Derivation of name.* Latin, *formosus*, beautifully formed, referring to the surface ornamentation.

*Locality and horizon.* Only from La Tagua, S. Colombia, locality CAE/GEO/33, Plio-Pleistocene.

*Material.* Holotype, OS 11056, female right valve, and several single valves.

*Dimensions*

	L	H	W		L	H
Holotype:				Paratypes:		
OS 11056 ♀ RV	0.36	0.23		OS 11058 ♀ LV	0.36	0.21
Paratypes:				OS 11059 ♂ RV	0.40	0.21
OS 11044 ♀ car.	0.35	0.19	0.17	OS 11060 ♀ RV	0.37	0.21
OS 11051 ♀ RV	0.36	0.21		OS 11061 ♂ RV	0.38	0.21
OS 11057 ♀ LV	0.35	0.20				

*Diagnosis.* Species of *Perissocytheridea* with heavily sculptured pitted shell surface and strong ventro-lateral alar development.

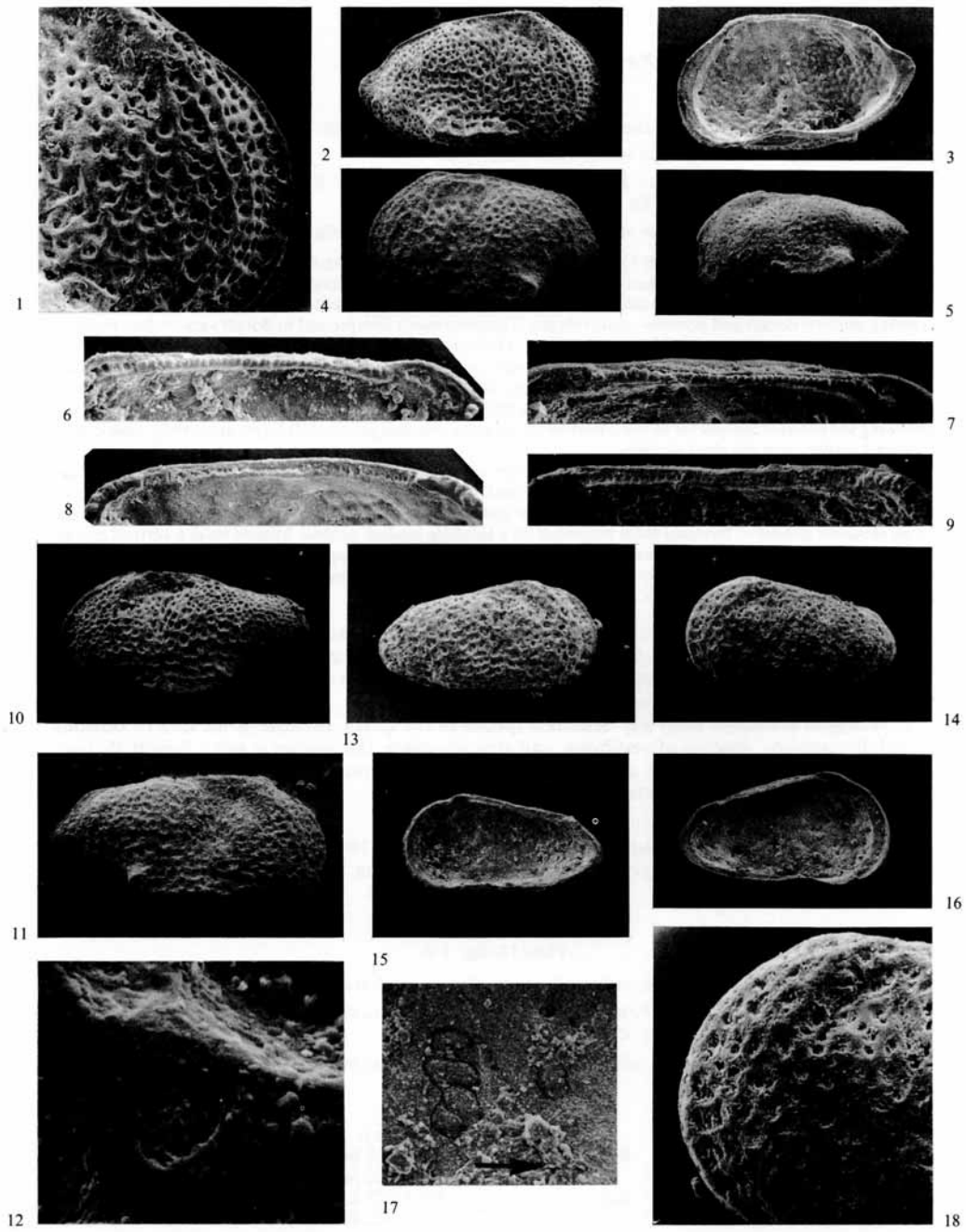
*Description.* Carapace small (0.35–0.40 mm in length), subpyriform to subquadrate in lateral view with nearly straight dorsal margin and convex ventral margin. Left valve the larger: anterior broadly rounded, posterior triangular. Anterior and posterior cardinal angles well defined; a shallow sulcus extends down from the region of the anterior cardinal angle to approximately the mid-point of each valve. Extension of the shell developed ventro-laterally into a ridge which is definitely wing-like in some specimens. The greatest height, equal to about half the length, is in the anterior third, passing through the anterior cardinal angle; greatest length passes through mid-point of the shell. Surface ornamentation of irregularly shaped and arranged deep pits, forming parallel rows around the anterior margin. Anterior border compressed, so too to a lesser extent is the postero-ventral border. Sexual dimorphism pronounced, females shorter, taller, and more subquadrate. The dorsal margin in the males has a tendency to become slightly incurved towards the posterior. Normal pore canals large, with sieve-plates, few in number and scattered evenly over the shell. Internally the hinge is a weakly developed antimerodont type with, in the left valve, terminal loculate sockets connected by an intervening denticulate median bar. The inner margin and line of concrescence apparently coincide; duplicature narrow. Muscle scars not seen.

*Remarks.* The juveniles of *P. formosa* have weakly developed ornamentation but strongly developed wing-like processes.

The type species of *Perissocytheridea*, *P. matsoni* (Stephenson, 1935), a Miocene species from Louisiana, U.S.A., closely resembles *P. formosa* in ornamentation but differs by being more strongly sulcate, by tapering more to the posterior, and by being more inflated postero-dorsally in the male dimorph. *P. formosa* is not similar to living species of *Perissocytheridea*. *P. gibba* (Klie, 1939a), originally described from Brazil, is a non-sulcate, smooth-shelled species with broadly compressed marginal areas both posteriorly and anteriorly. *P. krömmelbeini* Pinto and Ornellas, 1970 described from a brackish-water lagoon channel from Southern Brazil, is a strongly pitted species, like *P. formosa*, but differs by possessing a distinct swelling to the carapace in the postero-dorsal and antero-median regions. *P. meyerabichi* (Hartmann) (see Swain 1967), described from the Gulf of California, is distinguished by its coarsely reticulate surface ornamentation. Van den Bold (1975) described a species as *Perissocytheridea* sp. B from the Pliocene of the Dominican Republic which is close to *P. formosa* in shape and ornament. It is distinguished from *P. formosa* by possessing a horizontal sulcus which runs from the valve centre to the posterior margin. It is noted that *P. formosa* does not possess the terminal vestibules which are characteristic of the genus. We do, however, consider that the shape, sulcation, ornament, and hinge adequately ally this species to *Perissocytheridea*.

## EXPLANATION OF PLATE 12

Figs. 1–6, 8, 10–12. *Perissocytheridea formosa* sp. nov., locality CAE/GEO/33, Colombia. 1–3, 8, 12, female right valve, holotype, OS 11056. 1, anterior enlarged to show ornamentation, ×248. 2, 3, external and internal views, ×111. 8, enlarged view of hinge, ×222. 12, sieve plate, ×5K. 4, 6, female left valve, paratype, OS 11057, external view, ×111, and hinge, ×222. 5, left side, female carapace, paratype, OS 11044, ×111. 10, male left valve (specimen lost), ×111. 11, male right valve, paratype, OS 11059, ×111.  
Figs. 7, 9, 13–18. *Perissocytheridea? elongata* sp. nov., Pebas Beds, Peru. 7, 16, 17, left valve, paratype, OS 11064. 7, hinge, ×222. 16, internal view, ×111. 17, muscle scars, ×2K. 9, 15, right valve, paratype, OS 11063, hinge, ×222, internal view, ×111. 13, external view, right valve, holotype, OS 11062, ×111. 14, 18, external views, left valve, paratype, OS 11065, (14) ×111, (18) ×172.



SHEPPARD and BATE, Plio-Pleistocene ostracods

*Perissocytheridea? elongata* sp. nov.

Plate 12, figs. 7, 9, 13-18

*Locality and horizon.* Only from Pichua, Marañon River, Peru. Pebas Beds, Plio-Pleistocene.*Material.* Holotype, OS 11062, right valve. Three paratypes.*Dimensions.* Holotype: OS 11062 RV L 0.33, H 0.17; Paratypes: OS 11063 RV L 0.30, H 0.17; OS 11064 LV L 0.31, H 0.17; OS 11065 LV L 0.32, H 0.18.*Diagnosis.* Elongate species of *Perissocytheridea?* with pitted shell surface and weakly developed alae.*Description.* Carapace small (0.30-0.33 mm in length), elongate, subrectangular to triangular, greatest height occurring in the anterior third, greatest length passing below mid-point. Dorsal margin straight, ventral margin straight to slightly convex. Anterior margin broadly rounded and compressed: posterior is triangular due to the tapering postero-dorsal and postero-ventral slopes. Carapace much compressed in dorsal view, valves more or less parallel sided; the greatest width occurs medially. On each valve there is a slight lateral swelling of the shell in a postero-ventral position; this alate development is more pronounced in some specimens than in others. Surface ornamentation of small irregularly shaped pits which, around the anterior border, develop into a single row of large evenly spaced depressions. Shallow sulcus present in an antero-dorsal position which describes a small arc following the anterior margin for about a third of its distance. Normal pore canals large, apparently simple, and scattered widely over the shell surface.

Internally hinge straight, well developed, of antimerodont type with, in the left valve, an anterior loculate socket, a median denticulate bar, and a posterior loculate socket. There is a tendency for the median bar to become more coarsely dentate at the extreme anterior and posterior ends. Correspondingly, in the right valve the hinge elements consist of terminal teeth separated by a locellate median groove. Muscle scars a vertical row of four oval adductors. The only frontal scar which has been observed is apparently oval but this is somewhat obscured. Duplication narrow, inner margin and line of conrescence coinciding throughout; marginal pore canals not seen. Sexual dimorphism is not apparent.

*Remarks.* In 1977 Purper figured a species from the late Tertiary of Brazil which she named *Perissocytheridea* sp. nov. A. Apart from being rather more sulcate, this very closely resembles *P.?* *elongata* but from the illustrations alone, with no description, it would be unreasonable to place this in synonymy with the present species.*P.?* *elongata* is distinct from any described species of the genus. Because of the lack of obvious sexual dimorphism, absence of vestibules, and elongate shape this species is not a typical *Perissocytheridea*. The ornament, hinge, and sulcation (although not pronounced) are otherwise characteristic of the genus, to which it is tentatively assigned.

Superfamily CYPRIDACEA Baird, 1846  
 Family CYCLOCYPRIDIDAE Kaufmann, 1900  
 Genus CYPRIA Zenker, 1854  
*Cypria aqualica* sp. nov.

Plate 13, figs. 1-6

*Derivation of name.* Latin, *aqualicus*, belly, referring to the rotund shape of the shell.*Locality and horizon.* Type locality Pichua, Marañon River, Peru, from the Pebas Beds, Plio-Pleistocene. Also locality CAE/GEO/33, La Tagua, S. Colombia.*Material.* Holotype, OS 11016, left valve. A few single valves and one broken carapace.*Dimensions*

	L	H		L	H	W
Holotype:			Paratypes:			
OS 11016 LV	0.61	0.43	OS 11019 broken car.	0.59	—	0.24
Paratypes:			OS 11020 juv. LV	0.32	0.24	
OS 11017 RV	0.60	0.42	OS 11021 LV	0.49	0.36	
OS 11018 broken LV	—	—	OS 11022 RV	0.53	0.38	

*Diagnosis.* Smooth-shelled species of *Cypria* with broadly rounded anterior and posterior margins, straight to slightly concave ventral margin, and convex dorsal outline with pronounced posterior cardinal angle.

*Description.* Thin-shelled fragile carapace, subovate, with greatest height and length occurring medially. Dorsal margin broadly convex with somewhat steeper postero-dorsal slope; ventral margin nearly straight to slightly concave. Anterior is broadly rounded while the posterior is rather more truncate. Shell surface smooth. In dorsal view carapace somewhat compressed with maximum width medially; left valve slightly larger than right. Normal pore canals small and inconspicuous.

Internally cardinal angles more pronounced than externally. Shallow terminal vestibules are developed anteriorly and posteriorly. Muscle scar pattern consists of four unequal oval-shaped adductors.

*Remarks.* This species has been placed in the genus *Cypria* rather than *Cyclocypris* due to the compressed carapace in dorsal view and the larger left valve. The majority of species of *Cypria* are still living, and are largely distinguished on soft-part morphology. They show little affinity with the present species. Two fossil species which closely resemble *C. aqualica* are *C. tocorjescui* Hanganu (in Malz 1973b) and *C. dorsalta* Malz, 1973b, both Miocene forms from Germany. *C. tocorjescui* is distinctly subquadrate with a pronounced posterior cardinal angle and a convex ventral margin. *C. dorsalta* is quite distinct having a very highly arched dorsal margin.

Other fossil forms of *Cypria* include *C. anterosinuata* Staplin, 1963, a Pleistocene species from Illinois with a surface ornamentation of fine anastomosing lines; *C. nevadensis* Dickinson and Swain, 1967, a Plio-Pleistocene species from Nevada which is recognized on its truncated antero-dorsal slope; *C. parva* Grekoff, 1957, L. Cretaceous of the Belgian Congo, a small elongate species, and *C. subangulata* Chapman, 1896, a Pliocene form from California with, in dorsal view, distinctly compressed anterior margin. *C. pellucida* Sars, 1901 from Brazil is the Recent species closest to *C. aqualica*, but is distinguished from it by having a short truncated posterior margin and a projecting flange on the postero-ventral margin.

Family PARACYPRIDIDAE Sars, 1923

Genus PARACYPRIS Sars, 1866

*Paracypris* sp.

Plate 13, figs. 8-10

*Material and distribution.* Three adult single valves from the Pebas Beds of Pichua, Peru.

*Dimensions.* OS 11083 RV L 0.64, H 0.23; OS 11084 LV L 0.61, H 0.24; OS 11085 RV L 0.58, H 0.21.

*Description.* Non-dimorphic carapace elongate, subtriangular in lateral view with broadly arched dorsal outline tapering to a ventrally situated pointed posterior and rounded anterior margin; ventral margin slightly concave. Greatest height occurs just anterior to mid-point, greatest length ventral. Valves compressed; valve surfaces smooth. Duplicature very wide anteriorly, slightly less wide posteriorly with large irregular terminal vestibules. Marginal pore canals and muscle scars not seen. Hinge adont, dorsal margin of right valve fitting into a groove in the larger left valve.

*Remarks.* Insufficient material is available for formal specific identification. *P. labocana* Bold, 1972 from the Panama Canal differs in having a straight ventral margin and a more broadly rounded anterior margin. Although the characteristic bifurcating marginal pore canals have not been seen, this species is placed in *Paracypris* because it is otherwise similar in shape and size (*Macrocypris* is much larger). Preservation is poor. Since they were marine forms they were probably washed into the depositional area, rather than being indigenous.

Superfamily DARWINULACEA Brady and Norman, 1889

Family DARWINULIDAE Brady and Norman, 1889

Genus DARWINULA Brady and Robertson, 1885

*Darwinula* sp.

Plate 13, fig. 7

*Material and distribution.* One single valve and a few fragments only, from the Pebas Beds of Pichua, Peru.

*Dimensions.* OS 1055 RV L 0.51, H 0.21.

*Description.* Shell elongate, ovate, rounded anteriorly and posteriorly with straight, parallel dorsal and ventral margins. Maximum length occurs medially; maximum height just posterior to mid-point. Shell surface smooth and featureless. Muscle scars typical *Darwinula*-type rosette of scars, precise number of which it is impossible to see. Hinge simply adont.

*Remarks.* The presence of *Darwinula* sp. in the Pebas sample is indicative of a fresh to brackish-water environment. It is unlikely that extensive transport of the specimens has taken place because the fragile valves are complete. This species is left under open nomenclature because of the lack of material.

Family PONTOCYPRIDIDAE G. W. Müller, 1894

Genus PONTOCYPRIS Sars, 1866

*Pontocypris?* sp.

Plate 13, figs. 11-15

*Material and distribution.* A few valves, only in the Pebas Beds of Pichua, Peru.

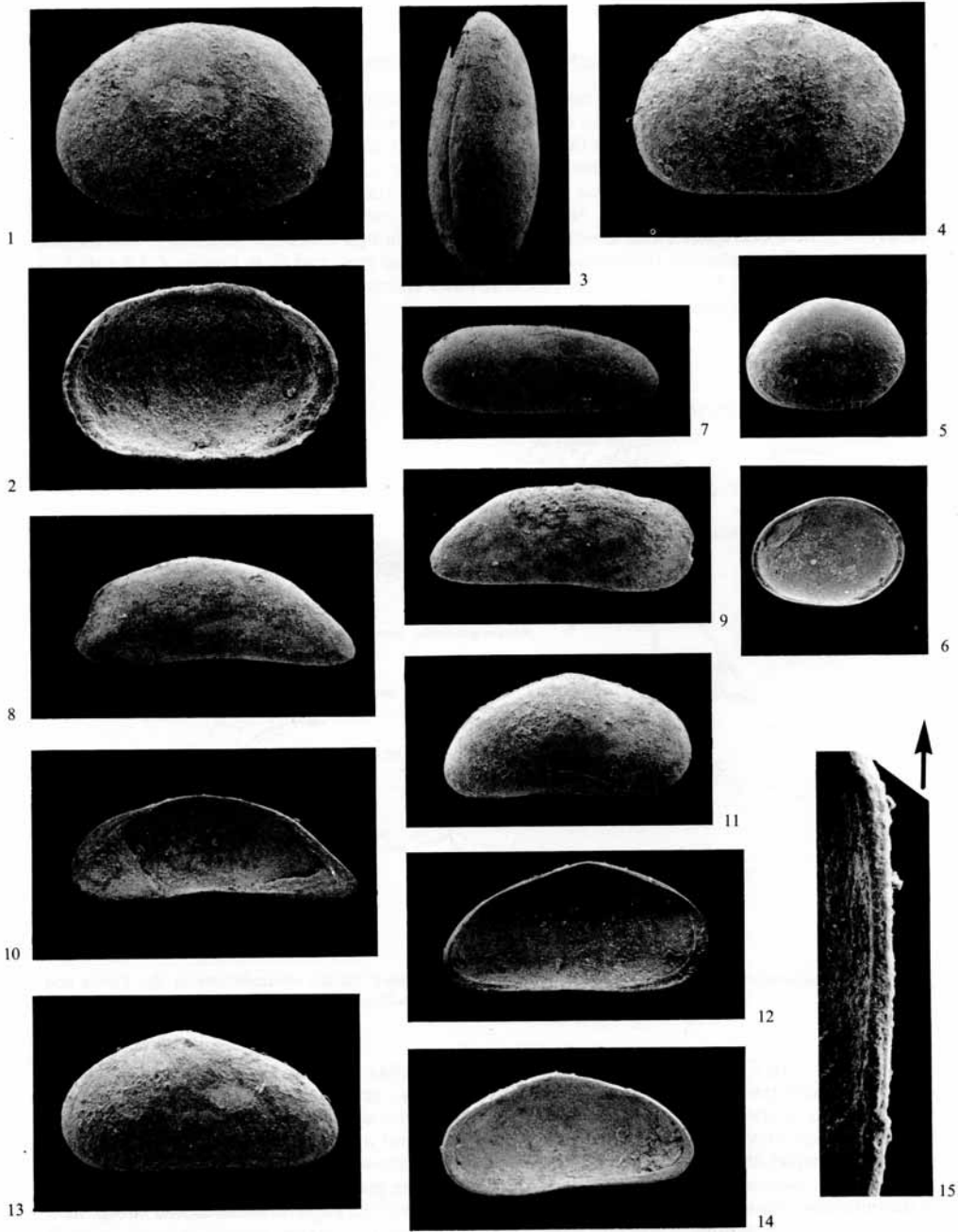
*Dimensions.* OS 11023 RV L 0.70, H 0.34; OS 11024 LV L 0.59, H 0.29; OS 11025 RV L 0.55, H 0.28; OS 11026 LV L 0.59, H 0.29; OS 11027 RV L 0.56, H 0.28.

*Description.* Shell elongate subtriangular with maximum height just anterior of the mid-point, greatest length ventrally. Dorsal margin strongly arched with a steep antero-dorsal slope to broadly rounded anterior margin; postero-dorsal slope tapers to posterior cardinal angle and then slopes steeply to posterior valve margin. Ventral margin slightly concave. Entire valve margins smooth, as are valve surfaces. Sexual dimorphism unknown. Internally inner margin very narrow with slight vestibules anteriorly and posteriorly. Marginal pore canals not seen but were probably very short. Hinge apparently adont. Muscle scars not seen.

*Remarks.* Insufficient material of this species is available for a specific name to be assigned to it. The generic name is queried mainly because of the very narrow duplicature; true *Pontocypris* species have a very wide anterior duplicature and narrower posterior duplicature. The genus usually has spines on the postero-ventral margin of the right valve only, which are absent in the present species. *Propontocypris* differs by having the greatest valve height medially. Although no complete carapaces have been found of *Pontocypris?* sp. the left valve appears to be the larger valve (by the presence of a marginal groove, at the posterior and anterior ends, that serves to accommodate the free edge of the right valve). In *Pontocypris* and *Propontocypris* the larger valve is the right valve. We suggest that *Pontocypris?* sp. may in fact belong to a genus closely related to *Pontocypris*: more material will have to be obtained to confirm this.

EXPLANATION OF PLATE 13

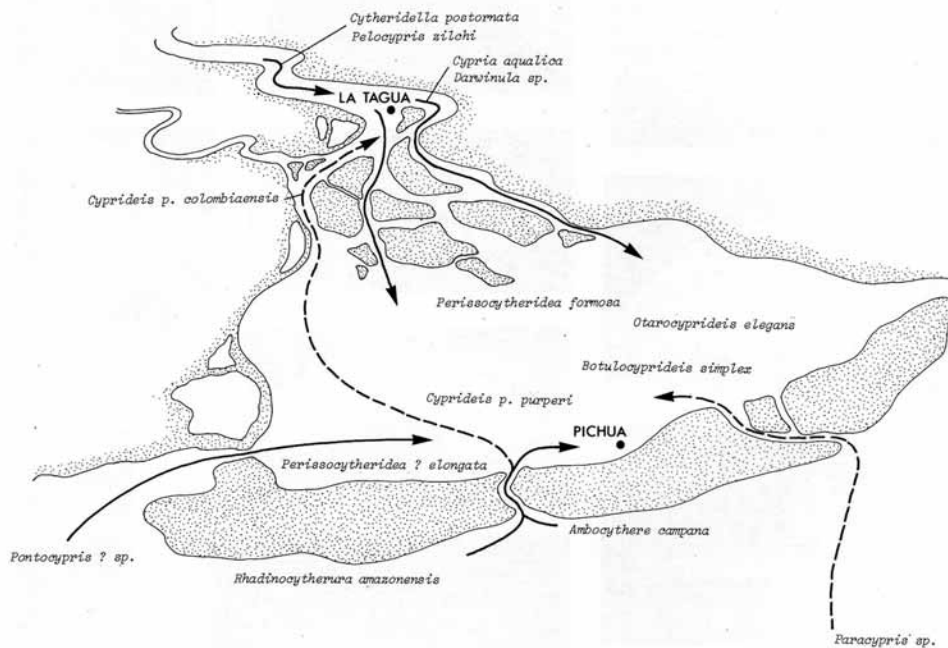
- Figs. 1-6. *Cypria aqualica* sp. nov., Pebas Beds, Peru. 1, external view, left valve, holotype, OS 11016,  $\times 75$ . 2, internal view, left valve, paratype, OS 11018,  $\times 75$ . 3, dorsal view, carapace, paratype, OS 11019,  $\times 77$ . 4, external view, right valve, paratype, OS 11017,  $\times 75$ . 5, 6, external and internal views, juv. left valve, paratype, OS 11020,  $\times 75$ .
- Fig. 7. *Darwinula* sp., Pebas Beds, Peru, right valve, OS 11055,  $\times 76$ .
- Figs. 8-10. *Paracypris* sp., Pebas Beds, Peru. 8, external view, left valve, OS 11084,  $\times 76$ . 9, external view, right valve, OS 11085,  $\times 76$ . 10, internal view, right valve, OS 11083,  $\times 76$ .
- Figs. 11-15. *Pontocypris?* sp. Pebas Beds, Peru. 11, external view, right valve, OS 11023,  $\times 76$ . 12, internal view, left valve, OS 11024,  $\times 76$ . 13, external view, left valve, OS 11026,  $\times 76$ . 14, 15, internal view, right valve,  $\times 76$ , and hinge,  $\times 150$ , OS 11025.



SHEPPARD and BATE, Plio-Pleistocene ostracods

## ENVIRONMENT OF DEPOSITION

Of the three samples examined, the one from locality CAE/GEO/54, a grey clay full of crushed molluscs contained a fauna limited to a single ostracod species—*Cytheridella postornata* sp. nov. Although a large species, the shell is thin and delicate and no extensive transport of the material is envisaged. As *Cytheridella* is a freshwater genus there is no reason to regard the grey clay exposed on the river bank south of La Tagua as being anything other than a freshwater, possibly lake deposit. The other two samples, however, contain an ostracod fauna which is mixed both in variety of genera and species and in salinity tolerance. Although brackish, freshwater, and marine ostracods are all represented, the faunas of the Pebas Beds of Peru and from locality CAE/GEO/33 of Colombia are both dominated by the brackish-water species *Cyprideis purperi* sp. nov. of which two subspecies are recognized.



TEXT-FIG. 5. Palaeogeographic interpretation of the brackish-water lagoon environment in the Pebas and La Tagua regions during the Plio-Pleistocene.

Associated with *C. purperi purperi* subsp. nov. in the Pebas Beds are the new ostracods *Otarocyprideis elegans* gen. et sp. nov. and *Botulocyprideis simplex* gen. et sp. nov. both belonging to the same family as *Cyprideis* and considered to have inhabited a similar brackish-water environment. Like *C. purperi* they are represented by juvenile instars and are considered to have lived on the sediments in which they are now found. Two further brackish-water forms, both species of *Perissoocytheridea*, *P. formosa* sp. nov. and *P. ? elongata* sp. nov. are present in the Pebas Beds. *P. formosa* is the only brackish-water species that is found associated with *C. purperi colombianaensis* subsp. nov. in the Colombian sample CAE/GEO/33. Two shallow-water marine species present in both



Colombia (locality CAE/GEO/33) and Peru are *Ambocythere campana* sp. nov. and *Rhadino-cytherura amazonensis* gen. et sp. nov. It is only at Pichua in the Pebas Beds that the deeper-water marine *Paracypris* is found, admittedly as a rare representative of the total fauna; the marine *Pontocypris* sp. is slightly more common in the Pebas Beds.

At the opposite end of the salinity gradient (see text-fig. 6) the Colombian locality CAE/GEO/33 has a larger freshwater ostracod fauna than does the Pichua sample of Peru with *Cytheridella postornata* sp. nov., *Pelocypris zilchi* Triebel, *Darwinula* sp., and *Cypria aqualica* sp. nov. Only *Darwinula* sp. and *C. aqualica* occur at Pichua. Thus we have two areas under consideration, the first in Colombia represented by locality CAE/GEO/54 with an entirely freshwater fauna and locality CAE/GEO/33 with a larger freshwater fauna associated with brackish and shallow marine ostracods. The second area is that of northern Peru in the region of Pichua where both the brackish-water and the marine elements of the fauna are increased. Text-fig. 5 illustrates our interpretation, though probably oversimplified, of the environment during the Plio-Pleistocene, with a marine transgression, possibly from the east, extending into the Pichua-La Tagua region, La Tagua being situated furthest from the sea. We consider, therefore, that the ostracods present in the Plio-Pleistocene deposits of La Tagua and Pichua reflect a series of different environments that belong, in our opinion, to a slow-moving river system having freshwater lakes on the flood plain and passing into the sea through a series of brackish-water lagoons. The lagoons would have been separated from the sea by islands and sand bars, the sea entering and the river flowing out through narrow channels.

Within the river system the slow movement of the water would permit the development of sand bars and the silting up of river channels would enable the brackish-water lagoons to develop. Fresh-water lakes on the flood plain would support the *Cytheridella postornata* fauna while the other freshwater ostracods *Cypria aqualica*, *Pelocypris zilchi*, and *Darwinula* sp. would be equally at home in either still or very slow-moving water.

Saline conditions in a region of low relief exert an influence some distance from the sea to produce a brackish-water environment. Whether marine ostracods would be able to extend very far inland would depend on the strength of the freshwater flow in the opposite direction (although in tidal estuaries the incoming sea water does not mix but flows in over the outgoing fresh water), the strength and extent of the tidal flow, and the ability of the ostracods in question to survive in water of a lowered salinity. Significantly, those ostracods known to be solely marine in habit (in this case *Paracypris* sp.), occur only in the Pichua area, considered to have been fairly close to the sea—it is unlikely that purely marine ostracods such as *Paracypris* could survive for long in a brackish-water environment. Certainly *Paracypris* is a very rare member of the fauna. Such extensive transportation would also result in the sorting out of any larger marine species.

We have not been able to undertake a detailed palaeogeographical reconstruction of the area based on three samples but we do consider that the presence of brackish-water lagoons on the edge of a purely marine environment is the only rational interpretation of the geology. A sedimentological study of the region would be rewarding in terms of confirming the postulated direction of river flow from the north-west to the east and south-east. Thus, with land to the west and north-west the open sea would have lain to the east, the marine transgression entering along the present-day Amazon Basin. With the Andes to the west it is unlikely that any marine transgression could have entered from that direction. The surface topography during Plio-Pleistocene times could not have differed very much from what it is today where the whole of the Amazon Basin, from the headwaters in Peru and S. Colombia to the mouth of the river, lies within a height range of from sea-level to 200 metres. Little fluctuation in land and sea-level would be needed to bring marine conditions into the Peru/S. Colombia area.

In conclusion, we can state that the study of the ostracods has enabled us not only to suggest an age for the deposition of the sediments (see next section) but has revealed a much more complex situation than has generally been understood before. The presence of freshwater and of brackish-water ostracods is of less importance than is the occurrence of marine ostracods, for it is these that point to the presence, at that time, of a substantial marine transgression in the Plio-Pleistocene. The



alternative explanation, that a series of brackish-water lakes existed and that the more marine ostracods were introduced at the egg stage by way of the feet or plumage of wading birds is not considered to be practicable. Certainly the presence of the deeper-water *Paracypris* would not support this hypothesis.

#### AGE AND CORRELATION

The basis for regarding the ostracod fauna as being of Plio-Pleistocene age rests primarily with the occurrence, in the Colombian material, of *Pelocypris zilchi*, a freshwater ostracod described from the Pleistocene of El Salvador. The complete geographical range of this ostracod is not known but its association, again in Colombia, with *Cytheridella postornata*, *Cytheridella* being a Pleistocene to Recent genus, again supports a Pleistocene age determination. The remainder of the fauna whether it be brackish, freshwater, or marine does not offer such precise information but certainly points to a late Tertiary age. Because we are dealing with faunas containing marine ostracods, and the necessity of envisaging a marine transgression to get them into the Upper Amazon, we consider that a late Pliocene to early Pleistocene age would be more accurate for these sediments.

The Colombian and the Peruvian samples are of the same age, based on the similarity of the ostracod faunas. Correlation of the two Colombian samples (text-fig. 6) is effected by the common occurrence of *C. postornata*, while correlation with the Pebas Beds of Pichua is possible through a larger fauna of fresh, brackish, and marine ostracods.

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