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Taxonomy and ecology of the Family Cytheruridae (Ostracoda) in Recent sediments from the northern Rio de Janeiro coast, Brazil

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ABSTRACT - A study of the family Cytheruridae in Recent sediments from the coast of northern Rio de Janeiro State revealed the presence of four new species: (*Hemicytherura auriculata*, *Oculocytheropteron delicatum*, *Oculocytheropteron circumcostatum* and *Semicytherura caudata*,) and four previously described species (*Semicytherura rugosoreticulata* Whatley, Chadwick, Coxill & Toy, 1988, *Oculocytheropteron macropunctatum* Whatley, Chadwick, Coxill & Toy, 1988, *Oculocytheropteron reticulopunctatum* Whatley, Chadwick, Coxill & Toy, 1988 and *Paracytheridea bulbosa* Purper & Ornellas, 1989). A further two species *Cytheropteron* sp. and *Kangarina* sp. are left in open nomenclature due to paucity of the material. The ecology and distribution of the fauna suggest that the presence of many of these species, which also occur in colder waters off the coast of Uruguay and Argentina, is probably due to the upwelling of the South Atlantic Central Water in this area. *J. Micropalaeontol.* **18(1):** 1–16, June, 1999.

INTRODUCTION

The cytherurids are one of the most diverse and abundant families of cytheracean marine and brackish water Ostracoda. Their diversity in either shallow or deep water changes little from the poles to the equator and, in addition, they commonly represent one of the most abundant families. One of the characteristics of the Cytheruridae is their small size but, because they frequently have very species-specific ornamentation, they are easily recognized. Notwithstanding this, they are often left in open nomenclature or dealt with solely at the generic level.

In Brazil, only Ornellas & Fallavena (1978) and Purper & Ornellas (1987a, b; 1989) have made detailed specific studies of cytherurids. The former workers described a new species, *Cytherura purperae*, a mixohaline species from southern Brazil, while Purper & Ornellas (1987a, b; 1989) studied the taxonomy and zoogeography of the genus *Paracytheridea* along the Brazilian coast. Dias-Brito *et al.* (1988) and Coimbra *et al.* (1992) studied Sepetiba and Tamandaré Bays, respectively, and recorded the occurrence of cytherurids. Pinto *et al.* (1978) also surveyed the Ostracoda along the Brazilian coast, including the cytherurids. Whatley *et al.* (1988) monographed the Cytheruridae from the Antarctic to southern Brazil and described a total of 34 species belonging to eight genera.

This paper deals with the taxonomy and ecology of the entire cytherurid fauna present in a specific geographical area of the Brazilian coast. The northern coast of Rio de Janeiro State was chosen because it records the greatest intensity of upwelling of cold water masses from the south. This area coincides with the southern portion of the zoogeographical 'transition zone' of the ostracod fauna of the Brazilian continental shelf as defined by Coimbra & Ornellas (1989).

MATERIAL AND METHODS

The 47 samples studied were collected during the GEOCOSTA RIO II expedition and were made available to the authors by the Department of Geography of the Universidade Federal do Rio de Janeiro, where the project 'Levantamento Físico Ambiental da Plataforma Continental Interna entre as cidades do Rio de Janeiro e Cabo Frio' was developed.

The samples were collected in March 1986. All the ostracods were picked from dry sediment samples, each weighing 20 g, and mounted using conventional micropalaeontological techniques.

The constancy (C) of the species (the frequency of the species in the samples, expressed as a percentage) was calculated using the following formula: $C = p.100/P$, where p = number of samples in which the species occurs and P = total number of analysed samples. Dominance (D) was calculated using the formula $D = t.100/T$, where t = number of total specimens of each species and T = total number of specimens (Tinoco, 1989).

The diversity index was calculated using the Shannon–Wiener information function. The diversity index is expressed by the equation $H(S) = -\Sigma pi.\ln p_i$, where p_i = the proportion of each species i and $\ln p_i$ = natural logarithm of p_i.

The percentage of sediment types in each water depth interval was calculated using the 'Idrisis' program for Windows.

The type material, together with a series of homotypes and hypotypes, is deposited at the Museu de Paleontologia da Universidade Federal do Rio Grande do Sul, Porto Alegre, UFRGS, under numbers MP-O-1483 to MP-O-1503 and MP-0-1462, MP-0-1463.

STUDY AREA

A rectangular area (35×15 km) with depths ranging from 20 to 75 m, of the continental shelf of Rio de Janeiro State, between Cabo Frio Island and Saquarema Lagoon (22°55′S–23°05′S and 42°00′W–42° 20′W), was studied. This area is about 80 m north of the city of Rio de Janeiro, immediately offshore of Lagoon Araruama (Fig. 1).

Sedimentology

Mainly relict sands, resulting from the lack of input of continental sediments and the presence of a barrier beach, cover

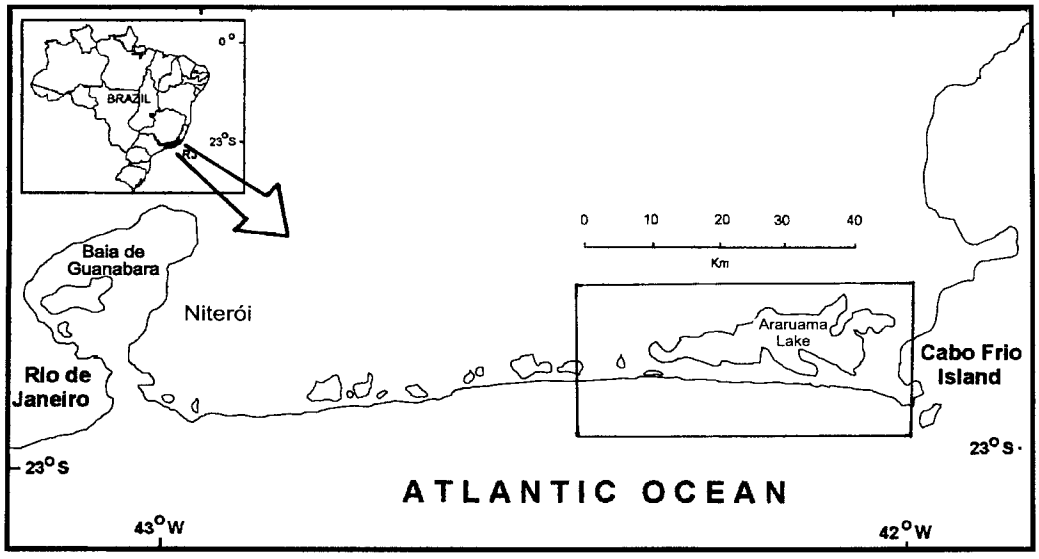


Fig. 1. Location of the study area.

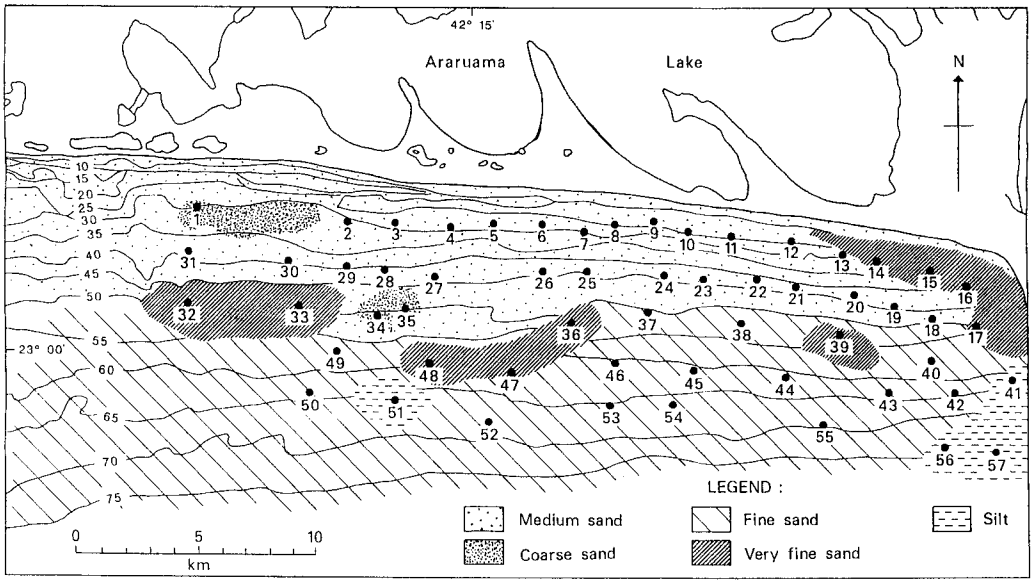
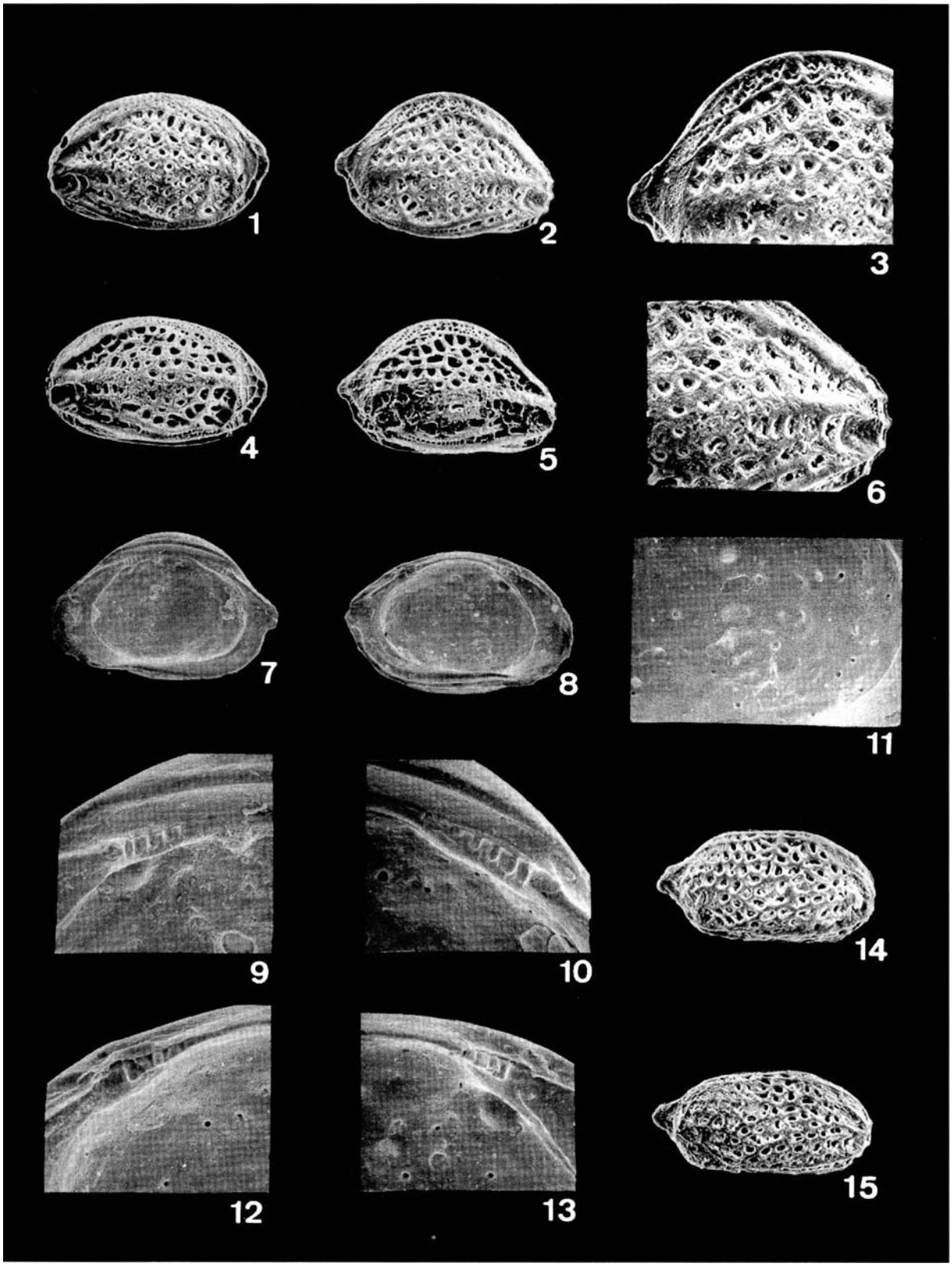


Fig. 2. Location of samples and distribution of bottom sediment types.

the study area. The erosion of the unfossiliferous Barreiras Group (Plio/Pleistocene) from alluvial deposits and sediments produces the relict sands. These sands are also the result of reworking by waves and currents. Grain size analysis shows a decreasing gradient both towards the east and towards deeper waters. Between the coast and a depth of 50 m, medium sand predominates (80%); an exception is in the far east of this area, near the town of Arraial do Cabo, where very fine sand predominates (15%) within this depth range. Coarse sands occur in the west of the area and in isolated parts of the more central portion of the studied area. At depths greater than 50 m, fine sand predominates. Very fine sand occurs in the western, central and eastern areas, but only in isolated patches between 60 and 70 m depth. Silt-grade sediments occur in the far southeast and also in a single sample from the central portion of this area, always at depths greater than 65 m (Figs. 2–9).

Physical oceanography

The main water masses affecting the area of study are: coastal water with temperatures $>18°C$ and salinities $<35\%$; South Atlantic Central Water with temperatures between 6 and 18° and salinities between 34.6 and 35.8%; and Surface Tropical



Explanation of Plate 1

figs 1–13. *Hemicytherura auriculata* sp. nov. **figs 1–3, 6–13**. Holotype. MP-O-1490. **fig. 1**. LV, external view, ×68. **fig. 2**. RV, external view, ×68. **fig. 3**. RV, Detail of postero-dorsal region, ×124. **fig. 4**. Paratype. MP-O-1491. LV, External view, ×76. **fig. 5**. Paratype. MP-O-1492, RV, external view, ×76. **fig. 6**. Holotype. RV detail of anterior region, ×124. **fig. 7**. Holotype. RV, internal view, ×85. **fig. 8**. Holotype. LV, internal view, ×74. **fig. 9**. Holotype. RV, internal view, detail of anterior hinge, ×267. **fig. 10**. Holotype. RV, internal view, detail of posterior hinge, ×318. **fig. 11**. Holotype. LV, internal view, detail of muscle scar, ×228. **fig. 12**. Holotype. LV, internal view, detail of posterior hinge, ×246. **fig. 13**. Holotype. LV, internal view, detail of anterior hinge, ×219. **figs 14, 15.** *Semicytherura rugosoreticulata* **Whatley, Chadwick, Coxill & Toy, 1988**. **fig. 14.** Homotype. MP-O-1500, female, RV, external view, ×77. **fig. 15.** Homotype. MP-O-1501, male, RV, external view, ×74.

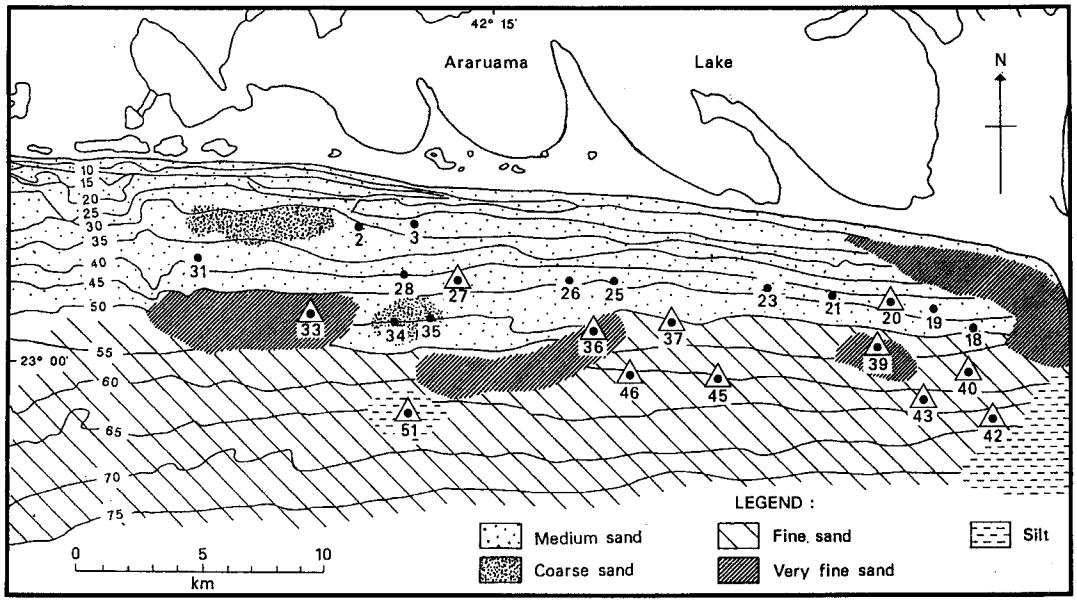


Fig. 3. Distribution of *Oculocytheropteron delicatum* sp. nov. and *Hemicytherura auriculata* sp. nov. △ Occurrence of *O. delicatum* only. •, Occurrence of both *O. delicatum* and *H. auriculata*.

Water with temperatures >18°C and a salinity >35.9‰. The Coastal Water results from the mixing of water coming from the continental drainage of superficial tropical water and of South Atlantic Central Water. The South Atlantic Central Water is produced by a mixture of Tropical Water and Subantarctic Water which occurs in the subtropical convergence (Weber, 1994).

The hydrology of the Rio de Janeiro coast between Cabo Frio and Ponta de Joatinga (southern Rio de Janeiro State) is related mainly to the intensity and variability of the upwelling process, which is greatest between Cabo Frio Island and Saquarema Lagoon. The prevailing winds are east-to-west as a consequence of the Coriolis force. This causes drift of the superficial coastal water towards the ocean, which is equalized by the elevation of the South Atlantic Central Water coming from the continental slope between 200 and 300 m.

The process of downwelling, which represents the return of warm and more saline waters of the Brazil Current to the coast, occurs during the passage of cold fronts with southwesterly winds. In winter, the hydrological structure is typical of downwelling, with a homothermic water column down to 50 m. Homothermy with cold water is more common in spring and in some summer months, due to the maximum upwelling of the cold South Atlantic Central Water. With intensive upwelling, the surface temperature of the ocean can reach between 13 and 18°C, and 5°C lower between 20 and 30 m. More details of the physical–chemical conditions and the influence of upwelling in the area can be found in Weber (1994).

SYSTEMATIC DESCRIPTIONS

Suborder **Podocopina** Sars, 1866
Superfamily **Cytheracea** Baird, 1850
Family **Cytheruridae** Müller, 1894
Genus ***Hemicytherura*** Elofson, 1941

Hemicytherura auriculata sp. nov.
(Plate 1, figs 1–13)

1979 *Hemicytherura howei* (Puri) Sanguinetti: 135 and 136, pl. 5, figs 1a, 1b, 1c.
1985 *Hemicytherura howei* (Puri) Kotzian & Eilert: 84–86 and 90, pl. 1, figs 2, 3.
[non] 1953 *Kangarina howei* Puri: 246–247, pl. 4, fig. 7, text-figs 6i and j.
[non] 1965 *Hemicytherura howei* (Puri) Pooser: 49, pl. 9, figs 1, 3.
[non] 1979 *Cytherura howei* (Puri) Cronin: 144 and 145, pl. 14, fig. 7.

Derivation of name. *L.* from the rather ear-like aspect of the right valve of this species in lateral view.

Diagnosis. Carapace with the right valve ear-like in lateral view and ornamentation formed by coarse and rounded reticulae. Large median rib that is interrupted medianly.

Holotype. Carapace, MP-O-1490.

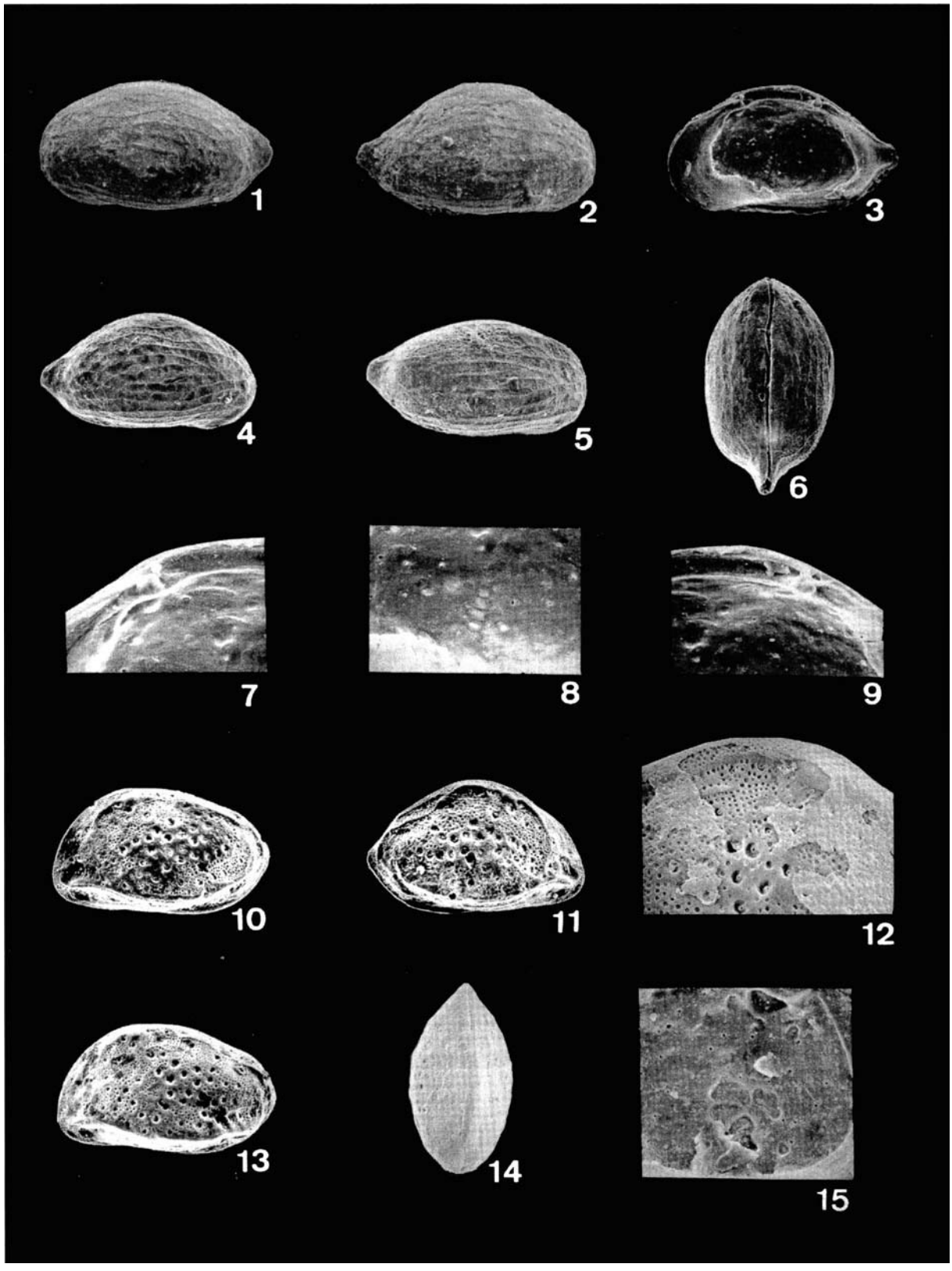
Paratypes. Carapace, MP-O-1491.

Material. Nineteen adult valves and five juvenile valves.

Type locality. Rio de Janeiro coast, GEOCOSTA RIO II, sample 46.

Age. Recent.

Description. Thick-shelled carapace, right valve ear-like in lateral view. Anterior margin angular and quadridentate. Apex below mid-height. Ventral margin with a distinct oral concavity. Posterior margin bluntly caudate in right valve, less pronounced in left valve. Dorsal margin strongly convex in right valve and stronger than in left valve. Ornament strongly reticulate, formed by circular reticulae. Dorsal region delicately punctate. Large median rib interrupted by reticulate ornament medianly. Two strong ventral ribs extend from the mid-anterior margin, parallel to the ventral margin. Two prominent depressions: one antero-ventral and another postero-ventral occur below the median rib. Internal features typical of the genus. Sexual dimorphism not evident.



Explanation of Plate 2

figs 1–9. *Semicytherura caudata* sp. nov. **figs 1–3, 7–9**. Holotype. MP-O-1493, female. **fig. 1**. LV, external view, ×83 **fig. 2**. RV, external view, ×88. **fig. 3**. RV, internal view, ×92. **fig. 4**. Paratype. MP-O-1462, female, RV, external view, ×83. **fig. 5**. Paratype. MP-O-1463, RV, male, external view, ×83. **fig. 6**. Paratype. MP-O-1503, female carapace, dorsal view, ×88. **fig. 7**. Holotype. RV, internal view, detail of anterior hinge, ×175. **fig. 8.** Holotype. RV, internal view, detail of muscle scars, ×175. **fig. 9.** Holotype, RV, internal view, detail of posterior hinge, ×175. **figs 10–15.** *Oculocytheropteron delicatum* sp. nov. **figs 10, 11**. Holotype. MP-O-1486, female. **fig. 10**. Holotype. LV, external view, ×92. **fig. 11**. Holotype. RV, external view, ×92. **fig. 12**. Paratype. MP-O-1492, RV, external view, detail of dorsal region, ×194. **fig. 13.** Paratype. MP-O-1488, LV, external view, ×88. **fig. 14**. Paratype. MP-O-1489, female, dorsal view, ×79. **fig. 15**. Paratype. MP-O-1492, LV, internal view, detail of muscle scar, ×194.

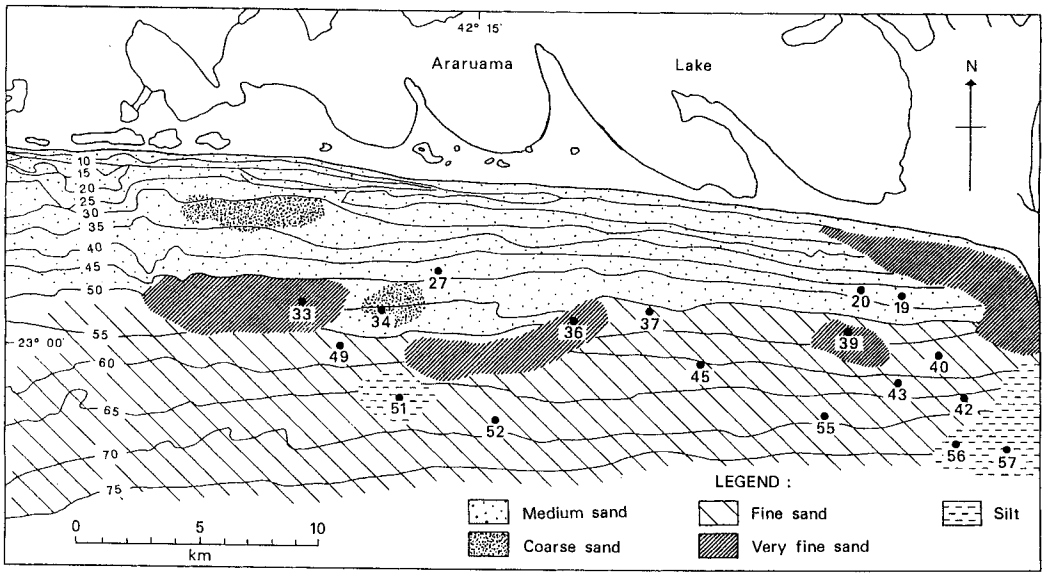


Fig. 4. Distribution of *Semicytherura caudata* sp. nov.

Dimensions (mm) (length, height)

Holotype, RV, MP-O-1490	0.51	0.35
Holotype, LV, MP-O-1490	0.51	0.33
Paratype, RV, MP-O-1491	0.46	0.32
Paratype, LV, MP-O-1491	0.44	0.28

Remarks. The present material is identical with *Hemicytherura howei* (Puri) (in Sanguinetti, 1979) from the Miocene of the Pelotas Basin. However, a comparative study of the present species with type material of *Kangarina howei* Puri, 1953, demonstrated that they are distinct species. *Hemicytherura auriculata* sp. nov. has less prominent ribs, the caudal process is shorter and straighter and it is bigger than *Kangarina howei* Puri, 1953. The species is known from the Miocene of the Pelotas Basin from Rio Grande do Sul (Brazil), the Miocene of Uruguay and from Recent sediments from Rio de Janeiro coast, GEOCOSTA RIO II, samples 33, 46, 47, 48, 49, 51, 52, 53, 55 and 57 on fine sand and mainly between 51 and 72 m depth (Fig. 3).

Genus ***Semicytherura*** Wagner, 1957

Semicytherura rugosoreticulata Whatley, Chadwick, Coxill & Toy, 1988.
(Plate 1, figs 14, 15)

1982 *Kangarina* sp. Kotzian (in Bertels, Kotzian & Madeira-Falcetta): 146 and 149, pl. VII, fig. 1a, b.
1988 *Semicytherura rugosoreticulata* Whatley, Chadwick, Coxill & Toy: 179, pl. 2, figs 12–18.
1990 *Semicytherura rugosoreticulata* Whatley, Chadwick, Coxill & Toy. Bertels & Martínez: 153, pl. 3, fig. 25.
Homotypes. Female, RV, MP-0-1500; male, RV, MP-0-1501.
Age. Recent.
Material. Twenty-one adult valves and seven juvenile valves.

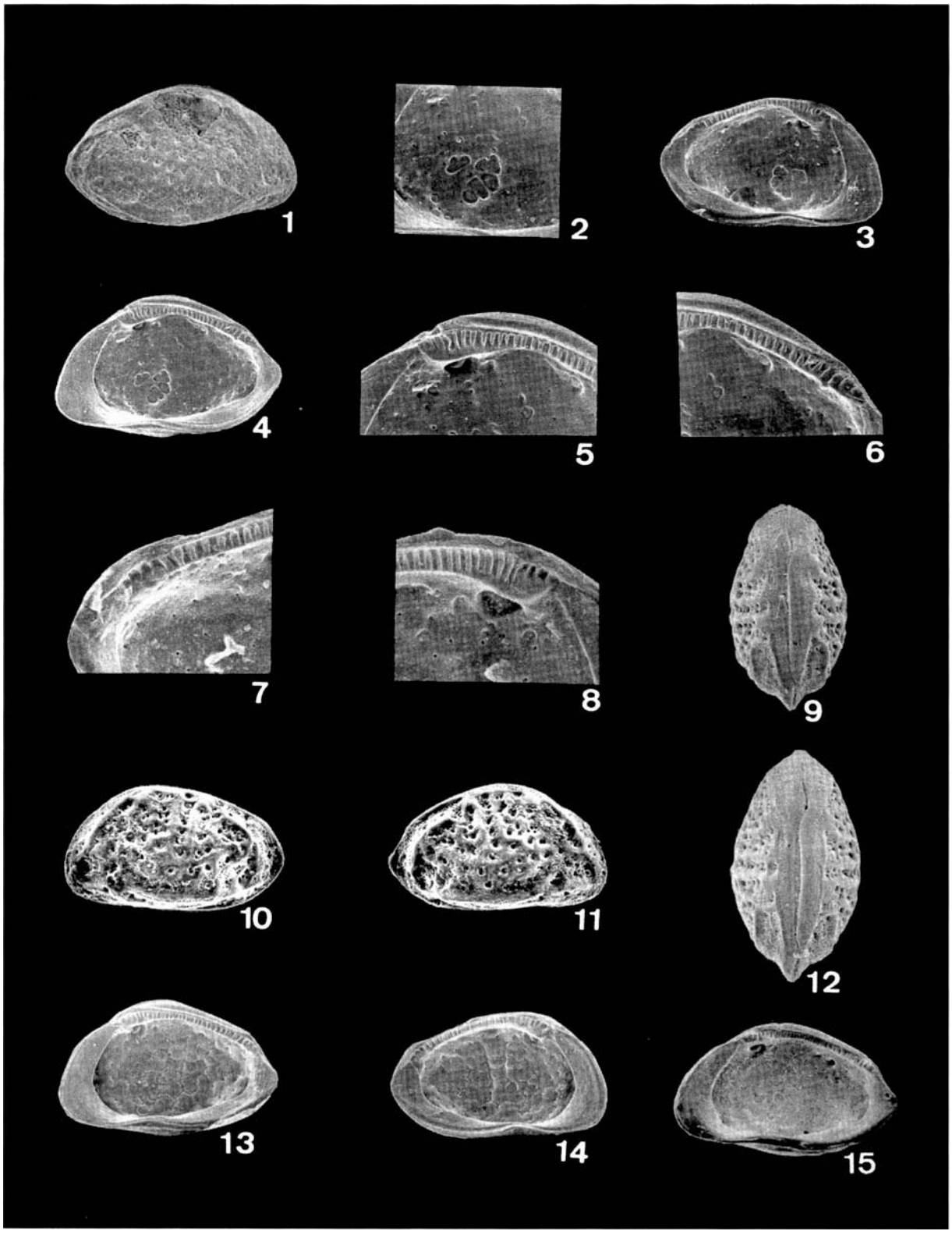
Dimensions (mm). (length, height)

Homotype, female, RV, MP-O-1500	0.45	0.25
Homotype, male, RV, MP-O-1501	0.47	0.23

Remarks. The present record is considerably further north than the records of Whatley *et al.* (1988), who found this species in the littoral zone of the Patagonian coast between 49°18'S and 42°47'S, and also on the continental shelf north to 36°05'S. It also occurs in the Quaternary of the Pelotas Basin, Chui Formation, Rio Grande do Sul State, Brazil; In the Holocene from Argentina; and in Recent sediments from the Rio de Janeiro coast, GEOCOSTA RIO II, samples 20, 27, 33, 36, 37, 39, 40, 42, 43, 45, 46 and 51. It occurs in depths up to 13 m in Recent sediments from Argentina and in the present study is distributed between 47 and 72 m, being more abundant between 43 and 57 m. It occurs predominantly in fine sands and, more rarely, in very fine and medium sands (Fig. 7).

Semicytherura caudata sp. nov.
(Plate 2, figs 1–9)

1982 *Cytherura* sp. Bertels, Kotzian & Madeira-Falcetta: 131, 144–146, pl. 6, fig. 2a–c.
Derivation of name. *L.* with reference to the prominent caudal process.
Diagnosis. A subovate species of *Semicytherura* with large and upturned caudal process above mid-height in RV. Dorsal margin strongly arched. Ornament consists of numerous sinuous parallel horizontal ribs with short interconnecting riblets in the dorsal region. Finely punctate between the ribs.
Holotype. Female, carapace, MP-O-1493.
Paratype. Female, carapace, MP-O-1503; female, RV, MP-0-1462; and male, RV, MP-0-1463.



Explanation of Plate 3

figs 1–8. *Oculocytheropteron delicatum* sp. nov. **fig. 1**. Paratype. MP-O-1487, RV, male. **figs 2–6**. Holotype. MP-O-1486, female. **fig. 1**. Paratype. RV, external view, ×91. **fig. 2**. Holotype. RV, internal view, detail of muscle scar, ×408. **fig. 3**. Holotype. LV, internal view, ×92; **fig. 4**. Holotype. RV, internal view. X107; **fig. 5.** Holotype, RV, internal view, detail of anterior hinge, ×500. **fig. 6.** Holotype. RV, internal view, detail of posterior hinge, ×500. **fig. 7**. Paratype. MP-O-1492, LV, internal view, detail of posterior hinge, ×301. **fig. 8**. Paratype. MP-O-1492, LV, internal view, detail of anterior hinge, ×246. **figs 9–15.** *Oculocytheropteron circumcostatum* sp. nov. **fig. 9**. Paratype. MP-O-1496, female, carapace, dorsal view, ×88. **figs 10, 11, 13, 14**. Holotype. MP-O-1495, female. **fig. 10**. LV, external view, ×90. **fig. 11**. RV, external view, ×97. **fig. 12**. Paratype. MP-O-1497. Male, carapace, dorsal view. ×96. **figs 13, 14**. Holotype. MP-O-1495, female. **fig. 13**. RV, internal view, ×97. **fig. 14**. LV, internal view, ×90. **fig. 15**. Paratype. MP-O-1498, RV, internal view, ×96.

Material. Eighty-three adult valves and seven juvenile valves.
Type locality. Rio de Janeiro coast, GEOCOSTA RIO II, sample 43.
Age. Recent.
Description. Carapace inflated, thin-shelled and subovate in lateral view. Slightly inequivalve. Cardinal angles not prominent; a few specimens are more accentuated in the posterior region. Anterior margin rounded. Posterior margin with large and upturned caudal process above mid-height in RV. Dorsal margin strongly arched. Ventral margin sinuous and slightly concave in the antero-median region. Ornament consists of sinuous parallel horizontal ribs interconnected with short riblets in the dorsal region. A median rib curves dorsally, almost forming a posterior loop. Internal features as for genus. Sexual dimorphism strongly developed, males more elongate and more inflated than females.

Dimensions (mm). length, height

Holotype, female, carapace, MP-O-1493	0.45	0.22
Paratype, female, carapace, MP-O-1503	0.45	0.22
Paratype, female, RV, MP-0-1462	0.42	0.23
Paratype, male, RV, MP-0-1463	0.42	0.22

Remarks. *Semicytherura caudata* sp. nov. differs from *Semicytherura closteria* Whatley, Chadwick, Coxill & Toy, 1988 from Recent sediments of Argentina in that the caudal process is upturned in RV and more prominent and the ornament does not have the fine anterior and posterior reticulae seen in *Semicytherura closteria*. It is similar to *Semicytherura* sp. 1 (of Whatley, Chadwick, Coxill & Toy, 1988), but the ventral rib is less strongly developed, the caudal process is more upturned, and the ornament is less punctate. The species occurs in the Quaternary of the Pelotas Basin, Chui Formation, - Rio Grande do Sul, Brazil and off the Rio de Janeiro coast. It occurs in GEOCOSTA RIO II, samples 18, 20, 27, 28, 33, 36, 37, 39, 40, 41, 42, 43, 45, 46, 47 and 48. *Semicytherura caudata* sp. nov. is more numerous than either *Hemicytherura auriculata* or *Semicytherura rugosoreticulata* in the studied area. It is distributed between 42 and 72 m depth and is most abundant in medium sand. However, it is also found more rarely on very fine sands (Fig. 4).

Genus ***Oculocytheropteron*** Bate, 1972
Oculocytheropteron delicatum sp. nov.
(Plate 2, figs 10–15; Plate 3, figs 1–8)

Derivation of name. *L.* with reference to the delicately ornate carapace of this species.
Diagnosis. *Oculocytheropteron* with subovate right valve and subtrapezoidal left valve. Fragile, with coarse central and fine peripheral punctation and marginal ribs.
Holotype. Female, carapace, MP-O-1486.
Paratypes. Male, carapace, MP-O-1487; male, LV, MP-O-1488; female, carapace, MP-O-1489; and carapace, female, MP-O-1492.
Material. Two hundred and thirty-four adult valves and 113 juvenile valves.
Type locality. Rio de Janeiro coast, GEOCOSTA RIO II, sample 33.
Age. Recent.
Description. Small, fragile, sub-oval right valve and subtrapezoidal left valve in lateral view. Anterior margin asymmetrically rounded. Posterior caudal process bluntly pointed in the left valve, slightly upturned in the right valve. Arched dorsal margin, much less strongly in the male than in the female. Ventral margin strongly overhung in the female, much less than in the male. Prominent eye spot. Valve surface with large rounded, well-spaced central puncta and much finer puncta peripherally. Delicate dorsal rib paralleling margin. Small postero-dorsal rib and distinct ventral rib extend from the postero-median region to the antero-ventral region. Internal features as for the genus. Sexual dimorphism not strongly marked.

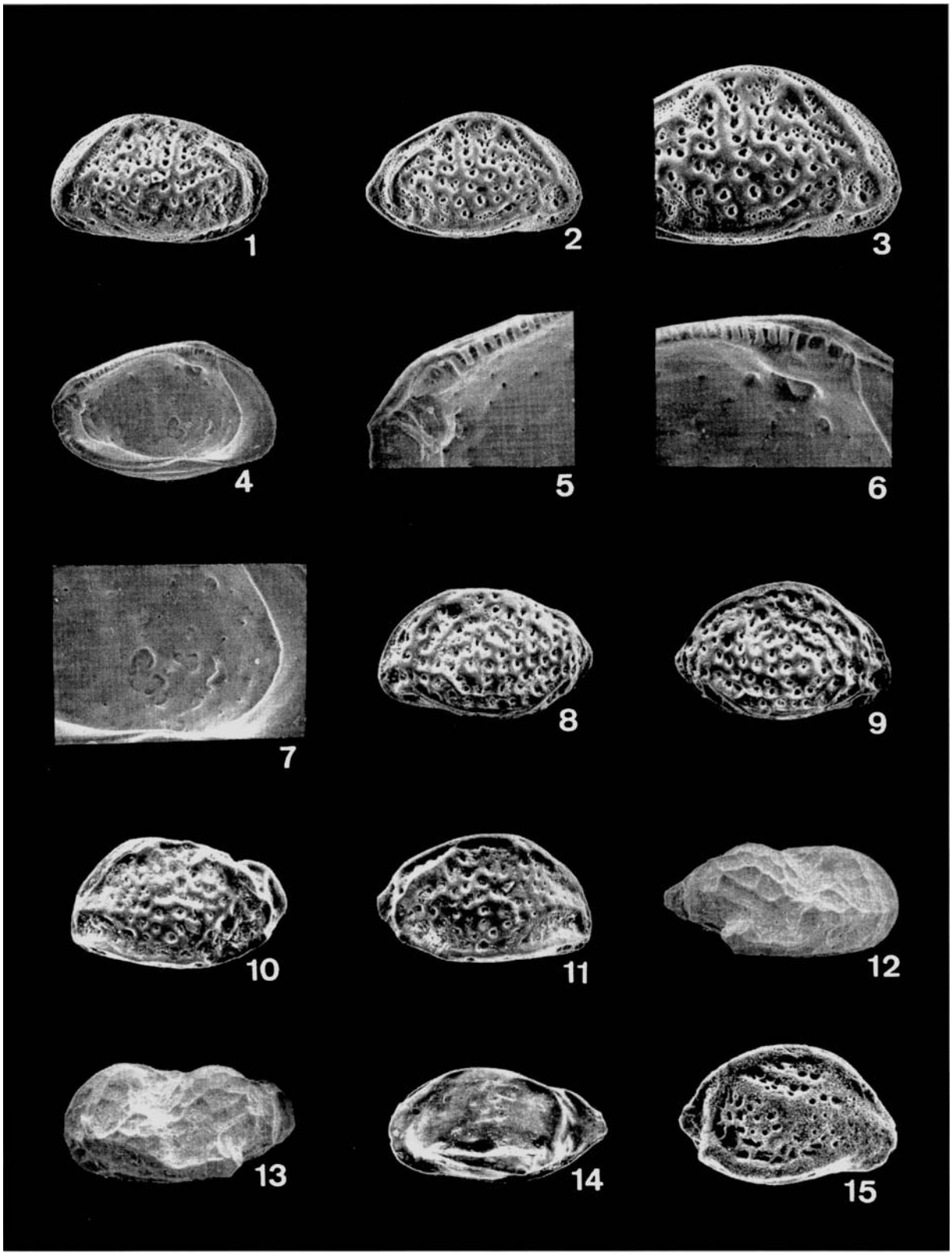
Dimensions (mm). (length, height)

Holotype, female, RV, MP-O-1486	0.38	0.24
Holotype, female, LV, MP-O-1486	0.38	0.22
Paratype, male, RVMP-O-1487	0.38	0.22
Paratype, male, LV, MP-O-1487	0.39	0.22
Paratype, male, LV, MP-O-1488	0.40	0.27
Paratype, female, carapace, MP-O-1489	0.41	0.27
Paratype, female, RV, MP-O-1492	0.41	0.25
Paratype, female, LV, MP-O-1492	0.41	0.26

Remarks. This species is similar to *Hemicytherura chuiensis* Kotzian (in Bertels, Kotzian & Madeira-Falcetta, 1982) from the Quaternary of Rio Grande do Sul. However, it differs in that the puncta of the central area are much more spaced and fewer in number, and the ventral rib is more convex in the posterior region. It occurs along the Rio de Janeiro coast, GEOCOSTA RIO II, in samples 20, 22, 23, 27, 33, 35, 36, 37, 39, 40, 42, 43, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56 and 57 at depths ranging between 40 and 72 m, and mainly on fine sand sediments (Fig. 3).

Oculocytheropteron circumcostatum sp. nov.
(Plate 3, figs 9–15, Plate 4, figs 1–7)

1975 *Hemicytherura* aff. *Cytherura lilljeborgii* Brady, 1880. Bertels: 335, pl. 5, fig. 16.
1988 *Hemicytherura* sp. Dias-Brito, Moura & Würdig: p. 10, 11, pl. 2, fig. 38.
Derivation of name. *L.* due to the strong sub-marginal rib.
Diagnosis. Small, subovate, thick-shelled. Valve surface coarsely punctate to almost reticulate and with two short vertical oblique parallel ribs extending over the dorso-median surface. A marginal anterior and posterior ribs running parallel to the margin.
Holotype. Female, carapace, MP-O-1495.
Paratypes. Female, carapace, MP-O-1496; male, carapace, MP-O-1497; and female, carapace, MP-O-1498.
Material. Two hundred and thirty-four adult valves and one juvenile valve.
Type locality. Rio de Janeiro coast, GEOCOSTA RIO II, sample 33.
Age. Recent.
Description. Small, subovate and thick-shelled. Anterior margin asymmetrically rounded with apex below mid-height. Posterior slightly caudate in the right valve, rounded in the left valve. Arched dorsal margin, most strongly in the female and in the right valve. Ventral margin slightly overhung in the female, much less so in the male. Eye spot is not evident. Valve surface coarsely punctate to almost reticulate; tiny secondary puncta;



Explanation of Plate 4

figs 1–7. *Oculocytheropteron circumcostatum* sp. nov. Paratype. MP-O-1498, female. **fig. 1**. LV, external view, ×89. **fig. 2**. RV, external view, ×85. **fig. 3**. RV, external view, detail of anterior region, ×131. **fig. 4**. LV, internal view, ×98. **fig. 5**. LV, internal view, detail of posterior hinge, ×263. **fig. 6**. LV, internal view, detail of anterior hinge, ×263. **fig. 7**. LV, internal view, detail of muscle scar, ×194. **figs 8, 9.** *Oculocytheropteron macropunctatum* Whatley, Chadwick, Coxill & Toy, 1988. Homotype. MP-O-1494, female. **fig. 8**. LV, external view, ×74. **fig. 9**. RV, external view, ×77. **figs 10, 11.** *Oculocytheropteron reticulopunctatum* Whatley, Chadwick, Coxill & Toy, 1988. Homotype. MP-O-1499, female. **fig. 10**. LV, external view, ×85. **fig. 11**. RV, external view, ×81. **figs 12, 13.** *Paracytheridea bulbosa* Purper & Ornellas, 1989. **fig. 12**. Homotype. MP-O-1484. RV, female, external view, ×48. **fig. 13**. Homotype. MP-O-1485, LV, male, external view, ×48. **fig. 14.** *Cytheropteron* sp. Hypotype. MP-O-1502, LV, external view, ×54. **fig. 15**. *Kangarina* sp. Hypotype. MP-O-1483, RV, external view, ×116.

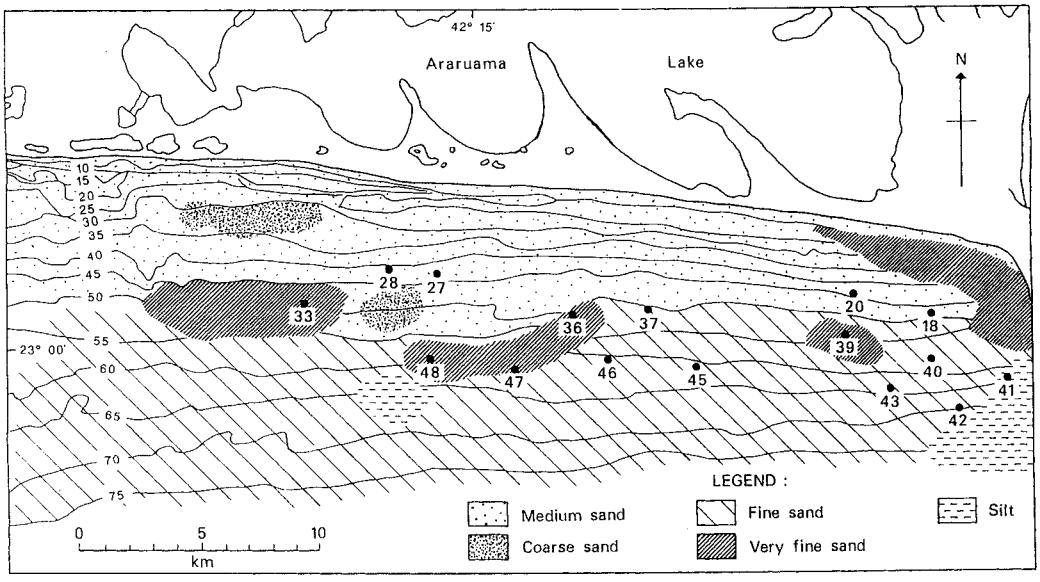


Fig. 5. Distribution of *Oculocytheropteron circumcostatum* sp. nov.

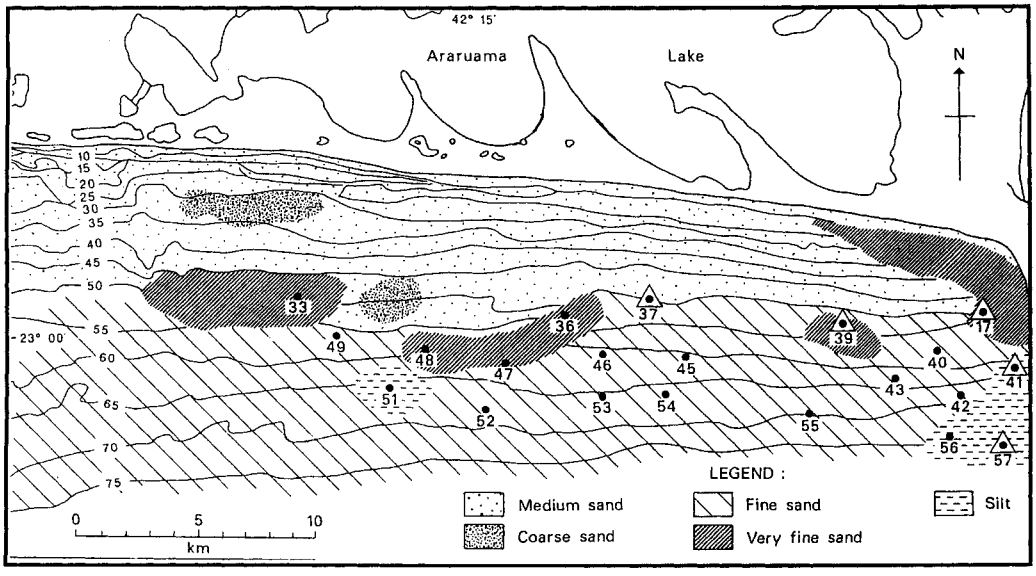


Fig. 6. Distribution of *Oculocytheropteron macropunctatum* Whatley *et al.*, 1988 and *O. reticulopunctatum* Whatley *et al.*, 1988. △, Occurrence of *O. macropunctatum*, only. •, Occurrence of both *O. macropunctatum* and *O. reticulopunctatum*.

small parallel oblique vertical ribs formed from the muri in the middle dorsal region; small postero median rib, parallel to caudal process. A strong rib borders the periphery of the carapace. Internal features as for the genus. Sexual dimorphism not strongly marked, male more elongated than the female.

Dimensions (mm). (length, height)

Holotype, female, RV, MP-O-1495	0.36	0.22
Holotype, female, LV, MP-O-1495	0.37	0.22
Paratype, female, RV, MP-O-1496	0.39	0.22
Paratype, female, LV, MP-O-1496	0.39	0.24
Paratype, male, RV, MP-O-1497	0.41	0.22
Paratype, male, LV, MP-O-1497	0.41	0.22
Paratype, female, RV, MP-O-1498	0.41	0.24
Paratype, female, LV, MP-O-1498	0.39	0.24

Remarks. *Oculocytheropteron circumcostatum* sp. nov. is clearly the same species as *Hemicytherura* aff. *Cytherura lilljeborgii* Brady (in Bertels, 1975) from the Quaternary of Argentina. It occurs in the Pleistocene of Argentina (Buenos Aires Province) and the Recent of the Rio de Janeiro coast, GEOCOSTA RIO II, in

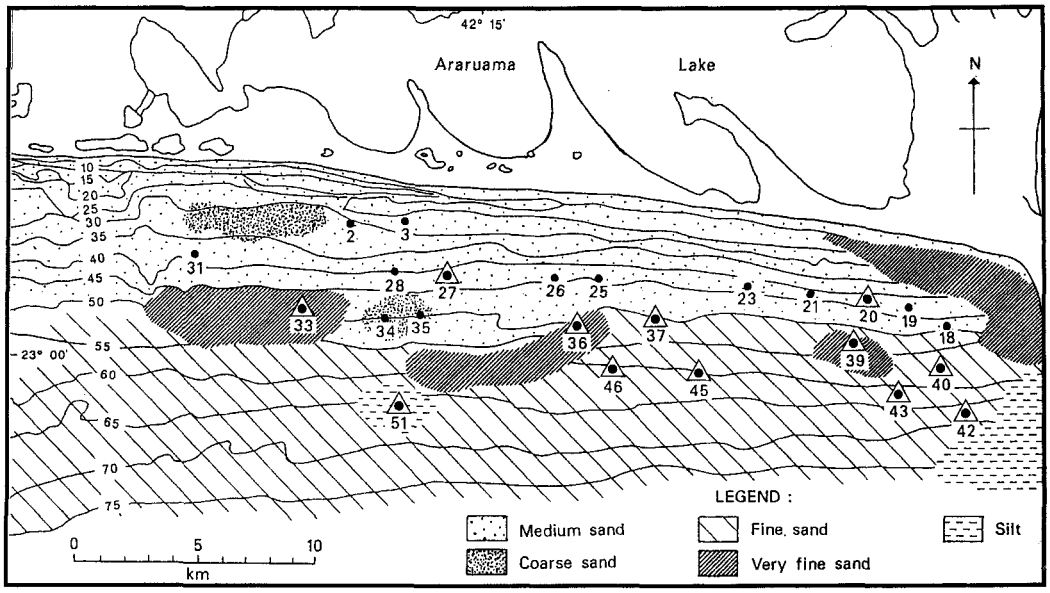


Fig. 7. Distribution of *Paracytheridea bulbosa* Purper & Ornellas, 1989 and *Semicytherura rugosoreticulata* Whatley *et al.*, 1988. △, Occurrence of *S. rugosoreticulata*, only. •, Occurrence of both *S. rugosoreticulata* and *Paracytheridea bulbosa*.

samples 19, 20, 27, 33, 34, 36, 37, 39, 40, 42, 43, 45, 49, 51, 52, 55, 56 and 57, with a bathymetric distribution between 42 and 74 m, being more abundant between 51 and 72 m. It prefers fine and very fine sandy sediments (Fig. 5).

Oculocytheropteron macropunctatum Whatley, Chadwick, Coxill & Toy, 1988
(Plate 4, Figs 8, 9)

1977 *Hemicytherura* sp. Vicalvi, Kotzian & Forti-Esteves: 83, 90, 91, pl. 3, fig. 5.
1988 *Oculocytheropteron macropunctatum* Whatley, Chadwick, Coxill & Toy: 184–188, pl. 4, figs 6–10.
Homotype. Female, carapace, MP-0-1494.
Age. Recent.
Material. One thousand one hundred and thirty-eight adult valves and 489 juvenile valves.

Dimensions (mm). (length, height)

Homotype, female, RV, MP-O-1494	0.45	0.31
Homotype, female, LV, MP-O-1494	0.47	0.29

Remarks. The present material is identical to *Hemicytherura* sp. of Vicalvi *et al.* (1977) described from the Quaternary of the São Paulo coast. The species occurs in the Quaternary of Argentina and southern Brazil, between 52°15.8′S and 24°2′S; Pleistocene sediments from the coast of São Paulo State, Brazil and in the area studied, GEOCOSTA RIO II, samples 17, 33, 36, 37, 39, 40, 41, 42, 43, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56 and 57, where it has a bathymetric distribution between 50 and 74 m and occurs mainly in fine sand (Fig. 6). Whatley *et al.* (1988) found this species in samples of fine calcareous mud with algal debris and from 118 m on clean fine sand.

Oculocytheropteron reticulopunctatum Whatley, Chadwick, Coxill & Toy, 1988.
(Plate 4, figs 10, 11)

1988 *Oculocytheropteron reticulopunctatum* Whatley, Chadwick, Coxill & Toy: 186, 187, pl. 5, figs 3–7.
1990 *Hemicytherura chuiensis* (Kotzian) Bertels & Martínez: 156, pl. 3, fig. 23.
(Non) 1982 *Hemicytherura chuiensis* Kotzian (in Bertels, Kotzian & Madeira-Falcetta): 145-147, pl.6, fig. 3a–c.
Homotype. Female, carapace, MP-0-1499.
Age. Recent.
Material. One hundred and sixty-one adult valves and 68 juvenile valves.

Dimensions (mm). (length, height)

Homotype, female, RV, MP-O-1499	0.43	0.26
Homotype, female, LV, MP-O-1499	0.41	0.24

Remarks. The present material is identical to *Hemicytherura chuiensis* Kotzian (in Bertels & Martínez, 1990) from the Quaternary of Argentina. It occurs in the Recent of Argentina from the northern coast of Tierra del Fuego (53°56′S) and also in littoral samples between 40°25′S and 38° and on the shelf and in the estuary of the Río de La Plata between 42°23′S and 36°05′S. In the present study it was recovered from Recent sediments from the coast of Rio de Janeiro, GEOCOSTA RIO II, in samples 33, 36, 40, 42, 43, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55 and 56 with a depth range between 50 and 72 m on fine sand (Fig 7).

Genus ***Paracytheridea*** Müller, 1894
Paracytheridea bulbosa Purper & Ornellas, 1989
(Plate 4, figs 12, 13)

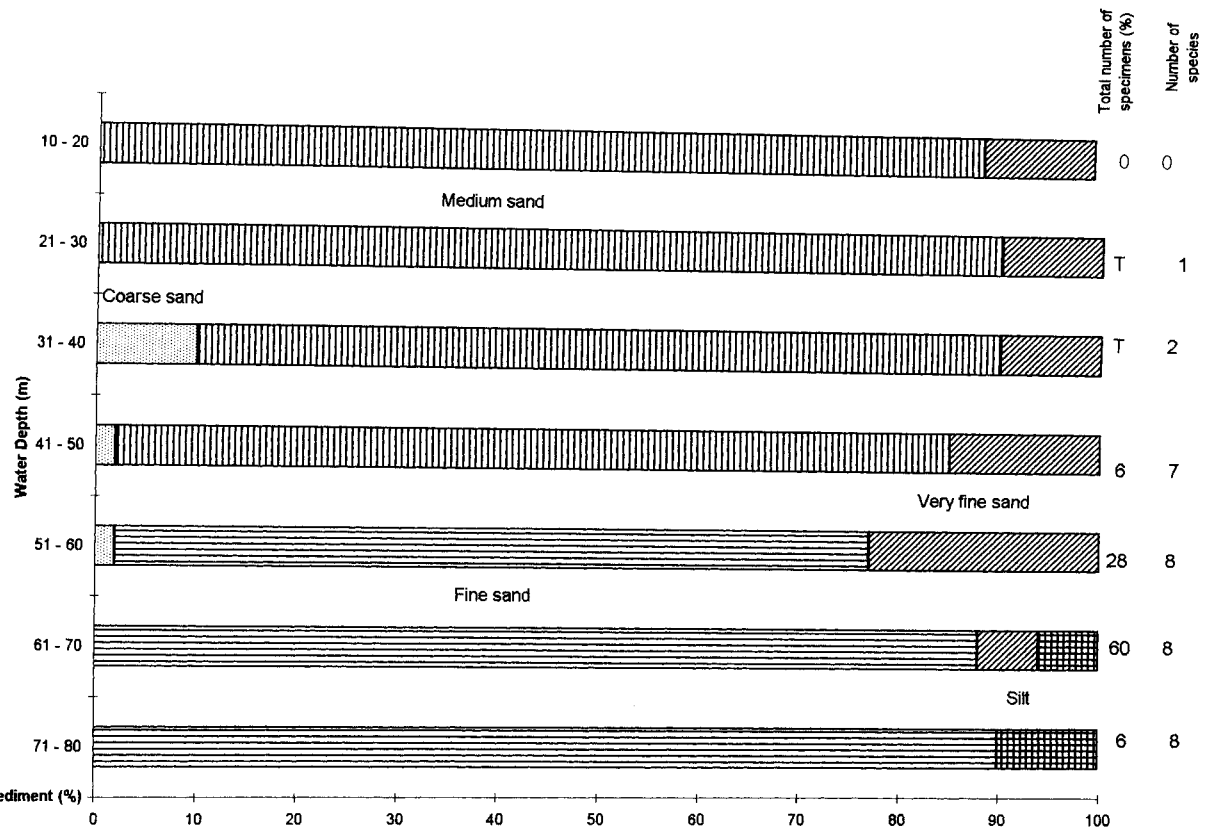


Fig. 8. Proportion of sediment types by depth (T < 1%).

1988 *Paracytheridea* sp. Whatley, Chadwick, Coxill & Toy: 191, 192, pl. 6, figs, 18.
1989 *Paracytheridea bulbosa* Purper & Ornellas: 723, 724, pl. 2, figs 1–15.
Homotype. Female, RV, MP-0-1484; male, LV, MP-0-1485.
Age. Recent.
Material. Eighty adult valves and 447 juvenile valves.

Dimensions (mm). (length, height)

Homotype, female, RV, MP-O-1484	0.75	0.41
Homotype, male, LV, MP-O-1485	0.77	0.41

Remarks. Whatley *et al.* (1988) found this species in a sample at 25 m off the coast of southern Brazil, 24°02′S, 45°43′W. Purper & Ornellas (1989) recorded it in the south of Brazil between 31°06′S and 22°01′S. In the studied area, it occurred in GEOCOSTA RIO II, samples 2, 3, 18, 19, 20, 21, 23, 25, 26, 27, 28, 31, 33, 34, 35, 36, 37, 39, 40, 42, 43, 45 and 46 with a depth range between 27.5 and 74 m and a preference for medium sand (Fig. 7). Purper & Ornellas (1989) found it at depths between 31 and 164 m in muddy, arenaceous, biodetritic sediments. Whatley *et al.* (1988) recorded it in shallower waters down to 25 m, further south off the Argentinean coast.

Genus ***Cytheropteron*** Sars, 1866
Cytheropteron sp.
(Plate 4; fig. 14)

Hypotype. MP-O-1502, VD. GEO COSTA RIO II, sample 45.
Age. Recent.
Material. Nine adult valves and seven juvenile valves.

Dimensions (mm). (length, height)

Hypotype, LV, MP-O-1502	0.64	0.44

Remarks. As a result of the small number of specimens found, this species is left in open nomenclature, although it is probably new. It occurs in samples 43, 45, 46, 51, 54, 56 and 57, mainly on fine sand and silt and at depths between 57 and 74 m.

Genus ***Kangarina*** Coryell & Fields, 1937
Kangarina sp.
(Plate 4; fig. 15)

Hypotype. MP-O-1483, RV. GEO COSTA RIO II, sample 47.
Age. Recent.
Material. Five adult valves.

Dimensions (mm). (length, height)

Hypotype, RV, MP-O-1483	0.30	0.22

Remarks. This species is similar to *Kangarina abyssicola* Ruggieri, 1953 *sensu* Medeiros & Coimbra, 1989. However, it differs in its less prominent ribs, its caudal apex being located nearer mid-height and in lacking a well-developed dorsal rib. As

Water Depth (m) / species (%)	*Hemicytherura auriculata*	*Semicytherura rugosoreticulata*	*Semicytherura caudata*	*Oculocytheropteron circumcostatum*	*Oculocytheropteron macropunctatum*	*Oculocytheropteron reticulopunctatum*	*Oculocytheropteron delicatum*	*Paracytheridea bulbosa*	Number of specimens	Number of samples	Number of species	Percent of total specimen	Diversity = H(s)
10 - 20	–	–	–	–	–	–	–	–	–	–	–	–	–
21 - 30	0	0	0	0	0	0	0	1	1	7	1	T	0
31 - 40	0	0	0	0	0	0	8	2	10	6	2	T	0.27
41 - 50	0	4	20	25	12	3	11	53	128	13	7	6	1.5
51 - 60	5	5	45	102	314	23	65	20	579	7	8	28	1.4
61 - 70	16	10	16	87	817	123	167	3	1239	12	8	60	1.3
71 - 80	1	3	7	25	24	15	19	1	95	2	8	6	1.6
Total number of specimens	22	22	88	239	1167	164	270	80	2052	47	–	–	–
0 = absent													
_ = no data													
T = <1													

Table 1. Distribution of species by depth.

a result of the small number of specimens encountered, this species is left in open nomenclature, although it is probably new. The species occurred in samples 40, 45 and 47 on fine sand and at depths of 55 and 62 m. Owing to the rarity of both *Kangarina* sp. and *Cytheropteron* sp., distribution maps were not made for these species.

DISCUSSION AND CONCLUSIONS

Of the 47 samples studied, 36 yielded members of the Cytheruridae. The ten cytherurid species encountered belong to six genera: *Hemicytherura*, *Semicytherura*, *Oculocytheropteron*, *Cytheropteron*, *Kangarina* and *Paracytheridea*. Four new species are described: *Hemicytherura auriculata, Semicytherura caudata, Oculocytheropteron delicatum* and *Oculocytheropteron circumcostatum*. Two species are left in open nomenclature, *Kangarina* sp. and *Cytheropteron* sp., because of the paucity of the specimens. *Oculocytheropteron macropunctatum* Whatley *et al.*, 1988 and *Oculocytheropteron reticulopunctatum* Whatley *et al.*, 1988, have previously been described from the Argentinean coast. *Semicytherura rugosoreticulata* Whatley *et al.*, 1988 was described from the Recent of Patagonia and the Quaternary of Argentina and southern Brazil. *Paracytheridea bulbosa* Purper & Ornellas, 1989 was previously recorded from southern Brazil. The distribution of the fauna clearly shows that most of the ostracods studied in this area have a preference for finer sands and greater depths offshore, where the influence of wave action on the bottom is diminished (Fig. 8).

The results show that ostracods are more abundant between 51 and 70 m, where 88% of the total number of specimens occur (Table 1). Fine sand predominates in this depth range (Fig. 8). The abundance of the fauna is inversely proportional to grain size and directly proportional to depth range. Only two samples were analysed between 71 and 80 m, although the number of specimens found (95) in this depth range is considerably higher than from samples shallower than 51 m (Table 1, Fig. 8).

Between 20 and 40 m, where medium sand predominates, few specimens occur (less than 1%). *Paracytheridea bulbosa* and *Oculocytheropteron delicatum* occur in shallower water than other species; *Paracytheridea bulbosa* occurs in almost all samples with a large depth range, between 27.5 and 74 m, but is more abundant between 45 and 51 m on medium and very fine sand. Although *Oculocytheropteron delicatum* occurs between 40 and 74 m, it is more abundant between 60 and 70 m. *Semicytherura caudata* and *Oculocytheropteron circumcostatum* are more abundant between 50 and 60 m, where the sediment size ranges from medium to very fine sand (Figs 4 and 5, Table 1). *Hemicytherura auriculata, Semicytherura rugosoreticulata, Oculocytheropteron macropunctatum* and *Oculocytheropteron reticulopunctatum* are more abundant between 60 and 70 m, in sediments of fine and very fine sands.

The highest diversity is between 71 and 80 m, where the fauna is homogeneously distributed. The lowest diversity occurs between 20 and 30 m, closer to the coast, where a single species is represented by only one specimen (Table 1). The highest number of specimens recovered, per genus, was for *Oculocytheropteron*. *O. macropunctatum* predominates over all other species and, together with *O. delicatum*, it has the highest percentage of constancy (Fig. 9).

Table 2 shows the number of specimens per species in each sample. The samples are listed in depth order. In Table 2, j represents the presence of juveniles. Table 1 shows the

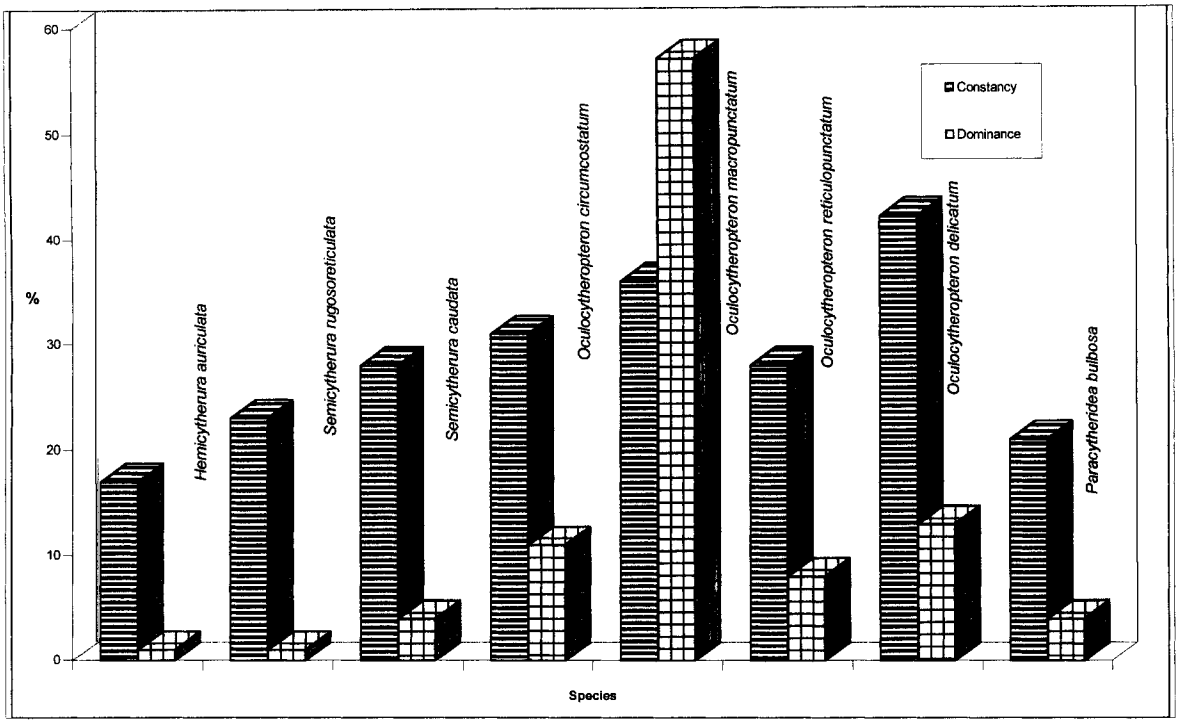


Fig. 9. Ostracod constancy and dominance.

distribution of species and the diversity of the fauna against depth, at 10 m intervals.

Many specimens exhibit dissolution and overgrowth of calcium carbonate. This can probably be explained by the effect of upwelling in this area. Normally, upwelled waters contain higher concentrations of nutrients (such as phosphates, silicates and nitrates) than surface water, which has been depleted as a result of biological consumption. Thus dissolution results from the corrosiveness of the water, due to a charge in the water's carbonate ion content, low temperature, and high hydrostatic pressure, increased water flow through the sediments and high pCO_2. Carbon dioxide in the water changes to carbonic acid, which eventually dissolves the calcium carbonate; carbon dioxide is produced by the respiration of benthonic organisms, which increases in upwelled waters (Kennet, 1982: 466).

Although dissolved and overgrown specimens might, in many circumstances, be thought to be the product of reworking of older sediments, in this area, given that the sediments are derived from the unfossiliferous Barreiras Group, this is considered unlikely.

The presence of *Hemicytherura auriculata* sp. nov., *Semicytherura rugosoreticulata* Whatley, Chadwick, Coxill & Toy, 1988, *S. caudata* sp. nov., *Oculocytheropteron macropunctatum* Whatley, Chadwick, Coxill & Toy, 1988, *O. reticulopunctatum* Whatley, Chadwick, Coxill & Toy, 1988, *O. circumcostatum* sp. nov., *O. delicatum* sp. nov. and *Paracytheridea bulbosa* Purper & Ornellas, 1989 (species having been recorded earlier as far south of the studied area as Uruguay and Argentina) can be explained by the presence of relatively cold waters due to the upwelling of the South Atlantic central water.

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Sample	Depth (m)	A	E	F	B	C	D	G	H	Sediment
03	27,5								1	Medium sand, little organic material
02	30,5								j	Medium sand, little organic material
22	40							1		Medium sand, little organic material
21	40								j	Medium sand, organic material
23	42							1	j	Medium sand, little organic material
19	42						6		1j	Medium sand, organic material
28	42					1			1	Medium sand, organic material
20	43				1	6	6	4j	10j	Medium sand, little organic material
26	43,5								3	Medium sand, little organic material
25	45								2	Medium sand, little organic material
27	45,5				1	6	2	5	19	Medium sand, organic material
31	48								4	Medium sand, abundant organic material
34	49						2		3	Coarse sand, shells ,organic material
35	50							1	j	Coarse sand, shells, organic material
18	50					1			j	Medium sand
36	50		2	4	2	6	8	1	7	Very fine sand, abundant organic material
37	51		j		1	10	6	4	6	Fine sand, organic material
33	51	2	18	6	1	8	48	17	20	Very fine sand, organic material
17	53,5		5							Very fine sand
43	57		116j	5j	2	22j	27	23j	1	Fine sand, some shells
39	58		25		1	3	22	6	2	Very fine sand, organic material
47	58	2	88j	6j		1		4		Very fine sand, organic material
48	58	1	62j	6		1		12		Very fine sand, organic material
49	60,5	6	94j	7j			1	19		Fine sand, organic material
40	61		14j	6	2	14j	24	8j	j	Fine sand, organic material
45	62		109j	26j	5	1	56	37j	j	Fine sand, polychaetes
46	62	4	203j	11	1	1		30j	j	Fine sand, polychaetes
54	66		39j	5				j		Fine sand
53	66	1	60j	31j				4j		Fine sand, little organic material
55	67	1	56j	9j			2	5j		Fine sand, little organic material
51	67	2j	144j	13j	2		2	63j		Silt, organic material
52	68	2j	97j	15			5	5j		Fine sand, little organic material
41	71		8			1				Silt, little organic material
56	72		4j	6j	j		3	j		Silt, little organic material
57	72	j	8j				4	j		Silt, polychaetes
42	74		14j	8j	2	6j	19j	17j	j	Fine sand

Table 2. Samples with number of specimens per species, in depth order. A, *Hemicytherura auriculata* sp. nov.; B, *Semicytherura rugosoreticulata* Whatley et al., 1988; C, *Semicytherura caudata* sp. nov.; D, *Oculocytheropteron circumcostatum* sp. nov.; E, *Oculocytheropteron macropunctatum* Whatley *et al.*, 1988; F, *Oculocytheropteron reticulopunctatum* Whatley *et al.*, 1988; G, *Oculocytheropteron delicatum* sp. nov.; and H, *Paracytheridea bulbosa* Purper & Ornellas, 1989. j, presence of juveniles.

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