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Cainozoic and Recent Deep Sea Cytherurid Ostracoda from the South Western Pacific and Eastern Indian Oceans, Part I: Cytherurinae

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ABSTRACT. From a largely unpublished database the systematics, geographical and stratigraphical distribution of Cainozoic cytherurine Ostracoda found in the deep sea environment of the eastern Indian and south-western Pacific regions is presented. Eleven new species: *?Eucytherura anoda, Eucytherura batalaria, ?Eucytherura boomeri, Eucytherura elegantula, Eucytherura indianensis, Eucytherura multituberculata, Eucytherura pacifica, Eucytherura parabatalaria, ?Eucytherura polydictyota, Eucytherura tumida* and *Hemiparacytheridea vanharteni* are described. Five species are assigned to previously established taxa and four species are left in open nomenclature due to paucity of material.

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Deep sea ostracod studies which have examined the fine fraction (less than 250 micron aperture seive) of samples frequently report species of the Cytheruridae. That this family comprises very small species (less than 0.40 mm in length) explains why they are poorly represented in most published faunal lists of deep sea ostracods. This study indicates that the group is well represented in the deep-sea at least in the Indo-Pacific region and that this has been so throughout the Cainozoic. The present study is concerned with the Cytherurinae. A subsequent paper will describe the Cytheropterinae.

Taxonomic knowledge of deep sea forms of the genera considered in this report, is based on material collected mainly from the Atlantic region (Maddocks & Steineck, 1987; Whatley & Coles, 1987; Coles & Whatley, 1989). Material collected from the deep Indo-Pacific and compiled through comprehensive studies undertaken in the Micropalaeontological Research Unit, Aberystwyth, Wales, is still incorporated in largely unpublished theses. To assimilate the nomenclature contained therein with the present taxonomic study it is considered useful to list all names—unpublished as well as published—that have been applied to these taxa during the course of our work. (Unpublished references are indicated by asterisk *). This valuable source of information, useful for improving our understanding of the systematics and zoogeography of the taxa, is the focus of this report.

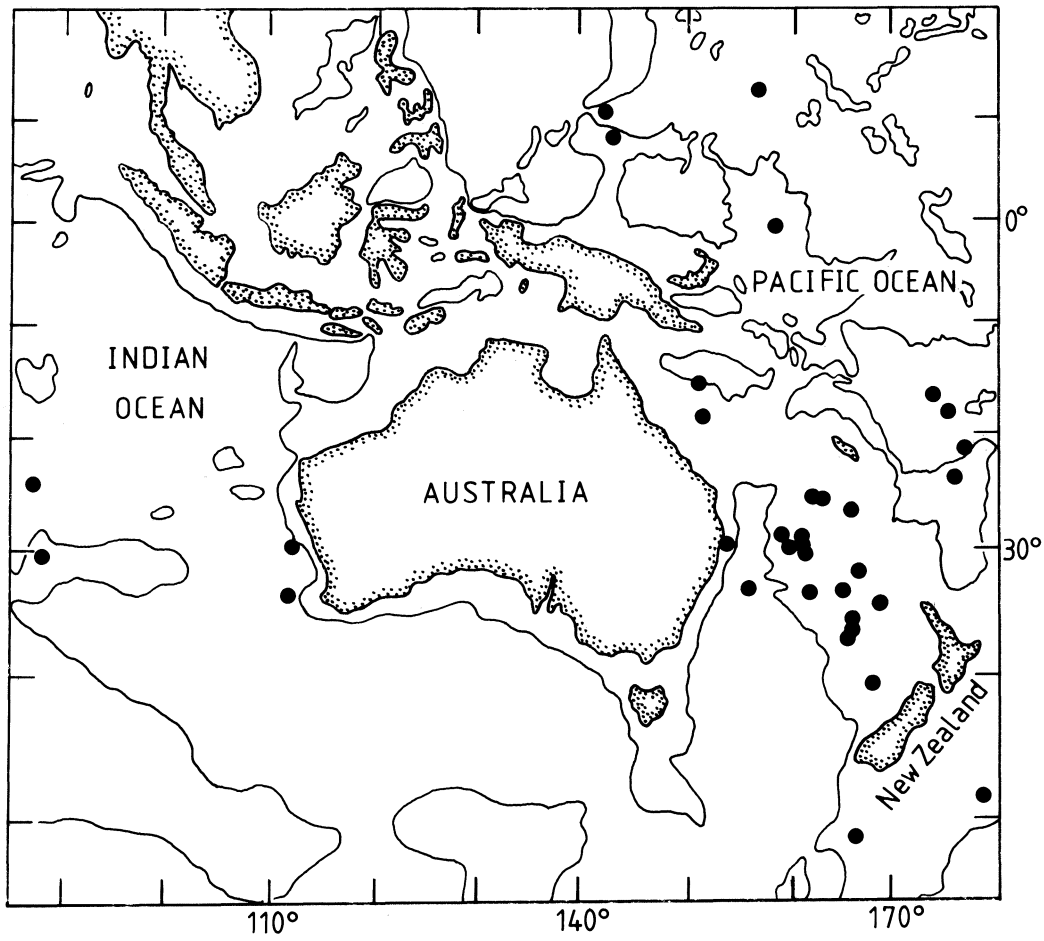

Fig. 1. Eastern Indian Ocean and Southwest Pacific site locations in which the species described in the text were found.

This study aims to formally describe hitherto unpublished cytherurine species of the genera *Eucytherura* and *Hemiparacytheridea* encountered within the bathyal and abyssal environment. Our database includes Cainozoic and Recent material from the south-western Pacific and eastern Indian Ocean regions (Fig. 1). The higher systematic affinities of cytherurine species are somewhat in flux, complicated by the erection of monospecific genera and the discovery of many new species displaying considerable morphological variation. Maddocks and Steineck (1987) proposed an emended subfamily Eucytherurinae to unite genera with solum pore clusters. We adopt a rather broad approach herein assigning all species to either *Eucytherura* or *Hemiparacytheridea* on the basis of solum pore clusters and hingetype; further we synonymise other cytherurine genera *Typhlocythere, Typhloeucytherura* and *Parahemingwayella* with the former and *Tuberculocythere* with the latter. This is discussed in the relevant sections below.

Material. Site locations from which the species described herein were recovered are shown in Fig. 1. A list of samples with their stratigraphical and geographical details is given in Table 1. The stratigraphical range of all species considered in this study is shown in Table 2. Most type and figured specimens were selected from the collections at the Micropalaeontological Research Unit, Aberystwyth, Wales. The types and some figured specimens from this material have been deposited at the British Museum of Natural History, London; the registration numbers prefixed OS apply to these. Other figured specimens remain in Aberystwyth and are catalogued with numbers prefixed MA or SD. Type and figured specimens not chosen from the Aberystwyth collections have been deposited at the Australian Museum, Sydney and are catalogued with numbers prefixed AMF.

Systematic Palaeontology

Cytherurinae Müller, 1894

Eucytherura Müller, 1894

Type species. *Cythere complexa* Brady, 1867.

Emended Diagnosis. A genus of the subfamily Cytherurinae with a small carapace of subrectangular, quadrate or subtriangular lateral outline. Ventral margin gently sinuous, often obscured by posteroventral tumidity or tubercle. Eye tubercle present or absent. Surface very ornate with reticulation, tubercles and ridges. Normal pore canals usually of two types: those emergent through mural pore conuli; and those arranged in groups through the solum of the reticulation. Muscle scars consist of four subovate adductor scars in a vertical row and a subreniform frontal scar ahead of the row. Hinge, in right valve, consists of a small but prominent circular or ovate tooth on anterior and posterior ends, with a finely locellate median groove very narrow at mid-length and often flexured or sinuous.

Comparisons. Our concept of *Eucytherura* indicated in the above emended diagnosis allows us to synonymise *Typhlocythere* Bonaduce, Ciampo & Masoli, 1975, *Typhloeucytherura* Colalongo & Pasini, 1980 and *Parahemingwayella* Dingle, 1984. These three genera were proposed mainly to accommodate the fact that they differ from *Eucytherura* (as presently diagnosed by Weingeist, 1949) in lacking eyes. Deep sea taxa always lack eyes as a result of living in an aphotic environment. Consequently, this feature cannot be used to recognise genera in the deep sea. It may well be that blindness of these genera in shallow environments had preadapted them for deeper water existence, but we can find no consistent features which might reveal their separate generic identity. Previous workers have stressed the importance of certain features for generic identification such as inflation and outline, absence of dorsal ridges or tubercles and nature of ornament. We recognise these features as being variable in number or nature, and moreover, as occurring in variable combination in different species. For this reason, we prefer to retain species previously assigned to *Parahemingwayella, Typhlocythere* and *Typhloeucytherura* within *Eucytherura*. The latter genus can be separated from *Hemiparacytheridea* by virtue of its hingement, having a distinct ovate posterior terminal element, and its solum pore clusters.

Key to Deep-sea Species of *Eucytherura*

1. Solum pore clusters present 4

—— Normal pores large and regularly distributed, valve size small 2

2. Weakly inflated; ornament predominantly reticulation ..... *E. anoda*

—— Moderately well inflated; ornament of ridges and reticulation 3

3. Alate; subcentral tubercle present; surface ridges distinct ..... *E. polydictyota*

—— Not alate; subcentral tubercle absent; surface ridges diffuse ..... *E. boomeri*

4. Lateral outline subtriangular 5

—— Lateral outline subrhomboidal, subquadrate or subrectangular 8

5. Bituberculate ventrally; surface not strongly spinose 6

—— Single posteroventral swelling; surface strongly spinose ..... *E. elegantula*

6. Subcentral tubercle high on lateral surface; deep concavity in dorsal margin ..... *Eucytherura* sp. 3

—— Posterodorsal tubercle or ridge present; strong anterior marginal rim 7

—— Posterodorsal tubercle or ridge absent; weak anterior marginal rim ..... *E. batalaria*

7. Dorsal margin sinuous; reticulation well developed with extensive ventral microreticulation ..... *E. parabatalaria*

—— Dorsal margin gently convex; reticulation relatively irregular with only poorly developed ventral microreticulation ..... *E. downingae*

8. Strongly tuberculate ..... *E. multituberculate*

—— Tubercles not well developed or absent 9

9. Caudal process well developed ..... *Eucytherura* sp. 1

—— Caudal process short or absent 10

10. Carapace tumid, often spinose 11

—— Carapace moderately inflated, may have intrafossal spines 13

11. Reticulation spinose; short horizontal median ridge present 12

—— Reticulation lacks spines; median ridge absent ..... *E. tumida*

12. Lateral spines weakly developed; microreticulation present on anteroventral surface ..... *E. indianensis*

—— Strongly spinose; ventral microreticulation absent ..... *E. calabra*

13. Lateral outline rhomboidal ..... *E. pacifica*

—— Lateral outline quadrate to rectangular 14

14. Large bulbous posteroventral swelling; lacks a median ridge ..... *Eucytherura* sp. 2

—— Posteroventral tubercle moderately swollen; median oblique ridge present 15

15. Fossal spines present ..... *E. pseudoantipodum*

—— Fossal spines absent ..... *Eucytherura* **sp. aff.** ***antipodum***

?Eucytherura anoda n.sp.

Fig. 2 E–G

Etymology. Latin, without swellings. Referring to the lack of nodosity of this species.

Type material and dimensions. Holotype, AMF 91143, adult right valve, length 0.20 mm, height 0.11 mm. Paratype: AMF 91144, adult left valve, length 0.22 mm, height 0.12 mm. Both specimens are from the type locality and horizon.

Type locality and horizon. Central Lord Howe Rise, present day water depth 1416 m, OSI cruise 12-87, core 13GC10, coretop, Recent.

Diagnosis. *?Eucytherura* with weakly inflated, well-rounded, elongate ovate carapace. Surface coarsely reticulate, fossae circular diminishing in size distally; anteriorly muri are concentrically aligned parallel to anterior margin. Arcuate ridge posterodorsally. Median hinge element slightly convex.

Description. Very small, subovate in lateral view. Anterior margin symmetrically convex; posterior margin strongly convex, apex at mid-height. Dorsal margin slightly undulating, gently sloping posteriorly. Ventral margin gently biconvex. Weakly calcified and weakly inflated, posteroventral margin compressed. Arcuate ridge posterodorsally. Surface coarsely reticulate, fossae circular, diminishing in size and increasing in density towards the free margins; anteriorly muri are concentrically aligned parallel to anterior margin. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead or dorso-median adductor scar; normal pores, simple and well distributed,

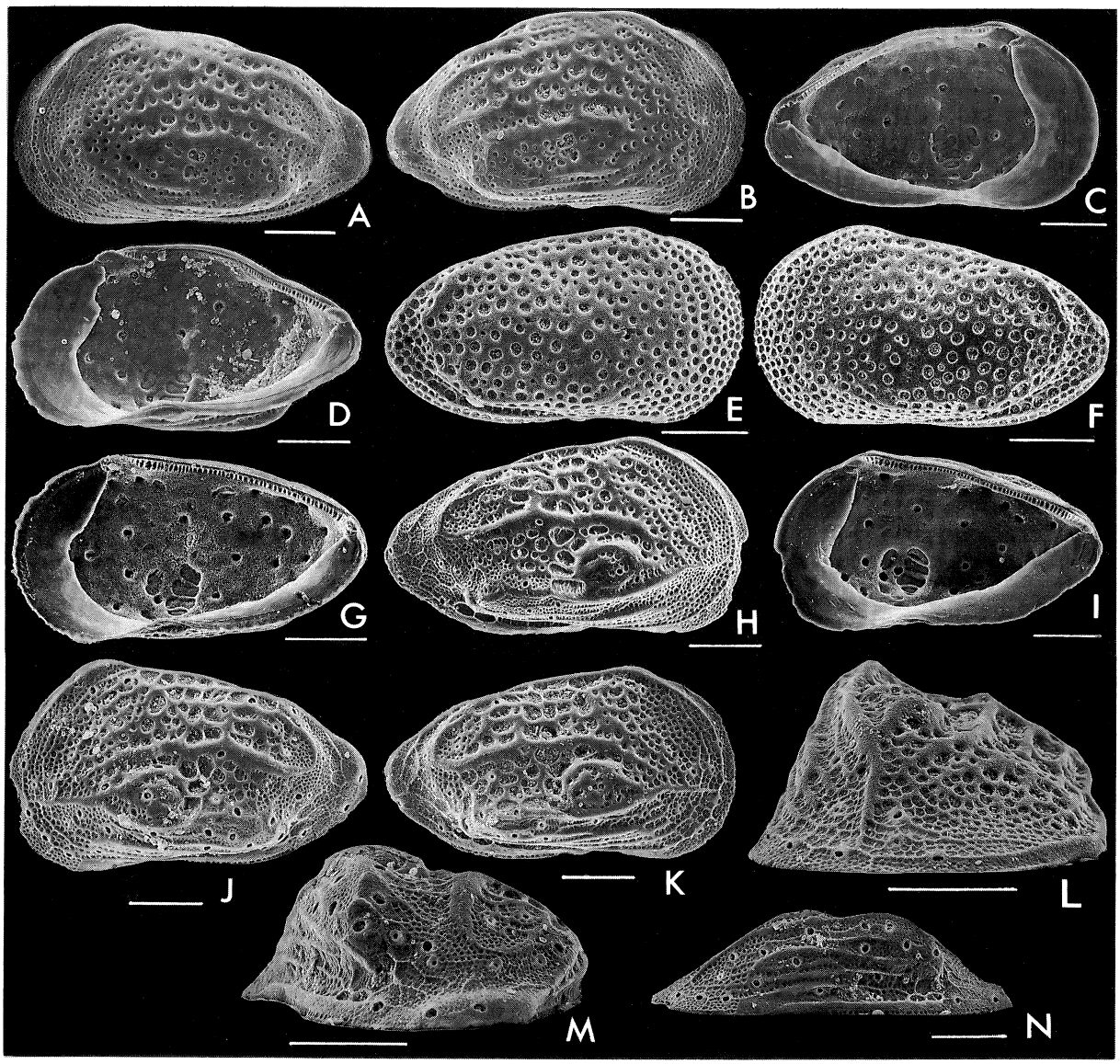

Fig. 2. Scanning electron micrographs. All scale bars are 50 μm. **A–D**, *?Eucytherura boomeri* n.sp., **A**, external lateral view of adult left valve (holotype, AMF 91141), Late Pleistocene, **B**, external lateral view of adult right valve (AMF 91142), Late Pleistocene, **C**, internal view of holotype (AMF 91141), **D**, internal view of paratype (AMF 91142); **E–G**, *?Eucytherura anoda* n.sp., **E**, external lateral view of adult right valve (holotype, AMF 91143), Late Pleistocene, **F**, external lateral view of adult left valve (AMF 91144), Late Pleistocene, **G**, internal view of holotype (AMF 91143); **H–N**, *?Eucytherura polydictyota* n.sp., **H**, external lateral view of adult right valve (AMF 91145), Late Pleistocene, **I**, internal view of same specimen, **J**, external lateral view of adult left valve (AMF 91147), Late Pleistocene, **K**, external lateral view of adult right valve (holotype, AMF 91146), Late Pleistocene, **L**, anterior view of same specimen, **M**, posterior view of same specimen, **N**, ventral view of same specimen.

internally emergent at base of large pits. Antimerodont hinge: finely crenulate median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4–5 true anteriorly, 3 posteroventrally.

Comparisons. Differs considerably from the other species of the genus in its more uniform reticulation with circular fossae and weaker inflation. It lacks normal pore clusters and for this reason is only tentatively placed in *Eucytherura*.

Distribution. Known only from the type locality and horizon.

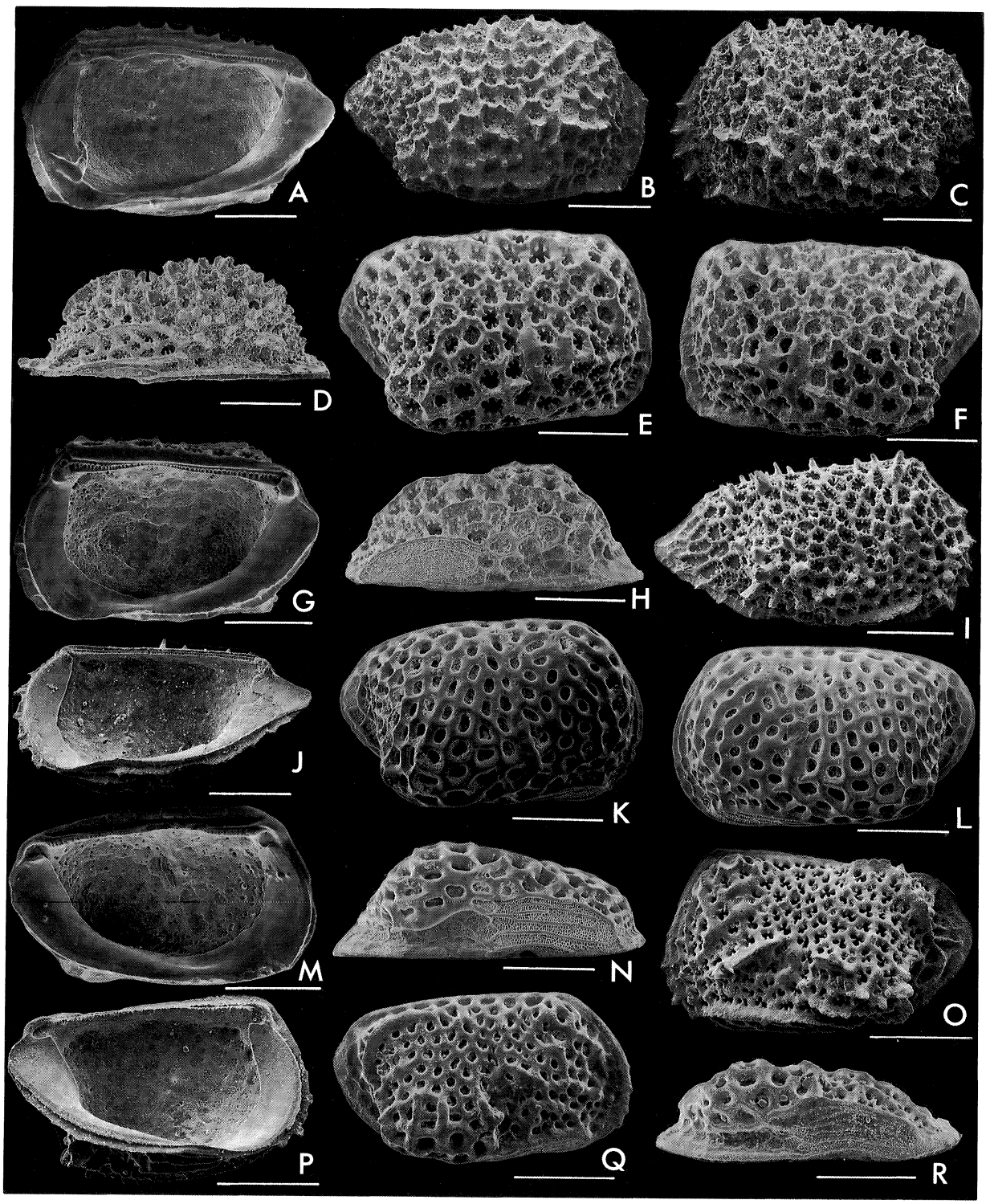

Fig. 3. Scanning electron micrographs. All scale bars are 100 μm. **A–D**, *Eucytherura calabra* (Colalongo & Pasini), **A**, internal view of adult right valve (MA/IP/414) from DSDP Site 209, core 2, section 2, Early Pleistocene, **B**, external lateral view of same specimen, **C**, external lateral view of adult left valve (MA/IP/413) from DSDP Site 209, core 1, section 5, Early Pleistocene, **D**, ventral view of same specimen; **E–H**, *Eucytherura indianensis* n.sp., **E**, external lateral view of adult right valve (OS 14069), Pleistocene, **F**, external lateral view of adult left valve (holotype, OS 14068), Pleistocene, **G**, internal view of adult right valve (OS 14069), Early Pleistocene, **H**, ventral view of holotype (OS 14068); **I–J**, *Eucytherura* sp. 1, **I**, external lateral view of adult right valve (MA/IP/421) from DSDP Site 289, core 3, section

Eucytherura aff. *antipodum* Neale, 1975

Fig. 3 Q–R

"*Eucytherura* sp. 8" Ayress, 1988*: 624; pl. 22, figs 7–9.

Dimensions. Adult right valve, MA/IP/426, length 0.31 mm, height 0.13 mm.

Diagnosis. Subrectangular and weakly inflated. Surface reticulate, fossae well rounded, muri thickened over posteroventral tubercle which overhangs ventral margin. Strong crescentic rib extends close to margin posterodorsally and a short oblique rib is present subcentrally. Ventral surface microreticulate.

Comparisons. The single specimen found in this study has strong affinities with *E. antipodum* Neale recorded in the Late Cretaceous Gingin Chalk of western Australia and clearly is closely related to it. The specimen differs from that species only in having weaker anterodorsal and subcentral tubercles and lacking fossal infillings. It is also very similar to *E. pseudoantipodum* Coles & Whatley, differing from that species in its more elongate lateral outline, its thickened muri on the posteroventral tubercle and lack of fossal spines.

Distribution. So far this species has been recorded only in the Pleistocene of DSDP Site 254, at the southern limit of the Ninetyeast Ridge, Indian Ocean.

Eucytherura batalaria n.sp.

Fig. 4 A–D

"*Eucytherura batalaria*" Downing, 1985*: 448, pl. 19, figs 19,20.–Ayress, 1988* (in part), p. 582, pl. 20, figs 1–4.

Etymology. Latin, a warship armed with battering ram. Referring to the resemblance of the anterior marginal spine to a battering ram.

Type material and dimensions. Holotype, OS 14080, adult right valve, length 0.35 mm, height 0.20 mm. Paratypes: OS 14081, adult left valve, length 0.35 mm, height 0.20 mm, Site 209, core 2, section 2, interval 75–80 cm, Early Pleistocene, Zone NN 19; OS 14082, adult left valve, length 0.28 mm, height 0.18 mm, Site 207A, core 1, section 4, interval 8–17 cm, Early Pliocene, Zone NN 13.

Type locality and horizon. Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19.

Diagnosis. A subtriangular to subovate species of *Eucytherura* with a long marginal spine at mid-height anteriorly, lacking tubercles or ridges dorsally and a narrow anterior marginal rim. Primarily and secondarily reticulate.

Description. Small, subtriangular to subovate in lateral view. Anterior margin bluntly convex, weakly rimmed with three prominent denticles: the uppermost at mid-height longest, the lower two projecting downward. Posterior margin very short with a prominent spine at ventral and dorsal angle. Dorsal margin weakly convex usually interrupted by short spines, one prominent just behind mid-length. Ventral margin gently convex with very weak oral incurvature. Thin-shelled and weakly inflated. Tuberculate ventrally: sub-central tubercle subhemispherical bearing horizontal ridge; posterior tubercle longitudinally elongate bearing a row of at least three prominent spines. Ventro-lateral ridge extends from anteroventral margin below ventral tubercles. Lateral surface covered with polygonal primary and secondary reticulation; primary muri have slightly raised conjunctions, primary fossae subdivided usually into three secondary fossae over most of the valve surface but more numerous towards the valve periphery. Microreticulate anteroventrally and on the posteroventral periphery. Internal surface with clusters of 4 to 5 perforations. Other internal features as for genus.

Comparisons. The close similarity of this species to *Eucytherura downingae* (Coles & Whatley) clearly indicates a close relationship with that species. *Eucytherura batalaria* can be distinguished by its lack of a posterodorsal tubercle or ridge, its very weakly developed anterior rim and more rugose ornament.

Distribution. Found so far only in the south-west Pacific region, viz: Early Miocene of DSDP Site 593; Middle Miocene and Pleistocene of DSDP Site 209; Middle Miocene of DSDP Site 56; Middle to Late Miocene of DSDP Site 592; Pliocene of DSDP Sites 207A and 208; Late Pleistocene of cores Z2108, Sonne 36–61 and 1–86/6GC3; Recent (coretop) of OSI core 12–87/13GC10.

4, Early Pleistocene, **J**, internal view of same specimen; **K–N**, *Eucytherura tumida* n.sp., **K**, external lateral view of adult right valve (holotype, OS 14074), Pleistocene, **L**, external lateral view of adult left valve (OS 10), Pleistocene, **M**, internal view of adult left valve (OS 14076), Early Pleistocene, **N**, ventral view of holotype (OS 14074) Pleistocene; **O–P**, *Eucytherura pseudoantipodum* Coles & Whatley, **O**, external lateral view of adult left valve (MA/IP/423) from DSDP Site 209, core 1, section 1, Late Pleistocene, **P**, internal view of adult right valve (MA/IP/424) from DSDP Site 209, core 1, section 1, Late Pleistocene; **Q–R**, *Eucytherura* aff. *antipodum* Neale, **Q**, external lateral view of adult right valve (MA/IP/426) from DSDP Site 254, core 1, section 3, Early Pleistocene, **R**, internal view of same specimen.

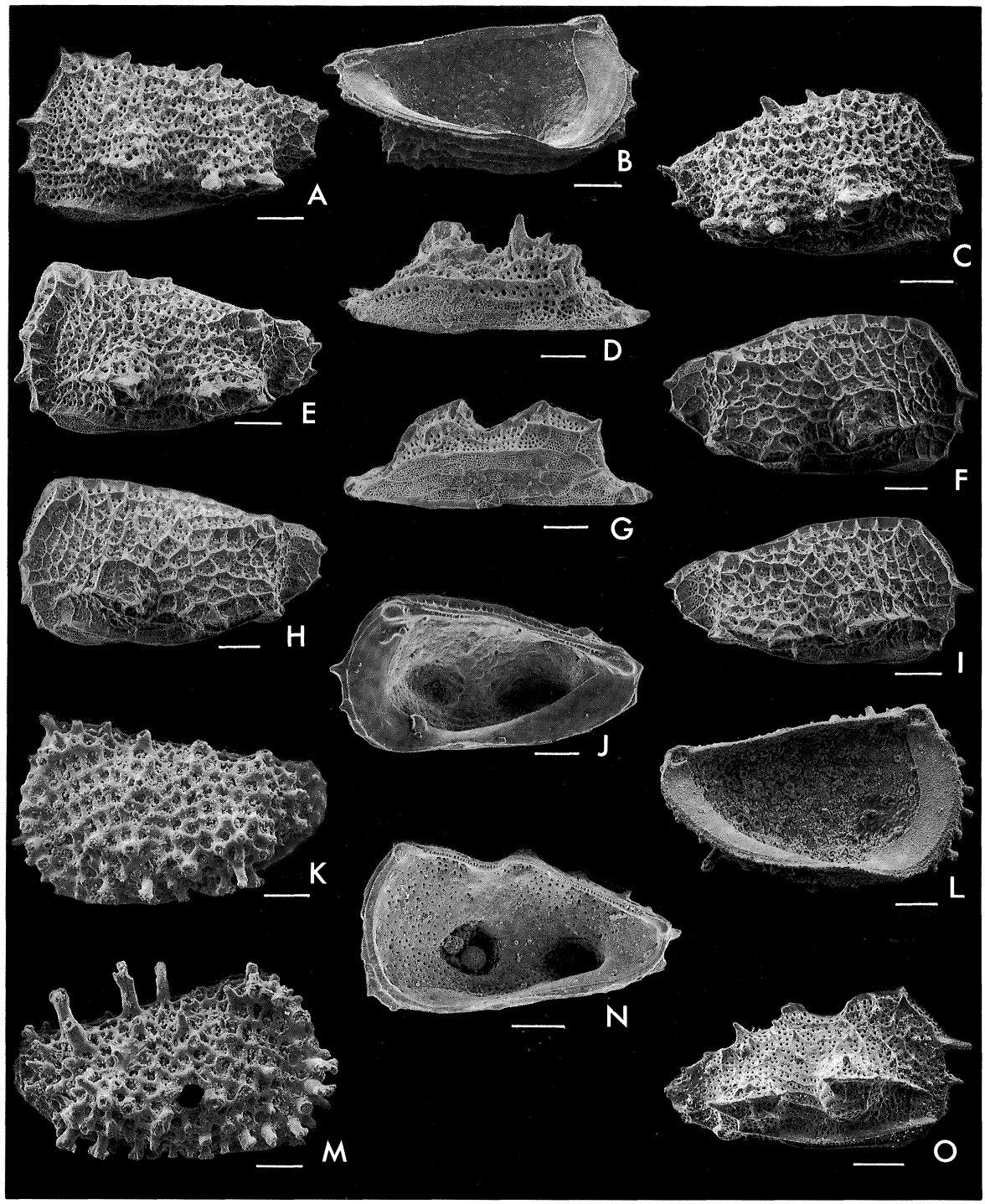

Fig. 4. Scanning electron micrographs. All scale bars are 50 μm. **A–D**, *Eucytherura batalaria* n.sp., **A**, external lateral view of adult left valve (OS 14081) Early Pleistocene, **B**, internal view of adult left valve (MA/IP/393) from DSDP Site 209, core 1, section 1, Late Pleistocene, **C**, external lateral view of adult right valve (SD/WPP/342) from DSDP Site 208, core 9, section 5, Early Pliocene, **D**, ventral view of paratype (OS 14081); **E**, *Eucytherura downingae* (Coles & Whatley), external lateral view of adult left valve (MA/IP/392) from DSDP Site 209, core 1, section 5, Early Pleistocene; **F–J**, *Eucytherura parabatalaria* n.sp., **F**, external lateral view of adult right valve (holotype, OS 14083), Early Pleistocene, **G**, ventral view of adult left valve (OS 14084), Early Pleistocene, **H**, external lateral view of same specimen, **I**, external lateral view of adult right valve (OS 14085), Early Pleistocene, **J**, internal view of adult right valve (MA/IP/397) from DSDP Site 254, core 1, section 2, Pleistocene; **K–M**, *Eucytherura elegantula*

?Eucytherura boomeri n.sp.

Fig. 2 A–D

Etymology. For Dr Ian Boomer in recognition of his innovative work on deep-sea Ostracoda.

Type material and dimensions. Holotype, AMF 91141, adult left valve, length 0.25 mm, height 0.12 mm. Paratype: AMF 91142, adult right valve, length 0.24 mm, height 0.13 mm. Both specimens are from the type locality and horizon.

Type locality and horizon. Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne core 36–61, interval 12–13 cm, Late Pleistocene.

Diagnosis. *?Eucytherura* with convex dorsal margin, low longitudinal ridges and intercostal reticulation in posterior half. Reticulation grades to dense punctation distally. Weakly alate posteroventrally. Median hinge element sinuous.

Description. Very small, subovate in lateral and dorsal view, shell moderately well calcified. Anterior margin convex; posterior margin short and convex. Dorsal margin convex, weakly undulating; ventral margin gently biconvex. Weakly inflated, slightly longitudinally swollen posteroventrally. Diffuse longitudinal ridges through posterior half with intercostal reticulation bounding well rounded fossae and secondarily reticulate, grading to fine, dense punctation distally. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead or dorso-median adductor scar; normal pores, simple and well distributed, internally emergent at base of large pits. Antimerodont hinge: finely crenulate, flexured median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4–5 true anteriorly, 3 posteroventrally.

Comparisons. The species can be distinguished from *?E. polydictyota* n.sp. by its more curved dorsal margin, less distinct ridges and reticulation, and lack of an alar ridge. It is placed only tentatively within *Eucytherura* due to its lack of normal pore clusters.

Distribution. Found only in the Late Quaternary of the type locality.

Eucytherura calabra (Colalongo & Pasini, 1980)

Fig. 3 A–D

Typhloeucytherura calabra Colalongo & Pasini, 1980: 122; pl. 20, figs 1–8; pl. 21, figs 1–2.
?Eucytherura hirsuta Ciampo, 1980: 16; pl. 3, figs 2,4.
Eucytherura calabra.–Whatley & Coles, 1987: pl. 3, figs 14–16.–Whatley & Ayress, 1988: pl. 1, figs 9a,b.–Ayress, 1988*: 607; pl. 21, figs 8–11.
Eucytherura sp. 1 Ruan & Hao, 1988: 291; pl. 49, fig. 18.
"*Eucytherura palatuberculata*" Davies, 1981*: 145; pl. 3, figs 15,16.–Porter, 1984*: 152; pl. 9, figs 4,5.
"*Eucytherura reticulospinosa*" Smith, 1983*: 87; pl. 8, fig. 6.–Downing, 1985*, pl. 29, figs 13–15.–Millson, 1987*: 282; pl. 15, figs 9–14.

Remarks. Colalongo & Pasini (1980) assigned this species to a new genus *Typhloeucytherura* based on its lack of an eyespot and considerable difference from the only blind cytherurine genus, *Typhlocythere*, then available to them. Maddocks & Steineck (1987) further identified certain unique carapace features of *T. calabra* that might serve to distinguish the genus from *Eucytherura*. In our evaluation of species during this study we are unable to assign any of them confidently to *Typhloeucytherura* as presently diagnosed, formally or otherwise. We feel that the features identified as unique for *Typhloeucytherura* are variable in nature and serve to distinguish taxa only at the species level.

Distribution. The species is widespread in the deep-sea. In the Indo-Pacific material considered in this study the species has been recorded both at bathyal and abyssal site depths in the south-west Pacific: coretops TL 8730, TS 8648; Late Quaternary cores OSI 12–87/12GC9, 13GC10, 1–86/6GC3, 6–85/25GC18, Sonne 36–61; Pleistocene of DSDP Sites 207A, 209, 289; Middle Miocene to Pliocene of DSDP Sites 207A and 209; Late Oligocene to Late Pleistocene of DSDP Site 593; Late Eocene to Early Pleistocene of DSDP Site 592; Early Eocene and Late Oligocene of DSDP Site 277; Early to Middle Eocene of DSDP Site 207A; in the eastern Indian Ocean: Pleistocene of DSDP Sites 258 and 259. The species also occurs in the Mediterranean, Atlantic and Okinawa Trough.

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n.sp., **K**, external lateral view of adult left valve (OS 14066), Middle Eocene, **L**, internal view of adult left valve (OS 14067), Middle Eocene, **M**, external lateral view of adult right valve (holotype, OS 14065) Middle Eocene; **N–O**, *Eucytherura* sp. 3, **N**, internal view of adult right valve (MA/IP/400) from DSDP Site 209, core 1, section 1, Late Pleistocene, **O**, external lateral view of same specimen.

Eucytherura downingae (Coles & Whatley, 1989)

Fig. 4 E

Eucytherura sp. 3 Whatley & Coles, 1987: pl. 3, fig. 19.
"? Gen. et sp. 3" Ruan & Hao, 1988: 389; pl. 45, fig. 22.
"Gen. 1 et sp." Ruan, 1989: 131; pl. 24, figs 15,16.
Parahemingwayella downingae Coles & Whatley, 1989: 91; pl. 2, figs 14–16.
"*Eucytherura batalaria*" Ayress, 1988* (in part), p. 582, pl. 20, fig. 5.

Remarks. This species is closely similar to the Pacific *Eucytherura batalaria* n.sp. but differs from that species in having a posterodorsal tubercle and less rugose ornament. The specimen illustrated by Whatley & Coles (1987) displays a rather weakly developed posteroventral tubercle and is here considered to be a variant of this species. Ruan & Hao (1988) illustrate a very similar form found in Quaternary sediments of the Okinawa Trough which, although it has an unusally high anterior hinge ear for this species, is probably conspecific.

Distribution. Found in this study in the Late Pleistocene of Tasman Sea cores Sonne 36–61, 1–86/6GC3 and Coral Sea DSDP core 209.

Eucytherura elegantula **n.sp.**

Fig. 4 K–M

"*Eucytherura elegantula*" Millson, 1987*: 283; pl. 15, figs 15–18.

Etymology. Latin, very fine. Referring to the elegant ornamentation of the carapace.

Type material and dimensions. Holotype, OS 14065, adult right valve, length 0.34 mm, height 0.19 mm. Paratypes: OS 14066, adult left valve, length 0.35 mm, height 0.19 mm, OS 14067, adult left valve, length 0.35 mm, height 0.20 mm. All specimens are from the type locality.

Type locality and horizon. Lord Howe Rise, present day water depth 1389 m, DSDP Site 207A, core 11, section 4, interval 85–90 cm, Middle Eocene, Zone NP 16.

Diagnosis. A non tuberculate species of *Eucytherura* with weak posteroventral inflation. Uniformly reticulate with raised mural conjunctions and fine inwardly directed spines. Marginal and posteroventral regions bear long spines which may have clavate or secondarily spinose terminations. Anterior marginal rim has laterally projecting as well as forward projecting spines.

Description. Small sized, subtriangular in lateral view, weakly inflated and thinly calcified. Anterior margin convex with thin rim. Ventral margin sinuous tapering to short posterior margin dorsally. Dorsal margin straight. Posteroventral tubercle weakly developed, strongly spinose, spines usually clavate. Whole surface covered by a regular reticulum: muri with raised conjunctions and edged with fine inwardly directed spines. Long spines, with secondarily spinose terminations over marginal regions. Internal features where preserved as for genus. Radial pore canals and muscle scars not preserved.

Comparisons. This species is easily distinguished from most other species of *Eucytherura* by its distinctive spinose ornament and lack of tuberculation. It is similar to *Eucytherura ginginensis* (Boomer & Whittaker, 1994) from the Late Cretaceous Gingin Chalk of Western Australia. However, differences between these species can be seen in the nature and distribution of the external spines. For example, *E. ginginensis* has only marginal spines well developed on the anterior marginal rim, whereas *E. elegantula* has both laterally and anteriorly directed spines well developed.

Distribution. Known only from the Early to Middle Eocene of DSDP Site 207A.

Eucytherura indianensis **n.sp.**

Fig. 3 E–H

"*Eucytherura indianensis*" Ayress, 1988*: 611; pl. 21, figs 12–17.

Etymology. From its occurrence in the Indian Ocean.

Type material and dimensions. Holotype, OS 14068, adult left valve, length 0.35 mm, height 0.23 mm. Paratypes: OS 14069, adult right valve, length 0.37 mm, height 0.23 mm, Site 254, core 1, section 2, interval 20–26 cm, Pleistocene; OS 14070, adult right valve, length 0.37, height 0.23 mm, Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

Type locality and horizon. East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 2, interval 20–26 cm, Pleistocene.

Diagnosis. A species of *Eucytherura* with a very bluntly convex anterior margin and very short sub-dorsal caudal process. Coarsely reticulate with polygonal fossae; muri bear short conjunctive and disjunctive lateral spines and inwardly directed spines. Anterior half of ventral surface microreticulate. Low mid-anterior ridge extends onto posteroventral tumidity.

Description. Small, sub-quadrate in lateral view. Anterior margin bluntly convex; posterior margin with short

caudal process just above mid-height. Dorsal margin straight to slightly undulating with distinct anterior cardinal angle. Ventral margin tapers upwards posteriorly, interrupted by posteroventral tumidity which overhangs and overreaches ventral margin. Lateral surface coarsely reticulate: fossae deep and polygonal, muri bear short, blunt conjunctive and disjunctive spines and fine inwardly directed spines. Low ridge extends longitudinally through mid-anterior and obliquely across ventral tumidity, interrupted medianly by thickened mural strut associated with adductor muscle scars. A second low arcuate ventro-lateral ridge borders a sub-ovate microreticulate region in anterior half of ventral surface. Internal surface with clusters of 6–7 perforations. Other internal features as for genus.

Comparisons. The species is similar to *E. calabra* (Colalongo & Pasini), but differs from that species in having much shorter spines and a microreticulate anteroventral surface. In this latter respect it is similar to *E. tumida* n.sp., however, that species lacks spines or ridges and the cells of the microreticulation are more ordered.

Distribution. Found only in the Late Pliocene to Pleistocene of DSDP Site 254 on the Ninetyeast Ridge, eastern Indian Ocean.

Eucytherura multituberculata n.sp.

Fig. 5 A–E

?Tuberculocythere sp. Cronin, 1983: pl. VI, fig. A.
"*Eucytherura* sp." Davies, 1981*: 147.
"*Eucytherura* sp. 2" Porter, 1984*: 155, pl. 9, fig. 11.–Whatley & Coles, 1987: pl. 3, fig. 18.–Millson, 1987*: 287; pl. 15, figs 21–23.
"*Eucytherura multituberculata*" Downing, 1985*: 442; pl. 29, figs 1,2.–Ayress, 1988*: 594; pl. 20, figs 18–21.

Etymology. Latin. Referring to the numerous tubercules which ornament this species.

Type material and dimensions. Holotype, OS 14071, adult left valve, length 0.30 mm, height 0.18 mm. Paratypes: OS 14072, adult right valve, length 0.30 mm, height 0.18 mm, Site 209, core 1, section 1, Late Pleistocene; OS 14073, adult left valve, length 0.30 mm, height 0.19 mm, Site 209, core 2, section 2, Early Pleistocene.

Type locality and level. Lord Howe Rise, present day water depth 1389 m, DSDP Site 207A, core 1, section 1, interval 45–57 cm. Early Pliocene, Zone NN 14.

Diagnosis. *Eucytherura* with valve surface bearing four lateral swellings or nodes as follows: a large, subcentral node of circular section; irregular, spinose posteroventral node; angular anterodorsal node; and an irregular posterodorsal node. A short, almost vertically aligned ridge present high on the dorsal surface close to mid-length. Remainder of valve surface both primarily and secondarily reticulate.

Description. Small, subrectangular in lateral view. Anterior margin bluntly rounded, asymmetrical, extremity below mid-height with six well-spaced denticles, uppermost three strongest forming prominent blunt spines. Posterior margin convex with short caudal process just above mid-height. Dorsal margin straight to slightly convex, punctuated by tuberculate ornament. Ventral margin convex with a shallow oral incurvature just ahead of mid-length. Thick-shelled, not well inflated. Reticulate and tuberculate. Distinct tubercle just anteroventral of centre, circular in section with variable ridged or spinose rounded summit. Well-developed, irregular, longitudinally extended, spinose tubercle partially obscured by strong primary muri which form short conjunctive spines and ridges on the tubercle, at anterodorsal corner and high on the posterodorsal corner. Weak subvertical ridge extends between the ventral tubercles terminating mid-dorsally at a strong dorsal spine. Smooth, narrow ventro-lateral ridge curves from anteroventral corner, subparallel to ventral margin, terminates just ventral to an irregularly spinose posteroventral tubercle. Remainder of valve surface covered with irregular primary reticulation, and an almost equally strong secondary reticulum. Marginal rims narrow and smooth. Ventral surface primarily and coarsely secondarily reticulate; two thin costae occur in anterior field, these diverge toward mid-length subparallel to ventral margin. Numerous conjunctive pore conuli. Internal features as for genus.

Comparisons. *Eucytherura multituberculata* is similar in shape and tuberculate nature to *Eucytherura complexa* Brady, 1866, a species widely distributed in shallow water. The reticulation of the latter species differs, however, in having a trefoil fossal pattern. Certain features of *E. multituberculata* are notably variable, particularly the strength of the secondary reticulation and development of the mid-dorsal spine. The latter feature is absent in specimens of Cretaceous to Eocene age of the Tasman Sea and those found on the Ita Mai Tai Guyot (DSDP Site 200).

Distribution. This species is known from the Tasman Sea in the Late Palaeocene to Pliocene of DSDP Site 207A, in the Late Cretaceous of DSDP Site 208; from the Coral Sea in the Miocene and Pleistocene of DSDP Site 209; from the Ita Mai Tai Guyot, western Pacific in the Miocene and Pleistocene of DSDP Site 200; Late Pleistocene of Sonne 36–61 and OSI 1–86/6GC3; Recent (coretop) of cores TS 8637 and TS 8655; and from the Pleistocene eastern Indian Ocean DSDP Sites 253 and 254. Occurrences outside the Indo-Pacific region include the Recent North Atlantic records of Cronin (1983) 1029 m from the Blake Plateau, western mid Atlantic; Davies (1981) from depths between 500–2000 m of the north

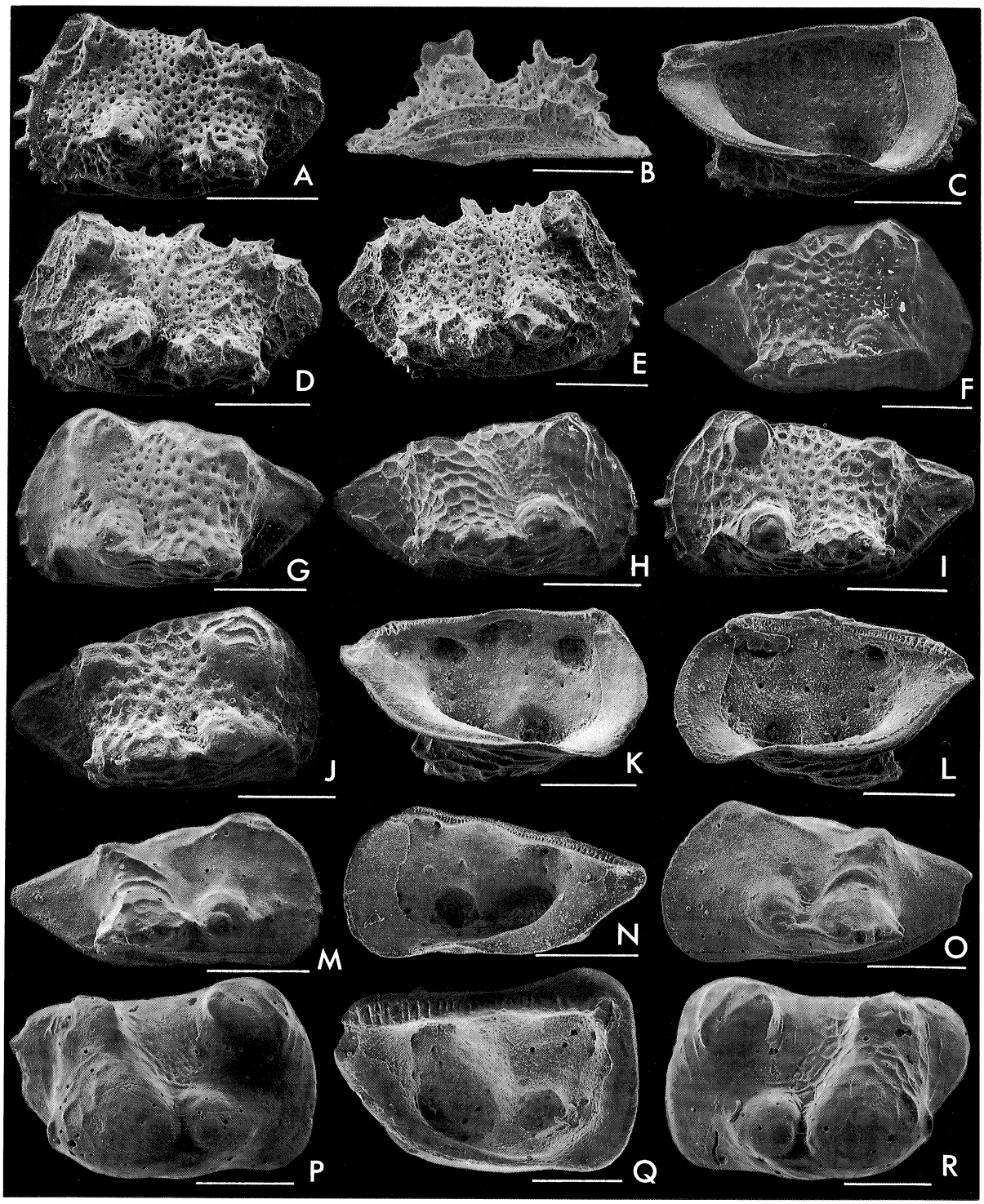

Fig. 5. Scanning electron micrographs. All scale bars are 100 μm. **A–E**, *Eucytherura multituberculata* n.sp., **A**, external lateral view of adult left valve (OS 14073), Early Pleistocene, **B**, ventral view of same specimen, **C**, internal view of adult left valve (MA/IP/404) from DSDP Site 209, core 2, section 2, Early Pleistocene, **D**, external lateral view of adult left valve (SD/WPP/329) from DSDP Site 207A, core 3, section 1, Early Pliocene, **E**, external lateral view of adult right valve (SD/WPP/330) from DSDP Site 207A, core 3, section 5, Early Pliocene; **F–L**, *Hemiparacytheridea leopardina* (Ruan & Hao, 1988), **F**, external lateral view of adult right valve (OS 14079), Late Pleistocene, **G**, external lateral view of adult left valve (OS 14077), Early Pleistocene, **H**, external lateral view of adult right valve (MA/IP/409) from DSDP Site 209, core 1, section 1, Late Pleistocene, **I**, external lateral view of adult left valve (SD/WPP/337) from DSDP Site

eastern Atlantic; and Whatley & Coles (1987) from abyssal depths in the central Atlantic in the Late Pliocene.

Eucytherura pacifica n.sp.

Fig. 6 F–I

"*Typhlocythere pacifica*" Smith, 1983*: 92, pl. 8 fig. 11.–Dainty, 1984*: 219.–Downing, 1985*: 454; pl. 29, figs 17,18.–Ayress, 1988*: 634; pl. 22, figs 16–18.

Etymology. From its occurrence in the south-west Pacific.

Type material and dimensions. Holotype, OS 14086, adult left valve, length 0.34 mm, height 0.22 mm. Paratypes: OS 14087, adult right valve, length 0.31 mm, height 0.19 mm, Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19; OS 14088, adult right valve, length 0.28 mm, height 0.20 mm, Site 208, core 5, section 6, interval 7–18 cm, Late Pleistocene, Zone NN 21.

Type locality and level. Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19.

Diagnosis. *Eucytherura* rounded, subrhomboidal lateral outline, tumid posteroventrally. Coarsely reticulate, fossae partially celate. Anterior and posterior marginal and ventral surface microreticulate.

Description. Small, sub-rhomboidal in lateral view. Anterior margin broadly rounded; asymmetrical, extremity below mid-height. Posterior margin convex with very short caudal process sub-dorsally. Dorsal margin slightly sinuous. Ventral margin slightly convex interrupted by posteroventral tumidity. Moderately thick-shelled and tumid posteroventrally, compressed only postero-marginally. Lateral surface coarsely reticulate, fossae mostly polygonal except anteriorly and over posteroventral swelling where fossae are partially celated and well rounded. Anteriorly primary muri aligned sub-parallel to anterior margin. Ventral surface and anterior and posterior marginal regions microreticulate. Surface of inner lamella with clusters of about 6 pores. Other internal features as for genus.

Comparisons. This species is most similar to *Eucytherura ruggierii* (Bonaduce, et al., 1975) of the Adriatic Sea, from which it differs in its partially celate fossae and ventral microreticulation.

Distribution. Widely distributed in the south-west Pacific region: Late Oligocene to Early Pleistocene of DSDP Site 593; Middle Miocene and Pleistocene of DSDP Site 207A and 209, Early Miocene to Late Pleistocene of DSDP Site 592; Pliocene to Pleistocene of DSDP Site 208; Pleistocene of DSDP Sites 277, 282 and 284; Late Pleistocene of cores Sonne 36–61 and OSI 1–86/6GC3.

Eucytherura parabatalaria n.sp.

Fig. 4 F–J

"*Eucytherura* cf. *?Cytheropteron tetrapteron* (Bonaduce, Ciampo & Masoli)" Porter, 1984*: 153; pl. 9, figs 6,7.
"*Eucytherura parabatalaria*" Ayress, 1988*: 585; pl. 20, figs 6–12.

Etymology. Greek, close. Referring to the close similarity of this species to *Eucytherura batalaria* n.sp.

Type material and dimensions. Holotype, OS 14083, adult right valve, length 0.33 mm, height 0.19 mm. Paratypes: OS 14084, adult left valve, length 0.36 mm, height 0.19 mm; OS 14085, adult right valve, length 0.34, height 0.17 mm. All specimens from Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

Type locality and horizon. East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

Diagnosis. A species of *Eucytherura* with a gently sinuous dorsal margin and two ventral tubercles, the anterior-most subhemispherical with a low longitudinal ridge, the posterior-most elongate and somewhat tumid. L-shaped ridge posterodorsally; Coarsely primarily reticulate, fossae polygonal, and uniformly secondarily reticulate. Whole of ventral surface microreticulate.

Description. Small, elongate sub-triangular in lateral view. Strongly sexually dimorphic: male valves more elongate than female valves. Anterior margin convex,

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208, core 4, section 4, late Pliocene, **J**, external lateral view of adult right valve (SD/WPP/335) from DSDP Site 207A, core 3, section 5, Early Pliocene, **K**, internal view of adult left valve (SD/WPP/340) from DSDP Site 208, core 4, section 4, Late Pliocene, **L**, internal view of adult right valve (SD/WPP/339) from DSDP Site 206, core 16, section 3, Late Pliocene; **M–O**, *Hemiparacytheridea vanharteni* n.sp., **M**, external lateral view of adult right valve (holotype, OS 14582) Early Pleistocene, **N**, internal view of same specimen, **O**, external lateral view of adult left valve (OS 14583) Pleistocene; **P–R**, *Hemiparacytheridea mediopunctata* (Coles & Whatley), **P**, external view of right valve (MA/IP/430) from DSDP Site 254, core 1, section 3, Early Pleistocene, **Q**, internal view of adult left valve (MA/IP/431) from DSDP Site 254, core 2, section 1, Late Pliocene, **R**, external lateral view of adult right valve (MA/IP/429) from DSDP Site 254, core 1, section 2, Pleistocene.

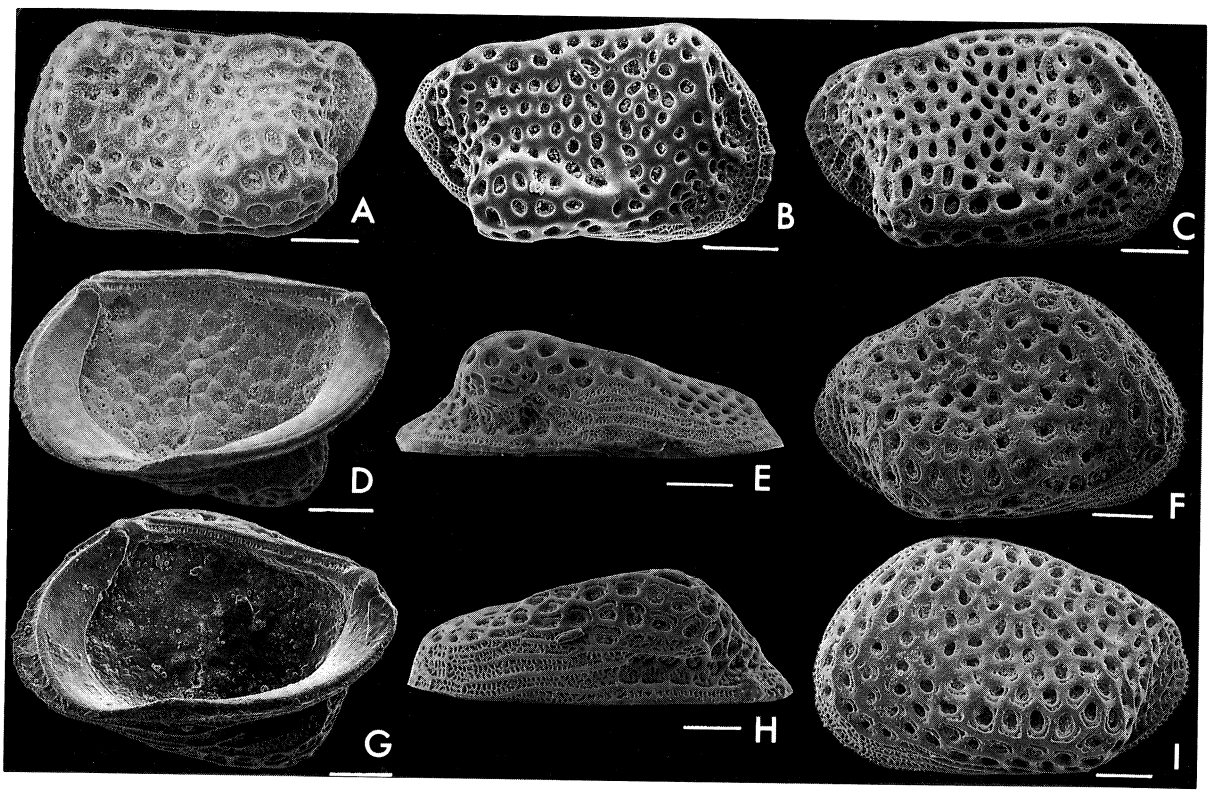

Fig. 6. Scanning electron micrographs. All scale bars are 50 μm. **A–E**, *Eucytherura* sp. 2, **A**, external lateral view of adult left valve, specimen lost, from DSDP Site 593, core catcher 44, Early Miocene, **B**, external lateral view of adult right valve (AMF 91148) from eastern Australian continental slope, sample details unknown, **C**, external lateral view of adult right valve (MA/IP/427) from DSDP Site 209, core 2, section 2, Early Pleistocene, **D**, internal view of same specimen, **E**, ventral view of same specimen; **F–I**, *Eucytherura pacifica* n.sp., **F**, external lateral view of adult right valve (SD/WPP/348) from DSDP Site 208, core 5, section 6, Late Pliocene, **G**, internal view of same specimen, **H**, ventral view of adult left valve (MA/IP/435) from DSDP Site 209, core 2, section 6, Early Pleistocene, **I**, external lateral view of adult left valve (holotype, OS 14086) Early Pleistocene.

asymmetrical, strongly rimmed, with a strong denticle at mid-height and two shorter downward projecting denticles anteroventrally. Posterior margin short, straight to slightly convex with two denticles, one at each corner. Dorsal margin sinuous, gently convex ahead of mid-third, gently concave behind. Ventral margin biconvex. Moderately thin-shelled and inflated. Tuberculate: well-developed, sub-hemispherical tubercle just anteroventral of centre, bearing a short longitudinal ridge which extends down anterior slope of tubercle. Posteroventral tubercle elongate longitudinally with a low spine midway on posteroventral slope. L-shaped ridge close to margin posterodorsally formed by accentuated mural elements. Coarse primary reticulation over entire lateral surface, fossae polygonal; muri on anterior rim form a continuous ridge, and muri form a smooth border along anterior half of dorsal margin. Uniformly secondary reticulate, primary fossae subdivided into 5 rounded sub-fossae which are sometimes edged by numerous short ingrowing spines. Ventral surface microreticulate. Ventro-lateral smooth narrow ridge extends from margin anteroventrally across ventral surface. Internal surface of outer lamella with clusters of 4 to 5 normal pores. Other internal features as for genus.

Comparisons. This species is most similar to *Eucytherura batalaria* n.sp, *Eucytherura downingae* (Coles & Whatley) and the Mediterranean *Eucytherura tetrapteron* (Bonaduce et al.). It can be distinguished from the former two species by its lack of spinosity and more extensively distributed ventral microreticulation, and from the latter species by its more regular primary reticulation.

Distribution. Recorded only from the eastern Indian Ocean in the Pleistocene of DSDP Sites 253, 258 and 259, and in the Late Pliocene to Pleistocene of DSDP Site 254.

?Eucytherura polydictyota n.sp.

Fig. 2 H–N

Etymology. Greek, many plus net. Referring to the varied reticulation on the valve external surface.

Type material and dimensions. Holotype, AMF 91146, adult right valve, length 0.25 mm, height 0.14 mm. Paratype: AMF 91145, adult right valve, length 0.25 mm, height 0.14 mm, from core Z2108/3, level 65 cm, Late Pleistocene; AMF 91147, adult left valve, length 0.24 mm, height 0.13 mm, from the type locality and horizon.

Type locality and horizon. Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne Core 36–61, level 41 cm. Late Pleistocene.

Diagnosis. An alate species of *?Eucytherura* with strong ventro-lateral ridge, and median ridge which joins dorsal ridge in a posterior loop. Murae thickened over position of adductor muscle scars. Surface reticulate: fossae large centrally grading to dense secondary reticulation distally. Median hinge element slightly flexured. Normal pores well distributed with one conspicuously positioned between the anterior ends of the median adductor scars.

Description. Very small, subrectangular to subtriangular in lateral view. Anterior margin convex with apex below mid-height. Posterior margin convex and very narrow with extremity at mid-height. Dorsal margin straight to slightly undulating, with small anterior hinge ear. Ventral margin biconvex about median oral incurvature. Moderately well inflated ventrally forming a blunt alar process which bears a distinct ridge anteriorly. Adductor muscle scar region distinct externally as a low hemispherical swelling just anteroventral of valve centre. A second conspicuous ridge extends across central field tapering at each end, looping backwards posterodorsally. Remainder of lateral surface covered with reticulation. Fossae large centrally and mid dorsally, are secondarily subdivided and elsewhere. Primary murae diminish in strength away from valve mid-length, becoming almost equal with fine secondary murae over distal compressed regions and over ventral surface. Normal pores well distributed with one inserted between the anterior ends of the median adductor scars. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead or dorso-median adductor scar; normal pores, simple and well distributed, internally emergent at base of large pits. Antimerodont hinge: finely crenulate median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4–5 true anteriorly, 3 posteroventrally.

Comparisons. This species can be confused with *?Eucytherura boomeri* n.sp. but the alate ventrum, strong median ridge and subcentral tubercle, with its central normal pore, readily serve to distinguish this species. Its normal pores are not clustered, for this reason it is only tentatively placed within *Eucytherura*.

Distribution. Western flank of Lord Howe Rise, present day water depths 1340 m and 1448 m of cores Sonne 36–61, level 41 cm and Z2108/3, level 65 cm respectively; both occurrences are of Late Pleistocene age.

Eucytherura pseudoantipodum Coles & Whatley, 1989

Fig. 3 O–P

"*Eucytherura* sp. 7" Ayress, 1988*: 621; pl. 22, figs 5,6.
Eucytherura pseudoantipodum Coles & Whatley, 1989: 93; pl. 3, figs 5–7.

Remarks. The two specimens found in this study seem to conform to *E. pseudoantipodum* Coles & Whatley, known from the Middle Eocene to Late Oligocene of the North Atlantic. Some minor differences between the Atlantic and Pacific material can be seen, such as the somewhat straighter dorsal margin and fossal spines of the Pacific forms. Such differences could be attributable to geographic variation.

Distribution. In this study the species was recorded only in the Pleistocene of DSDP Site 209, Queensland Plateau.

Eucytherura tumida n.sp.

Fig. 3 K–N

"*?Typhlocythere tumida*" Ayress, 1988*: 638; pl. 22, figs 23–24; pl. 23, figs 1–5.

Etymology. Latin. Referring to the tumid ventro-lateral inflation of this species.

Type material and dimensions. Holotype, OS 14074, adult right valve, length 0.34 mm, height 0.22 mm. Paratypes: OS 14075, adult left valve, length 0.34 mm, height 0.20 mm, Site 254, core 1, section 2, interval 20–26 cm, Pleistocene; OS 14076, adult left valve, length 0.33, height 0.20 mm, Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

Type locality and horizon. East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 2, interval 20–26 cm, Pleistocene.

Diagnosis. A sub-rectangular to sub-ovate, ventro-laterally tumid species of *Eucytherura*. Strongly reticulate, fossae somewhat vertically aligned in posterior half, arranged in rows parallel to anterior margin in anterior half. Ventral surface conspicuously ornamented with microreticulation which extends to anterior and posterior marginal regions; ventral microreticulate field expanded in anterior half and regularly arranged between five primary mural rows.

Description. Small sized, sub-rectangular to sub-ovate in lateral view. Anterior margin bluntly convex; posterior margin with extremely short caudal process just below dorsal margin. Dorsal margin straight to slightly convex; ventral margin gently convex, oral incurvature indistinct. Moderately thick shelled and well inflated; tumid posteroventral swelling overhangs ventral margin. Coarsely reticulate: fossae deep and ovate, subvertically aligned in posterior half, concentrically aligned in anterior half; edges of muri rarely bear incipient ingrowing spines. Sinuous ventro-lateral ridge borders primary reticulation and ventral microreticulation, the latter extends to anterior and posterior marginal regions. Anterior half of ventral surface with a conspicuous field of microreticulation infilling five rows of horizontally aligned thin primary muri. Normal pore canals numerous and well spaced. Internal pore clusters consist of clusters of 2–3 pores. Other internal features as for genus.

Comparisons. This species differs from *E. indianensis* n.sp. primarily in its more ordered reticulum, less angular outline and lacks the longitudinal anterior ridge.

Distribution. Late Pliocene to Pleistocene of DSDP Site 254 on the Ninetyeast Ridge, eastern Indian Ocean.

Eucytherura sp. 1

Fig. 3 I–J

"*Eucytherura* sp." Ayress, 1988*: 616; pl. 21, figs 22,23.

Dimensions. Adult right valve, MA/IP/421, length 0.36 mm, height 0.20 mm.

Diagnosis. *Eucytherura* with sub-rectangular lateral outline and strongly caudate. Reticulation of irregular polygonal fossae with thin delicate inwardly directed spines and lateral spines, both conjuctive and disjunctive, strongest on posteroventral swelling. Solum perforated by fine pores reflected internally by a regular pattern of 9–10 pore clusters. Narrow, straight accommodation groove above hinge.

Distribution. Only a single specimen was recorded from the Early Pleistocene of DSDP Site 209, Queensland Plateau.

Eucytherura sp. 2

Fig. 6 A–E

"*Eucytherura* sp. 9" Ayress, 1988*: 626; pl. 22, figs 10–12.

Dimensions. Adult right valve, MA/IP/427, length 0.29 mm, height 0.18 mm.

Diagnosis. A subrectangular species of *Eucytherura* with a somewhat bulbous posteroventral swelling which overreaches ventral margin. Short ridge anterodorsally and posterodorsally. Lateral surface coarsely reticulate, fossae well rounded, ventral surface microreticulate.

Comparisons. Although very similar to *E. pacifica* it can be distinguished from that species by its more rectangular lateral outline, its more irregular inflation and dorsal ridges. It is left in open nomenclature due to paucity of material.

Distribution. Late Pleistocene of eastern Australian continental shelf, Early Pleistocene of DSDP Site 209, Queensland Plateau, and Early Miocene of DSDP Site 593, Lord Howe Rise.

Eucytherura sp. 3

Fig. 4 N–O

"*Eucytherura* sp. 2" Ayress, 1988*: 591; pl. 20, figs 16,17.

Dimensions. Juvenile ?A–1 right valve, MA/IP/400, length 0.32 mm, height 0.17 mm.

Diagnosis. *Eucytherura* with a deep-concavity in dorsal margin corresponding to a sinuous median hinge element at anterior third of valve length. Primarily and secondarily reticulate. Two ventro-lateral tubercles high on lateral surface.

Comparisons. Although this species is similar in many respects to *Eucytherura batalaria* n.sp. it can easily be identified by its dorsal concavity. This feature is present in *Eucytherura tetrapteron* (Bonaduce et al.) but that species clearly differs in its distinctive surface mural pattern.

Distribution. In the study region this species has been recorded only from the Late Pleistocene of DSDP Site 209, Queensland Plateau. It is also known from 2580 m in the central North Atlantic (pers. comm. Van Harten, 1985).

Hemiparacytheridea Herrig, 1963

Type species. *Hemiparacytheridea occulta* Herrig, 1963

Diagnosis. A genus of the subfamily Cytherurinae with a small carapace of subrectangular or quadrate lateral outline commonly with long caudal process above mid-height. Posteroventral and subcentral tubercle present often forming a bitubercular alar structure. Eye tubercle present or absent. Normal pore canals large and regularly distributed. Muscle scars consist of four subovate adductor scars in a vertical row and a subreniform frontal scar ahead of the row. Hinge, in right valve, consists of a small circular anterior terminal tooth, posterior tooth very much reduced or absent, and a locellate median groove expanded posteriorly.

Comparisons. This genus lacks the solum pore clusters and distinct posterior terminal hinge element of *Eucytherura*. *Tuberculocythere* Colalongo & Pasini, 1980 also lacks these features and is considered to be a strongly tuberculate form of *Hemiparacytheridea*.

Key to Deep-sea Species of *Hemiparacytheridea*

1. Ventral bitubercular alae with curved ventro-lateral ridge; extensive reticulate to punctate ornament ..... *leopardina*

—— Ventro-lateral ridge absent; ornament only weakly developed 2

2. Dorsal tubercles weakly developed; lateral outline elongate ..... *vanharteni*

—— Tubercles well developed and bulbous; lateral outline subquadrate ..... *mediopunctata*

Hemiparacytheridea leopardina (Ruan & Hao, 1988)

Fig. 5 F–L

"*Eucytherura* sp. 1" Whatley & Coles, 1987: pl. 3, fig. 17.
"*Eucytherura* sp. 5" Millson, 1987*: 291; pl. 16, figs 4,5.
Bythoceratina leopardina Ruan & Hao, 1988: 257, pl. 41, figs 20–23.
?Typhlocythere tetrandosa.–Ruan, 1989: 123, pl. 22 fig. 24.
"*Eucytherura variabile*" Downing, 1985*: 444; pl. 29, figs 3–9.–Smith, 1983*: 88, pl. 8 fig. 5.–Ayress, 1988*: 598, pl. 20 figs 22–24.

Dimensions. OS 14077, female left valve, length 0.35 mm, height 0.20 mm; OS 14078, female left valve, length 0.33 mm, height 0.20 mm, both from Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19. OS 14079, female right valve, length 0.33 mm, height 0.20 mm, Site 209, core 1, section 1, interval 75–80 cm, Late Pleistocene, Zone NN 21.

Emended diagnosis. *Hemiparacytheridea* with a moderately large posteroventral alar structure, forward from which extends a laterally directed ridge that turns sharply downward just anterior of a hemispherical sub-central tubercle. Ribbed pyramidal tubercle anterodorsally, irregular subtriangular tubercle posterodorsally. Sinuous ridge extends subvertically anterodorsally. Reticulation fossae circular medially, polygonal elsewhere. Caudal process somewhat downturned.

Comparisons. Our material of this species displays considerable variation in the strength of the reticulation muri. The ventral bitubercular alar structure and associated downward curving anteroventral ridge, together with the pyramidal anterodorsal tubercle, seem to be consistent diagnostic features of this species and we have no doubt that our material belongs to *H. leopardina*. It is clearly closely related to *Hemiparacytheridea hemingwayi* Neale, 1975 described from the Late Cretaceous Gingin Chalk of Western Australia. The latter species differs only in having a straight dorsal margin. The large anterodorsal tubercle of *H. leopardina* lacks an ocular sinus internally. Neale describes the same tubercle of *H. hemingwayi* as an "eye tubercle" but no internal description is given in support of this interpretation. If indeed ocular structures (glassy lens or internal sinus) are present then these features also could serve to distinguish the two species. A similar species, as yet undescribed, has been recorded in the Middle Eocene to Middle Miocene of ODP Site 214, eastern Indian Ocean (Boomer, pers. comm. 1993) which differs in having a more elongate upturned caudal process.

Distribution. Ruan & Hao (1988) first described this species from 1405 m and 1540 m in the Okinawa Trough, East China Sea. Ruan (1988) recorded this species in a Quaternary core taken at 2004 m in the South China Sea. In our material the species is recorded at both bathyal and abyssal depths in the south-west Pacific from the Recent (coretop) of OSI cores 1–86/

19GC11, 12–87/13GC10, TL 8731, 8771, 8730, 8695, TS 8646, 8636; Pleistocene of DSDP Sites 203, 208, 209, 588, Sonne 36–61, AGSO 71GC044, OSI 12–87/12GC9, 1–86/6GC3, Z2108; Pliocene of DSDP Sites 206, 207A, 208 and 289; Late Miocene to Late Pliocene of DSDP Site 592; Middle Miocene of DSDP Sites 62 and 209; Late Oligocene to Early Pliocene of DSDP Site 593; Middle Eocene of DSDP Site 207A; and in the eastern Indian Ocean from the Pleistocene of DSDP Sites 253, 254 and 258. Whatley & Coles (1987) recorded this species in the Late Miocene of DSDP Site 608, North Atlantic.

Hemiparacytheridea vanharteni n.sp.

Fig. 5 M–O

"*Eucytherura* sp. 1" Ayress, 1988*: 589; pl. 20, figs 13–15.
"*Eucytherura* sp. 4" Coles, 1989*, pl. 18, fig. 5.

Etymology. For Professor Dick van Harten in recognition of his work on deep-sea Ostracoda.

Type material and dimensions. Holotype, OS 14582, adult right valve, length 0.30 mm, height 0.17 mm. Paratype, OS 14583, adult left valve, length 0.30 mm, height 0.16 mm, Site 253, core 1, section 4, interval 13–19 cm, Pleistocene.

Type locality and level. Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19.

Diagnosis. *Hemiparacytheridea* with long caudal process, mid-ventral, bitubercular alar process and low pyramidal posterodorsal tubercle. Arcuate ridge behind centre, essentially smooth elsewhere. Normal pores are large with stellate external openings.

Description. Small, elongate sub-triangular in lateral view. Anterior margin bluntly convex, asymmetrical, extremity below mid-height and weakly rimmed. Posterior margin acuminate produced into a long caudal process dorsally. Dorsal margin straight, interrupted by low, subtriangular tubercle just behind mid-length; weak hinge ear anteriorly in right valve. Ventral margin weakly biconvex. Thin-shelled; well inflated posteroventrally, rather compressed elsewhere. Large posteroventral longitudinally extended swelling with weak terminal spine, joined to subcentral hemisperical tubercle by low sub-horizontal ridge, together forming a bitubercular alar process mid-ventrally. Low arcuate ridge behind centre and a second ridge extends close to margin anterodorsally, remainder of lateral surface smooth. Normal pores well scattered, external openings large and stellate. Internal features as for genus.

Comparisons. This is a distinctive species by virtue of its weak inflation and smooth external surface. It is somewhat similar to *Hemiparacytheridea leopardina* (Ruan & Hao, 1988) but is more elongate and lacks the dorsal tubercle and reticulation of that species.

Distribution. Widely distributed but usually rare: Early Pleistocene of DSDP Site 209, Queensland Plateau; Pleistocene of DSDP Site 253, Ninetyeast Ridge; Recent (coretop) of OSI core 12–87/13GC10; Recent and Lower Oligocene of central North Atlantic (Van Harten pers. comm. 1985 and Coles, 1989 respectively). The species has also been found recently at DSDP Guyot Site 171, central Pacific Ocean (Boomer, pers. comm. 1993).

Hemiparacytheridea mediopunctata (Coles & Whatley, 1989)

Fig. 5 P–R

Eucytherura mediopunctata Coles & Whatley, 1989: 92; pl. 3, figs 2–4.
"*Tuberculocythere horrida*" Ayress, 1988*: 629; pl. 22, figs 13–15.

Remarks. Material illustrated here is from DSDP Site 254 in the eastern Indian Ocean, and represents the only record of this species outside the North Atlantic. The Indian Ocean specimens differ slightly from the Atlantic material in having a more inflated posteroventral tubercle which may be attributable to geographical variation. In several species of *Hemiparacytheridea* the degree of inflation of the lateral tubercles can be seen to be rather variable and end members with very swollen tubercles have been placed in *Tuberculocythere* Colalongo & Pasini, 1980. The tubercular inflation is not, therefore, considered to represent a natural generic character, and for this reason *Tuberculocythere* is not used here.

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Table 1. Cores from which the genera discussed in the text were recovered together with their stratigraphical and geographical provenence.

Core/grab Site	PDWD(m)	Latitude	Longitude	Age range sampled
South-west Pacific				
DSDP 56	2508	8°22.4'N	143°33.6'E	Middle Miocene
DSDP 62	2591	10°52.2'N	141°56.3'E	Middle Miocene
DSDP 200	1469	12°50.2'N	156°47.0'E	Miocene and Pleistocene
DSDP 203	2720	22°09.22'S	177°32.7'E	Pleistocene
DSDP 206	3196	32°00.75'S	165°27.15'E	Pliocene
DSDP 207A	1389	36°57.75'S	165°26.06'E	M. Palaeocene–L. Pleist.
DSDP 208	1545	26°06.61'S	161°13.27'E	L. Cret.–L. Olig., Plio.–Pleist.
DSDP 209	1428	15°56.19'S	152°11.27'E	M. Eoc.–L. Olig., L. Pleist.
DSDP 277	1214	52°13.43'S	166°11.48'E	M. Palaeocene–L. Olig.
DSDP 289	2206	00°29.92'S	158°30.69'E	Pliocene
DSDP 588	1533	26°06.70'S	161°13.60'E	L. Pleistocene
DSDP 592	1088	36°28.40'S	165°26.53'E	L. Eoc.–L. Pleist.
DSDP 593	1068	40°30.47'S	167°40.47'E	L. Eoc.–L. Pleist.
AGSO 71GC044	1321	29°31.464'S	153°53.976'E	L. Pleistocene
Sonne 36-61	1340	30°33.017'S	161°26.294'E	L. Pleistocene
Z2108	1448	33°22.59'S	161°36.75'E	L. Pleistocene
OSI 6-85/25GC18	2970	48°17.7'S	178°14.8'E	L. Pleistocene
OSI 1-86/6GC3	1540	32°58.8'S	159°59.9'E	L. Pleistocene
OSI 1-86/19GC11	2067	29°57.6'S	159°50.5'E	Recent
OSI 12-87/12GC9	3281	27°23.2'S	165°20.3'E	L. Pleistocene
OSI 12-87/13GC10	1416	29°15.5'S	161°15.3'E	Recent
RC12-210 TL 8771	1529	24.14°S	177.36°E	Recent
RC9-128 TL 8731	1234	36.13°S	166.07°E	Recent
RC9-127 TL 8730	1533	34.01°S	167.54°E	Recent
V24-161 TL 8695	1670	18.12°S	151.27°E	Recent
OPR-476 TS 8655	3040	33.30°S	165.02°E	Recent
NOVA-A48 TS 8646	2220	28.12°S	158.13°E	Recent
ANT 226 TS 8636	2472	18.35°S	176.45°E	Recent
ANT 231 TS 8637	2238	17.09°S	175.54°E	Recent
NOVA-A53 TS 8648	1607	28.08°S	161.31°E	Recent
Indian Ocean				
DSDP 253	1962	24°52.65'S	87°21.97'E	Pleistocene
DSDP 254	1253	30°58.15'S	87°53.72'E	Pleistocene
DSDP 258	2793	33°47.69'S	112°28.42'E	Pleistocene
DSDP 259	4706	29°37.05'S	112°41.78'E	Pleistocene

Table 2. Stratigraphical range in the study region of the species discussed in the text. E = Early, L = Late.

Epoch	Cret.	Pal.	Eocene							Olig.	Mio.		Plio.		Pleist.			Rec.
	Late	E.–L.	Early		Middle					Late	Early		Late		E.		Late	
Nannofossil zone NP/NN		1 – 9	10	11	12–15	16	17–24		25	1	2 –17		18		19	20	21	
Eucytherura multituberculata n.sp.	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Eucytherura calabra	–	–	–	–	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Eucytherura elegantula n.sp.	–	–	–	–	–	×	×	×	–	–	–	–	–	–	–	–	–	–
Hemiparacytheridea leopardina	–	–	–	–	–	–	–	×	×	×	×	×	×	×	×	×	×	×
Eucytherura pacifica n.sp.	–	–	–	–	–	–	–	–	–	–	×	×	×	×	×	×	×	–
Eucytherura sp. 2	–	–	–	–	–	–	–	–	–	–	–	×	×	×	×	×	×	–
Eucytherura batalaria n.sp.	–	–	–	–	–	–	–	–	–	–	–	×	×	×	×	×	×	×
Hemiparacytheridea mediopunctata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Eucytherura indianensis n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Eucytherura parabatalaria n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Eucytherura tumida n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Eucytherura sp. 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	–	–	–
Eucytherura aff *antipodum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Eucytherura pseudoantipodum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	–
Hemiparacytheridea vanharteni n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×	×	×
?Eucytherura boomeri n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	–
Eucytherura downingae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	–
Eucytherura sp. 3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	–
?Eucytherura polydictyota n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×	×
?Eucytherura anoda n.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	×