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OBSERVATIONS ON LOXOCYTHE (LOXOCYTHE) OUYENENSIS (CHAPMAN, 1914) (OSTRACODA) FROM THE CENOZOIC OF S.E. AUSTRALIA WITH COMMENTS ON SPECIES ATTRIBUTED TO MICROCYTHURA MÜLLER, 1894 AND HEMIPARVOCYTHE HARTMANN, 1982 FROM AUSTRALIAN AND NEW ZEALAND MARINE WATERS.

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The type material of Loxocythe (Loxocythere) ouyenensis (Chapman, 1914) from mid Cenozoic strata of the Mallec Bore No. 11 in the Murray Basin, S.E. Australia is partially redescribed and refigured. This species belongs to a discrete group of large elongate Cenozoic fossil and living Loxocythere species, the carapaces of which possess sub-rectangular inner margin outlines, and broadly rounded posterior extremities. Some much smaller but otherwise very similarly shaped species, that have previously been placed under the genus Microcytherura (i.e. Microcytherura? peterroyi Yassini and Jones, 1995) or the genus Hemiparvcythe Hartmann, 1982 (i.e. Hemiparvcythe lauricola Hartmann, 1982), are also known from marine Cenozoic strata and modern seas of the Australasian region. There is a marked difference in the shape of the inner margin between this group of small Australasian forms and European species of Microcytherura s.s.. The former have broadly rounded posterior inner margins, whilst the latter have acutely rounded posterior inner margins. The latter also usually possess posterior extremities located well below midpoint carapace height. It is here argued that this difference in inner margin shape between smaller Australasian species such as Microcytherura? peterroyi, and European species of Microcytherura s.s., suggests that there is not a direct phylogenetic relationship between these two species groups.

Key words: Ostracoda, Loxocythere (Loxocythere) ouyenensis, Microcytherura, Hemiparvcythe, Cenozoic,

Australia, New Zealand.

A VARIETY of species groups attributed to the genera Loxocythere Hornibrook, 1952 or Microcytherura Müller, 1894 have existed in Australasian marine waters throughout the Cenozoic and into the modern day. Previously, larger species have generally been assigned to the genus Loxocythere and smaller species to the genus Microcytherura (see also discussion in Warne, 2004). This paper will firstly describe the various species groups of the genus / subgenus Loxocythere (Loxocythere). Secondly, the phylogenetic relationship between some elongate Loxocythere (Loxocythere) species and some similarly shaped but smaller Australasian species, variously attributed to the genera Microcytherura and Hemiparvcythe Hartmann, 1982, will be discussed. Thirdly, the type material of species Loxocythere (Loxocythere) ouyenensis (Chapman, 1914) will be reviewed. Specimens illustrated herein are housed in Museum Victoria and have the registration numbers, P12529, P122297, P311646 - P311652.

COMPARATIVE MORPHOLOGY

Loxocythere (Loxocythere) Hornibrook, 1952

There are three types or groups of species here recognised under the genus / subgenus Loxocythere (Loxocythere). The first, is the Loxocythere type species L. (L.) crassa Hornibrook, 1952, which has a thick shell, rugose reticulate ornament, subquadrate shaped inner margin and posterior extremity below mid height. The second group, which includes L. (L.) kingi Hornibrook, 1952 and L. (L.) variasculpta

257
Whatley et al., 1997, have subdued ornament, relatively elongate subrectangular carapaces/inner margins, and acutely rounded posterior outlines with valve posterior extremities well below mid height. The third group includes the species L. (L.) hornibrooki McKenzie, 1967, L. (L.) ouyensis Chapman, 1914, L. (L.) inflata Hanai, 1959 and L. (L.) sp. (this study), which also have relatively elongate subrectangular carapaces and inner margin outlines, but differ from other groups of Loxocystherae (Loxocysthera) species by possessing broadly rounded posterior extremities. This group of species is transitional in carapace morphology between Loxocystherae (L.) crassa and species of the genus Cytherea O. F. Müller, 1785 (see Hanai, 1959, p. 414-415; plate 28).

Thus, Loxocysthera (Loxocystherae) species in groups two and three can be distinguished from L. (L.) crassa by possessing relatively elongate carapaces. Further, Loxocysthera (Loxocystherae) species in groups two and three can be distinguished from each other by differences in the shape of the posterior inner margin. These species groups are not designated as separate subgenera because the carapace shape differences that are used here to delineate species groups are rather gradual in nature. Species of *Loxocysthera* (Novolasocysthera) Warne, 2004 can be clearly distinguished from Loxocysthera (Loxocystherae) spp. as the former possesses posterior extremities well above mid height (i.e. adjacent to the dorsal margin).

The species L. (L.) crassa is only known from the New Zealand region. Species in Loxocysthera (Loxocystherae) group two have been variously recorded from shallow marine waters or sedimentary facies of the New Zealand and Antarctic regions, and from the south-west Atlantic continental shelf. Species in Loxocysthera (Loxocystherae) group three are known from the western Pacific region, current records being from coastal Australasia and Japan.

Microcythera G. W. Müller, 1894

The genus *Microcythera* was originally established to accommodate European ostracod specimens with *Microcythera nigrescens* G. W. Müller, 1894 being designated as the type species. A distinctive carapace characteristic of this species and other European species of *Microcythera* such as *M. fulva* (Brady and Robertson, 1874) and *M. angulosa* (Seguenza 1880), is a strong oblique dorsal truncation of the posterior margin (see fig 2 A-D). These delicately ornamented species possess posterior extremities near or below mid carapace height and possess an acutely rounded and elongated posterior margin with a relatively small angle between a short posteriorvalentral margin and longer posterodorsal margin. Species with this type of posterior carapace shape and delicate carapace surface ornament occur in European and nearby seas, and can be considered as one distinctive group within the genus Microcythera. One Australian species, *Microcythera sulcata* Yassini and Jones, 1995, is similar in general shape to European *Microcythera* spp., although differs by possessing a strongly ornamented carapace. In general shape and ornament *M. sulcata* resembles various west African species such as *Microcythera reticulata* Hartmann, 1974 and *Microcythera ornata* Jellinek, 1993. These three Australian / west African species make up a second, very distinctive group of species, within the genus Microcythera. On the basis of similarities in carapace shape (in particular the presence of acutely rounded posteriors) these two *Microcythera* species groups as outlined above are here considered to have a close phylogenetic relationship.

Within Australian shallow marine environments there is a diversity of cytherid "species groups" that have been attributed to the genus *Microcythera*. Aside from *M. sulcata*, few of the species in these groups
have posterior carapace or inner margin shapes akin to those of European (or west African) Microcytherura species. One of these species groups, which includes the species Microcytherura? peterroyi Yassini and Jones, 1995, Microcytherura? aestuarica Hartmann, 1980, Microcytherura? triebel McKenzie, 1967 and Microcytherura? sp. (this study, Figs. 13-0), possess broadly rounded posterior with posterior extremities around (or slightly above / below) mid height. These posterior carapace shape characteristics are in contrast to those of European Microcytherura species, but are very similar to the posterior outlines of some (larger) species belonging to the genus Loxocythere (Loxocythere) such as L. (L.) ouyenensis (see Plates 1 & 2). It is here argued that the difference in inner margin shape between this group of Australasian “Microcytherura” species (with broadly rounded posterior margins), and species of Microcytherura s.s. (i.e. European forms), suggests that there is not a direct phylogenetic relationship between these two species groups. Australasian species, such as Microcytherura? peterroyi, are herein thought to have evolved from ancestral stock allied to elongate Loxocythere (Loxocythere) species such as L. (L.) ouyenensis and as a result, considered examples of evolutionary modifications related to changes in carapace size. As a consequence, the genus Microcytherura, as it is generally and broadly applied to both European and Australian ostracod faunas, appears to be a polyphyletic taxon. However, if only applied to the European species (i.e. M. nigroceps, M. fulva and M. angulosa), as well as perhaps Australian and west African species such as M. sulcata, this genus may represent a monophyletic cluster of species. The latter taxonomic framework is here considered preferable, although a full taxonomic review of Australian “Microcytherura” species is beyond the scope of this paper.

As illustrated here, particularly significant morphological similarities occur between juvenile valves of Loxocythere (Loxocythere) ouyenensis (i.e. Figs. 13 F - I) and adult specimens of the Australian taxon Microcytherura? sp. (Figs. 13 J - O), although the latter tend to have slightly lower and less conspicuously caudate posterior extremities (just below mid-height). This observation suggests that paedomorphic processes, initially operating in Loxocythere “ancestral stock”, may have contributed to the radiation and diversification of some smaller Australian Cenozoic groups of so-called Microcytherura species.

Hemiparacythere Hartmann, 1980
Some very small Australasian species belonging to the family Parvocythereidae Hartmann, 1959 (for example Hemiparacythere lagunica Hartmann, 1982), are also similar in carapace morphology to larger Australian Cenozoic Loxocythere (Loxocythere) species, although there are marked differences in the soft part anatomy. In the Parvocythereidae, there is a reduction from three walking appendages (maxilla and two thoracic legs) to

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**Fig. 2.** *Microcytherura angulosa* (Seguenza, 1880) Specimens are from the seabed of the Adriatic Sea, Recent. A. Left valve, male, external view, P311650, x 100. B. Left valve, male, internal view, P311650, x 100. C. Right valve, female, internal view, P311651, x 100. D. Right valve, female, external view, P311651, x 100.
only two (maxilla and one thoracic leg) reflecting adaptation to an interstitial environment (Hartmann and Puri, 1974). Despite this substantial difference in soft part anatomy, Hartmann and Puri (1974) commented that there is a close phylogenetic relationship between the Cytheridae Baird, 1850 and Paracytheridae, the latter probably being derived from the former. The implication from this analysis by Hartmann and Puri (1974) is that close phylogenetic relationships are not always completely reflected in soft part anatomy, but rather may be more obvious in morphologically conservative carapace characters.

SYSTEMATIC PALAEONTOLOGY

Subclass Ostracoda Latreille, 1806
Order Podocopida G.W. Müller, 1894
Suborder Podocopina Sars, 1866
Superfamily Cytheracea Baird, 1850
Family Cytheridae Baird, 1850
Subfamily Cytherinæ Baird, 1850

Remarks: Most authors place the genus Microcythereina s.s. (European species') within the Cytheridae Baird (i.e. Jeffreys, 1993), although as discussed by van Morkhoven, 1963, there is good evidence for the genus being placed within the Cytheridiæ Müller, 1894. The latter view brings into question the often assumed close taxonomic relationship between Loxocythere and Microcythereina (i.e. Howe and McKenzie, 1989; Hartmann, 1982; McKenzie et. al., 1993; Yassini and Jones, 1995). This controversy is not here resolved. However it is the view of the present author that European species of Microcythereina are congeneric with the most robustly ornamented west African species M. reticulata and M. ornata, and one Australian species, M. salcata. Members of this ornate group of Microcythereina species, and the European species Microcythereina angulosa. (Seguenza, 1880) bear a close resemblance in inner margin outline to the New Zealand species Loxocythere (Loxocythere) kingi. All these species have a relatively elongated carapace posterior that is acutely rounded, the externity of which is positioned adjacent to, or near, the ventral margin. This observation suggests that a common family level taxonomic association is warranted for the genera Microcythereina and Loxocythere.

Whilst most Cytheriidae species possess a relatively simple merodont (hemimerodont or antimerodont) hinge, some species such as Loxocythere (L.) crassa Hornbrook, 1952 have pentodont – like terminal thickenings of the medium hinge element (pentodont hinge sensu Warne, 1996; see Hartmann 1982, Pl. 1, figs. 7 & 8). A pseudopentodont hinge is also apparent in the species Microcythereina angulosa (Figs. 2B and 2C herein; see also Bonaduce et. al., 1975, Pl. 46, figs 4-6). However, for these two species, this medium hinge feature is associated with typically crenulated or lobed, and overall subrectangular shaped cytherine posterior hinge elements, and not with the generally smooth, rounded or arched posterior hinge elements characteristic of the true pentodont hinges; the latter as usually found in leptoxytherid species belonging to the subfamily Pectocytherinae Hanai, 1957. Similarly, the paracytherid Hemiparacythere lagunensis Hartmann, 1982 also displays terminal thickening of the medium hinge element (Hartmann, 1982, Plate 5, figures, 4 & 5).

Genus Loxocythere Hornbrook, 1952
Subgenus Loxocythere Hornbrook, 1952

Type species, Loxocythere crassa Hornbrook, 1952

Remarks: Prior to the present study, a number of taxonomic schemes had been proposed for the genera Microcythereina Müller, 1894, Tetracythereina Ruggieri, 1952 and Loxocythere Hornbrook, 1952. Ruggieri (1959) and Hanai (1957) regarded Tetracythereina [type species = M. angulosa (Seguenza, 1880)] as a junior synonym of Loxocythere while van Morkhoven (1963) and Hartmann (1979) regarded Tetracythereina as a junior synonym of

Fig. 3 Loxocythere (Loxocythere) ouyensis Chapman, 1914; line drawing, left valve, juvenile, females?, internal view, P122297, from Koo-nee-nup 14 (87–113 m), early Middle Miocene, x 150.
Microcytherura. McKenzie (1967) and Bonaduce et al. (1975) maintained it as a separate genus. Whilst the type species of the genus *Tetracytherura* is much less elongate than the type species of *Microcytherura*, it is here considered that this morphology difference is insufficient in extent to recognise two separate genera. Hartmann (1980) considered *Loxocephera* a subgenus of *Microcytherura*, with *Microcytherura* (*Microcytherura*) being smaller and possessing only one type of normal pore canal, and *Microcytherura* (*Loxocephera*) being relatively large and possessing three types of normal pore canal. However, given the problematic family level taxonomic relationship between *Microcytherura* and *Loxocephera* (see above discussion) it would seem appropriate for the present to regard both as discrete genera. Some European loxoconchid species, such as *Elphosina baltica* (Hirschmann), are convergent in carapace morphology: towards some elongate *Loxocephera* species, although the former are generally thin shelled and less ventrally inflated.

**Loxocephera (Loxocephera) ouyenensis**

*(Chapman, 1914)*

Figs. 1A-C, F-l; 3.

1914 *Cytherura ouyenensis* Chapman, p. 44-45, pl.8, figs. 35a,b
1916 *Cytherura ouyenensis* Chapman, p. 379, pl. 74, figs. 35a & b
1987 *Loxocephera* sp.6 Warne, p.441.

**Holotype:** Adult, right valve, P12529.

**Type Locality:** Mallee Bore 11 at 267 -270 feet (see Chapman 1914 for further details).

**Material.** The type specimen is from subsurface mid Cenozoic marls of the Murray Basin, Victoria, Australia (Fig. 1A-C). Additional, mostly juvenile specimens examined for this study come from mid Miocene and Late Miocene shallow marine sand facies of the Port Phillip and Western Port Basins (Figs. 1F-1;3). Details of localities in the Port Phillip Basin and the Western Port Basin that are listed in the figure captions can be found in Warne, 1993 and 2002.

**Additional description:** The following comments are modifications or expansions of descriptive comments provided by Chapman, 1914 (p. 44 - 45). Carapace large, elongate, subrectangular and thick shelled with a faint, reticulate ornament (varies in strength between specimens). Carapace with posterolateral inflation that slightly overhangs the posterolateral margin. Posterior extremity of RV at about mid-height and slightly caudate; anterior extremity slightly below mid height. In RV maximum height anterior of mid length. Adductor muscle scar pattern consisting of a vertical row of four individual oblong scars. Inner margin well calcified in both adult and juvenile specimens. Normal pore canals numerous and very large, particularly as viewed from an internal perspective. Hinge is merodont with a smooth median element and laterally elongate and strongly crenulated terminal hinge elements.

**Dimensions:** Holotype, right valve, adult, P12529, length = 0.55 mm, height = 0.29 mm

**Remarks:** The dimensions of the holotype of *Loxocephera (Loxocephera) ouyenensis* recorded here are less than those recorded by Chapman, 1914. The Pleistocene S.E. Australian species *Loxocephera (L.) postlateralbulla* McKenzie, et al. 1990 differs from *L.(L.) ouyenensis* only by possessing a slightly more inflated posterolateral margin; the former being a closely related descendant, or junior synonym of the latter. The latest Miocene S.E. Australian species *Loxocephera (Loxocephera)* sp. (Fig. 1D - E) differs by possessing a smooth carapace (except for very faint reticulation in posterior third of carapace) and a greater height to length ratio.

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