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DESCRIPTION OF LOXOCYHERE (NOVOLOXOCYHERE) PELIUS SUBGEN. ET SP. NOV. (OSTRACODA) FROM THE CENOZOIC OF S.E. AUSTRALIA WITH COMMENTS ON SPECIES OF ANTARCTILOXOCONCHA HARTMANN, 1986 AND LOXORETICULATUM BENSON, 1964 FROM AUSTRALIAN AND ANTARCTIC MARINE WATERS

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Loxocythere (Novoloxocythere) pelius subgen. et sp. nov. is described from Upper Miocene strata of the Port Phillip and Western Port Basins, Victoria. It has its acme in shallow open marine facies of latest Miocene (Cheltenhamian) age. This species, along with Loxocythere (Novoloxocythere) kerryswansonii Yassin and Jones, 1995, forms a discrete group of rotund Australian Loxocythere species that possess posterior extremities in both valves that are positioned well above mid carapace height (i.e. adjacent to dorsal margin). This feature along with a sub-triangular inner margin outline, defines a carapace shape that is distinct from that of rotund species of Loxocythere (loxocythere) Hornbrook, 1952 and Antarctiloxoconcha Hartmann, 1986. The type species of Antarctiloxoconcha - A. frigida (Neal, 1967), possesses internal carapace features that are very similar to the type species of Loxocythere - L. crassa Hornbrook, 1952. Both have relatively short carapaces and sub-quadrate inner margin outlines with posterior extremities in both valves positioned below mid carapace height. Species of Loxocythere (Novoloxocythere), in particular L. (N.) kerryswansonii, have a carapace shape that is transitional between Loxocythere and Loxoreticulatum Benson, 1964. Species of Loxoreticulatum generally possess a sub-parallel gram shaped carapace / inner margin and arched median hinge element. The latter feature is distinct from the mostly straight median hinge elements of Loxocythere (Loxocythere) and Loxocythere (Novoloxocythere) species. Species of Loxocythere (Novoloxocythere) are also readily distinguishable from relatively elongate species of Loxocythere, such as L. (L.) hornbrooki McKenzie, 1967, as the latter possess long (for genus), sub-rectangular shaped carapaces / inner margin outlines and posterior extremities below mid height.

Key words: Ostracoda, Loxocythere (Novoloxocythere) pelius, Antarctiloxoconcha, Loxoreticulatum, Cenozoic, Australia, Antarctica

THE OSTRACOD genus Loxocythere Hornbrook, 1952 includes a number of different, morphologically discrete, species groups. Differentiation of these Loxocythere species groups can be achieved by analysis of overall carapace shape characteristics and valve inner margins outlines. The main aims of this paper are to describe one new species of Loxocythere present in Upper Miocene strata of S.E. Australia and to outline the carapace attributes of different Loxocythere species groups, one of which is here designated as a new subgenus. The genera Antarctiloxoconcha Hartmann, 1986 and Loxoreticulatum Benson, 1964 are here also considered as species belonging to these two genera possess carapace characteristics that are very similar to those of some Loxocythere species.

The specimens of Loxocythere (Novoloxocythere) pelius subgen. et sp. nov. illustrated herein (Figs. 1 & 2) were collected from a sedimentary unit referred to as the Warneet Sands by Warne 1987, 1993. This formation occurs subsurface over a restricted geographical extent near the township of Warneet in the northwest of the Western Port Basin, S.E. Australia. The specific sediment sample from which the figured specimens were extracted was a calcareous and ferruginous sand of shallow marine origin occurring.

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in the Geological Survey of Victoria borehole Sherwood 18 (38° 12' S, 145°16'E) between the intervals of 20m and 22m. The unit is probably latest Miocene being broadly equivalent in age to the basal "nodule bed" horizon of the Sandringham Sand in the Port Phillip Basin (Jenkins, 1962; Warne, 2002). The "Warneet Sands" disconformably overlie the Miocene Sherwood Formation of the Western Port Basin, and underlying Pliocene (?) non-marine sediments termed the Warneet Beds by Jenkins, 1962. It is here thought that the "Warneet Sands" / Warneet Beds succession of the Western Port Basin is similar to the Black Rock Sandstone / Red Bluff Sand (= Sandringham Sand) succession of the eastern Port Phillip Basin. *Loxocythe (Novoloxocythe) pelius* is quite common in both the basal units of these two successions and might be described as having its aecine in S.E. Australia during the early Cheltenhamian (see figure 3 in Warne 2002). Figured specimens of *L. (N.) pelius* are housed in Museum Victoria under the registration numbers P122290 - P122293, P122295, P311645. Other specimens figured herein have the Museum Victoria registration numbers P311653, P312080, P312081.

**COMPARATIVE MORPHOLOGY**

In practice, and up until the present time, larger Australasian adult specimens belonging to the broad *Loxocythe (Loxocythe)* Hornibrook, 1952

The *Loxocythe* type species *L. crassa* Hornibrook, 1952 is in part distinguished by its thick shell, rugose reticulate ornament, subquadrate shaped inner margin and posterior extremity below mid height. This particular combination of characters is seen in no other currently known species of *Loxocythe*. Other species here placed in *Loxocythe* (*Loxocythe*) fall into two morphological groups based on carapace features. The first group includes species such as *L. kingi* Hornibrook, 1952 and *Loxocythe variasculpta* Whatley et al., 1997, which have relatively elongate subrectangular carapaces and inner margins, and acutely rounded posterior outlines with valve posterior extremities well below mid height (i.e. *L. kingi*, Fig 3 A-B). The second group includes species such as *L. hornibrooki* McKenzie, 1967, *L. ouyenensis* (Chapman, 1914) and *L. inflata* Hanai, 1959, which also have relatively elongate subrectangular carapace and inner margin outlines, but differ from other groups of *Loxocythe (Loxocythe)* species by possessing broadly rounded posterior extremities. Further discussion of this latter group of *Loxocythe* species is included in Warne (2004).

*Loxocythe (Novoloxocythe) subgen. nov.*

The known species within this subgenus are *Loxocythe (Novoloxocythe) pelius* sp. nov. and *Loxocythe (Novoloxocythe) pelius* sp. nov. These species are distinguished by their thick shells, rugose reticulate ornament, subquadrate shaped inner margin and posterior extremity below mid height.
Loxocythere (Novoloxocythere) kerryswansoni
Yassini and Jones, 1995. These species are distinguished by their subtriangular shaped inner margin and posterior extremity well above mid-height. This subgenus includes species (in particular *L. (N.) kerryswansoni*) that are transitional or convergent in morphology (carapace shape) towards *Loxocricula*um. *L. (N.) kerryswansoni* is known from shallow marine waters of south-east and north-east Australia. *L. (N.) pelias* is only known from fossil material. Current records indicate that this species inhabited Mio-Pliocene shallow marine environments of S.E. Australia.

Antarcticiloxoconcha Hartmann, 1986

Hartmann, 1986 regarded the type species as belonging to the Loxoconchidae Sars while Neil, 2000 originally regarded the species *Antarcticiloxoconcha? phaseolus* as belonging to the family Eucycleroidea Puri. Whatley et al., 1998 considered that the species *Antarcticiloxoconcha frigida* to be a cytherurid placing it (with reservation) in the genus *Cytheropteron* Sars, and interestingly noted a possible affinity with the genus *Peleocythere* Athersuch. Despite these diverse views, the interior margin shape, adductor muscle scars, and to a lesser extent, terminal hinge elements of the *Antarcticiloxoconcha* type species *A. frigida* (see illustrations in Hartmann, 1989; plate 8, figs. 6 and 7), are very similar to the *Loxocythere* type species *L. crassa* (see Fig. 3C of this paper and Hartmann, 1982; plate 1, figs. 5 and 6). Hartmann, 1986 indicated that the soft part anatomy of the type species of *Antarcticiloxoconcha* is consistent with the placement of this species in the Loxoconchidae. However, as noted by Athersuch and Horne, 1984, there is variance in opinions concerning the diagnosis of the family Loxoconchidae. As a consequence, and
in spite of its name, the genus *Antarctiloxoconcha* it is here considered to have a close morphological relationship to some genera of the family Cytheridae Baird. This broadly agrees with the original placement of *A. frigida* by Neale (1967) in the genus *Laxocythere*. Compared to the *Laxocythere* type species (*L. crassa* - Fig. 3 C-D), species of *Antarctiloxoconcha* are more rounded in external shape, have more subdued external ornament and possess a strongly crenulated and slightly arched medium hinge element (see Hartmann, 1989; plate 8, figs 4-7). Species here included in *Antarctiloxoconcha* have or had a Southern Ocean (coastal Antarctica & southern Australia) or south-west Atlantic Ocean (continental shelf) distribution.

*Loxoreticulatum* Benson, 1964

This genus is distinguished by its sub-parallelgram shaped carapace and inner margin, lack of a strongly inflated venter and arched median hinge element. This combination of features is best developed in the type species *Laxoreticulatum fallax* G. W. Müller, 1908. Other species such as *Laxoreticulatum kempheli* Hartmann, 1987 possess a more sub-rectangular rather than sub-parallelgram shaped carapace, a *Laxocythere*-like inflated venter, a *Laxocythere*-like shaped inner margin and nearly straight median hinge elements. With respect to these carapace features, *Laxoreticulatum kempheli* is transitional towards species such as *Laxocythere* (*Novolaxocythere*) *kerryswansoni*. Since the taxon *Laxoreticulatum* includes forms that are transitional in carapace morphology towards some species of *Laxocythere*, it is here suggested that a relatively close taxonomic relationship exists between *Laxoreticulatum* and *Laxocythere*. This is despite the fact that G. W. Müller, 1908 (see Benson, 1964) noted that the soft part anatomy of *Laxoreticulatum* was *Cytheropetron*-like in character (see also Hartmann, 1987). Perhaps significantly, unlike the vast majority of species belonging to *Cytheropetron*, species of *Laxoreticulatum* lack a distinctly acute ventral region. Species of *Laxoreticulatum* have been recorded from shallow marine waters of coastal Antarctica and the south-west Atlantic region.

ORDER PODOPOPOIDIDA G.W. MÜLLER, 1894

SUBORDER PODOPOPOINA SARS, 1866

SUPERFAMILY CYTHERACEA BAIRD, 1850

FAMILY CYTHERIDAE BAIRD, 1850

SUBFAMILY CYTHERINAE BAIRD, 1850

**Genus Loxocythere** Hornibrook, 1952

**Subgenus Novolaxocythere** subgen.nov.

Type species, *Laxocythere* (*Novolaxocythere*) *pelius* subgen. et sp. nov.

**Etymology**: *Novo* (= new) added as a prefix to *Laxocythere*. A reference to this being a new group of *Laxocythere* species.

**Diagnosis**: A group of *Laxocythere* species with very distinct sub-triangular shaped inner margins and posterior extremities well above mid height. Other features as for *Laxocythere* s.s.

**Remarks**: *Laxocythere* (*Laxocythere*) and *Antarctiloxoconcha* differ from this new subgenus in having subquadrate to sub-rectangular shaped inner margins and posterior extremities below mid height. *Laxoreticulatum* differs from *Laxocythere* (*Novolaxocythere*) in that the former has a sub-parallelgram shaped inner margin and gently arched median hinge element. The sub-rectangular shaped inner margin in species of *Laxocythere* (*Novolaxocythere*) is developed because of the presence of a very much shorter posterior dorsal slope than occurs in *Laxocythere* s.s. Two named species are currently recognised as belonging to this subgenus; *Laxocythere* (*Novolaxocythere*) *pelius* sp.nov. and *Laxocythere* (*Novolaxocythere*) *kerryswansoni* Yassini and Jones, 1995. Whilst *Laxocythere* (*Novolaxocythere*) *kerryswansoni* has an inner margin shape that is transitional towards that of some species of *Laxoreticulatum*, it lacks the arched median hinge element characteristic of *Laxoreticulatum* species.

*Cytherurid species such as Cytheropetron? infrequens* Mostafawi, 1992, *Oculocytheropetron macropunctatum* Whatley et al., 1988, *Oculocytheropetron micropunctatum* Whatley et al., 1988 and *Oculocytheropetron reticulopunctatum* Whatley et al., 1988, are also very similar in carapace shape to *L. (N.) kerryswansoni*, although can be distinguished by their arched (to varying degrees) LV dorsal margins and medium hinge elements, lower posterior extremities and distinctive (although sub-
dual) Cytheropteron-like alate extensions. The close similarity in shape between L. (N.) kerryswansoni and species such as Cytheropteron? infaebus, is here considered to reflect convergent evolution in carapace morphology.

One other taxon, the cytheropterine Heinzmatzia rhombiformis (Chen) sensu Mostafawi, 1992 is superficially similar in external morphology to the type species of Loxocythere (Novoloxocythere) - L. (N.) pelius. However, H. rhombiformis has a very characteristic Cytheropteron-like alate extension (see Whatley and Zhao, 1987; plate 4, figs 21-22), which differs in shape from the more posterior and rounded ventral inflation of L. (N.) pelius. The genus Heinzmatzia Mostafawi, 1992 appears to have a close taxonomic affinity to the genus Eocytheropteron Alexander. Species of both these genera probably have discrete phylogenetic histories from species of the subgenus Loxocythere (Novoloxocythere).

The type species of Loxocythere (Novoloxocythere) - L. (N.) pelius has a very similar subtrangular shaped inner margin to the Australian Cretaceous progonyctherid species Majungaella annua Bate, 1972, Majungaella verseyi Neale, 1975, Majungaella queenslandensis Krömmllein, 1975, Majungaella ticka (Krömmllein, 1975) and Majungaella schelberaeae (Krömmllein, 1975) although these progonyctherids differ from L. (N.) pelius in internal view by having far more pronounced terminal hinge elements. A similar comparison can also be made between L. (N.) pelius and the African Cretaceous species Majungaella nematis Grekoff (sensu Dingle, 1984). However, in external view, Australian and African Majungaella species differ significantly from L. (N.) pelius by possessing a circular reticulate ornament and strongly compressed anterior margins.

Loxocythere (Novoloxocythere) pileus sp. nov.

Fig. 1 A-H; Fig. 2.

1987 Loxocythere sp. 4 Warne, p. 441

Holotype: Adult, right valve, female, P122293.

Type Locality: Warneet Sands (sensu Warne, 1987) in the Geological Survey of Victoria borehole Sherwood 18 between the intervals 20m and 22m, 30°12', 145°16'E.

Etymology: Pileus (Latin) - cap or hat. A reference to this species being shaped like a cap.

Material. Twenty-five mostly disarticulated adult and juvenile valves from the mid Miocene Sherwood Formation, and latest Miocene and/or Early Pliocene Sandringham Sand (basal Black Rock Sandstone), Moorabool Viaduct Formation and Warneet Sands of south-central Victoria. All type specimens, including those illustrated here, are from the Warneet Sands (sensu Warne, 1987, 1993).

Diagnosis: A large, heavily reticulate species with large fossae and two to three submarginal ridges parallel to the anterior, ventral and posteroventral margins. Inner margin has a sub-triangular shape and posterodorsal margin is relatively short for genus.

Description: Carapace large (for genus), subtrangular and very thick shellied with coarsely reticulate ornament including large fossae and two to three submarginal ridges parallel to the anterior, ventral and posteroventral margins. There is some variability in the degree of ridge development between adult specimens. Ventrally, the carapace is strongly inflated. From an internal perspective the outer margin is subtrangular. Left valve larger than right valve and overlapping it. Unlike some Loxocythere species (i.e. Loxocythere (L.) crassa), the right valve does not protrude beyond the extremity of the left valve in the posterior. Left valve with broadly asymmetrically rounded anterior; convex anterodorsal and anteroventral slopes; extremity below mid-height. Posteriorly, left valve is acutely rounded (from an internal perspective) with short convex posterodorsal slope, curving down to meet the posteroventral and ventral margin in a smooth arc. Externally, the posterior margin is obscured by the posterior protruding ventral inflation. Left valve posterior extremity well above mid-height. Left valve dorsal margin straight to slightly convex. Right valve similar to left valve except dorsal margin is more strongly arched with a slightly longer posterodorsal margin and the extremity occurring just above mid-height. Maximum length slightly above mid-height; maximum height anterior of mid length; maximum width distinctly ventral and posterior of mid-length. Normal pore canals are sieve-type with some variability in size. Inner lamellae medium sized with small vestibula; marginal pore canals straight and scattered; broader at base. Hinge merodont with a smooth left valve hinge bar. Anterior and posterior right valve terminal teeth consist of three small lobes.
that lock into three sockets in the left valve. Adductors consisting of a vertical row of four elliptical scars. Frontal scar irregularly rounded. Sexual dimorphism evident in adults and late stage juveniles with males having a narrower posterior in lateral view than females.

**Dimensions.** Holotype, right valve, female, P122293, length = 0.53mm, height = 0.32mm, Paratype, left valve, male, P311645, length = 0.53mm, height = 0.31mm, Paratype, left valve, male, P122292, length = 0.52mm, height = 0.32mm, Paratype, left valve, juvenile female?, P122290, length = 0.51mm, height = 0.31mm, Paratype, right valve, juvenile female?, P122291, length = 0.50mm, height = 0.31mm, Paratype, right valve, juvenile female?, P122295, length = 0.50mm, height = 0.29mm.

**Remarks.** This species has a distinctly different shape to *Loxoxythere (L.) crassa* Hornibrook, 1952, the only other very heavily ornamented species of this genus. Aside from possessing coarser ornament *L. (N.) pelius* differs from *L. (N.) kerryambwuni* in lacking a strongly concave mid ventral inner margin and a strongly upturned LV caudal process. The posterior inner lamella in *L. (N.) pelius* is much narrower than found in species of *Eucytherura* Möller, 1894. *L. (N.) pelius* is superficially similar in shape to some loxoconchid species such as *Laxoconcha variolata* Brady, although the former differs from the latter by possessing a greatly inflated posteroventral region and in lacking any semblance of a gongylodont hinge (even though thick shielded). The known age and lithostratigraphical range of *L. (N.) pelius* currently extends from mid Miocene sandy facies of the Sherwood Formation (Western Port Basin, Victoria) to the latest Miocene and/or Early Pliocene sandy facies of the Black Rock Sandstone, Moorabool Viaduct Formation (Port Phillip Basin) and Warneet Sands (Western Port Basin).

**ACKNOWLEDGEMENTS**

I acknowledge discussions on the genus *Loxoxythere* with the late K. G. McKenzie. Financial support and facilities provided by Deakin University enabled the completion of the research presented in this paper. The Recent New Zealand specimens illustrated here were originally collected by N. de B. Hornibrook and were passed onto me by K.G. McKenzie. The Auckland Museum is thanked for a loan of the type specimens of *L. kingi*. Reviewers of this manuscript are thanked for their detailed and constructive comments.

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Manuscript received 12 January 2004
Manuscript accepted 5 November 2004