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ENVIRONMENTAL INTERPRETATIONS OF LATE PLEISTOCENE OSTRACODE ASSEMBLAGES FROM THE RICHMOND RIVER VALLEY, NEW SOUTH WALES

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Abstract: Ostracode assemblages from Evans Head and shallow bores in and near Lismore, N.S.W., are identified and counted. Five species and one subspecies are described as new, namely: *Cytherella loukornickeri*, *Cytherella lismorensis*, *Oculocytheropteron raybatei*, *Keijella jankeiji*, *Paradoxostoma evansheadensis* and *Tanella gracilis minor*.

Environmental interpretations based on these ostracode assemblages indicate two main facies types: one more exposed, open marine (Evans Head); the other representing the environments of a relatively protected bay with an immediate hinterland of generally low relief. Possibly, aquatic temperatures were rather warmer (up to 20°C) than at present in the region, when the sequences were deposited.

The assemblages offer conclusive proof that the sediments of the Gundurimba Clay, in which they occur, were deposited during a period when the embayment was entirely open to access of marine water, and that the Inner Barrier Beach ridges were deposited later. Models for emplacement of beach ridges must take account of this fact.

Pleistocene deposits in the Richmond River valley have been the focus of a number of investigations in recent years (Marshall & Thom 1976, Pickett 1981, Drury & Roman 1983), with the result that the Pleistocene and Recent sediments of this valley are becoming better known than those of most other valleys on the coast. This has been due in large part to a systematic hydrogeological study of the area undertaken by the N.S.W. Water Resources Commission. The stratigraphical results of this programme are summarised by Drury & Roman (1983) and Drury (in press).

The work of Marshall & Thom (1976) supplied the first reliable age determinations for any sediments associated with the Inner Barrier, and was thus of considerable significance in calibrating events in the evolutionary development of coastal landforms in northern N.S.W. Using a comparison with present-day distributions, Pickett (1981) was able to document a climatic shift for the period since 120 000 yr B.P. towards a cooler regime equivalent to a minimum of 2° of latitude, on the basis of an assemblage of scleractinian corals from the locality dated by Marshall & Thom (1976). Pickett (1981, p. 72) also anticipated an age for the widespread estuarine sediments of the valley upstream of Coraki similar to that of the coral locality described by him, although direct evidence was lacking at that time. The isotope ages of Drury & Roman (1983) have borne out this correlation, the ages from corals in particular (124 000 yr, 128 000 yr) occurring close to the range of determinations on corals from the Evans Head coral site (112 000 to 127 000 yr) (Marshall & Thom 1976).

LITHOSTRATIGRAPHY

In the Pleistocene succession of the Richmond River valley the most significant stratigraphic unit and the most widespread is the Gundurimba Clay (Drury & Roman 1983), which occurs from Boatharbour, upstream of Lismore, and from a point 4 km east of Casino, eastwards beyond the present coastline (Drury & Roman 1983, fig. 3, Drury in press). Its base is everywhere unconformable. The unit rests on bedrock or on the South Casino Gravel in the area west of Coraki; to the east it overlies in addition either the Buckendoon Sand Member or the Doonbah Clay. In the west it is overlain by deltaic (?) sediments of the Greenridge Formation, in the central area by floodplain deposits and along the coast by the Woodburn Sand (the Inner Barrier). It is a dark, plastic clay, frequently containing marine invertebrates. The thickness varies greatly, reaching a maximum of 39.6 m in WRC 39140 (South Gundurimba), but only 8 m in WRC 39101 (Greenridge), 11 m in WRC 39135 (Boatharbour) and just 4.7 m in WRC 39152 (Evans Head). At the Evans Head coral locality it is only 2 m thick, though the top is eroded.

All the samples examined in the present article come from the Gundurimba Clay. The top of this unit lies at ca. +5 m AHD in WRC 39138 (Tuncester), ca. +4 m AHD in WRC 39140 (South Gundurimba), ca. −14 m in WRC 39149 (Tuckean Island) and −30 m in WRC 39152; hence the top of the unit lies at a progressively lower level towards the open ocean (data from Drury in press). Drury & Roman (1983) have indicated the contemporaneity of the coral locality and the Gundurimba Clay. We regard the coral locality as a shallow water deposit equivalent to the muds at deeper levels, as does Drury (pers. comm., Drury & Roman 1983, fig. 3). The coral-bearing strata (locality 18, Fig. 1) lie at approximately zero to −2 m AHD, and thus are considerably separated in depth (30 m) from the nearest known occurrence of true clays of the Gundurimba Clay (from −29.74 to −34.44 m in borehole WRC 39152, locality 10, Fig. 1), and are referred to the same formation. The

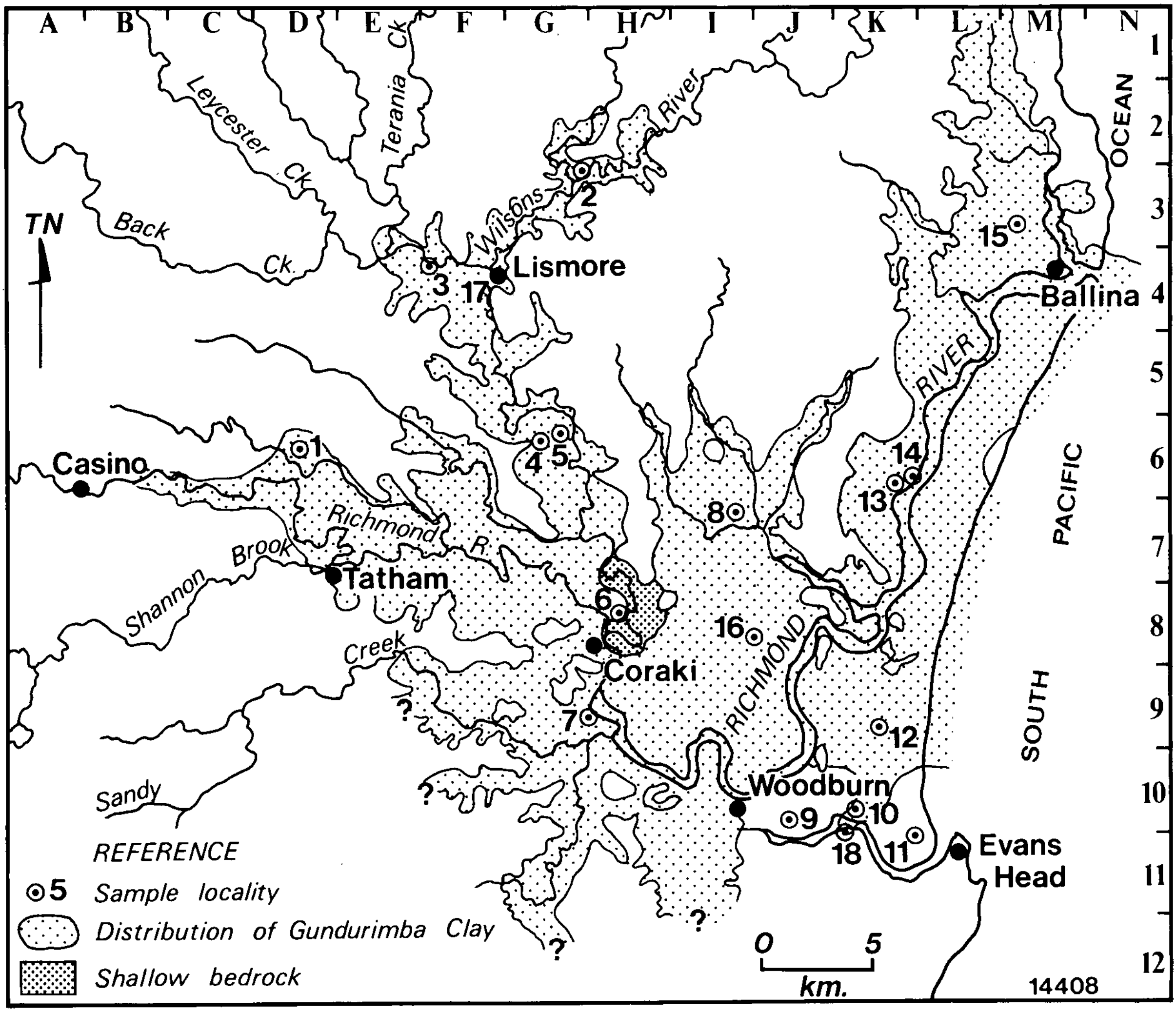


Fig. 1—Map of the lower Richmond River valley, showing location of samples discussed in the text and distribution of the Late Pleistocene Gundurimba Clay. Grid references to the numbered localities are given in brackets. 1, WRC 39101 Greenridge (D6). 2, WRC 39135 Boatharbour (G2/3). 3, WRC 39138 Tuncester (F4). 4, WRC 39139 South Gundurimba (G6). 5, WRC 39140 South Gundurimba (G6). 6, WRC 39143 Coraki (H8). 7, WRC 39145 Coraki (G9). 8, WRC 39149 Tuckean Island (I7). 9, WRC 39150 Woodburn (J10). 10, WRC 39152 Evans Head (K10). 11, WRC 39153 Evans Head (K10/11). 12, WRC 39155 North Evans Head (K9). 13, WRC 39157 Wardell (K6). 14, WRC 39158 Wardell (K6). 15, WRC 39163 Ballina (M3). 16, WRC 39165 Coraki East (I8). 17, Lismore Ambulance Station (F4). 18, Evans Head coral locality (J/K10/11).

shelly sediments of the coral bank include much mud, but this is locally diluted by sand presumably derived from the sandstones of the high bedrock adjacent to the locality, as well as by the great bulk of bioclastic material, resulting in a poorly sorted sediment. Particle size analysis of a sample from -1.5 m gave the following result: >2 mm, 26%; <2 mm >0.5 mm, 17%; <0.5 mm >0.25 mm, 15%; <0.25 mm >0.063 mm, 17%; <0.063 mm, 25%. The presence of such a proportion of fine-grained material we consider significant in relating the coral locality to the subsurface Gundurimba Clay.

The disparity in elevation of the top of the Gundurimba Clay between the coral locality and the nearest borehole reflects a sea floor topography falling 30 m in a distance of 1.5 km, by no means a remarkable drop. Fig. 3 of Drury & Roman (1983) and Fig. 1 herein show a southward prolongation of the Gundurimba Clay to include the coral site. In discussion Drury has also indicated that he considers the strata at the coral site a local variation in the Gundurimba Clay.

LOCATION OF SAMPLES

Ostracodes have been recovered from all localities marked on Fig. 1. The locality most distant from the ocean, WRC 39135 Boatharbour, lies 106 km from the present mouth of the Richmond River, following the course of the River.

Fig. 1 indicates the distribution of the Gundurimba Clay, and thus roughly defines the shape of the embayment in which the formation was deposited. This embayment was restricted by two meridional basement highs, one approximately along grid-line G/H of Fig. 1, the other along lines J and K. Some points on these highs rise well above the level of the alluvial plain, and would have represented islands or reefs at the time of flooding of the embayment. The blank area at grid square L/M6 is not a high, but represents a point at which the Gundurimba Clay appears to have been eroded. Pickett (1981, p. 72) remarked, after an initial examination of microfossil assemblages from the samples reported on here, that planktonic foraminifera have not been recovered from samples further upstream than the more westerly of these highs.

The distribution of samples includes environments ranging from relatively open marine (10-15, 18), semi-restricted, between the basement highs (7, 8, 16) to points near the probable extremities of the embayment (1, 2) (see Fig. 1).

ECOLOGICAL RESULTS

Tables 1 and 2 indicate that by and large the Evans Head and Lismore district ostracode assemblages are markedly dissimilar, as appears from the following details:

1, *Cytherella lismorensis* sp. nov. does not occur at the Evans Head coral locality.

2, *Macrocyprina* sp. is not found in the WRC bores.

3, *Loxoconcha australis minor* subsp. nov. is the common loxoconchid at Evans Head but *L. trita* is far more common in the Lismore district WRC bores.

4, *Loxoconchella pulchra* does not occur in the WRC bores.

5, *Osticythere reticulata* is characteristic of the Lismore district bores, but also occurs at Wardell (in WRC 39157 it is associated with planktonic forams).

6, '*Neomonoceratina*' *koenigswaldi* and *N. mediterranea* are absent from Evans Head.

7, *Oculocytheropteron raybatei* sp. nov. does not occur in the WRC bores.

8, *Trachyleberis dampierensis* is represented by only one gerontic individual at Evans Head, although it occurs in two other bores outside the embayment.

9, *Paradoxostoma evansheadensis* sp. nov. is exclusive to Evans Head.

10, *Xestoleberis cedunaensis* is the characteristic xestoleberidid in the Lismore district bores, but *X. limbata* and *X. tigrina* characterise the Evans Head assemblages, *X. limbata* being the dominant Evans Head species.

Of the above taxa, note that *Macrocyprina* sp. occurs only as juvenile valves or as fragments of adult valves.

Clearly, the Evans Head assemblages (Table 1) and those from the WRC bores (Table 2) represent different biofacies, both nearshore. Of these two biofacies types, that at Evans Head is more open marine; whereas the Lismore district bore assemblages probably represent lagoonal, estuarine and protected bay facies. Fortunately, Hartmann (1979, 1980, 1981) has provided ecological notes for many taxa, and combining these with the senior author's experience allows relatively reliable ecological interpretations to be developed.

The most common species at Evans Head (Table 1) are: *Paranesidea* cf. *attenuata*, *Macrocyprina* sp., *Paracypris bradyi*, *Loxoconcha australis minor*, *Loxoconchella pulchra*, *Parakrithella australis*, *Callistocythere dorsotuberculata*, *C. keiji*, *Tanella gracilis*, *Oculocytheropteron raybatei*, *Keijella jankeiji*, *Xestoleberis limbata* and *X. tigrina*. Of these, *C. dorsotuberculata* and *K. jankeiji* are also common in the WRC bores and can be ignored for comparative purposes.

Most of the Evans Head species are known phytal associates, often found among algae on rocks, or associated with seagrasses. This is particularly true for the dominant species *X. limbata*. The favoured substrates are sands, usually fine but including gravelly beach sands, and abrasion terraces (platforms). Depths would have been no greater than about 2-3 m. The assemblages are holomarine and more exposed than those from the WRC bores. The latter feature is indicated by the presence of juveniles and fragments of *Macrocyprina*, which is an offshore genus. Presumably, these specimens were washed inshore following storms. Further, *Oculocytheropteron raybatei* indicates a sublittoral environment and probably also was washed into the assemblages rather than forming part of the biocoenose. Important phytal indices include *Paranesidea* cf. *attenuata*, *Paracypris bradyi*, *Loxoconcha australis minor*, *Parakrithella australis*, *Paradoxostoma evansheadensis* and *Xestoleberis limbata*; the sand indices include *Loxoconchella pulchra* (sands with seagrass); *Xestoleberis tigrina* (sandy intertidals) and *Tanella gracilis* (a widely tolerant nearshore species with a preference for sandy substrates, including gravelly beaches).

Areally, as well as vertically, a greater number of facies is indicated by the WRC bore assemblages (Table 2, Appendix). The characteristic taxon is *Osticythere reticulata*; other common species are *Trachyleberis dampierensis* and *Keijella jankeiji*. Less common (occurring in 6 or fewer of the 15 bores) but important ecologically are the *Cytherella* species, *Phlyctenophora zealandica*, *Loxoconcha trita* and *Xestoleberis cedunaensis*.

Osticythere reticulata is an index for such marginal environments as estuaries and shoreline lagoons. The favoured substrates are shallow sands, silts and muds, especially when organic detritus is present.

The presence of *Osticythere reticulata* in the two boreholes at Wardell is not in agreement with both the fossil (Lismore district boreholes) and recent (Hawkesbury River) distributions, which indicate a clear association with an upper estuarine environment. The

TABLE 1
OSTRACODE SPECIES COUNTS FROM EVANS HEAD SAMPLES.

Species List	Sample Numbers—Evans Head 27	28	29	30	31	32	33	34
Depth (m) 0.36	– 0.55	– 0.73	– 0.91	– 1.09	– 1.27	– 1.45	– 1.64	– 1.82
Cytherella loukornickeri	1	–	–	2	1	–	–	–
Paranesidea cf. *attenuata*	7	29	9	12	8	3	7	12
Triebelina amicitiae	2	–	1	–	–	1	1	–
Macrocyprina sp.	2	2	–	3	1	3	–	1
Paracypris bradyi	23	8	8	10	9	9	5	14
Phlyctenophora zealandica	–	–	–	–	–	–	1	2
Indet. juv. Cypridacea	2	–	1	–	–	2	–	–
Loxoconcha australis minor	21	18	27	17	13	23	31	27
Loxoconcha trita	2	2	–	–	–	1	–	–
Loxoconcha abditocostata	1	–	1	–	–	–	–	2
Loxoconchella pulchra	–	1	1	–	1	1	3	–
Hemicytheridea reticulata	2	–	–	–	2	–	–	–
Bishopina vangoethemi	2	–	1	–	2	–	1	–
Parakrithella australis	7	12	11	9	9	15	5	9
Callistocythere dorsotuberculata	2	4	1	1	2	4	–	–
Callistocythere keiji	3	2	–	–	3	1	–	2
Tanella gracilis	3	1	–	1	2	2	–	–
Oculocytheropteron raybatei	4	–	1	–	1	–	1	6
Ponticocythereis militaris	–	1	1	–	1	–	1	–
Trachyleberis dampierensis	–	1*	–	–	–	–	–	–
Keijella jankeiji	–	–	–	1	3	1	1	1
Mutilus sp.	–	–	1	–	–	–	–	–
Paracytheroma sudaustralis	–	–	–	–	–	–	2	–
Paradoxostoma evansheadensis	1	3	–	–	–	–	1	1
Paradoxostoma sp.	–	–	–	–	–	1	–	–
Machaerina sp.	–	–	–	–	–	1	–	–
Xestoleberis cedunaensis	1*	1	–	–	1	1	1	–
Xestoleberis limbata	106	113	135	149	133	124	133	115
Xestoleberis tigrina	8	3	3	4	9	14	10	9
TOTAL	200	201	202	209	201	207	204	201

Note that Samples 25 and 26 were barren of Ostracoda. These represent the topmost 36 cm of sediment.
* Indicates a gerontic specimen.

geographical situation (see Fig. 1) suggests that this is unlikely at Wardell. Both ostracode and foraminiferal assemblages are very poor in species, and *O. reticulata* is represented by only two specimens from WRC 39157 and six specimens from WRC 39158. The situation is rendered even less clear by the presence of a single globigerinid in WRC 39157. It seems most likely that these apparently mixed assemblages are due to some local complication, the details of which are not clear from the available data. It may be that these localities represent a shoreline lagoon rather than part of an estuarine system.

Of the other species, *'N.' koenigswaldi* and *X. cedunaensis* are associated with sandy to muddy substrates and also with mangroves. The *Cytherella* species and *P. zealandica* on the other hand indicate a shallow water phytobenthos.

Among the rarer species, *Aspidoconcha* sp. represents a genus which is commensal on burrowing isopods and amphipods, and *Neomonoceratina mediterranea* is associated with sandy beaches as is *Pseudopsammocythere* sp. Further, *Paracytheroma sudaustralis* is a known associate of marginal environments (McKenzie 1978, Hartmann 1980) usually indicating nearby freshwater influences.

In summary, the WRC bores assemblages at Coraki and upstream indicate a variety of marginal facies such as could be expected in a relatively protected bay, with an immediate hinterland of low relief including meandering estuaries and nearshore lagoons; but also with associated fine sand beaches and silty littorals having an interstitial and burrowing (endobenthic) fauna. Mangroves were certainly present. The lower intertidal and subtidal parts of such beaches were colonised by seagrasses.

A number of species indicate a warmer temperature regime for the assemblages than is typical of the region today. These species include *Paranesidea* cf. *attenuata*, *Triebelina amicitiae*, *Bishopina vangoethemi*, *Hemicytheridea reticulata* and *Keijella jankeiji*; all belong in genera which are more typical of tropical and subtropical assemblages. The mean summer shallow water temperature limit for the faunas may have been about 20°C. Hartmann (1980, p. 139) indicated that at this temperature *Loxoconcha trita* begins to cut out, unlike *L. australis minor*, which can tolerate higher temperatures.

The Appendix, which gives the vertical distributions of the WRC bore assemblages, indicates that this suite of marginal and relatively protected facies shifted with time. The available samples are too few for an analysis of their variation. In general, however, the more marine facies are represented by bores 39139, 39140, (South Gundurimba), 39143, 39145 (Coraki), 39149 (Tuckean Island), 39152 (Evans Head) and, possibly, 39155 (North Evans Head), while more estuarine and lagoonal conditions are represented by bores 39101 (Greenridge), 39135 (Boatharbour), 39138 (Tuncester), 39157 and 39158 (Wardell). Bores 39163 (Ballina) and 39165 (Coraki East) cannot be interpreted ecologically with much confidence. The Lismore Ambulance Station Bore could be dominantly estuarine, but, unfortunately, only one assemblage from this bore has a known depth.

Sufficient ostracodes were picked from bores WRC 39135 (Boatharbour), 39140 (South Gundurimba), 39145 (Coraki) and from Evans Head to allow definition of the estuarine horizons *vis à vis* their holomarine counterparts and to provide for a more detailed interpretation of the former group.

In general, the estuarine horizons are characterised by assemblages dominated by the species *Osticythere reticulata*, *Trachyleberis dampierensis* and *Keijella*

TABLE 2
OSTRACODE SPECIES FROM WRC BORES NEAR LISMORE, N.S.W.

Locality/WRC bore no.	39101	39135	39138	Ambulance Station	39139	39140	39143	39145	39149	39165	39152	39155	39157	39158	39163
Cytherella loukornickeri	–	–	–	–	X	1	–	X	X	–	X	X	–	–	–
Cytherella lismorensis	–	–	–	–	X	4	–	X	X	–	–	–	–	–	–
Paranesidea cf. *attenuata*	–	–	–	–	X	7	X	–	–	–	–	–	–	–	–
Paracypris bradyi	–	–	–	–	X	2	X	–	–	–	–	–	–	–	–
Phlyctenophora zealandica	–	X	–	X	–	2	–	X	X	–	–	–	–	–	–
Propontocypris sp.	–	–	X	–	–	X	–	–	–	–	–	–	–	–	–
Loxoconcha australis minor	–	–	–	–	X	3	–	X	–	–	X	–	–	–	–
Loxoconcha trita	–	–	X	X	X	34	–	X	X	–	–	–	–	–	–
Hemicytheridea reticulata	–	–	–	–	X	–	–	–	X	–	–	–	–	X	–
Cytherurid? sp. juv.	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Bishopina vangoethemi	–	–	–	–	X	–	X	X	–	–	–	–	–	–	–
Osticythere reticulata	X	X	X	X	X	17	–	X	–	–	–	–	X	X	–
'Neomonoceratina' koenigswaldi	X	–	X	X	–	15	–	X	–	–	–	–	–	X	–
Neomonoceratina mediterranea	–	–	–	–	X	2	–	–	–	–	–	–	–	–	–
Parakrithella australis	–	–	–	–	–	4	–	–	X	–	–	–	–	–	–
Callistocythere dorsotuberculata	–	X	–	–	X	1	X	X	–	X	X	–	–	–	–
Callistocythere hartmanni	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–
Callistocythere keiji	–	–	–	–	X	1	X	–	–	–	–	–	–	–	–
Tanella gracilis	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Tanella gracilis minor	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–
'Pectocythere' portjacksonensis	–	–	X	–	X	–	–	–	–	–	–	–	–	–	–
Ponticocythereis militaris	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–
Trachyleberis dampierensis	–	X	X	–	X	34	X	X	X	X	X	X	–	–	–
Australimoosella sp.	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–
Cletocythereis rastromarginata	–	–	–	–	X	3	–	–	–	–	–	–	–	–	–
Bradleya juv. indet.	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Keijella jankeiji	X	X	X	X	X	62	–	X	X	X	X	–	–	–	X
Paracytheroma sudaustralis	–	–	–	X	–	1	–	–	–	–	X	–	–	–	–
Machaerina sp.	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Xestoleberis cedunaensis	X	–	–	–	X	16	–	X	X	–	–	–	–	–	–
Xestoleberis limbata	–	–	X	–	X	–	–	–	–	–	–	–	–	–	–
Xestoleberis sp.	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–
Aspidoconcha sp.	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–
Pseudopsammocythere sp.	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–

The count was made at the 20-21 m sample in Bore No. 39140. X = present; = absent.
The localities are arranged according to their distance from the ocean, the most distant at the left.

jankeiji. These three species, for example, form 92% of the ostracode assemblage at Boatharbour, a well-defined estuarine bore, but less than 1% of the species at the holomarine Evans Head site.

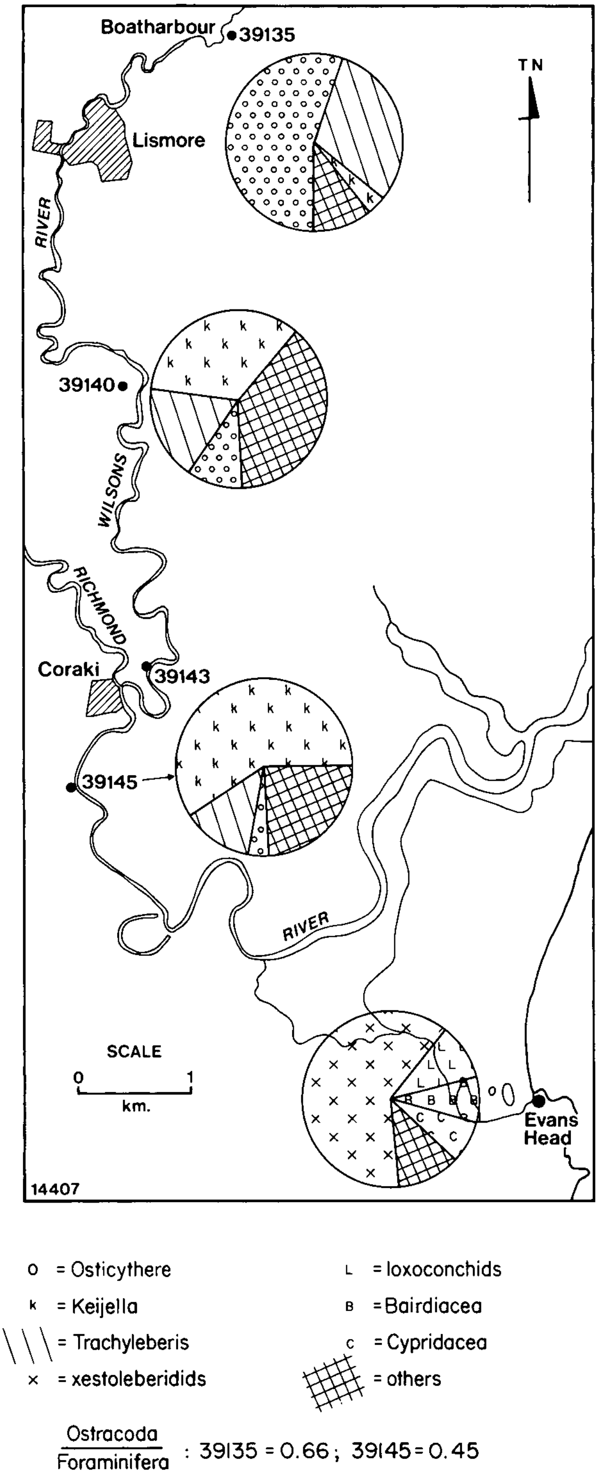


Fig. 2—Proportional representation of ostracode taxa in samples from a range of locations. The genera *Osticythere*, *Keijella* and *Trachyleberis*, typical of estuarine conditions, together comprise more than 60% of the three assemblages from the more inland area, but less than 1% of the fauna from near Evans Head, which is dominated by holomarine xestoleberidids, indicating clearly that the Evans Head locality is not estuarine. Within the three estuarine faunas, *Keijella*, characteristic of the outer estuary, is progressively less significant upstream, whereas *Osticythere*, typical of the inner estuary, shows the reverse distribution. Ostracode/foraminifera ratios are 0.66 for WRC 39135, 0.45 for WRC 39145. Key to hachures: 0 = *Osticythere; Keijella*; X = xestoleberidids; L = loxoconchids; B = Bairdiacea; C = Cypridacea; diagonal lines = *Trachyleberis*; cross-hatching = other groups.

Of the three species, *Osticythere reticulata* (56%) is dominant in the estuarine environments which lie furthest upstream); in these environments *Keijella jankeiji* is rare (3%) and *Trachyleberis dampierensis* (33%) is very common (WRC 39135, Fig. 2). Downstream from Boatharbour *O. reticulata* (8%) begins to cut out and the assemblage is dominated by *K. jankeiji* (29%) and *T. dampierensis* (16%)— this is the situation in WRC bore 39140 (Fig. 2). Finally, near the mouth of the former estuary, *O. reticulata* (3%) is rare, and the assemblage is dominated by *K. jankeiji* (55%), with *T. dampierensis* (11%) less common (WRC 39145, Fig. 2). Confirmation of the interpretation that WRC 39145 is located in the channel of a former estuary is provided by the nearby WRC bore 39143, which is dominated by polyhaline (lagoonal) species (Fig. 2). It seems that the three species discussed above can be considered indices for an ecological gradient from well-defined estuarine to near marine environments. This is probably the most useful result to emerge from our study of the ostracode faunas in the Evans Head and Lismore district bores. The ostracode faunas show a clear discontinuity between the two seaward localities of Fig. 2, which is correlated with the change from estuarine to marine conditions.

IMPLICATIONS OF THE STUDY

The ecological results clearly support the statement of Pickett (1981, p. 72) that the "estuary was wide open at some stage prior to barrier formation", i.e. at the time of deposition of the Gundurimba Clay.

It is helpful to draw an analogy between the Richmond River valley during Gundurimba time and a modern embayment, such as that of the Hawkesbury River (Broken Bay), on which rather more data are available than for most others. The more seaward of the basement highs would come closest to representing the entrance to Broken Bay, the width of the entrance being approximately 11 km, though broken by a series of islands with a maximum separation of approximately 3 km. The entrance to Broken Bay has an unbroken width of 4 km, the single island, Lion Island, being set well back, and serving more to divide the two major arms of the embayment than to obstruct general access of ocean water. The two estuaries may then be con-

TABLE 3
MICROFAUNAL ASSEMBLAGES AND ASSOCIATED ENVIRONMENTAL FACTORS, HAWKESBURY RIVER.

Sample numbers	1	2	3	4	5	6	7	8	9	10	11	12
OSTRACODA												
Paracypria sp.							1					
Osticythere reticulata	2	1		4		2	27	125	186	22	14	27
Callistocythere sp.									1	3		
'Hiltermannicythere' bassiounii reticulata								1	5			
trachyleberidinid sp.									1			
'Bythocythere' sp.								1				
FORAMINIFERA												
Protoschista findens									1			
Miliammina fusca											2	
Haplophragmoides australiensis						5			1			2
Haplophragmoides canariensis									2			11
Ammobaculites foliaceus							1		16	3		
Trochammina inflata	1					2			3	1		5
Quinqueloculina seminula								1		1		
Triloculina oblonga								5				
Spirillina vivipara							1					
Discorbis mirus		1										
Ammonia beccarii							1		37	5		
Elphidium advenum									1			
Cribrononion hawkesburiensis									2			
Molluscans						X		X	X	X	X	X
Bryozoans								X	X			
Serpulids											X	
Plant remains						X	X	X	X	X		
framboidal pyrite												X
>silt fraction (%)	5.2	14.4	91.4	3.6	90.6	4.0	0.6	0.4	4.6	3.4	7.0	1.0
depth (m)	0.2	2.5	5.7	15.0	17.5	0.25	2.5	10.0	14.5	20.0	3.0	2.0
distance from bank (m)	b	20.0	40.0	*	25.0	p	25.0	50.0	*	50.0	*	2.0

1-5, Gunderman, GR 40848666. 6-10, Gentlemans Reach, GR 41658640. 11-12, Road bridge, Mangrove Creek, GR 41568706. All map references (yards) refer to Sydney 1:250,000 sheet. 1-5 were collected at low tide; 6-10 were collected when tide was about 0.6 m below HWM. Of the total of 12 samples, 3 and 5 were barren. Determinations by K.G.M.
* = mid channel; b = bank between mangrove roots; p = limit of mangrove pneumatophores; X = present.

sidered roughly comparable at this point, the greater number of smaller gaps in the Richmond embayment compensating for the greater width of the Hawkesbury entrance.

On this basis, the extreme samples from the Richmond embayment (Greenridge and Boatharbour) would have lain 27 km and 35 km respectively from the entrance, thus corresponding to points such as Spencer at the junction of Mangrove Creek with the Hawkesbury, and either Gunderman on the main river or Lower Mangrove on Mangrove Creek.

Table 3 records the results of a recent survey by us of Hawkesbury River sites (Gunderman; Gentlemans Reach near Spencer; Mangrove Creek). It includes the ostracodes and foraminiferans as well as some associated faunal elements and other environmental factors (depth, distance from bank, percentage coarser than silt size in the substrate). As at Boatharbour in the Richmond embayment assemblages, *Osticythere reticulata* clearly predominates at the Hawkesbury River sites, thus vindicating the analogy we have drawn above. The Gunderman samples more closely resemble those from Greenridge than those from Boatharbour, which is in accord with the positions of those localities on the main river channels.

The presence of a contemporaneous subaerial sand barrier in the present position of the Inner Barrier would have produced such a restriction in circulation that estuarine faunas as varied as that at Boatharbour (7 species) could not have survived. This, coupled with the straightforward marine nature of the assemblage at the Evans Head coral locality (inside the Inner Barrier), makes it obvious that the Inner Barrier must have been emplaced well after the rise in sea level which flooded the estuary. It is generally held (following Thom 1965) that the Inner Barrier ridges were established during a time when the sea level was higher than at present. Roy & Thom (1981, p. 483) produced a model for barrier emplacement by which "during each transgression, mud . . . accumulated in an estuary behind a landward-moving barrier that was mostly reworked and incorporated into a new barrier . . ."; in other words, an emergent barrier was constantly present between ocean and estuary. On the present evidence, as well as that presented elsewhere on the basis of planktonic foraminifera (Pickett 1983), this model is untenable. Therefore, emplacement of the Inner Barrier beach ridges must have taken place either near the still stand of maximum sea level, or during the early stages of regression, or conceivably at a later high stand of sea level (Pickett *et al.* in press). Whenever it occurred, the establishment of the barrier would rapidly have terminated estuarine sedimentation of the type implied by the faunas of the Gundurimba Clay.

No analogy is known on today's coastline of a situation which is sheltered enough to allow muddy sediment to accumulate, but at the same time open enough for marine circulation adequate to allow ostracode, coral and planktonic foraminiferan assemblages characteristic of open situations to occur. This anomaly, first pointed out by Pickett (1983), is apparent also in the style of coral assemblages at Evans Head (Pickett 1981) and North Stradbroke Island (Pickett *et al.* in press), both of which imply better access of oceanic water than in modern Moreton Bay.

Two circumstances suggest that the emplacement is associated with the peak of the interglacial, though the evidence is somewhat equivocal.

Firstly, the repetition of a considerable number of similar ridges making up the barrier system clearly implies recurrent events of similar type, possibly with considerable intervals between them. The relatively constant height of the ridges implies that there was little change in sea level during emplacement, suggesting that the ridges were not formed during a regressive period.

Secondly, the Gundurimba Clay is overlain along its seaward margin by the Woodburn Sand (the Inner Barrier), which terminated deposition of the earlier formation. Elsewhere it is overlain by very thin floodplain deposits or by the Greenridge Formation in the most landward parts. This latter is regarded as deltaic by Drury (in press); if this is so it may represent sediments laid down in the now relatively fresh waters of the embayment largely dammed by the youthful Inner Barrier.

A corollary of this provides an estimate of maximum sea level. The top of the Gundurimba Clay in WRC 39138 (Tuncester) is ca. +6 m AHD. It is overlain by ca. 6 m of deltaic Greenridge Formation and ca. 1 m of floodplain deposit. If the Greenridge Formation was indeed deposited under water, the top water level may thus have been as high as + 12 m AHD. This is however considerably higher than the highest point on the Inner Barrier ridge system (ca. 8 m), so there is some inconsistency.

TAXONOMIC NOTES

Recent work by Hartmann (1979, 1980, 1981) and McKenzie (1967, 1978) has complemented the early work of Brady (1866, 1880) — based on material sent to him by private collectors and that from several conveniently sited "Challenger" stations — so that the marine ostracode fauna of southeastern Australia is becoming relatively well known. The following notes indicate recognition of some remaining taxonomic uncertainties with this Pleistocene-Holocene N.S.W. fauna; both are at the generic level.

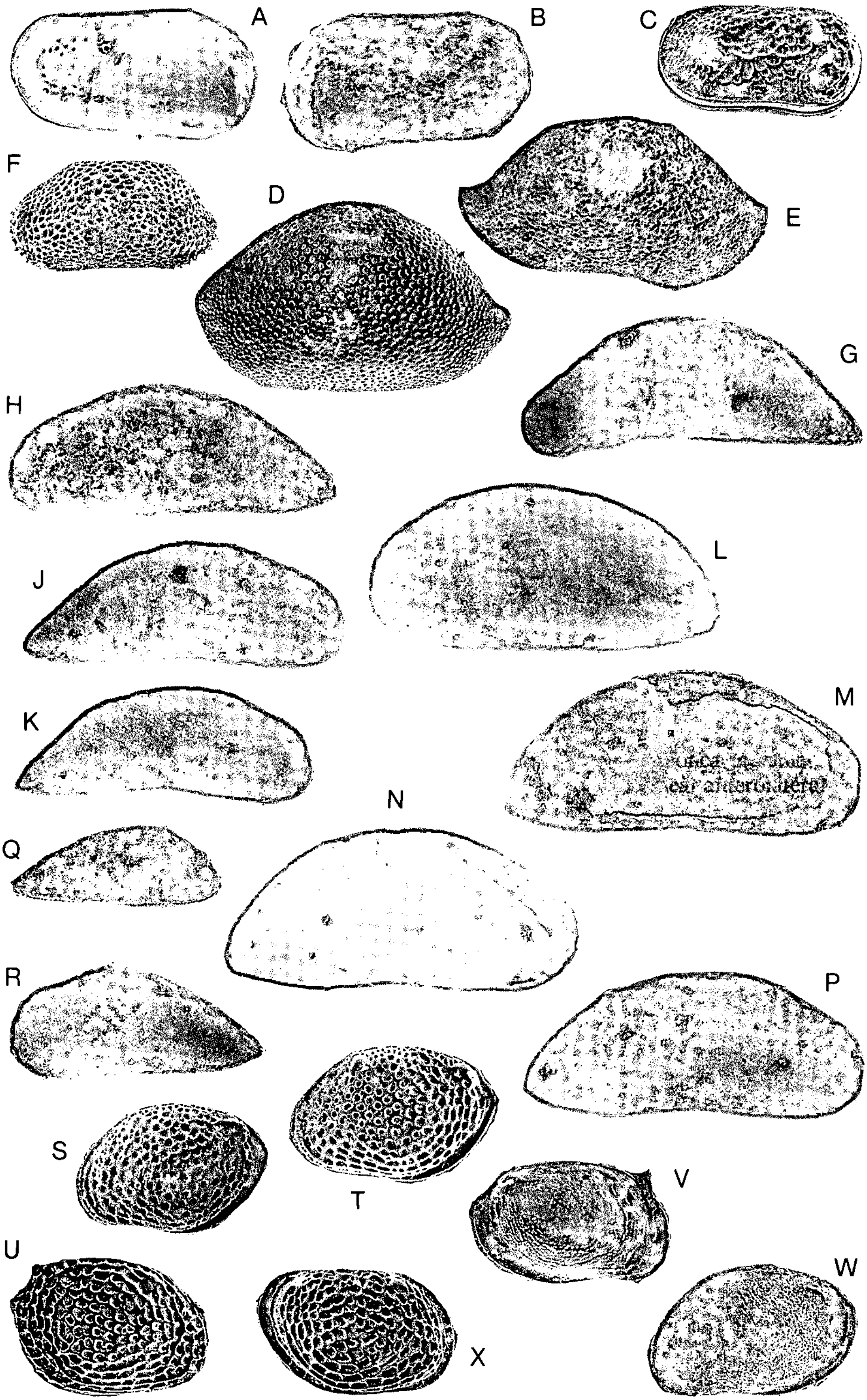
'Neomonoceratina' koenigswaldi Keij 1954.

McKenzie & Sudijono (1981) drew attention to the need for a revision at the generic level of this commonly encountered Indo-West Pacific species. What is needed is a comparison of living material of this species with another, more typical, living *Neomonoceratina* (such as *mediterranea* Ruggieri 1953) in order to decide whether or not there is soft parts evidence to complement the gross size difference between *koenigswaldi* and all other *Neomonoceratina* species in order to validate a new generic name.

'Pectocythere' portjacksonensis (McKenzie 1967).

There is a general agreement among interested workers (correspondence and verbal discussions with Hartmann and Bentley) that this species represents a new generic taxon; a manuscript name for the genus already exists in a Macquarie University thesis which, it is hoped will soon be submitted for publication.

Fig. 3 — Representative ostracodes from the Late Pleistocene Gundurimba Clay. Locality numbers refer to Fig. 1. All ×50. A, B, *Cytherella loukornickeri* sp. nov., loc. 18, 0.97-1.09 m. A, holotype ♀ LV, MMMC01646. B, paratype ♀ RV, MMMC01647. C, *Cytherella lismorensis* sp. nov., holotype ♂ carapace, loc. 4, 13-14 m, MMMC01648. D, E, *Paranesidea attenuata* (Brady), loc. 18, 0.36-0.55 m.D, ♀ LV, MMMC01649. E, ♀ RV, MMMC01650. F, *Triebelina amicitiae* Keij, ♀ LV, loc. 18, 0.36-0.55 m, MMMC01651. G, *Macrocyprina* sp., juvenile LV, loc. 18, 0.55-0.73 m, MMMC01652. H-K, *Paracypris bradyi* McKenzie. H, ♀ LV, loc. 18, 0.91-1.09 m, MMMC01655. J, ♀ RV, loc. 18, 0.36-0.55 m, MMMC01654. K, ♂ RV, same, MMMC01653. L-P, *Phlyctenophora zealandica* Brady. L, ♀ LV, loc. 8, 19-20 m, MMMC01659. M, ♀ RV, loc. 18, 1.64-1.82 m, MMMC01657. N, ♀ RV, loc. 18, 1.45-1.64 m, MMMC01656. P, ♂ RV, loc. 8, 19-20 m, MMMC01658. Q, R, *Propontocypris* sp. juv., loc. 5, 21-22 m. Q, RV, MMMC01661. R, LV, MMMC01660. S-U, *Loxoconcha australis minor* Hartmann. S, ♀ LV, loc. 18, 0.36-0.55 m, MMMC01662. T, ♀ LV, loc. 18, 1.45-1.64 m, MMMC01663. U, ♀ RV, same, MMMC01664. V, W, *Loxoconcha abditocostata* Hartmann, loc. 18, 0.36-0.55 m. V, ♀ RV, MMMC01665. W, ♀ LV, MMMC01666. X, *Loxoconcha trita* McKenzie, ♀ RV, loc. 18, 0.36-0.55 m, MMMC01667.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The species *portjacksonensis* has a similar size and general shape to *Tanella gracilis minor* which is described in this paper. More careful examination, however, indicates differences in the surface ornament and in the internal marginal features (especially the radial pore canals) as well as in the hinge—the *portjacksonensis* hinge is a pentodont type—which enables the two taxa to be separated readily.

SYSTEMATICS

Family CYTHERELLIDAE Sars 1866
Genus **Cytherella** Jones 1849
Cytherella loukornickeri McKenzie sp. nov.
Figs 3A, B, 6A, B

ETYMOLOGY: For Dr L. S. Kornicker, Smithsonian Institution.

DESCRIPTION: Carapace medium sized; elongate subrectangular in lateral view; anterior broadly rounded; posterior also broadly rounded, especially in females where it is swollen to accommodate the internal brood chamber; dorsum and venter both nearly straight; surface lustrous, smooth except for a discontinuous girdle of pits anteromedially, with a slight depression in the adductor muscle scar region; greatest height medial in males, posteromedial in females. In dorsal view subcuneate; tapering anteriorly, broader posteriorly. Internally: pseudoradial pore canals well developed anteriorly; normal pore canals simple, unrimmed; adductor muscle scars biserial, pinnate; hinge simple, adont, right valve (RV) accommodates left (LV) and is somewhat larger in consequence. Sex dimorphism distinct—females swollen and males slender posteriorly. Soft parts unknown.

DIMENSIONS: Holotype ♀ LV MMMC01646, length 0.69 mm, height 0.31 mm.

TYPE LOCALITY: Evans Head coral locality, N.S.W. (locality 18, Fig. 1) at 0.91-1.09 m.

OTHER LOCALITIES: The species also occurs in samples from 0.36-0.55 m and 1.09-1.27 m at locality 18, and in WRC bores 39139, 39140, 39145, 39149, 39152, 39155 (cf. Appendix).

REMARKS: The species resembles most closely *Cytherella pulchra* Brady 1866, but differs in that the surface is not completely smooth but bears a discontinuous girdle of pits anteromedially.

Cytherella lismorensis McKenzie sp. nov.
Figs 3C, 6C

ETYMOLOGY: For Lismore, N.S.W.

DESCRIPTION: Carapace medium sized; subrectangular in lateral view; anterior broadly rounded; posterior broadly subtruncate, swollen in females to accommodate the internal brood chamber; dorsum and venter both nearly straight; surface pitted by numerous shallow pits, in females smooth over part of the swollen posterior, slightly depressed in the adductor muscle scar region; greatest height posteromedial in females. In dorsal view compressed, subcuneate; tapering anteriorly, broader posteriorly. Internally: pseudoradial pore canals present; duplicature marginal; normal pore canals simple, unrimmed; adductor muscle scars biserial, pinnate; hinge adont; RV and LV subequal. Sex dimorphism distinct—females swollen and males slender posteriorly. Soft parts unknown.

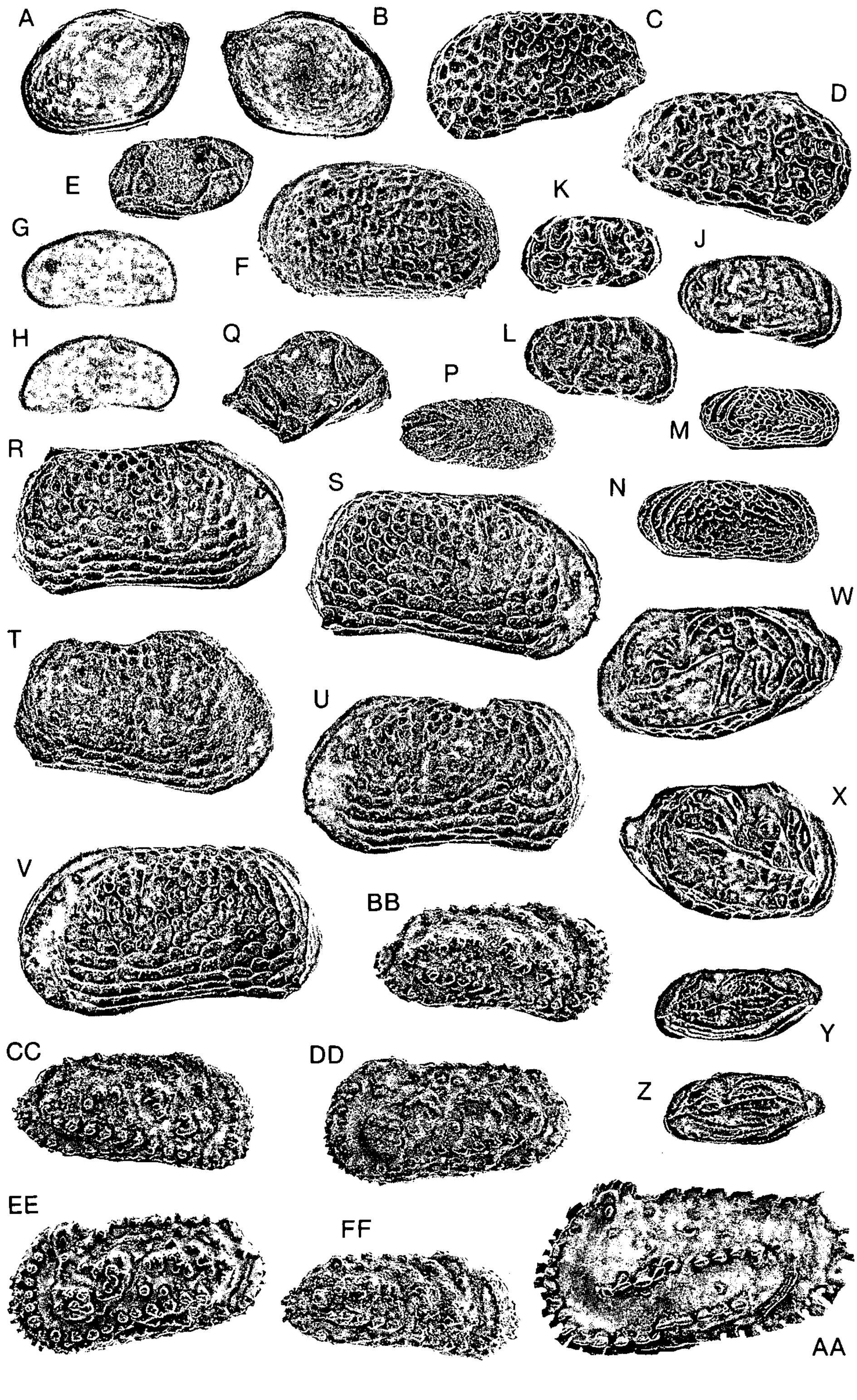
DIMENSIONS: Holotype ♂ carapace MMMC01648, length 0.56 mm, height 0.33 mm, breadth 0.25 mm.

TYPE LOCALITY: WRC bore 39139, South Gundurimba, near Lismore, N.S.W., 13-14 m.

OTHER LOCALITIES: The species also occurs in bores 39140, 39145, 39149 (cf. Appendix).

REMARKS: This species bears little resemblance to any previously described Australian cytherellid. It is closest to the Indo-Malaysian species *Cytherella semitalis* Brady, 1868, but has a different pattern of pits and lacks the clear medial area in each valve which characterises that species. The pits in *C. semitalis* are much larger

Fig. 4—Representative ostracodes from the Late Pleistocene Gundurimba Clay. Locality numbers refer to Fig. 1. All ×50. A, B, *Loxoconchella pulchra* McKenzie, loc. 18, 0.55-0.73 m. A, ♀ LV, MMMC01668. B, ♀ RV, MMMC01669. C, D, *Hemicytheridea reticulata* Kingma, loc. 4, 13-14 m. C, ♀ LV, MMMC01670. D, ♀ RV, MMMC01671. E, cytherurid? sp. juv., LV, loc. 5, 20-21 m, MMMC01672. F, *Bishopina vangoethemi* Wouters, ♀ LV, loc. 18, 0.36-0.55 m, MMMC01673. G, H, *Parakrithella australis* McKenzie, loc. 18, 0.36-0.55 m. G, ♀ LV, MMMC01674. H, ♀ RV, MMMC01675. J, *Callistocythere dorsotuberculata* Hartmann, ♀ RV, loc. 18, 0.36-0.55 m, MMMC01676. K, L, *Callistocythere* cf. *keiji* (Hartmann). K, ♂ LV, loc. 5, 20-21 m, MMMC01678. L, ♂ RV, loc. 7, 17-18 m, MMMC01677. M, *Tanella gracilis minor* subsp. nov., holotype ♀ RV, loc. 17, 14-15.5 m, MMMC01683. N, *Tanella gracilis gracilis* Kingma, ♀ RV, loc. 18, 0.36-0.55 m, MMMC01679. P, *"Pectocythere" portjacksonensis* (McKenzie), carapace, dorsal view, loc. 3, 20-21 m, MMMC01684. Q, *Oculocytheropteron raybatei* sp. nov., holotype ♀ RV, loc. 18, 0.36-0.55 m, MMMC01686. R-V, *Osticythere reticulata* Hartmann. R, ♀ RV, loc. 2, 20-21 m, MMMC01688. S, ♂ RV, loc. 5, 20-21 m, MMMC01690. T, ♀ RV, loc. 2, 20-21 m, MMMC01687. U, ♂ LV, same, MMMC01689. V, ♂ LV, loc. 5, 20-21 m, MMMC01691. W, X, *"Neomonoceratina" koenigswaldi* Keij, loc. 5, 20-21 m. W, ♂ LV, MMMC01693. X, ♀ RV, MMMC01692. Y, Z, *Neomonoceratina mediterranea* Ruggieri, loc. 5, 20-21 m. Y, ♂ LV, MMMC01694. Z, ♀ LV, MMMC01695. AA, *Ponticocythereis militaris* (Brady), ♀ LV, loc. 18, 0.73-0.91 m, MMMC01696. BB-FF, *Trachyleberis dampierensis* (Hartmann). BB, ♂ RV, loc. 5, 20-21 m, MMMC01701. CC, ♂ RV, same, MMMC01700. DD, ♀ LV, loc. 2, 20-21 m, MMMC01698. EE, ♀ LV, loc. 18, 0.55-0.73 m, MMMC01697. FF, ♂ RV, loc. 2, 20-21 m, MMMC01699.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than in *C. lismorensis* and the shape more elongate; its size is 0.61 mm (examination of Brady's 'Fonds de la Mer' types in the Brady Collection at the Hancock Museum, Newcastle-upon-Tyne, Reg. No. B57).

Family Leptocytheridae Hanai 1957
Genus **Tanella** Kingma 1948
Tanella gracilis Kingma, 1948 **minor** McKenzie subsp. nov.
Figs 4M, 6J-L

Etymology: *minor* (L.) = lesser, smaller.

Description: This subspecies has all the characteristics of the nominate taxon but is consistently more fragile and smaller in adult moults.

Dimensions: Holotype ♀ RV MMMC01683, length 0.39 mm, height 0.19 mm. Paratype ♂ RV MMMC01682, length 0.38 mm, height 0.18 mm.

Type Locality: Ambulance Station bore, 14-15.5 m, Lismore, N.S.W.

Remarks: *Tanella gracilis* was first recorded from the coast of N.S.W. by Hartmann (1981); and it is common in the Evans Head samples, where its size is about 0.51 mm – considerably greater than that of the new subspecies.

The description of a new subspecies is justified on the grounds also that this occurrence is allopatric to all occurrences of the nominate subspecies.

Family Cytheruridae Müller 1894
Genus **Oculocytheropteron** Bate 1972
Oculocytheropteron raybatei McKenzie sp. nov.
Figs 4Q, 6G, H

Etymology: For Dr R. H. Bate, British Museum (Natural History).

Description: Carapace small; subquadrangular in lateral view; markedly inequivalved, RV strongly arched dorsally while LV is nearly straight dorsally (cf. Figs 6G, 6H); ventral margin inflexed anteromedially; anterior subacuminate anteroventrally; posterior terminating in a short posterodorsal cauda; eye tubercle small but distinct (generic character); ventral alae prominent; surface micropunctate, with a slender dorsomarginal ridge and other ridges extending from the alae posterodorsally and anteroventrally; greatest height anteromedial, behind the eye spot. Internally: duplicature well developed, moderately broad; radial pore canals few, grouped anteroventrally and also including 2 into the posterodorsal cauda; normal pore canals simple, rimmed; central muscle scars located within the alae, comprising a subvertical row of 4 adductor scars, plus a single frontal scar (all readily visible on the external valve surfaces); hinge artioperatodont, comprising crenulate terminal projections in the RV, with a crenulate median furrow which is more coarsely crenulate at either end. Sex dimorphism distinct, males relatively lower than females. Soft parts unknown.

Dimensions: Holotype ♀ RV MMMC01686 length 0.48 mm, height 0.28 mm. Paratype ♀ LV MMMC01685 length 0.46 mm, height 0.24 mm.

Type Locality: Coral site at Evans Head, N.S.W. (locality 18, Fig. 1), 0.36-0.55 m.

Other Localities: The species also occurs in samples from the type locality at depths of 0.73-0.91 m, 1.09-1.27 m, 1.45-1.64 m, and 1.64-1.82 m.

Remarks: As a cytheropteronine taxon, this species would be part of the sublittoral (offshore) assemblage which accounts for the fact that Hartmann (1981) failed to record it from the N.S.W. coast. Of the several New Zealand species described by Hornibrook (1952) it is closest to *O. fornix* but differs from that species by its more pointed alae and better defined dorsal and posterior ridges.

Family **Trachyleberididae** Sylvester-Bradley 1948
Genus **Keijella** Ruggieri 1967
Keijella jankeiji McKenzie sp. nov.
Figs 5F, 6E, F

Etymology: For Dr A. J. Keij, petroleum consultant, Rijswijk, Netherlands.

Description: Carapace medium sized; subovate in lateral view; anterior broadly rounded, posterior less broadly rounded; dorsum gently convex and sloping backwards; venter also weakly convex and inflexed anteromedially; surface ornamented almost all over by large pits (with some indication of a polygonal reticulation posteriorly); also bearing several very short anterior marginal spines and a short, curved posteroventral spine; eye spot depressed; greatest height anteromedial. In dorsal view, subelliptical. Internally: duplicature well developed, moderately broad; radial pore canals rather numerous and straight; normal pore canals simple, celated; central muscle scars comprising 4 adductors in a curved subvertical series (concave anteriorly) plus a broadly V-shaped frontal scar and 2 small mandibulars; hinge powerful, hemiamphodont, comprising a prominent, lobate front tooth behind which is a depression followed by a finely crenulate median furrow leading to a strong lobate posterior tooth. Sex dimorphism present, males relatively more elongate than females. Soft parts unknown.

Dimensions: Holotype ♀ RV MMMC01707 length (excluding spines) 0.68 mm, height 0.40 mm.

Type Locality: Evans Head, N.S.W. (locality 18, Fig. 1), 0.91-1.09 m.

Other Localities: The species also occurs in samples 1.09-1.27 m, 1.27-1.45 m, 1.64-1.82 m, from Evans Head, and in WRC bores 39101, 39135, 39138, 39139, 39140, 39145, 39149, 39152, 39163, 39165 and the Ambulance Station Bore.

Remarks: The new species may be compared with the common Indo-Malaysian taxon *K. hodgii* (Brady 1866) originally described from a Levant sponge sand but later also recorded from the Indopacific (Brady 1880, p. 95) and recently figured by McKenzie and Sudijono (1981, plate 3, fig. 6). It differs from that species by being pitted almost all over whereas *hodgii* has scarcely any pits but instead is ridged posteriorly.

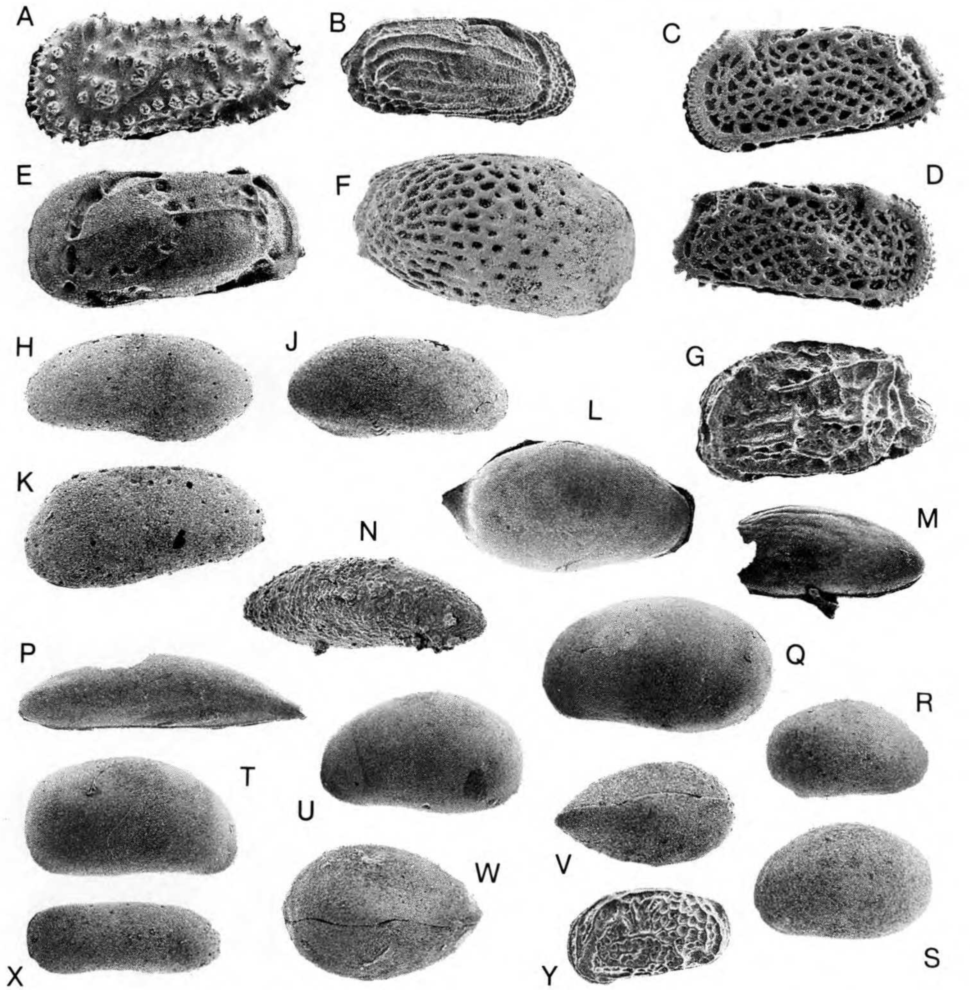

Fig. 5 – Representative ostracodes from the Late Pleistocene Gundurimba Clay. Locality numbers refer to Fig. 1. All ×50. A, *Trachyleberis dampierensis* (Hartmann), gerontic ♂ LV, lcc. 5, 20-21 m, MMMC01702. B, *Australimoosella* sp., ♀ RV, loc. 10, 38-39 m, MMMC01703. C, D, *Cletocythereis rastromarginata* (Brady), loc. 5, 20-21 m. C, ♂ LV, MMMC01705. D, ♂ RV, MMMC01704. E, *Bradleya* sp., ♀ LV, loc. 8, 19-20 m, MMMC01706. F, *Keijella jankeiji* sp. nov., paratype ♀ RV, loc. 18, 0.91-1.09 m, MMMC01708. G, *Mutilus* sp., ♀ LV, loc. 18, 0.73-0.91 m, MMMC01709. H-K, *Paracytheroma sudaustralis* (McKenzie), loc. 10, 36-37 m. H, ♀ LV, MMMC01712. J, ♀ RV, MMMC01710. K, ♀ RV, MMMC01711. L, *Paradoxostoma evansheadensis* sp. nov., holotype ♀ RV, loc. 18, 0.36-0.55 m, MMMC01713. M, *Paradoxostoma* sp. broken RV, loc. 18, 1.27-1.45 m, MMMC01714. N, *?Machaerina* sp. ♂ carapace, loc. 5, 20-21 m, MMMC01716. P, *Machaerina* sp., ♂ LV, loc. 18, 1.27-1.45 m, MMMC01715. Q-S, *Xestoleberis cedunaensis* Hartmann. Q, ♀ LV, loc. 18, 0.36-0.55 m, MMMC01717. R, juvenile RV, loc. 5, 20-21 m, MMMC01719. S, juvenile RV, same, MMMC01718. T, *Xestoleberis limbata* Hartmann, ♀ RV, loc. 18, 0.36-0.55 m, MMMC01720. U, *Xestoleberis tigrina* (Brady), ♂ LV, loc. 18, 0.36-0.55 m, MMMC01721. V, *Xestoleberis* sp., carapace, loc. 7, 15-16 m, MMMC01722. W, *Aspidoconcha* sp., ♀ carapace, loc. 10, 36-37 m, MMMC01723. X, *Pseudopsammocythere* sp., ♂ LV, loc. 7, 16-17 m, MMMC01724. Y, *Callistocythere hartmanni* McKenzie, ♂ carapace, loc. 17, 14-15.5 m, MMMC01725.

Family Paradoxostomatidae Brady & Norman 1889
Genus **Paradoxostoma** Fischer 1855
Paradoxostoma evansheadensis McKenzie sp. nov.
Figs 5L, 6D

Etymology: For Evans Head, N.S.W.

Description: Carapace medium sized, subovate in lateral view; dorsum regularly convex; venter nearly straight, weakly inflexed anteromedially and upswept posteriorly; anterior subacuminate anteroventrally; posterior terminating in a small but definite cauda; eye spot distinct, clear; patch pattern of 2 clear patches (the

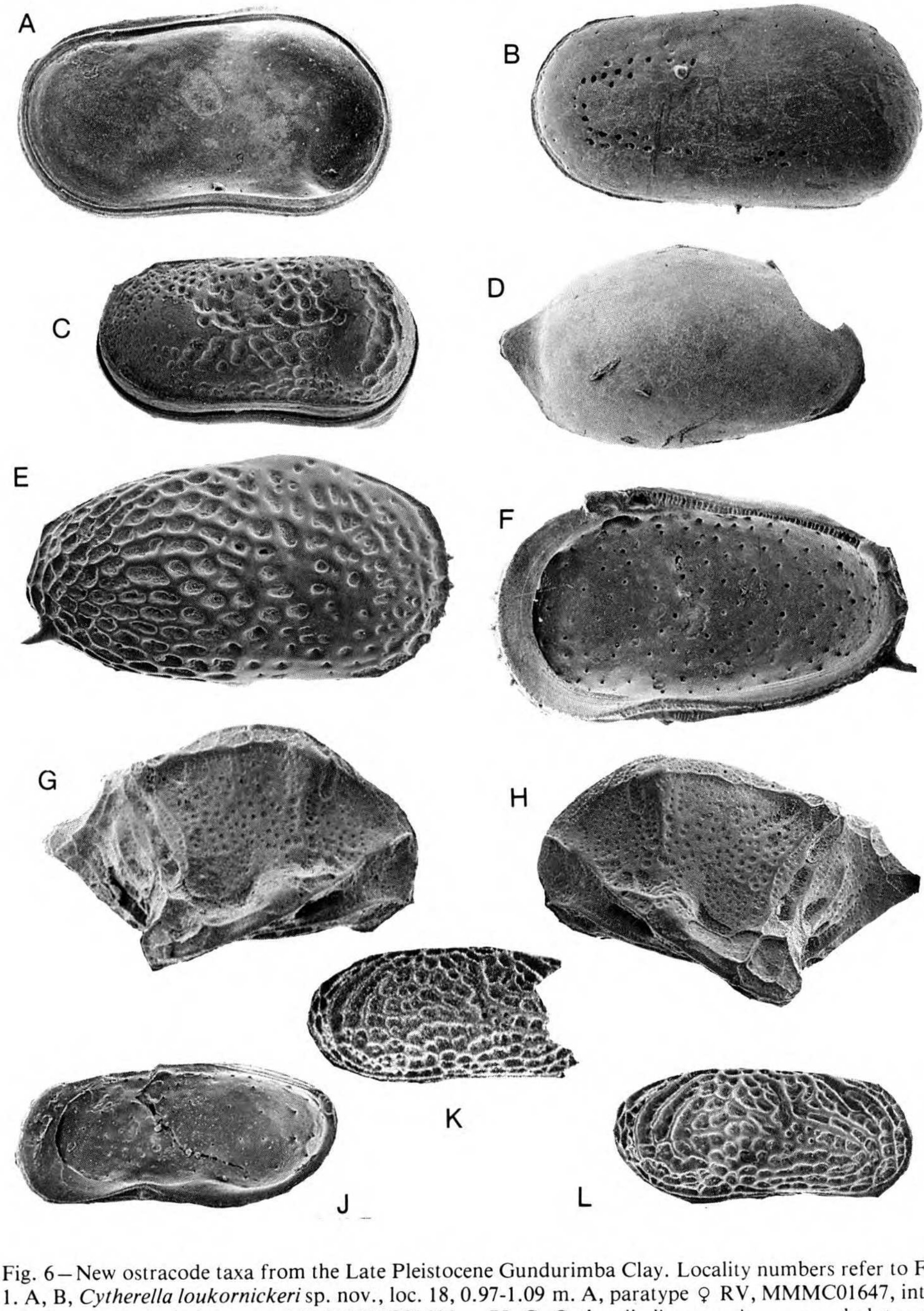

Fig. 6 – New ostracode taxa from the Late Pleistocene Gundurimba Clay. Locality numbers refer to Fig. 1. A, B, *Cytherella loukornickeri* sp. nov., loc. 18, 0.97-1.09 m. A, paratype ♀ RV, MMMC01647, internal view, ×75. B, holotype ♀ LV, MMMC01646, ×75. C, *Cytherella lismorensis* sp. nov., holotype ♂ carapace, loc. 4, 13-14 m, MMMC01648, ×75. D, *Paradoxostoma evansheadensis* sp. nov., holotype ♀ RV, loc. 18, 0.36-0.55 m, MMMC01713, ×75. Specimen slightly damaged prior to re-photography. E, F, *Keijella jankeiji* sp. nov., holotype ♀ RV, loc. 18, 0.91-1.09 m, MMMC01707. E, external view, ×75. F, internal view, ×75. G, H, *Oculocytheropteron raybatei* sp. nov., loc. 18, 0.36-0.55 m. G, holotype ♀ RV, MMMC01686, ×100. H, paratype ♀ LV, MMMC01685, ×100. J-L, *Tanella gracilis minor* subsp. nov., loc. 17, 14-15.5 m. J, internal view of paratype ♂ RV, MMMC01681, ×100. K, paratype ♀ RV, broken, MMMC01680, ×100. L, holotype ♀ RV, MMMC01683, ×100.

anterior patch lying below the eye spot) with the remainder of each valve fuscous; greatest height medial and over half the length (in females). In dorsal view regularly and broadly elliptical, pointed at both ends (more prominently in the rear—an effect of the cauda); greatest breadth medial, about the same as or slightly greater than the height. Internally: the marginal duplicature is well developed and moderately broad, with prominent anterior and posterior vestibules, radial pore canals rather few, short and straight, including 2 into the cauda; normal pore canals simple, rimmed; central muscle scar comprising a subvertical series of 4 adductors but no frontal scar (generic character); hinge adont, consisting of a ridge in the RV and the groove in the LV. Sex dimorphism weak, males relatively more elongate than females. Soft parts unknown.

DIMENSIONS: Holotype, ♀ RV MMMC01713, length = 0.64 mm; height = 0.36 mm, breadth = 0.38 mm (after doubling the breadth of the RV).

TYPE LOCALITY: Evans Head, N.S.W. (loc. 18) 0.36-0.55 m.

OTHER LOCALITIES: The species also occurs in Evans Head samples at 0.55-0.73 m, 1.45-1.64 m and 1.64-1.82 m.

REMARKS: The patch pattern of this species is similar to that of *Paradoxostoma fuscumaculosum* Hartmann 1981 described from Heron Island, Capricorn Group, Great Barrier Reef (Hartmann 1981, pp. 126-127, figs 72-75). The shape of Hartmann's species, however, is elongate ovate and it lacks the posterodorsal cauda of *P. evansheadensis*.

REPOSITORY

All samples are housed in the collections of the Geological and Mining Museum, Sydney. Specimen numbers with the prefix MMMC refer to the microfossil register of that institution.

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APPENDIX

OSTRACODA WITH RESPECT TO DEPTHS—WRC BORES, LISMORE DISTRICT, N.S.W.

Bore No. 39101

12-13 m: *Osticythere reticulata* Hartmann 1980; '*Neomonoceratina, koenigswaldi* Keij 1954.

15-16 m: *O. reticulata*; *'N'. koenigswaldi*; *Callistocythere hartmanni* McKenzie 1967; *Keijella jankeiji* sp. nov.; *Xestoleberis cedunaensis* Hartmann 1980.

Bore No. 39135

15-16 m: *O. reticulata*; *Trachyleberis dampierensis* (Hartmann 1978).

20-21 m: *O. reticulata*; *T. dampierensis*; *K. jankeiji*.

21-22 m: *Phlyctenophora zealandica* Brady 1880; *O. reticulata*; *T. dampierensis*; *K. jankeiji*.

22-23 m: *O. reticulata*; *Callistocythere dorsotuberculata* Hartmann 1980; *T. dampierensis*; *K. jankeiji*.

Bore No. 39138

20-21 m: *Propontocypris* sp.; *Loxoconcha trita* McKenzie 1967; *O. reticulata*; *'N'. koenigswaldi*; *'Pectocythere' portjacksonensis* (McKenzie 1967); *T. dampierensis*; *K. jankeiji*.

Bore No. 39139

13-14 m: *Cytherella loukornickeri* sp. nov.; *Cytherella lismorensis* sp. nov.; *Paranesidea* cf. *attenuata* (Brady 1880); *Paracypris bradyi* McKenzie 1967; *Loxoconcha australis* Brady 1880 *minor* Hartmann 1978; *L. trita*; *Hemicytheridea reticulata* Kingma 1948; *Bishopina vangoethemi* Wouters 1981; *O. reticulata*; *Neomonoceratina mediterranea* Ruggieri 1953; *C. dorsotuberculata*; *Callistocythere keiji* Hartmann 1978; *'P.' portjacksonensis*; *T. dampierensis*; *Cletocythereis rastromarginata* (Brady 1880); *K. jankeiji*; *X. cedunaensis*; *Xestoleberis limbata* Hartmann, 1980.

Bore No. 39140

10-11 m: Nil.

11-13 m: *O. reticulata*; *K. jankeiji*.

13-15 m: *K. jankeiji*.

15-16 m: *L. trita*; *T. dampierensis*; *K. jankeiji*.

16-17 m: *C. loukornickeri*; *C. lismorensis*; *N. mediterranea*; *T. dampierensis*; *K. jankeiji*.

17-18 m: *C. loukornickeri*; *O. reticulata*; *N. mediterranea*; *K. jankeiji*.

18-19 m: *C. loukornickeri*; *N. mediterranea*; *K. jankeiji*.

19-20 m: *C. loukornickeri*; *O. reticulata*; *T. dampierensis*; *K. jankeiji*.

20-21 m: *C. loukornickeri*; *C. lismorensis*; *P.* cf. *attenuata*; *P. bradyi*; *P. zealandica*; *L. australis minor*; *L. trita*; cytherurid? sp. juv.; *O. reticulata*; *'N'. koenigswaldi*; *N. mediterranea*; *Parakrithella australis* McKenzie 1967; *C. dorsotuberculata*; *C. keiji*; *Tanella gracilis* Kingma 1948; *T. dampierensis*; *C. rastromarginata*; *K. jankeiji*; *Paracytheroma sudaustralis* (McKenzie 1978); *Machaerina* sp.; *X. cedunaensis*.

21-22 m: *C. loukornickeri*; *P. zealandica*; *Propontocypris* sp; *L. australis minor*; *L. trita*; *'N'. koenigswaldi*; *T. dampierensis*; *X. cedunaensis*.

Bore No. 39143

17-18 m: *C. keiji* (fragment).

20-21 m: *P.* cf. *attenuata*; *P. bradyi* (fragment); *B. vangoethemi*; *C. dorsotuberculata*; *Ponticythereis militaris* (Brady 1866); *T. dampierensis*.

Bore No. 39145

15-16 m: *Xestoleberis* sp.

16-17 m: *C. loukornickeri*; *K. jankeiji*; *Pseudopsammocythere* sp.

17-18 m: *C. lismorensis*; *P. zealandica*; *L. australis minor*; *L. trita*; *B. vangoethemi*; *O. reticulata*; *'N'. koenigswaldi*; *C. dorsotuberculata*; *Callistocythere purii* McKenzie 1967; *T. dampierensis*; *K. jankeiji*; *X. cedunaensis*.

19-20 m: *L. trita*; *T. dampierensis*; *K. jankeiji*.

20-21 m: *K. jankeiji*.

21-22 m: *K. jankeiji*.

22-23 m: Nil.

Bore No. 39149

19-20 m: *C. loukornickeri*; *C. lismorensis*; *P. zealandica*; *L. trita*; *H. reticulata*; *P. australis*; *T. dampierensis*; *Bradleya* sp. (juv.); *K. jankeiji*; *X. cedunaensis*.

Bore No. 39150

33.5-33.6 m: Nil.

Bore No. 39152

35.25-36 m: *C. loukornickeri*; *C. dorsotuberculata*; *K jankeiji*.

36-37 m: *L. australis minor*; *T. dampierensis*; *P sudaustralis*; *Aspidoconcha* sp.

37-38 m: Nil.

38-39 m: *C. loukornickeri*; *T. dampierensis*; *Australimoosella* sp.

Bore No. 39155

40-41.5 m: *C. loukornickeri*; *T. dampierensis*.

41.5-43 m: Nil.

63-64.5 m: Nil.

Bore No. 39157

25.5-26 m: *O. reticulata* (fragment).

26-27.5 m: Indet. fragment, possibly *Loxocythere* sp.

27.5-29 m: *O. reticulata*.

29-30.5 m: Nil.

30.5-33 m: Nil.

Bore No. 39158

29-30.5 m: *O. reticulata*; *'N'. koenigswaldi*.

35.5-37 m: *O. reticulata*; *'N'. koenigswaldi*.

37-38.5 m: *H. reticulata*.

38.5-40 m: Nil.

Bore No. 39163

3-4.5 m: *K. jankeiji*.

4.5-6 m: Nil.

Bore No. 39165

18.5-20 m: *C. dorsotuberculata*; *T. rugibrevis*.

20-21.5 m: *T. dampierensis*; *K. jankeiji*.

Lismore Ambulance Station Bore

14-15.5 m: *L. trita*; *O. reticulata*; *'N'. koenigswaldi*; *C. hartmanni*; *Tanella gracilis* Kingma 1948 *minor* subsp. nov.; *K. jankeiji*.

No Depth Indicated: *P. zealandica*; *L. trita*; *O. reticulata*; *'N'. koenigswaldi*; *K. jankeiji*; *P. sudaustralis*.

Localities Unknown

12-13 m: *O. reticulata*.

15-16 m: *O. reticulata*.

33.5-33.6 m: Nil.