

# MARINE OSTRACODA (CRUSTACEA) FROM THE LATE OLIGOCENE GELLIBRAND MARL, OTWAY BASIN, VICTORIA, AUSTRALIA

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**ABSTRACT:** A subsurface sample from Heywood-10 borehole, Otway Basin, Victoria, has provided the first ostracod assemblage of Oligocene age from the Gellibrand Marl (Heytesbury Group). Previous Gellibrand Marl ostracod assemblages were Miocene. This Late Oligocene assemblage of 384 specimens includes 50 species and subspecies from 34 genera across 18 families; 24 taxa are placed in open nomenclature. Of the taxa discussed, several appear to be new species but with too few specimens for them to be described as such. The reciprocal of Simpson's Diversity Index was applied to assist assemblage comparisons. The Gellibrand Marl assemblage is larger, contains more families, genera and taxa but is less diverse than a smaller assemblage from the Early Oligocene Narrawaturk Formation (Nirranda Group) at the same location, and more diverse than an assemblage from the Early Oligocene/Ruwarung Member, South Australia. There are notable differences in the dominant taxa present in each assemblage. In the Gellibrand Marl, Pontocyprididae predominate; in Narrawaturk Formation, Cytheruridae and Xestoliberididae are most abundant; and in the South Australian assemblage, Bairdiidae by far the most numerous. This Gellibrand Marl collection has the characteristics of an at least partly allocthanous assemblage, the habitat a well-oxygenated mid-shelf environment. No cold or deep-water taxa are present.

**Keywords:** Oligocene, Ostracoda, taxonomy, Gellibrand Marl, Narrawaturk Formation, Heytesbury Group, Otway Basin, Australia

There are few studies of Australian marine Oligocene Ostracoda. Crespin (1943) compiled a lengthy list of Oligocene–Miocene ostracods from the Gippsland area of Victoria but did not include illustrations. Not recognising their unique nature, she assigned most to Recent taxa. McKenzie (1974) undertook a wide-ranging study of Victorian Cenozoic ostracod assemblages, making comparisons primarily at the family level. He erected one new genus, *Hanaiceratina*, and described several new species; many other new taxa were placed in open nomenclature. McKenzie (1974) sampled strata that included the Oligocene Jan Juc Marl, Upper Glen Aire Clays

and Calder River Limestone (Late Oligocene: Holdgate & Gallagher 2003). He was the first to comprehensively use the recently developed SEM techniques for illustrating Ostracoda from the region. McKenzie (1979a) examined borehole samples from the Willunga Embayment of South Australia and compiled a list of Eocene to Miocene taxa in open nomenclature. McKenzie and Warne (1986) erected a new ostracod genus, *Alataleberis*, embracing southern Australian Eocene to Oligocene taxa. McKenzie et al. (1991) was a major contribution to ostracod taxonomy for the southern Australian region; it included Late Oligocene strata from Bells Headland, Victoria, and incorporated taxa

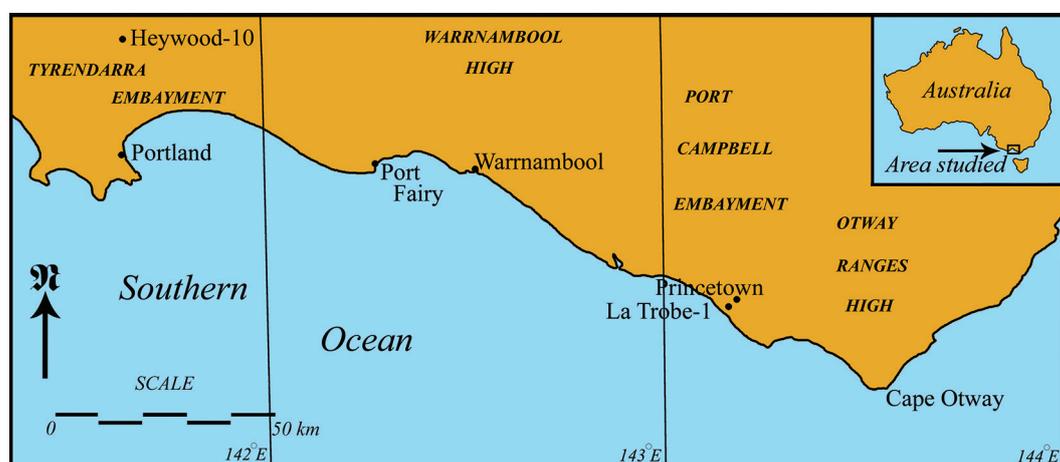


Figure 1: Location of the Heywood-10 bore, Otway Basin, Victoria, Australia (after Wopfner & Douglas 1971).

from his earlier Willunga Embayment report (McKenzie 1979a). Neil (1995) published a comparative analysis at genus level of Oligocene to Miocene assemblages from 13 southern Australian localities, two of which were Oligocene. The Eocene–Oligocene boundary was the focus of three ostracod studies: McKenzie and Guha (1987) and Majoran (1996b, 1997). McKenzie and Guha (1987) compared South Australian and Indian assemblages, largely at the family level.

The availability of a single Heywood-10 bore sample from the Late Oligocene section of the Gellibrand Marl has provided the first ostracod assemblage of that age from the unit. McKenzie et al. (1991) and Neil (1995) are Miocene Gellibrand Marl assemblages. The only subsurface Oligocene ostracod assemblage from southern Australia is that of McKenzie (1979a) from the Port Willunga Formation, Willunga Embayment, South Australia.

Heywood-10 bore is located in the coastal region of southern Victoria, 15 km inland, approximately two kilometres southwest of the town of Heywood (Figure 1). This government bore, sunk for groundwater exploration in 1960, bottomed at 1643.0 m.

#### GEOLOGICAL SETTING

The Heywood-10 bore (Figure 1) lies within the Victorian Otway Basin, one of a series of basins in southern Australia formed during Gondwana rifting (Krassay et al. 2004). The basin is east–west trending, approximately 500 km long, extends laterally both onshore and offshore, and contains thick Mesozoic and Cenozoic strata (Wopfner & Douglas 1971; Abele et al. 1976; Holdgate & Gallagher 2003).

The principal Cenozoic sedimentary units intercepted in the Heywood-10 bore (Table 1) are: Port Campbell Limestone and Gellibrand Marl, both within the Heytesbury Group, and the Narrawaturk Formation/Nirranda Group (Gallagher & Holdgate 2000; Holdgate & Gallagher 2003). The Late Oligocene–Early Miocene Gellibrand Marl,

consisting largely of grey marl (Gallagher & Holdgate 2000; Holdgate & Gallagher 2003) was deposited in a neritic marine environment during a transgressive phase (Bock & Glenie 1965). The foraminiferal content indicates a low energy environment (Holdgate & Gallagher 2003). The sampled section of the Narrawaturk Formation in Heywood-10 is from the upper part of the unit and has a high carbonate content with mudstone grading into marl and marly mudstone, ferruginous sandstone, and sandy limestone. Faunal assemblages indicate an inner shelf environment for the Narrawaturk Formation at this northern location (Holdgate & Gallagher 2003).

#### METHODOLOGY

Eight Heywood-10 residues and slides collected and processed for foraminiferal studies by Taylor (1964) were rewashed, separated by sieving into coarse (>1.4 mm), medium (0.3–1.4 mm), fine (<0.3 mm) fractions, and picked. Residues varied between 35 and 80 g; eight contained ostracods. One of the five samples from the Gellibrand Marl (sample AG at depth 335.28 m; 54.65 g) was Oligocene (Table 1).

Picking was carried out under an Olympus VMT stereoscopic incident light microscope. Specimens selected for SEM imaging were mounted on carbon stubs, gold coated and photographed using a model JEOL JSM 648 OLA scanning electron microscope, and images edited in Photoshop.

Sulphides occurring in the stored Victorian core sediments have resulted in loss of calcitic microfossils (Taylor 1965; Eglington 2006). As the residues used in this study were sampled and washed very soon after bore completion, it is possible that this assemblage contains the only surviving Gellibrand Marl Oligocene ostracod specimens from these old onshore Otway Basin boreholes.

Table 1: Heywood-10 bore, Otway Basin, southern Victoria, Oligocene to Miocene stratigraphy, biostratigraphy and positions of samples AG and AH, (GEDIS; Chaponiere et al. 1996).

Stratigraphic unit	Age	Biostratigraphy	Sample/Depth
Heytesbury Group			
Port Campbell Limestone	Middle Miocene	<i>Orbulina suturalis</i>	58.21 m
Port Campbell Limestone	Middle Miocene	<i>Globigerinoides sicanus</i>	122.83 m
Gellibrand Marl	Early Miocene	<i>Globoquadrina dehiscens</i>	260.60 m
Gellibrand Marl	Early Miocene	<i>Globoquadrina dehiscens</i>	300.53 m
<b>Gellibrand Marl</b>	<b>Late Oligocene</b>	<b><i>Globigerina euapertura</i></b>	<b>AG: 335.28 m</b>
Nirranda Group			
<b>Narrawaturk Formation</b>	<b>Early Oligocene</b>	<b><i>Globigerina labiacrassata</i></b>	<b>AH: 371.85 m</b>

## RESULTS AND DISCUSSION

*Composition of the ostracod assemblage*

Three hundred and eighty-four specimens were picked from sample AG. Adult carapaces outnumber valves (217:32), juveniles are not abundant, and the great majority of these are carapaces (59 carapaces, 3 valves). The remaining specimens are identifiable fragments and are included in the tally. The 384 specimens are from 18 families, 34 genera and 50 species and subspecies (Figure 2; Table 2); 84% of the species/subspecies contain ten or fewer specimens; of these 20 (40% of total) are represented by single specimens (Table 2). The most prolific species is *Maddocksella tarparriensis* (79 specimens; 20.6%) making Pontocyprididae the most abundant family. Cytheruridae is the most diverse family at both genus and species levels (six genera, nine taxa).

Of the 59 juvenile carapaces, 50 are smooth, thick-walled *Maddocksella* spp. that are more able to survive transportation than fragile taxa. Considering the abundance of carapaces and scarcity of valves, this assemblage is presumed to be, at least in part, allochthonous, the warmer, shallower-water taxa possibly transported downslope.

Single or low numbers of specimens made assessment of intraspecific variation problematic, or precluded creation of new species, therefore 24 taxa are in open nomenclature. Of these, 9 are similar to described species, but possess sufficient morphological variation to leave some uncertainty as to precise species attribution, while 13 are identified to genus level. Table 2 lists the composition of the ostracod assemblage.

*Comparison with other assemblages*

A single Narrawaturk Formation sample, also from Heywood-10 at 371.85 m (sample AH, Table 1) has yielded an Early Oligocene ostracod assemblage consisting of 239

specimens from 11 families, 21 genera and 33 taxa (paper in preparation). Comparing the Gellibrand Marl and this Narrawaturk Formation assemblage, the former is 37.7% larger, has more families (18:11), genera (34:21) and species (50:33), and fewer phytal associates.

To compare the overall diversity of the two assemblages, the reciprocal of Simpson's Diversity Index (1/D) was applied:

$$D = \sum \frac{n(n-1)}{N(N-1)}$$

where D = Simpson's Diversity Index, 1/D = reciprocal, n = total number of organisms of a particular taxon, and N = total number of organisms of all species. The higher the value the greater the diversity. When this formula is applied at family, genus and species levels, the Gellibrand Marl assemblage (AG) is demonstrated to be less diverse than the smaller Narrawaturk Formation (AH) (family level = 5.71:6.28; genus level = 8.33:11.48; species level = 12.24:14.87).

The two Heywood-10 assemblages were compared at genus level to sample R4 of Majoran (1996a) from the South Australian Early Oligocene, Port Willunga Formation/Ruwarung Member. The Port Willunga Formation/Ruwarung Member assemblage (R4) was less diverse than either of the Victorian (R4 = 8.2; AG = 8.33; AH = 11.48).

Comparing the three assemblages at family level: in Gellibrand Marl, Pontocyprididae are most abundant (33.6%), with Cytheruridae next (13.8%); Narrawaturk Formation has both Cytheruridae (22.6%) and Xestoliberididae (22.2%) most abundant with Pontocyprididae next (18.8%); and in the South Australian assemblage, Bairdiidae are by far the most numerous (31.3%) with Cytherellidae second (9.6%).

*Palaeoenvironmental interpretation*

In the Early Oligocene, the Heywood-10 bore location was shallow marine, about five kilometres from the shore (Taylor 1971a, 1971b). The Narrawaturk Formation assemblage is consistent with an inner shelf environment, as the phytal associates *Uroleberis* and *Xestoleberis* account for 22.2% of the specimens (Neil 1995) and deeper water taxa are absent (van Morkhoven 1963; McKenzie 1974; Gebhardt & Zorn 2008; Eglington paper in preparation).

The environment of the Gellibrand Marl assemblage was also offshore (presence of Bythocyprididae). The diversity of the assemblage is indicative of a well-oxygenated benthos. The smaller percentage of phytal associates (*Loxoconcha*, *Uroleberis* and *Xestoleberis* = 1.8%) and Hemicytheridae (*Neobuntonia* 10.4%) plus the appearance of Krithiidae (*Krithe postcircularis*) suggest

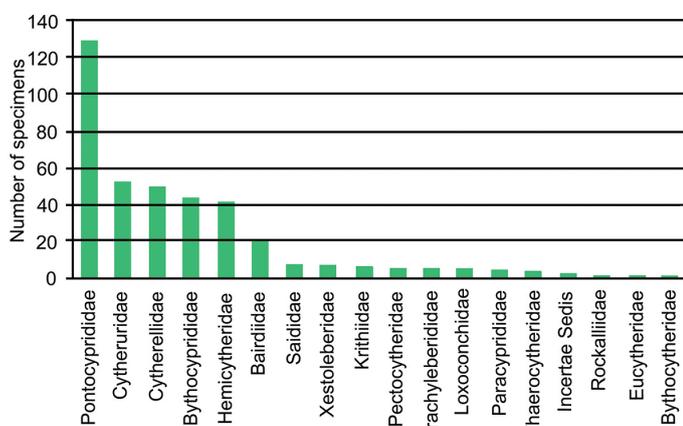


Figure 2: Abundance in families, Gellibrand Marl, Heywood-10 bore, Otway Basin, Victoria, Australia.

Table 2: Composition of the ostracod assemblage.

Cytherellidae	<i>Cytherella</i> sp. aff. <i>C. atypica</i> Bate, 1972	9
	<i>Cytherella</i> sp. aff. <i>C. paranitida</i> Whatley & Downing, 1983	7
	<i>Cytherella</i> sp.	3
	<i>Platella parapunctata</i> (Whatley & Downing, 1983)	7
	<i>Cytherelloidea marginopytta</i> McKenzie et al., 1991	1
	<i>Cytherelloidea jugifera</i> McKenzie et al., 1991	3
	<i>Cytherelloidea intermedia</i> (Chapman et al., 1928)	8
	<i>Geelongella antyx</i> McKenzie et al., 1991	12
Bairdiidae	<i>Paranesidea?</i> sp.	20
Bythocyprididae	<i>Bythocypris sudaustralis</i> McKenzie et al., 1991	43
	<i>Orlovibairdia</i> sp.	1
Sigillidae	<i>Cardobairdia?</i> sp.	1
Paracyprididae	<i>Paracypris</i> sp. aff. <i>P. bradyi</i> McKenzie, 1967	1
	<i>Paracypris</i> sp.	1
	<i>Tasmanocypris?</i> sp.	2
Pontocyprididae	<i>Propontocypris?</i> sp.	2
	<i>Argilloecia mesa</i> McKenzie et al., 1993	14
	<i>Argilloecia</i> sp. aff. <i>A. allungata</i> McKenzie et al., 1993	4
	<i>Maddocksella tarparriensis</i> McKenzie et al., 1993	79
	<i>Maddocksella</i> sp/spp.	30
Saididae	<i>Saida</i> sp. aff. <i>S. daisa</i> McKenzie et al., 1993	7
Bythocytheridae	<i>Sclerochilus</i> sp.	1
Krithiidae	<i>Krithe postcircularis</i> McKenzie et al., 1993	6
Eucytheridae	<i>Pseudeucythere pseudosubovalis</i> (Whatley & Downing, 1983)	1
Loxoconchidae	<i>Loxoconcha macgowrani</i> McKenzie et al., 1991	2
	<i>Loxoconcha punctabella</i> McKenzie et al., 1991	3
Xestoleberididae	<i>Uroleberis minutissima</i> (Chapman, 1926)	6
	<i>Xestoleberis noccia</i> McKenzie et al., 1993	1
Pectocytheridae	<i>Ruggieriella</i> sp.	1
	<i>Munseyella adaluma</i> McKenzie et al., 1993	1
	<i>Munseyella splendida</i> Whatley & Downing, 1983	3
Rockalliidae	<i>Rockallia</i> sp.	1
Cytheruridae	Cytherurinae	
	<i>Kangarina wareelacogorra</i> McKenzie et al., 1993	2
	<i>Eucytherura cameloides</i> McKenzie et al., 1993	10
	<i>Eucytherura horrida</i> McKenzie et al., 1993	20
	<i>Hemiparacytheridea</i> sp.	1
	Cytheropteroninae	
	<i>Cytheropteron</i> sp. aff. <i>C. ruwarungensis</i> Majoran, 1997	1
	<i>Oculocytheropteron</i> sp. aff. <i>O. ayressi</i> Majoran, 1997	4
<i>Oculocytheropteron microformix</i> Whatley & Downing, 1983	7	
<i>Aversoalva yaringa yaringa</i> McKenzie et al., 1993	7	
<i>Aversoalva yaringa minor</i> McKenzie et al., 1993	1	
Hemicytheridae	<i>Neobuntonia airella</i> McKenzie et al., 1991	40
Trachyleberididae	<i>Acanthocythereis?</i> sp.	1
	<i>Cythereis brevicosta major</i> (McKenzie et al., 1991)	1
	<i>Cythereis</i> sp. aff. <i>C. thomsoni</i> (Hornibrook, 1952)	1
	<i>Cletocythereis taroona</i> McKenzie et al., 1993	2
Thaerocytheridae	<i>Bradleya</i> sp. cf. <i>B. regularis</i> McKenzie et al., 1991	2
	<i>Bradleya (Quasibradleya) momitea</i> McKenzie et al., 1993	1
Incertae Sedis	Indet. spp. 1, 2	2
<b>Total</b>		<b>384</b>

that there had been a moderate increase in water depth compared to the Early Oligocene Narrawaturk Formation at this same site. Shallower-water families found down section in the Narrawaturk Formation are still very evident (AH: Bairdiidae and Xestoleberididae = 28.9%; AG: Hemicytheridae, Bairdiidae, Xestoleberididae, Loxoconchidae = 18.75%), and there is an absence of any truly deep- or cold-water taxa. Based on Foraminifera, Taylor (1971a) interpreted the Late Oligocene Heywood-10 location to be an open marine environment approximately 16 km seaward of the coast. Absence of colder, deeper-water taxa indicate that it was probably mid-shelf (M. Ayress pers. comm. 2014), part of a wide shelf in this northern region of the Australo-Antarctic Gulf. With adult carapaces outnumbering valves (217:32), and the few juveniles being mostly carapaces, this assemblage is presumed to be at least partially allochthonous, with shallower-water taxa possibly transported downslope.

#### SYSTEMATIC PALAEOONTOLOGY

The following taxa from the assemblage have been illustrated but not discussed; all are listed in Table 2: *Cytherelloidea jugifera* McKenzie et al. 1991 (Figure 3L), *Pseudeucythere pseudosubovalis* (Whatley & Downing 1983) (Figure 5M), *Loxoconcha macgowrani* McKenzie et al. 1991 (Figs 4A, B), *Kangarina wareelacogorra* McKenzie et al. 1993 (Figure 4K), *Eucytherura cameloides* McKenzie et al. 1993 (Figures 4L, Q), *Eucytherura horrida* McKenzie et al. 1993 (Figures 4O, R). *Hemiparacytheridea* sp. (Figures 4M, N, P), *Munseyella splendida* Whatley & Downing 1983 (Figs 4F, I), *Munseyella adaluma* McKenzie et al. 1993 (Figures 4G, H), *Oculocytheropteron* sp. aff. *O. ayressi* Majoran 1997 (Figures 5E, F, H), *Oculocytheropteron microformix* Whatley & Downing 1983 (Figs 5A–C), *Aversovalva yaringa yaringa* McKenzie et al. 1993 (Figures 5G, I–K), and *Bradleya (Quasibradleya) momitea* McKenzie et al. 1993 (Figure 6A). *Cythereis brevicosta major* (McKenzie et al. 1991) (Figure 6C) and *Cythereis* sp. aff. *C. thomsoni* (Hornibrook 1952) (Figures 6D, E) are mentioned in a discussion on the genera *Trachyleberis* and *Cythereis*. Only taxa with features requiring discussion have been included in the systematic palaeontology section.

The following conventions and abbreviations are used: approx. approximately; > greater than; C articulated carapace; LV left valve; RV right valve; F female; M male; juv. juvenile; A adult; A-1 final stage instar; int. internal; ext. external; CMS central muscle scars; MPC marginal pore canals; NPC normal pore canals, SEM scanning electron microscope.

Class OSTRACODA Latrielle, 1802  
Order PODOCOPIDA Müller, 1894  
Suborder PLATYCOPA Sars, 1866  
Family CYTHERELLIDAE Sars, 1866

*Cytherella* Jones, 1849

*Cytherella* sp. aff. *C. atypica* Bate, 1972  
(Figures 3F, G)

*Remarks.* Smooth, ovate *Cytherella* with a very narrow, flattened marginal rim and LV>RV. Females in dorsal view are somewhat wedge-shaped rather than ovate as in *C. atypica* Bate (1972); the latter lacks the flattened marginal rim.

*Measurements.* Adults: length 0.85–0.89 mm, height 0.52–0.58 mm, breadth 0.3–0.33 mm.

*Material studied.* Nine specimens including adults, juveniles and valve fragments.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

*Cytherella* aff. *C. paranitida* Whatley & Downing, 1983  
(Figures 3C–E)

*Description.* Moderately large *Cytherella*, subrectangular in lateral view with subparallel dorsal and ventral margins, convex anterior and posterior margins, and concave dorsal and ventral margins. The marginal rim has a narrow, flattened zone inside the edge of the margin that is widest from the antero-dorsal to antero-ventral areas. Lateral surface smooth, slightly depressed medially, coinciding with the CMS. Right valve overlaps left. There are numerous small punctae on the posterior surface and fine reticulation on the marginal rim. This latter feature is particularly well developed along the anterior margin.

*Remarks.* *Cytherella* aff. *C. paranitida* has a concave dorsum compared to the sinuous convex dorsum of *Cytherella paranitida* Whatley & Downing (1983). The size is comparable to Neil (2006) specimens and it displays the anterior and posterior marginal reticulation described by him.

*Measurements.* FC: length 0.80 mm, height 0.46 mm.

*Material studied.* Five carapaces, two valves, both sexes represented.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

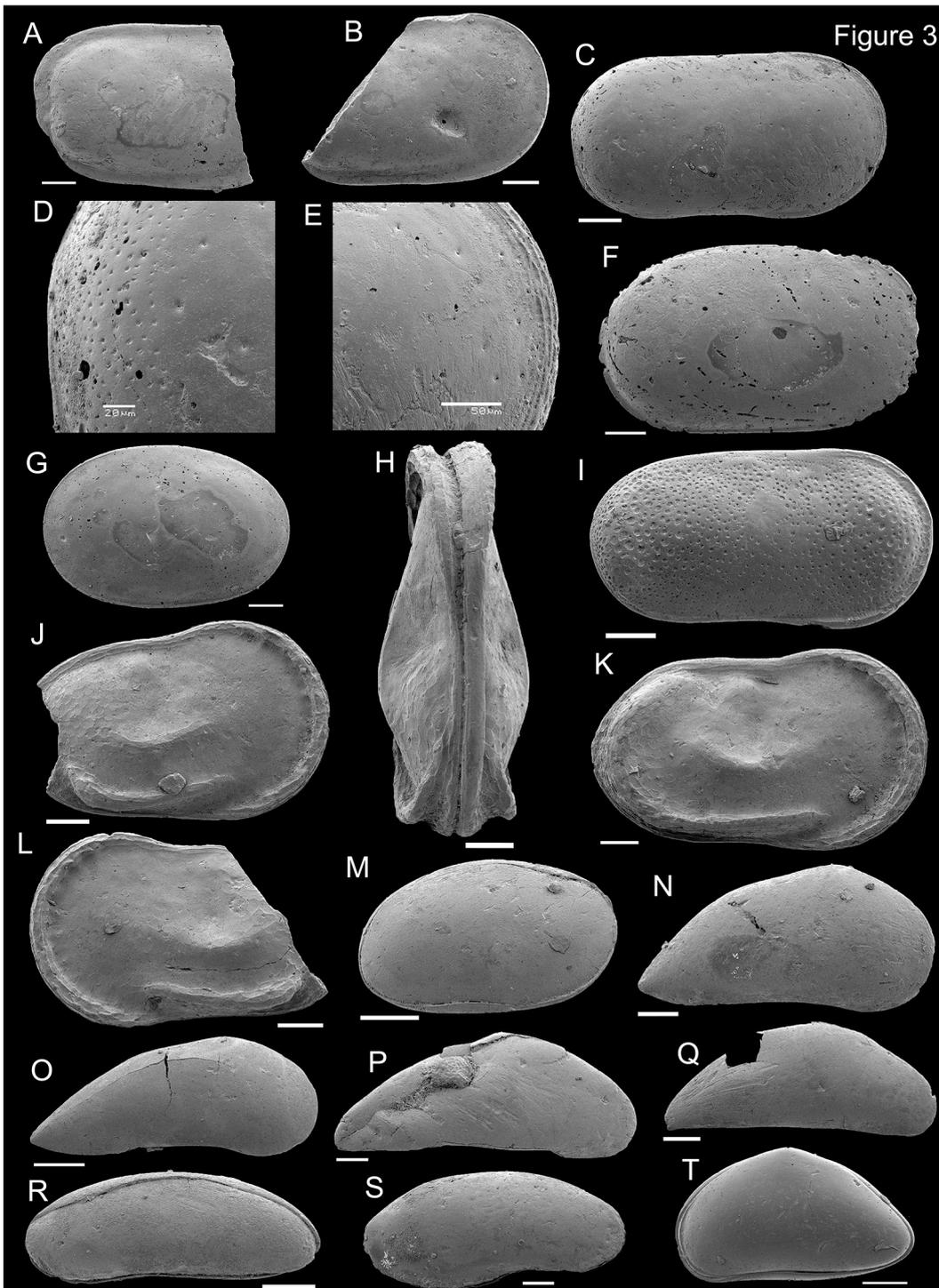


Figure 3: **A, B.** *Cytherella* sp. **A.** FRV. **B.** FRV. **C–E.** *Cytherella* sp. aff. *C. paranitida* Whatley & Downing, 1983, FCRV. **C.** FCRV. **D.** Detail posterior surface. **E.** Detail anterior surface. **F, G.** *Cytherella* sp. aff. *C. atypica* Bate, 1972. **F.** FRV. **G.** MLV. **H.** *Cytherelloidea intermedia* (Chapman et al., 1928), MC dorsal. **I.** *Platella parapunctata* (Whatley & Downing, 1983), CFRV. **J.** *Cytherelloidea jugifera* McKenzie et al., 1991, RV. **K.** *Cytherelloidea intermedia* (Chapman et al., 1928), FRV. **L.** *Cytherelloidea jugifera* McKenzie et al., 1991, LV. **M.** *Cardobairdia?* sp. CRV. **N.** *Paracypris* sp. CRV. **O.** *Paracypris* sp. aff. *P. bradyi*, McKenzie 1967, CRV. **P, Q.** *Tasmanocypris?* sp. CRVs. **R.** *Argilloecia* sp. aff. *A. allungata* McKenzie et al. 1993, CLV. **S.** *Sclerochilus* sp. **T.** *Propontocypris?* sp. CLV. **Scale bars:** 100  $\mu$ , A–C, F–M, O–R, T; 50  $\mu$ , E, N, S; 20  $\mu$ , D.

***Cytherella* sp.**

(Figures 3A, B)

*Description.* A moderately large *Cytherella*, subrectangular in lateral view with anterior outline evenly convex, dorsal and ventral margins parallel, and the postero-dorsal margin descending vertically to the mid-posterior margin then angling forward to meet the postero-ventral section. Maximum height anterior of median; maximum length just above the median. Twin brood chambers are very evident. These three right valves all display a continuous, broad, flattened area or rim around the entire margin. Surface smooth with no evidence of micropunctae. The CMS appear to be of regular pinnate form. Internally, these RVs display the hinge and valve margin structure characteristic of the larger overlapping valve.

*Remarks.* The subrectangular outline is similar to that of *Cytherella* sp. Eglington (2006), but the latter is smaller and lacks the continuous flattened marginal rim. The subrectangular shape is also reminiscent of *Cytherella parantida* Whatley & Downing (1983) but there is no evidence of micropunctae. The presence of twin brood chambers is unusual, this being regarded as a feature of *Cytherelloidea* not *Cytherella* (van Morkhoven 1963). However, variation from the single brood chamber per valve mode in *Cytherella* is known; Brandão (2008) has described the living cytherellid *Cytherella rwhatleyi* Brandão, 2008 from the Antarctic region of the Southern Ocean as possessing three brood chambers per valve to accommodate a total of up to six eggs.

*Measurements.* RVFs: length approx. 0.82 mm, height 0.5–0.53 mm.

*Material studied.* Three damaged adult right valves, (two identified as female).

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

***Cytherelloidea* Alexander, 1929**

***Cytherelloidea intermedia* (Chapman et al., 1928)**

(Figures 3H, K)

*Cytherella intermedia* Chapman et al., 1928: 129, 130, figs 69a, b.

*Cytherelloidea intermedia.* – Crespin, 1943: 100. – McKenzie 1974: 166, pl. 1.2. – Whatley & Downing 1983: 386, pl. 8 figs 12–15.

*Description.* A moderately large *Cytherelloidea*, subrectangular in lateral view with anterior margin evenly convex, dorsal and ventral margins inflexed, and postero-dorsal margin broadly angled medially. Two broad ribs: one small, curved rib mid-valve below the CMS depression;

the other rib close to the margin and extending from the postero-dorsal angle to the ventral margin. Sulcus deep and wide, inside of margin giving a bulging appearance to the broad marginal zone. Maximum height anterior of median; maximum length medial. Fine reticulation visible on marginal protrusions.

*Remarks.* *Cytherelloidea intermedia* (Chapman, 1928) has previously been reported from Middle Miocene (Balcumbian) strata of southern Victorian (Chapman et al. 1928; McKenzie 1974; Whatley & Downing 1983). This occurrence extends the range of the species back to the Oligocene. The specimens are larger than the Miocene material and less wide, with anterior marginal zone narrower, thinner and protruding, but in all other respects comparable. The author has obtained specimens of *Cytherella intermedia* from the Fishing Point Marl, a unit outcropping at Castle Cove that is equivalent to the lower Gellibrand Marl (Holdgate & Gallagher 2003) that are the same size as these adult female valves. The form identified as *Cytherelloidea* cf. *intermedia* McKenzie et al. (1991) in the author's opinion is *C. jugifera* McKenzie et al., (1991).

*Measurements.* FRVs: length approx. 0.89–0.92 mm, height 0.55–0.58 mm. MC: length approx. 0.88 mm, height 0.52 mm, breadth 0.36 mm.

*Material studied.* Eight specimens including adult and juvenile carapaces.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

***Cytherelloidea marginopytta* McKenzie et al., 1991**

(Figures 6G, H)

*Cytherelloidea* sp. McKenzie, 1979: 93, 94, pl. 1.6.

*Cytherelloidea marginopytta* McKenzie et al., 1991: 140, pls 2.1, 10.2, 3. — McKenzie et al. 1993: 79, 142, pl. 1.10. — Neil 1997: 170, figs 4A, B.

*Remarks.* This extremely ornate *Cytherelloidea* displays four orders of ornament; the coarsest is a pair of broad, well defined ridges, the ventral ridge, running from the lowermost brood pouch, swells to the antero-ventral area. The ridge from the uppermost brood pouch to the anterior incorporates the deep CMS depression. Much of the surface, including the ridges and marginal areas, has a reticulate system of low, sharp murae. On the sides of the ridges and in the depressions of this network are broad, deep punctae that give the species its distinctive, pitted appearance. Micropunctae are superimposed densely over the entire surface not occupied by the coarse punctae.

*Measurements.* FC: length 0.80 mm, height 0.45 mm.

*Material studied.* One adult female carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

*Platella* Coryell & Fields, 1937

*Platella parapunctata* (Whatley & Downing, 1983)

(Figure 3I)

*Cytherella parapunctata* Whatley & Downing, 1983: 386, pl. 8 figs 9–11.

*Platella* sp. McKenzie et al., 1993: 78, pl. 1.6.

*Remarks.* Though the punctae in the central area of the figured male carapace are smaller than those illustrated by Whatley & Downing (1983) and McKenzie et al. (1993), the configuration is similar. The punctae on these female carapaces are coarser.

*Measurements.* FCs: length 0.78–0.80 mm, height 0.41–0.42 mm. MCRV: length 0.72 mm, height 0.4 mm.

*Material studied.* Seven specimens, both sexes represented.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Suborder PODOCOPA Sars, 1866

Family BYTHOCYPRIDIDAE Maddocks, 1969

*Orlovibairdia* McKenzie, 1978

*Orlovibairdia* sp.

(Figure 5P)

*Description.* A single, elongate, adult carapace with fine punctae covering the surface; antero-ventral and postero-ventral margins bear spines; dorsal margin hemi-hexagonal in lateral view; ventral margin inflexed.

*Remarks.* *Orlovibairdia* sp. has similar punctate ornament to McKenzie's (1974) *Bairdia* aff. *angulata* but in the present specimen the ornament is less developed; posterior marginal denticles do not extend above the caudal process; postero-dorsal margin is concave not convex; antero-dorsal margin is longer, descending from the dorsum at a steeper angle and meeting the anterior margin much lower down. *Orlovibairdia mooraboolensis* Warne (1990) has a smoothly convex dorsal margin. *Orlovibairdia* sp. McKenzie et al. (1991) is larger, higher and the postero-dorsal margin descends more steeply than in this species. *Orlovibairdia?* sp. McKenzie et al. (1991) has much larger marginal denticulation. *Orlovibairdia* sp. McKenzie et al. (1993) is of similar size but is less inflexed ventrally, does not possess an upturned caudal process, has minimal marginal denticulation, and does not appear to have surface punctae. *Orlovibairdia* cf. *arcaforma* Swanson (Yassini & Jones 1995) has a straighter dorsal margin, larger punctae and more robust marginal denticulation.

*Measurements.* Adult C: length 0.55 mm, height 0.3 mm.

*Material studied.* Single adult carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family SIGILLIDAE Mandelstam, 1960

*Cardobairdia* van den Bold, 1960

*Cardobairdia?* sp.

(Figure 3M)

*Description.* A smooth carapace, ovate in lateral and dorsal views, with left valve overlapping right around the entire margin; caudal spine lacking. No CMS or other internal features observable.

*Remarks.* This single specimen is similar in shape, but larger than, *Cardobairdia* sp. McKenzie et al. (1993).

*Measurements.* C: length 0.48 mm, height 0.3 mm, breadth 0.21 mm.

*Material studied.* One carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family PARACYPRIDIDAE Sars, 1923

*Paracypris* Sars, 1866

*Paracypris* sp. aff. *P. bradyi* McKenzie, 1967

(Figure 3O)

*Description.* Smooth, elongate, subtriangular *Paracypris* with rounded anterior margin ascending to maximum height antero-dorsally, descending in a broad curve to the postero-dorsal area then in an almost straight line to the subacuminate posterior. Ventral margin inflexed.

*Remarks.* *Paracypris* sp. aff. *P. bradyi* is smaller and less elongate than *P. bradyi* McKenzie (1967) when compared to the original illustration, though when compared to *P. bradyi* (Yassini & Jones 1995), similarity in shape is more evident. This species lacks the dorsal outline angularity of *Paracypris* sp. Eglinton (2006).

*Measurements.* C: length 0.6 mm, height 0.26 mm.

*Material studied.* One carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

*Paracypris* sp.

(Figure 3N)

*Paracypris* sp. Eglinton, 2006: 97, figs 3E, F.

*Description.* Smooth, subtriangular *Paracypris* with

straight dorsum descending towards anterior and posterior. The antero-dorsal, mid-dorsal and postero-dorsal margins are each one-third of the length. Anterior margin rounded, ventral margin weakly inflexed, posterior margin subacuminate. Maximum height at a position approximately one-third of distance from anterior. Because of its thin shell and no vestibules visible through the translucent valves, the specimen is assumed to be juvenile.

*Remarks.* Based on the overall shape, this appears to be the same species as *Paracypris* sp. Eglington (2006) of the Late Paleocene?–Early Eocene for which there was only one broken adult valve. *Paracypris bradyi* McKenzie (1967) has its maximum height farther forward, ventrum more strongly inflexed, and the angled descent of the dorsum to the posterior is farther back. Late Eocene *Paracypris eocuneata* (Hornibrook 1952 in Ayress 1995) from New Zealand has a similar dorsal margin divided into three virtually straight sections, but the posterior section is much more extended, forming a more acutely angled posterior termination than in *Paracypris* sp.

*Measurements.* C: juv: length 0.39 mm, height 0.18 mm.  
 C: juv: length 0.47 mm, height 0.23 mm.

*Material studied.* One juvenile carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

*Tasmanocypris* McKenzie, 1979b

*Tasmanocypris?* sp./spp.

(Figures 3P, Q)

*Description.* Smooth, subtriangular paracypridids with maximum height at the median.

*Remarks.* The two carapaces may be the same species but the larger is deformed by crushing. It is not clear if the smaller is juvenile. They are similar to *Tasmanocypris? latrobensis* Eglington (2006) but with a smaller height proportional to length.

*Measurements.* C: length 1.01 mm, height 0.41 mm. C: length 0.8 mm, height 0.32 mm.

*Material studied.* Two carapaces.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family PONTOCYPRIDIDAE Müller, 1894

*Propontocypris* Sylvester-Bradley, 1948

*Propontocypris?* sp.

(Figure 3T)

*Description.* Relatively small, smooth carapaces,

subtriangular in lateral view, moderately compressed laterally, arched dorsum with maximum height slightly anterior of median; ventrum with rounded anterior and posterior, slightly inflexed. Maximum length below the median; maximum breadth anterior of the median.

*Measurements.* C: length 0.57 mm, height 0.33 mm, breadth 0.19 mm.

*Material studied.* Two carapaces, both presumed juveniles.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

*Argilloecia* Sars, 1866

*Argilloecia* sp. aff. *A. allungata* McKenzie et al., 1993 (Figure 3R)

*Argilloecia allungata* McKenzie et al., 1993: 82, 83, pl. 1.18, 19.

*Remarks.* *Argilloecia* sp. aff. *A. allungata* displays a more incurved ventral margin medially than is seen in *A. allungata* McKenzie et al. (1993) but to a lesser degree than in specimens from the older Narrawaturk Formation (paper in preparation).

*Measurements.* Length 0.52–0.58 mm, height 0.20–0.22 mm.

*Material studied.* Four carapaces.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family SAIDIDAE Aranki et al., 1992

The genus *Saida* Hornibrook (1952) was assigned to *incertae sedis* by its author and subsequent workers (Benson et al. 1961; Swanson 1969) until tentatively positioned in the family Cytheruridae?, subfamily Cytherurinae by Gründel (1969). McKenzie (1974) was the first to suggest tentative placing of the genus in the Cytherinae (Family Cytheridae Baird, 1850); this was supported by later studies (Neale 1975; Whatley & Downing 1983; McKenzie et al. 1991, 1993). Aranki et al. (1992) created the monotypic subfamily Saidinae and added much needed detail to the description of the type genus, *Saida* Hornibrook (1952). The subfamily was raised to family status by Wouters (2007) and its taxonomic position discussed, assisted by the addition of a new Cretaceous–Recent genus, *Saidella* Wouters (2007). The described soft anatomy of *Saidella gushikamiensis* (Nohara, 1987), the type species for this new genus, has greatly assisted in the taxonomic process.

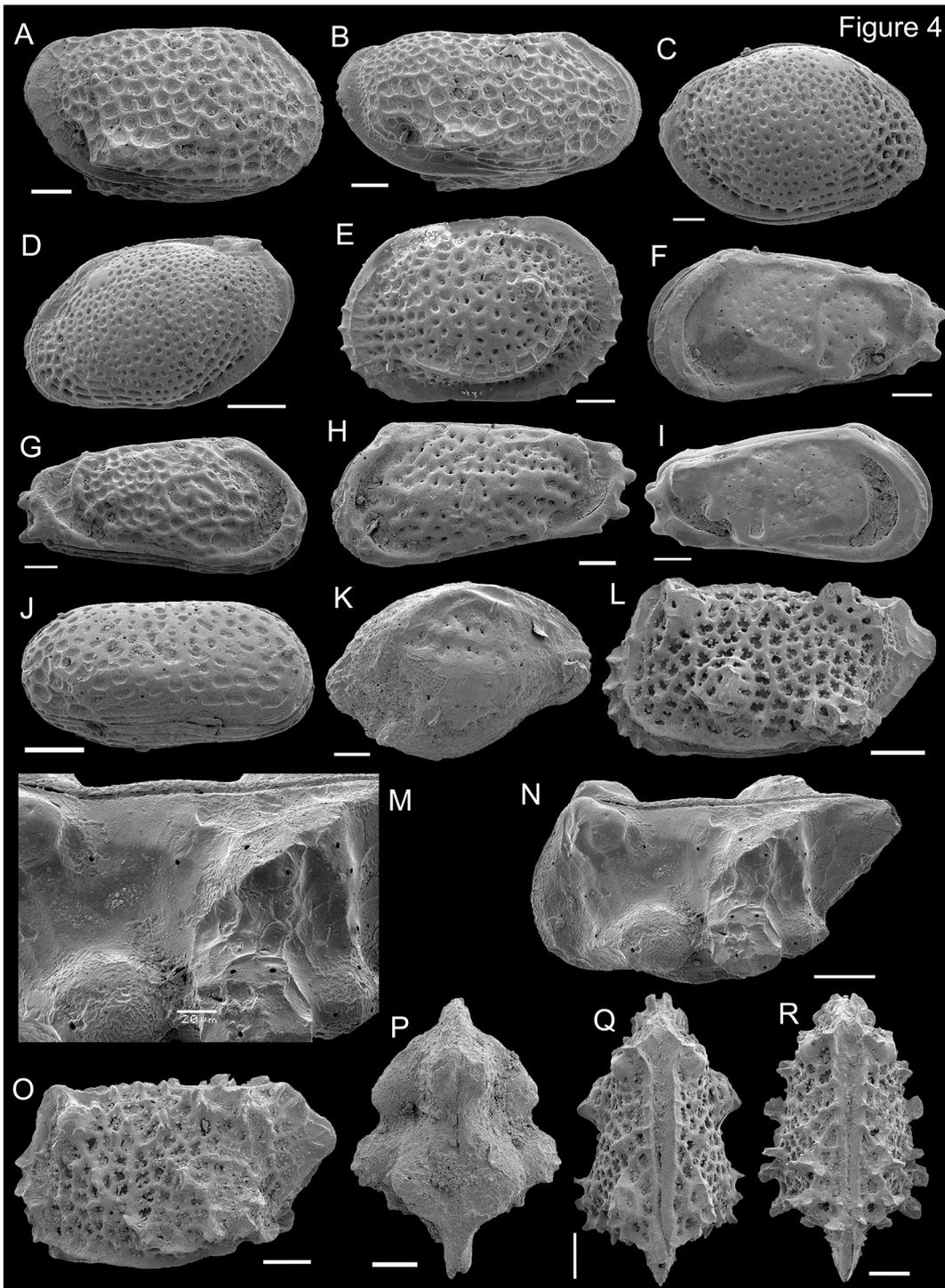


Figure 4: **A, B.** *Loxoconcha mcgowrani* McKenzie et al., 1991. **A.** FCRV. **B.** MCRV. **C, D.** *Loxoconcha punctabella* McKenzie et al., 1991. **C.** FCRV. **D.** MCLV. **E.** *Saida* sp. aff. *S. daisa* McKenzie et al., 1993, LV. **F.** *Munseyella splendida* Whatley & Downing 1983, CLV. **G, H.** *Munseyella adaluma* McKenzie et al., 1993. **G.** CRV. **H.** CLV. **I.** *Munseyella splendida* Whatley & Downing 1983, CRV. **J.** *Rockallia* sp. CRV. **K.** *Kangarina wareelacogorra* McKenzie et al., 1993, CRV. **L.** *Eucytherura cameloides* McKenzie et al. 1993, CLV. **M, N.** *Hemiparacytheridea* sp. detail and CLV. **O.** *Eucytherura horrida* McKenzie et al., 1993, CLV. **P.** *Hemiparacytheridea* sp. C dorsal. **Q.** *Eucytherura cameloides* McKenzie et al., 1993, C dorsal. **R.** *Eucytherura horrida* McKenzie et al. 1993, C dorsal. **Scale bars:** 100  $\mu$ , A, B, D, J; 50  $\mu$ , C, E–I, K, L, N–R; 20  $\mu$ , M.

Subfamily SAIDIINAE Aranki et al., 1992

*Saida* Hornibrook, 1952

*Saida* sp. aff. *S. daisa* McKenzie et al., 1993  
(Figure 4E)

**Description.** A relatively large *Saida* with a thick carapace, sub-ovo/rectangular in lateral view with straight dorsal margin, broadly curved anterior and posterior margins, and very slightly inflexed ventral margin. The height:length ratio is 2:3 with maximum height at a position 3/4 of the length from the posterior. In dorsal view the carapace is evenly ovate with protruding anterior and posterior margins. Maximum breadth medial, breadth:length ratio is 2:1. Left valve anterior margin protrudes over the right valve; posteriorly the right valve extends beyond the left. The ventral alae are inflated with a narrow surmounting ridge curving evenly from behind the antero-ventral margin to a medial position posteriorly. The postero-dorsal ridge is short and evenly curved. Macro-reticulation consisting of broad, smooth murae enclosing rounded pits constitutes much of the surface ornament. The murae are broadest in the central region of the valves, becoming narrower towards the margins where they tend to be more sharply edged on their upper surfaces. A finer network of secondary reticulation between the primary anterior and posterior reticulation results in less coarse punctae in those areas. The dominant murae across the lateral surface often extend in a continuous line to the pronounced marginal denticulation. Inner limits of the marginal rim are defined by a sharp ridge for much of the valve circumference.

**Remarks.** In lateral view *Saida daisa* McKenzie et al. (1993) and *S.* sp. aff. *S. daisa* have similar surface ornament, but *S. daisa* is considerably smaller than *Saida* sp. aff. *S. daisa*. They share the inflated alae, but *S. daisa* does not have the even, ovate outline that is seen in dorsal view in *S.* sp. aff. *S. daisa*. The short, rounded spine described as occurring behind maximum alar height for *S. daisa* could not be seen in the illustrations (McKenzie et al. 1993) nor was it present on these specimens.

Ayress (1995) treated the southern Victorian Late Eocene *Saida daisa* McKenzie et al. (1993) as synonymous with *S. limbata* Colalongo & Pasini (1980) from Calabrian Plio-Pleistocene but, based on comparison of ornament, this does not seem likely.

*Saida bellsensis* McKenzie et al. (1991) is also very similar to *Saida* sp. aff. *S. daisa* but the latter is larger, postero-dorsal ridge more pronounced, and the straight portion of the dorsum longer, resulting in a shorter, steeper antero-dorsal outline.

*Cythere torresi* Brady (1880), described from dredged Recent Torres Strait sediments, is 0.38 mm in length. Hornibrook erected the mono-specific genus *Saida* with *S. truncala* Hornibrook (1952) as type species, but

later, having examined *Cythere torresi* (Brady 1880), he regarded Brady's to be the senior synonym (Swanson 1969). This assumption was questioned by Wouters (2007); he suggested that despite the differences between *Saida* species being very small, *S. truncala* Hornibrook (1952) and *Cythere torresi* Brady (1880) may not be synonymous. Swanson (1969) identified a *Saida* species as *S. torresi* in one Early Miocene New Zealand assemblage. When illustrations from Swanson (1969), *Saida truncala* (Hornibrook 1952), and optical photographs by Puri and Hulings (1976) of the Brady (1880) lectotypes of *Cythere torresi*, are compared, there are evident similarities of outline in lateral view, especially in the low, oblique angles of the antero- and postero-dorsal margins as they descend from the virtually straight medio-dorsal area, but whether these similarities extend to other features is difficult to ascertain from their images. Whatley and Downing (1983) identified 31 *Saida* specimens in a Middle Miocene Victorian assemblage as *Saida torresi*. *Saida* sp. aff. *S. daisa* has comparable anterior, dorsal and posterior outlines, marginal rims of similar width, pattern of ornament the same, and the postero-dorsal ridge having the same shape and length. The notable differences are the more pronounced sinuosity of the former taxon's ventral margin and its smaller size. It is possible that the Whatley & Downing (1983) taxon is not *Saida torresi*, and that it is closely related to, or synonymous with, *Saida* sp. aff. *S. daisa*. Although Brandão and Lowe (2011) have re-examined Brady's "HMS Challenger" material extensively, this taxon has not yet been assessed (S. Brandão pers. comm. 2019). The author regards the identification of specimens from southern Australian Tertiary strata as *Saida torresi* to be problematic.

The Recent *Saida torresi* (Yassini & Jones, 1995) from the southeastern Australian coast has a postero-dorsal ridge of similar length and curvature but is thicker, broader and more rounded than *Saida* sp. aff. *S. daisa* and there is also a broader, raised mural alignment from the centre of the lateral surface to the postero-ventral angle of the ventral ala on their illustrated specimen. As the size bar is missing from their image, sizes cannot be compared. As per the above comments, the identification of this *Saida* as *S. torresi* should also be regarded as requiring further investigation.

A feature of the Australian *Saida* is the similarity between taxa in the pattern of both macro reticulation and the finer intramural reticulation, as seen in *Saida* sp. (McKenzie 1974), *Saida torresi* Whatley & Downing (1983), *Saida bellsensis* McKenzie et al. (1991), *Saida daisa* McKenzie et al. (1993), and *Saida torresi* (in Yassini & Jones 1995), even when other features such as outline in lateral or dorsal views, and shape or dimensions of alae and dorsal or postero-dorsal ridges differ.

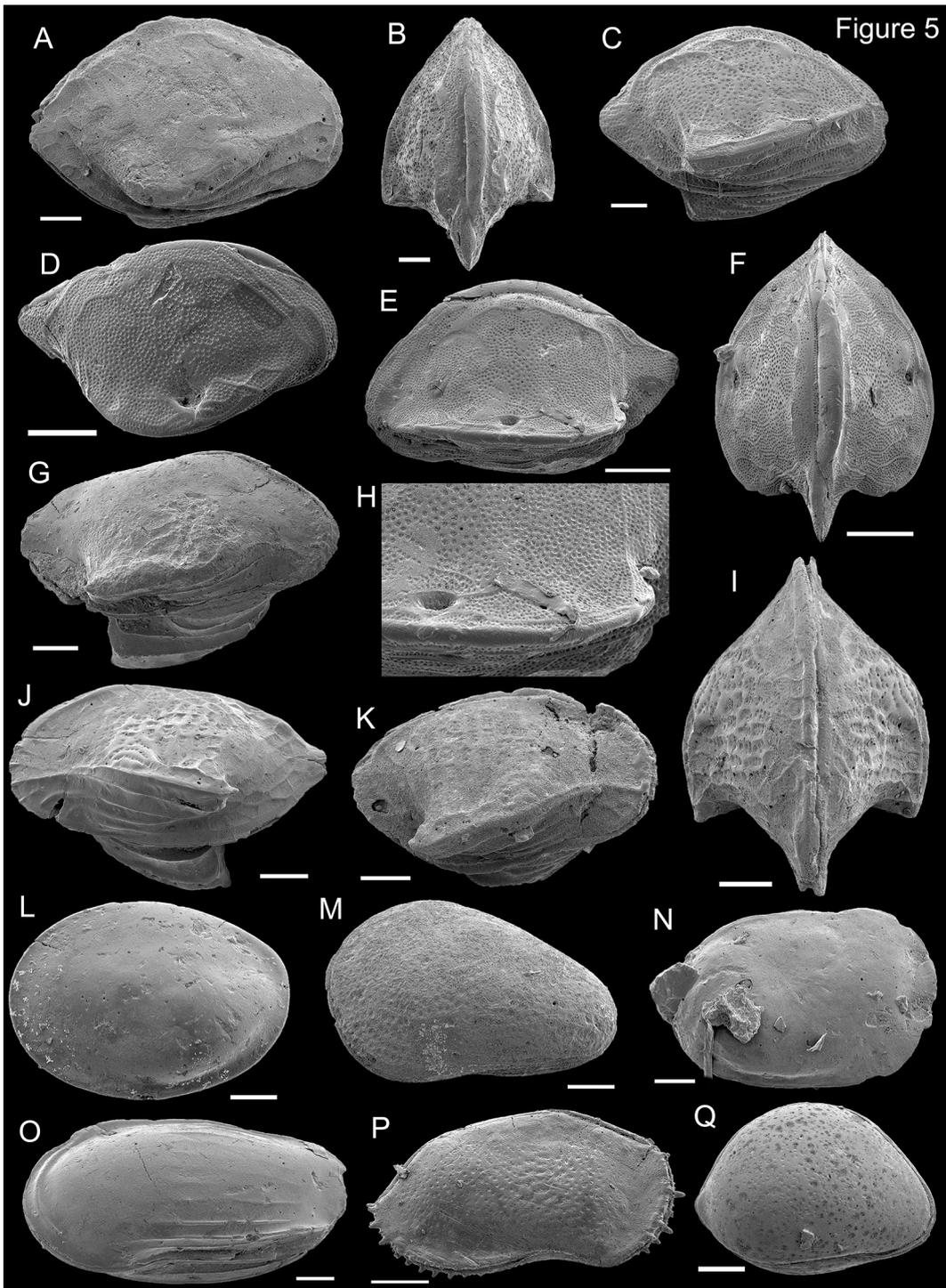


Figure 5: A–C. *Oculocytheropteron microformix* Whatley & Downing, 1983. A. CRV. B. dorsal. C. CRV. D. *Cytheropteron* sp. aff. *C. ruwarungensis* Majoran, 1997, CRV. E, F, H. *Oculocytheropteron* sp. aff. *O. ayressi* Majoran, 1997. E. CLV. F. C dorsal. H. Detail of E. G, I–K. *Aversoalva yarringa yarringa* McKenzie et al., 1993. G, K. CRV. I. C dorsal. J. CLV. L. Indet. gen. sp. 2 CLV. M. *Pseudeucythere pseudosubovalis* (Whatley & Downing, 1983), CLV. N. Indet. gen. sp. 1 CRV. O. *Ruggieriella* sp. CLV. P. *Orlovibairdia* sp. CRV. Q. *Uroleberis minutissima* (Chapman et al., 1926), CRV. Scale bars: 100  $\mu$ , D–F, P, Q; 50  $\mu$ , A–C, G–O.

Ayress (1996) described *Cytherura nonspinosa* from Late Eocene New Zealand assemblages, he has since indicated that the species belongs in *Saida* (M. Ayress pers. comm. 2014).

*Measurements.* LV: 0.5 mm, breadth 0.29 mm. C: length 0.45 mm, height 0.31 mm, breadth 0.23 mm. C: length 0.41 mm, height 0.29 mm, breadth 0.23 mm.

*Material studied.* Seven specimens (2C, 1LV, 1RV, 3RV fragments).

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family BYTHOCYTHERIDAE Sars, 1926

*Sclerochilus* Sars, 1866

*Sclerochilus* sp.

(Figure 3S)

*Description.* A smooth, elongate *Sclerochilus* with rounded anterior and dorsal margins, ventral margin sinuous and strongly inflexed anterior of the median. Maximum length medial; maximum height at two-thirds of length. Adductor muscle scars five in number, elongate, obliquely aligned. Anterior and posterior vestibules observed through thin carapace.

*Remarks.* *Sclerochilus* sp. McKenzie et al. (1993) is only slightly larger than this specimen, but is more elongate, and the ventral margin less inflexed.

*Measurements.* C: length 0.46 mm, height 0.21 mm.

*Material studied.* One specimen.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family LOXOCONCHIDAE Sars, 1925

*Loxoconcha* Sars, 1866

*Loxoconcha punctabella* McKenzie et al., 1991

(Figures 4C, D)

*Loxoconcha punctabella* McKenzie et al., 1991: 151, pls 4.3, 5.5, 6.

*Description.* A medium-sized, subrhomboid to subovate *Loxoconcha* with concentrically aligned punctae that are rectangular peripherally and round medially.

*Remarks.* *Loxoconcha propunctata* Hornibrook (1952) is very similar in appearance to *L. punctabella* but has a higher, more broadly rounded anterior margin and its caudal extension is below the mid-line. *Loxoconcha* sp. McKenzie et al. (1993) has a lateral view comparable to *L. punctabella* but with coarser ornament.

*Measurements.* Length 0.45–0.54 mm, height 0.32 mm.

*Material studied.* Three specimens.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family XESTOLEBERIDIDAE Sars, 1928

*Uroleberis* Triebel, 1958

*Uroleberis minutissima* (Chapman, 1926)

(Figure 5Q)

*Bairdia minutissima* Chapman, 1926: 132, pl. 10.2a, b.

*Uroleberis* sp. – Triebel, 1958: 111, pl. 3.14a, b. – McKenzie 1979a: 94.

*Uroleberis minutissima*. – McKenzie, 1974: 163, pl. 1.14. – Whatley & Downing 1983: 384, pl. 7.20. – Ayress 1995:

Tables 1, 3, figs 12.4–6. – Neil 2006: 56–57, figs 5K, L. *Foveoleberis minutissima*. – Warne, 1987: 444. – McKenzie et al. 1991: 154, pl. 5.12.

*Foveoleberis* sp. – McKenzie et al., 1990: 17, pls 5.4, 8.7.

*Uroleberis* sp. cf. *minutissima*. – Neil, 1992: 194, 195, pl. 17.H.

*Foveoleberis minutissima sublaevis*. – McKenzie et al., 1993: 89, pl. 3.9.

*Remarks.* As with Neil's (2006) Middle Miocene assemblage from the Wuk Wuk Marl, Gippsland, Victoria, these specimens display variability in the fine surface punctae. In some specimens these are uniformly distributed across the surface, others appear virtually smooth. As the carapaces are fragile, an attempt to open one to view the hinge elements was unsuccessful. For the diagnostic and taxonomic reasons discussed by McKenzie et al. (1991, 1993) and Neil (2006), *Foveoleberis* genus and *sublaevis* subgenus have not been adopted.

*Measurements.* C: length 0.55 mm, height 0.38 mm, breadth 0.38 mm.

*Material studied.* Six carapaces.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family PECTOCYTHERIDAE Hanai, 1957

*Ruggieriella* Colalongo & Pasini, 1980

*Ruggieriella* sp.

(Figure 5O)

?*Phlyctocythere* sp. 2 Whatley & Downing, 1983: 365, pl. 3.13.

*Remarks.* *Ruggieriella* sp. differs from *R. decemcostata* Colalongo & Pasini (1980) in being smaller, the longitudinal ridges on the lateral surface are far less well

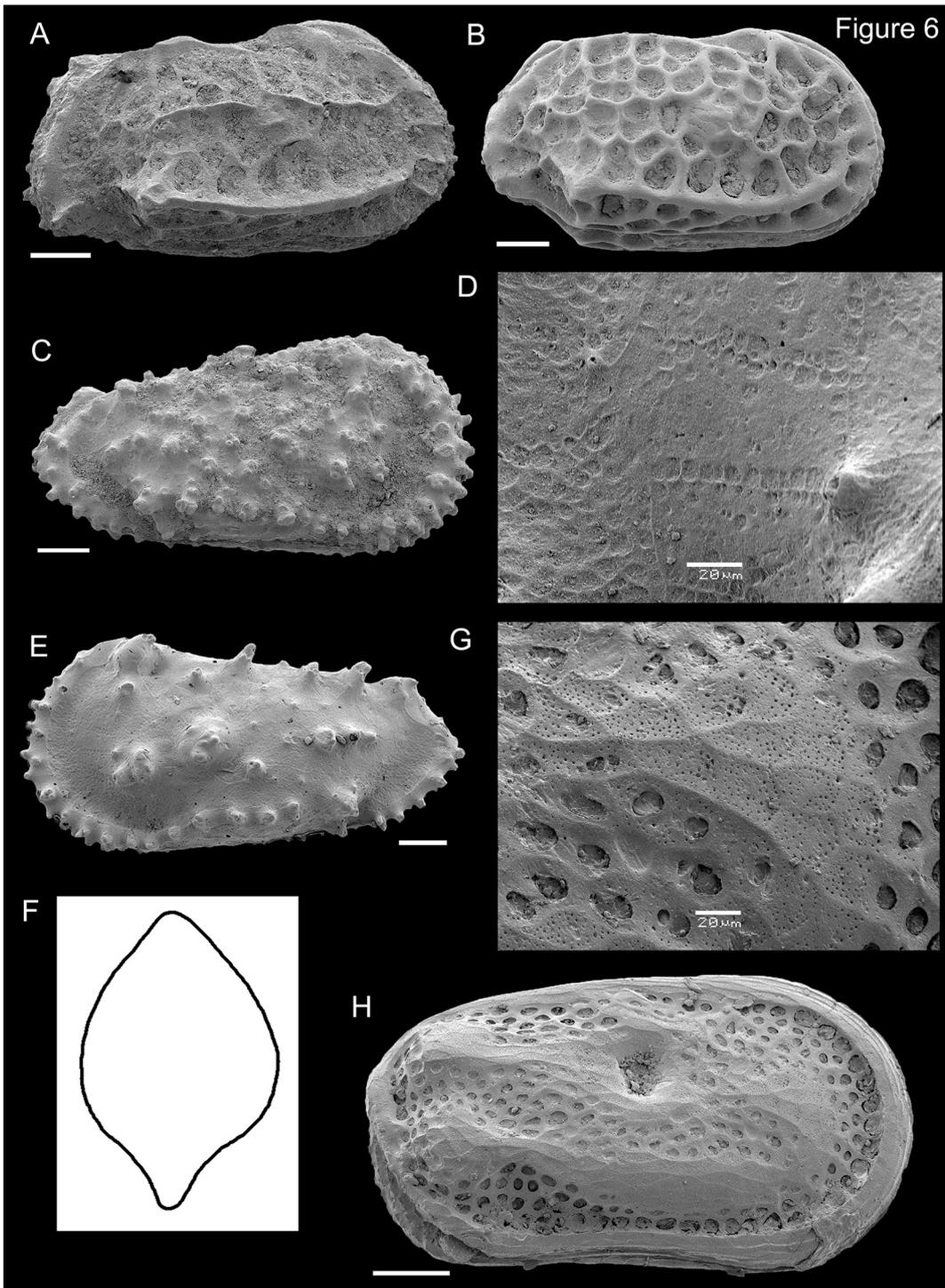


Figure 6: **A.** *Bradleya* (*Quasibradleya*) *momitea* McKenzie et al., 1993, CRV. **B.** *Bradleya* sp. cf. *B. regularis* McKenzie et al., 1991, CRV. **C.** *Cythereis brevicosta major* McKenzie et al., 1991 CRV. **D, E.** *Cythereis* sp. aff. *C. thomsoni* (Hornibrook, 1952). **D.** Surface detail. **E.** MLV. **F.** *Cytheropteron* sp. aff. *C. ruwarungensis* Majoran, 1997, C dorsal outline traced from digital optical photo, specimen is not tilted asymmetry is presumed to be due to deformation. **G, H.** *Cytherelloidea marginopytta* McKenzie et al., 1991. **G.** Detail of second, third and fourth orders of ornament. **H.** FCRV. **Scale bars:** 100  $\mu$ , A–C, E, H; 20  $\mu$ , D, G.

defined, the anterior margin projects further forward and possesses a narrow, distinct ridge just inside the inner margin (Colalongo & Pasini 1980; M. Ayress pers. comm. 2014). *Ruggieriella* sp. is similar to ?*Phlyctobothocythere* sp. 2 Whatley & Downing (1983) though *Ruggieriella* sp. is larger and its longitudinal ridges less well defined.

*Measurements.* C: length 0.45 mm, height 0.25 mm.

*Material studied.* One carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family ROCKALLIIDAE Whatley et al., 1982

*Rockallia* Whatley et al., 1978

*Rockallia* sp.

(Figure 4J)

*Arcacythere* sp. McKenzie, 1974: pl. 4.10.

*Arcacythere* sp. aff. *chapmani* Hornibrook, 1952. – McKenzie et al., 1991: 158, pl. 6.5. – McKenzie et al. 1993: 93, pls 3.26, 8.6.

*Arcacythere eocenica* Whatley et al., 1982. – Majoran 1995: Figure 3S, Appendix table. – Majoran 1996b: Appendix table 1.

*Remarks.* Based on the summary of criteria for distinguishing between *Arcacythere* and *Rockallia* (Mazzini, 2004), this specimen and its synonyms display the features characteristic of *Rockallia* – a subrounded to bluntly acuminate posterior outline in lateral view, lack of both anterior and posterior thick marginal rims, and absence of a pronounced antero-dorsal ridge; ornament dominated by fossae rather than by murae. One criterion not observed here is possession of a subcentral node. Though larger than the McKenzie et al. (1991, 1993) specimens, this single carapace has the same shape and distinctive pattern of fossae. Compared to the Australian examples of *Arcacythere eocenica*, *Arcacythere* cf. *eocenica* in Ayress (1994) has a less regular outline in lateral view with a more concave dorsal margin, a pointed rather than curved postero-dorsal angle, and has much coarser fossae differently aligned to that of *Arcacythere eocenica*. *Arcacythere chapmani* Hornibrook (1952) is retained in *Arcacythere*.

*Measurements.* C: length 0.53 mm, height 0.28 mm, breadth 0.26 mm.

*Material studied.* Single carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family CYTHERURIDAE Müller, 1894

Subfamily CYTHEROPTERONINAE Hanai, 1957

*Cytheropteron* Sars, 1866

*Cytheropteron* sp. aff. *C. ruwarungensis* Majoran, 1997

(Figures 5D, 6F)

*Description.* A medium-sized cytheropterine ostracod with an ovate dorsal view due to the narrow, in-curving alae, interrupted only by the blunt anterior and the short, keel-like caudal process. Alae lack terminal apical spine. Characteristic is a reticulate pattern of low, widely spaced ridges; the entire external surface is covered with micropunctae, and there is a large, deep mid-ala depression. The valves are subequal, right valve overlapping left.

*Remarks.* This taxon is closely related to *Cytheropteron ruwarungensis* Majoran (1997), but the reticulation — so evident on *Cytheropteron* sp. aff. *C. ruwarungensis* — is barely discernable in illustrations of the former and does not appear to always conform with that of this specimen. *Cytheropteron acutangulum* Hornibrook (1952) has a similar ovate dorsal view, but is smaller, and lacks the mid-ala depression.

*Measurements.* C: length 0.51 mm, height 0.3 mm, width 0.33 mm.

*Material studied.* Single carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

*Cythereis* Jones, 1849

There has been a long history of taxonomic problems associated with the genus *Trachyleberis* Brady, 1898. One feature causing difficulty has been the alignment or non-alignment of spines/tubercles on the lateral surfaces of the carapace. Puri (1953) erected the genus *Actinocythereis* to accommodate trachyleberidids that were closely related to *Trachyleberis*, but possessed spines aligned laterally in three distinct longitudinal rows to differentiate these from trachyleberidids with either non-aligned, or more uniformly arranged, spines or tubercles. Authors have dealt with the systematics of taxa falling within this ambit in a variety of ways (for example: van Morkhoven 1963; Hazel 1967; Milhau 1993; Ayress 1993a, 1993b, 1995; Neil 1994; Warne & Whatley 1996).

Jellinek and Swanson (2003) reviewed the genus *Trachyleberis* and erected five new trachyleberid genera, one of which was *Glencoeleberis*. The comprehensive reassessment of the *Trachyleberis* genus by Brandão et al. (2013) retained only 17 species (pending review of the many

hundreds of taxa previously regarded as *Trachyleberis*). Yasuhara et al. (2015) revised the taxonomy of deep-sea Trachyleberididae and erected four new genera. Their emended diagnoses of *Actinocythereis*, *Cythereis* and *Trachyleberis* removed the confusion over trachyleberids displaying varying degrees of spinous alignment. The emended generic concept of *Trachyleberis* Brady (1898) by Brandão et al. (2013) that required the genus to display an ocular ridge and internal snap-knob structure was further restricted by Yasuhara et al. (2015) to only include species of the genus occurring in shallow marine areas of mid-latitude northwestern Pacific (~20°N–40°N)” (Yasuhara et al. 2015).

Yasuhara et al. (2015) emended the diagnosis for the Genus *Cythereis* Jones, 1849 to include many species previously placed in *Trachyleberis*, *Glencoeleberis*, *Taracythere*, *Acanthocythereis*, *Actinocythereis* and *Cytherina*. Their diagnostics for *Cythereis* are: amphidont-type hinge; shallow, often indistinct primary reticulation (with some exceptions); distinct ventero-lateral ridge continuing into the anterior marginal rim; generally well developed subcentral tubercle; distinct anterior and posterior marginal rims; absence of ocular ridge; V-shaped frontal scar; no internal snap-knob structure at ventral mid-length; subtriangular-subtrapezoidal outline; presence of eye tubercle not a requirement (Yasuhara et al. 2015). They considered *Glencoeleberis*, Jellinek & Swanson (2003) to be a junior synonym of *Cythereis* and described *Cythereis* as a diverse genus extending from Cretaceous to Holocene, though conceded that further phylogenetic work may allow the genus to be divided into smaller evolutionary units (Yasuhara et al. 2015).

*Trachyleberis thomsoni* Hornibrook (1952) from the Australo-New Zealand region, has been problematic. Jellinek and Swanson (2003) tentatively assigned *Trachyleberis thomsoni* Hornibrook (1952) to *Glencoeleberis*, and Ayress (2006) was similarly cautious. Brandão et al. (2013) did not refer to this new genus but did exclude *T. thomsoni* Hornibrook (1952) from *Trachyleberis*. Brandão et al. (2013) specifically excluded *Trachyleberis thomsoni* Hornibrook (1952) based on the following carapace features: lack of ocular ridge, relatively few spines on the lateral surfaces, possession of the distinct ventero-lateral ridge and showing the antero-ventral cluster of four spines (Brandão et al. 2013). To this list may be added the possession of distinct antero- and postero-marginal rims in *Trachyleberis thomsoni*.

To conform with the emended diagnoses, two taxa previously identified as *Trachyleberis* are here allocated to *Cythereis*. They are *Cythereis brevicosta major* (McKenzie et al. 1991) and *Cythereis* sp. aff. *C. thomsoni* (Hornibrook 1952) (Figures 6D, E). The latter is represented by only

one specimen in this assemblage. A more comprehensive review is in preparation examining specimens from southern Victorian locations identified previously as belonging to the species *thomsoni*.

*Acanthocythereis* Howe, 1963

*Acanthocythereis?* sp.

*Acanthocythereis* sp. McKenzie et al., 1993: 106, pl. 6.10.

*Remarks.* This anterior fragment of an adult right valve is morphologically close to *Acanthocythereis* sp. McKenzie et al., (1993) from the Middle(?) Eocene of Browns Creek. It is not possible to determine from either this fragment or the McKenzie et al. remarks whether the features for the emended diagnosis for *Acanthocythereis* by Yasuhara et al. (2015) are present, based on their study this specimen may belong in *Cythereis*.

*Material studied.* One fragment adult right valve.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family THAEROCYTHERIDAE Hazel, 1967

*Bradleya* Hornibrook, 1952

*Bradleya* sp. cf. *B. regularis* McKenzie et al., 1991 (Figure 6B)

*Bradleya* sp. cf. *regularis* McKenzie et al., 1991: 164, pl. 6.13.

*Description.* A moderately-sized, inflated *Bradleya*, subrectangular in lateral view with surface covered by reticulate ornament; ventral ridge alate, extending from antero-ventral to postero-ventral area; less pronounced dorsal ridge curves evenly from below the semispherical eye tubercle to the postero-dorsal angle. Medial longitudinal murae are roughly aligned before and behind the subcentral tubercle. Median ridge, characteristic for the subgenus *Quasibradleya*, is lacking. Anterior margin convex, dorsum inflexed, posterior dentate and convex, ventrum straight to convex. Outline hastate in dorsal view; anterior margin blunt, projecting forward only minimally. CMS with two adductor scars.

*Remarks.* The convex posterior margin and ornament of the single carapace matches *Bradleya* sp. cf. *regularis* McKenzie et al. (1991). This specimen is similar in size to *Bradleya regularis* McKenzie et al. (1991) but *Bradleya* sp. cf. *B. regularis* is less elongate and the posterior margin convex not concave above the caudal process.

*Measurements.* C: length 0.81 mm, height 0.46 mm, breadth 0.5 mm.

*Material studied.* Two specimens: one an adult carapace, one RV fragment.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

Family INCERTAE SEDIS

**Indet. sp. 1**

(Figure 5N)

*Description.* A small, smooth, subovate ostracod. In lateral view, anterior, ventral and posterior margins are convex; dorsal margin highest antero-dorsally. There is a thin, narrow keel extending from one-third of the length to the posterior and parallel to the ventral margin. No internal details are visible. As the valves are damaged and slightly displaced relative to each other, the valve overlap is not clear.

*Remarks.* Although this specimen may be a cytherellid, there are no platycopid or podocopid diagnostic features visible, hence the rationale for incertae sedis.

*Measurements.* C: length 0.35 mm, height 0.24 mm.

*Material studied.* One damaged carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

**Indet. sp. 2**

(Figure 5L)

*Description.* A small, smooth, moderately thick-shelled, subrounded ostracod; anterior, posterior and ventral margins convex; dorsal margin highest antero-dorsally then slightly inflexed before descending convexly to the posterior. Maximum length approximately medial; maximum breadth two-thirds of the length and below the median. There is a narrow keel parallel and adjacent to the ventral margin. Normal pores scattered across the valve surfaces. Left valve overlaps right. No CMS or other diagnostic features observed.

*Measurements.* C: length 0.32 mm, height 0.24 mm, breadth 0.18 mm.

*Material studied.* One carapace.

*Occurrence and age.* Gellibrand Marl: Heywood-10 bore, depth 335.28 m: *Globigerina euapertura* foraminiferal zone (GEDIS), Late Oligocene (Chaproniere et al. 1996).

## CONCLUSIONS

This Heywood-10 sample provided the first ostracod assemblage of Oligocene age from the Gellibrand Marl and has yielded 384 specimens across 18 families, 34 genera and 50 species and subspecies. The assemblage is larger, has more families, genera and taxa, but with a lower level of diversity than an older (Early Oligocene) Narrawaturk Formation assemblage from the same location and is more diverse than a South Australian Early Oligocene Port Willunga Formation/Ruwarung Member assemblage. Dominant families for each of the three assemblage are: Gellibrand Marl — Pontocyprididae; Narrawaturk Formation — Cytheruridae and Xestoliberididae; South Australian assemblage — Bairdiidae. There are indications of at least part of the assemblage being allochthonous. No cold- or deep-water taxa are present. The depositional environment of the assemblage was offshore, still reasonably shallow and with a well-oxygenated benthos. It was somewhat deeper and further from shore than for the Early Oligocene Narrawaturk Formation at this location, indicative of a more transgressive phase.

It is beyond the scope of this study to incorporate the six undescribed up-section Miocene ostracod assemblages from Heywood-10 (Table 1), four from the Gellibrand Marl and two from the Port Campbell limestone, but they have the potential to provide further data for ostracod taxonomy and palaeoenvironmental interpretation at this location.

## Repository

Specimens illustrated in this paper and the assemblage slides will be deposited in Museum Victoria, Melbourne, Australia.

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