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MIOCENE OSTRACODA OF THE TRACHYLEBERIDIDAE AND HEMICYTHERIDAE FROM THE MUDDY CREEK AREA, SOUTH-WESTERN VICTORIA

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Abstract

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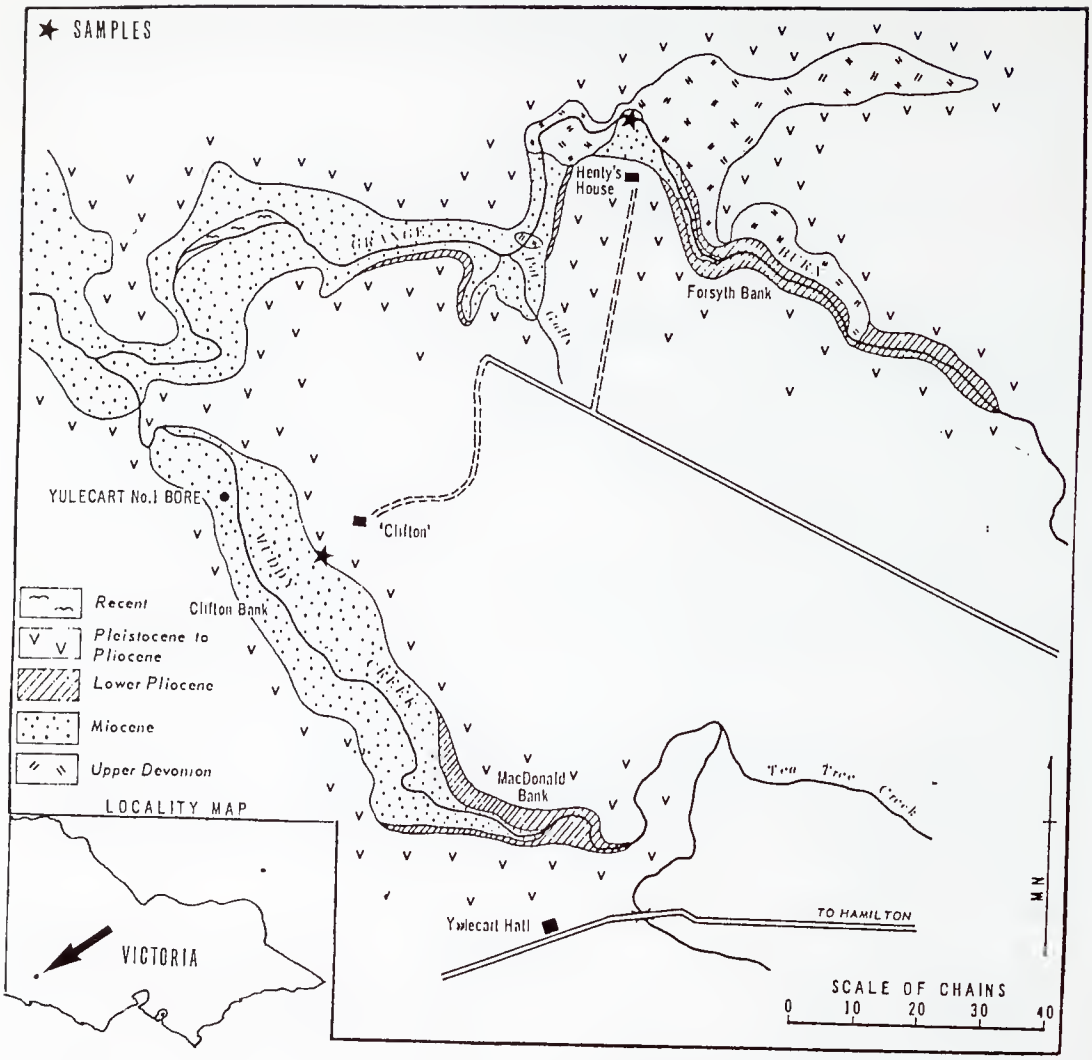
Eleven samples in a vertical section of the Muddy Creek Marl at Clifton Bank, Victoria, Australia, and one large sample from the Marl at Hentys produced nearly 10000 ostracode specimens. The fauna consists of 186 species from 85 genera. Of the Trachyleberididae and Hemicytheridae, 36 species are present. Of these, 15 species are new: *?Alatahermanites septarca, Deltaleberis warnei, 'Hemicythere' lubrica, 'H'. tenuicostata, Mackenzina foveolata, Notocarinovalva yulecartensis, 'Hermanites' thomasi, H. glyphica, Spinobradleya nodosa, Bradleya (Quasibradleya) pyxos, Quadracythere (Hornibrookellina) hentyensis, ?Dumontina cratis, Arculacythereis tatei* and *'Ambostracon' recta.* Three species are left in open nomenclature. Two previously described species have been reassigned: *'Cytheralison' postdeclivis* (Chapman, 1914) to *?Arculacythereis* and *Cythere flexicostata* (Chapman, 1914) to *Chapmanella* gen. nov. Three new genera and one new subgenus have been erected: *Chapmanella, Mackenzina, Notocarinovalva* and *Quadracythere (Hornibrookellina).*

The faunas have a warm-temperate to subtropical character, and indicate a shallow-water, high-energy, near-shore environment of deposition, with abundant phytal associates. The age of the samples ranges from late Early to early Middle Miocene (N8–N10); that is, from late Batesfordian, through the Balcombian to early Bairnsdalian stage, on the basis of planktonic foraminifers. The deposition of the beds in the section at Clifton Bank has occupied a period of approximately one million years. The sample from Hentys is a long-ranging thanatacoenosis.

Introduction

The ostracode fauna of the Muddy Creek Marl in south-western Victoria, Australia (Text-fig. 1) has been described by Neil (1992). Eleven samples from Clifton Bank on Muddy Creek, and one large sample form Hentys on Grange Burn, provided nearly 10000 specimens. The fauna consists of 186 species from 85 genera. Within this fauna, 37 species are new, five new genera will be erected and 57 species have been left in open nomenclature. More than 40% of the specimens, 36 species from 23 genera and 4 subgenera, are members of Trachyleberididae and Hemicytheridae. Three genera, one subgenus, and 14 species are described as new. Four species are left in open nomenclature. This preponderance of trachyleberids and hemicytherids is markedly different from the Miocene fauna from Fossil Beach, Mornington, Victoria which was monographed by Whatley and Downing (1983). The fauna had only 8.2% of individuals (as distinct from separate specimens) from the Trachyleberididae and Hemicytheridae — in all, five species, of which only one, *Bradleya [Bradleya] praemackenziei*, is a hemicytherid.

The dominant species (10% or more of the specimens) in the assemblages from the Clifton Bank samples were *Quadracythere (Q.) spica*, *'Hermanites' thomasi* and *Hermanites glyphica. 'Hermanites' thomasi*, endemic to Clifton Bank, constituted more than 30% of the specimens in one of these samples, whereas Whatley and Downing (1983) found that *Bradleya (B.) praemackenziei*, the most abundant of the five species of hemicytherids and trachyleberids referred to above, constituted only 7% of the total. The Hentys sample had no dominant species as defined above, but the commonest (>100 specimens) were *Quadracythere (Q.) spica, Quadracythere (Hornibrookellina) hentyensis, Hermanites glyphica* and *Chapmanella flexicostata.* Of these species *Q. (Hornibrookellina) hentyensis* is endemic to Hentys. By percentage, hemicytherids were dominant at both localities — 34.7% compared to 5.4% for trachyleberids,



Text-figure 1. Clifton Bank and 'Hentys' localities, Yulecart, near Hamilton, southwestern Victoria.

though the latter group were more common at Hentys (8.2%) than at Clifton Bank (3.3%).

The figured specimens (numbers prefixed NMV P) are housed in the Invertebrate Palaeontology Collections of the Museum of Victoria. Faunal slides from the samples used in the preparation of this study are in the collection of the author.

Provenance of the fossils

To the west of Hamilton, the Wannon River has been diverted along the margin of the Newer Basalt which forms much of the plains of the Western District. Several tributaries, notably the Grange Burn and its tributaries Muddy Creek and Violet Creek, have cut through the basalt capping, exposing sediments of Miocene and Pliocene age (Text-fig. 2). These sediments, shallow marine further west, but grading or intergrading into terrestrial deposits in the eastern section nearer to Hamilton, are richly fossiliferous.

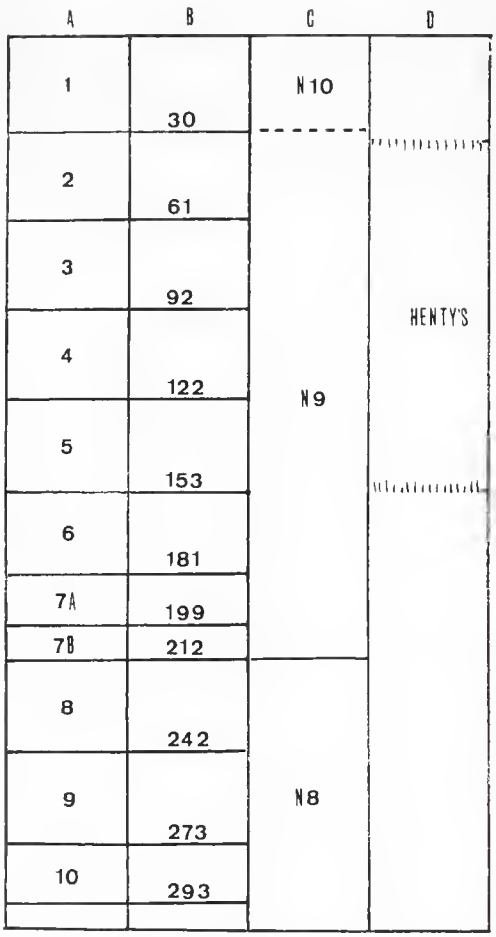
The basement is mid-Palaeozoic rhyolite, on which thin shelf deposits have been laid down. The oldest of these is a limestone, in part crystalline and described by Mallett (1977) as a coarse, yellow-brown calcarenite. Overlying the calcarenite is an unlithified calcareous silty sand, generally green-grey in colour, but tending to fawn or brown in the Grange Burn outcrops as depth of deposition increased and glauconitic effects gave way to ferruginous ones. The presence of coarser lag deposits throughout this sequence is notable, particularly in the upper section (Reeckmann, 1974). The base of the overlying coquinas is defined by a phosphatic nodule bed which marks a discontinuity between the 'marls' and the 'coquinas' (Gill, 1957; Carter, 1978). The lithologies in both the Grange Burn and Muddy Creek exposures show considerable lateral variation. In places, the coquinas give way to shelly silts, grading upward into laminated and sparsely fossiliferous silts which include a tuffaceous band. The final marine deposits at the top of the sequence are represented by a coarse green calcarenite up to 4 m thick. Terrestrial and lacustrine deposits cap the sequences immediately below the basalt, and in places a soil profile is developed in the top of the terrestrial beds (Gill, 1957) which are fine white siliceous sands.

Trachyleberididae and Hemicytheridae

There is partial agreement between the proponents of classificatory schemes for the Trachyleberididae and Hemicytheridae (Neale, 1959; Howe, Sylvester-Bradley, van den Bold and Reyment, 1961; van Morkhoven, 1962; Pokorny, 1955, 1957, 1964; Hazel, 1967; Benson, 1972; Hartmann and Puri, 1974; Liebau, 1975, McKenzie and Bonaduce, 1991). Pokorny's analysis suggested that whatever features are used to diagnose these families, a horizontal, polyphyletic classification will result. In practical terms, progress has been made towards establishing some features as primitive and others as advanced. The Hemicytheridae are generally agreed to be derived from Trachyleberididae. The features about which there is the greatest agreement are the single v-shaped or hooked frontal scar for the trachyleberids and the divided frontal scar for the hemicytherids, together with the six-jointed antennula for most trachyleberids compared to the five-jointed one for hemicytherids (McKenzie and Bonaduce, 1991), and the presence of complex chitin supports in the thoracic limbs of hemicytherids versus simple chitin supports in the legs of trachyleberidids. Other features such as subcentral tubercles, spines, marginal denticulations and eye-spots can be taken as part of a constellation of characters to determine family-level classification but singly they cannot be used safely for diagnostic purposes above genus. For the palaeontologist, soft-part differentiation cannot be applied.

The classification of Hartmann and Puri (1974) is generally followed here. They allowed some trachyleberids exceptionally to have 2 or 3 frontal scars and refused to rule out the possibility of some hemicytherids having v-shaped frontal scars, although none is yet known. The basic reason for this equivocation is the widely accepted transitional nature (in terms of carapace morphology) of many genera. The erection of 'form genera' on the basis of these morphological differences may or may not be consistent with the phylogeny of the species and genera so defined.

Hartmann and Puri endeavoured to strike a balance between neontological and palaeontological principles but Pokorny's original warning remains. The taxonomist faced with the practical problems of developing a phylogenetic classification to cover both neontological and palaeontological taxa must be subjective in weighting characters. The acceptance of weighting is part of the legacy of adopting a conservative taxonomy. In the approach adopted here, the frontal scar characteristics are taken as diagnostic for fossil trachyleberids and hemicytherids. If a cladistic approach were adopted shared-derived features such as muscle scars and frontal scars would be looked for and morphoclines, with or without polarity, would be established to eliminate poly-



Text-figure 2. Clifton Bank and 'Hentys' sections on Muddy Creek and Grange Burn. A, Clifton Bank sample numbers. B, depth from surface in centimetres. C, planktonic foraminiferal zones (Berggren, Kent and Flynn, 1985). D, 'Hentys' sample (time averaged).

phyletic and paraphyletic genera. Pokorny's criticism of a horizontal classification would be tackled at its source.

Liebau (1975: 373) wrote: "New suprageneric taxa should correspond to new information about natural relationships. The production of tribes and subfamilies within the taxonomy of the Trachyleberididae s.l. does not always correspond to an adequate increase of knowledge about evolution, nor to the development of a more practical system either, but is mainly the result of 'taxonomic accidents' (subjective synonyms, caused by uncorrelated taxonomic studies; nebulous phylogenetic ideas, neglecting the main part of observable data; old-fashioned form group concepts and general lack of adequate taxonomic standards)". Hartmann and Puri (1974) advised keeping the number of systematic units in the Trachyleberididae and Hemicytheridae to a minimum. They retained the Thaerocytherinae as a subfamily within the Hemicytheridae, consonant with Liebau's idea, and I concur with their decision.

Trachyleberididae Sylvester-Bradley, 1948

Trachyleberidinae Sylvester-Bradley, 1948 s. s.

Tribe **Trachyleberidini** Sylvester-Bradley, 1948

Trachyleberis Brady, 1898

?Trachyleberis robustus (Yassini and Jones) comb. nov.

Pl. 1 figs 1, 2, 3; pl. 14 fig. 1

Actinocythereis robustus Yassini and Jones, 1987: 823, figs 4.1, 4.2.

Figured specimens. NMV P123216 — Pl. 1 fig 1, Pl. 14 fig 1; NMV P134937 — Pl. 1 fig. 2; NMV P134938 — Pl. 1 fig. 3.

Dimensions. (P123216) RV: L=0.92; H=0.50.

Material 23 specimens, Clifton Bank and Hentys, Muddy Creek Marl, early Middle Miocene.

Remarks. The muscle scar pattern, with two frontal scars, a hooked dorsal adductor and a divided ventromedian adductor, is quite distinctive for a trachyleberid (Pl. 14 fig. 1). The two frontal scars are an unusual variant in Trachyleberidinae (Hartmann and Puri, 1974; Hazel, 1967). There is a very large, broad-ended spine developed at the posteroventral angle, and the spines coalesce to form a ventral ridge, extending from the anterior margin to short of the large spine at the posteroventral angle.

Although the development and size of the tubercles/spines is greater in these specimens than in the specimen of *Actinocythereis robustus* figured by Yassini and Jones (1987), their placement and orientation is such that these specimens may be conspecific. However, the assignment of this species to *Actinocythereis* cannot be sustained since there is no linearity in the arrangement of the tubercles/spines, the major diagnostic feature of that genus (Moore, 1961: Q334; Von Morkhoven, 1963: 178). Assignment to *Echinocythereis* on the basis of the double frontal scar is ruled out because *?Trachyleberis robustus* has stout tubercles/spines, randomly

distributed, unlike *Echinocythereis*, in which the spines are finer and the arrangement tends to concentric lines.

I assign the species tentatively to *Trachyleberis* on the basis of its tubercles/spines. Though this is a limited basis, Brady's (1898) diagnosis of the genus refers only to the tubercles/spines of the hard parts, the remainder of the diagnosis being entirely concerned with the soft parts. The assignment is tentative because of the unusual muscle scar and frontal scar pattern, and the quadrate valves. This latter characteristic is shared with *Ponticocythereis* McKenzie, 1967 but *?T. robustus* has well-developed spines all over the valve surface. On the other hand, *T. tridens* Hornibrook, 1953 does show a very similar pattern of tubercles/spines and has a subquadrate shape like *?T. robustus*. The former species has single frontal scar and no anterocentral tubercle like *?T. robustus*. Yassini and Jones (1987) did not refer to muscle scars in their description of *?T. robustus*.

?Trachyleberis robustus occurs at both localities and is distributed among the samples similarly to *?Actinocythereis* sp. A. With more material, it is possible that conspecificity will be confirmed but assignment to *Trachyleberis* s.s. will not be so resolved since the frontal scar is double and the adductors are unusual. *?Trachyleberis robustus* is another species from this fauna which appears to range from the Miocene to the Recent.

Actinocythereis Puri, 1953 (as diagnosed by Hazel, 1967)

?*Actinocythereis* sp. A

Pl. 1 figs 4, 5

Figured specimens. NMV P123221 — Pl. 1 fig. 4; NMV P134939 — Pl. 1 fig. 5.
Dimensions. (P123221) LV: L=0.80; H=0.42.
Material. 39 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Remarks. Actinocythereis is chosen tentatively for this species because of the linear arrangement of spines. Marginal spinosity is marked. A v-shaped frontal scar is indistinct in one specimen but the adductors cannot be seen because of the co-incidence of two large spines with the muscle scar node. There is minor resemblance to the type species *A. exanthemata* (Ulrich and Bassler) in type of ornament but insufficient characters can be identified to attribute the species unequivocally to this genus or to establish specific identity.

The material exhibits some distinctive characters. The eye tubercle is strong and prominent and in some specimens reddish in colour. In the anterior section, the spines are in four, rather than three, lines. The subcentral tubercle has two prominent spines, and the marginal spine at the posterodorsal angle is terminally trifid. The spines on the lateral surface of the valve terminate with a pore opening.

Ponticocythereis McKenzie, 1967

Remarks. This genus, by original diagnosis, differs inter alia from *Trachyleberis*, which has a subacuminate posterior, in its subquadrate shape in lateral view. The species described hereunder is tentatively placed in *Ponticocythereis* using lateral valve shape as a fundamental diagnostic feature. McKenzie (1967) remarked that for *Ponticocythereis* the "pattern of surface ornament (which is consistent in all known species) suffices to distinguish it from *Trachyleberis* which is spiny over the entire surface". This distinguishing characteristic, regarded as less fundamental than valve shape by Whatley and Titterton (1981), is lost in the present case, where the "'scale'-like protuberances" (to use their terminology) substantially cover the lateral surface of the valves.

?*Ponticocythereis* sp. aff. *P. manis* Whatley and Titterton, 1981

Pl. 2 figs 3, 4, 5

Trachyleberis sp. 2. — Scott, 1974: 125, pl. 9 figs 97-98.

Figured specimens. NMV P134945 — Pl. 2 fig. 3; NMV P134946 — Pl. 2 fig. 4; NMV P123217 — Pl. 2 fig. 5.
Dimensions. (P123217) RV: L=0.74; H=0.36
Material. 25 specimens, Clifton Bank (rare) and Hentys, Muddy Creek Marl, early Middle Miocene.

Brief description. Very spinose, subquadrate species of *?Ponticocythereis*. Squamose spines have a flattened and somewhat 'daisy'-shaped top (Pl. 11 fig 2), giving the appearance of having been squashed in a direction normal to valve surface (cf. *Trachyleberis* sp. 2. [Scott, 1974 unpublished]). 'Scales' cover valve surface including dorsum and venter, except for furrows parallel and close to anterior and posterior margins and 2 small central areas. Hinge strongly holamphidont. Muscle scars, with clearly v-shaped frontal scar, of characteristic trachyleberid form. RPCs are numerous.

Remarks. This species is very similar to *Ponticocythereis manis* Whatley and Titterton, 1981,

from which it differs in lacking the more spinose marginal dentieulation and in having only a small, ineonspieuous eye tubercle. The 'scales' show no concentration into a median ridge, as in Whatley and Titterton's species, nor is their surface punetate. The valves of *?P.* sp. aff. *P. manis* are more quadrate than of the other speeies whieh has an anterior hinge ear. There is considerable intraspeeifie variation in the form and distribution of the spines. Some specimens have a few squamose spines around the margins of the valve, with the remainder of the spines being more rounded at the ends. Other speeimens have openings or 'pores' in the flattened 'seales'.

This species differs from *P. militaris* (Brady, 1866), *P. ichthyoderma* (Brady, 1890) and *P. spinosa* Whatley and Titterton, 1981, all of whieh have large, often backward-directed spines with a linear arrangement, in the nature and distribution of its spines. Sylvester–Bradley and Benson (1971) referred to the spines of *Ponticocythereis militaris* as 'clavae', where the terminal extension of the spine is longitudinal to the orientation of the valve, but the flattened 'seales' of *?Ponticocythereis* sp. aff. *P. manis* are not clavae. The hinge strueture shows the anti-slip bar of *P. manis* s.s. The quadrate shape of the valves and the unusual form of the spines are sufficiently distinctive from *Ponticocythereis* s.s. to suggest that a new genus, inclusive of *P. manis* and *?P.* sp. aff. *P. manis*, might be considered.

Cletocythereis Swain, 1963

Discussion. The genus had a confusing beginning, with Swain using *Cythere rastromarginato* Brady, 1880 as the type species, but not redeseribing or refiguring it. Swain assigned a new species, *C. noblissimus*, to the new genus, describing and figuring it in detail, and the diagnosis of *Cletocythereis* reflected this latter species rather than the type species. Since *C. noblissimus* is not congenerie with *C. rastromarginata* (McKenzie, 1967: 232) and has been assigned to *?Acanthocythereis* by Hazel (1967) the genus needs rediagnosis. Benson (1972) published figures of *C. rastromarginata*, established a lectotype, and referred to the problem. The generic concept of *Cletocythereis* is now much more firmly based and Malz (1980) discussed it in detail, and erected new species and subspeeies.

The presumed derivation of *Cletocythereis* from *Hermanites* (Holden, 1967, 1976) was based on an assumption that Pliocene/Pleistoeene occurrences were the earliest appearances of the genus. However, confirmed occurrences from the Eocene and Oligocene (McKenzie, 1979; McKenzie et al., 1991) and Miocene of Australia (Whatley and Downing, 1983; M. T. Warne, 1987 — pers. comm. and this paper) and uneonfirmed ones from the Maastriehtian of Jamaica (Hazel in Benson, 1972) rule out *Hermanites tschoppi* (*H. paijenborchiana* auett.) as the ancestor. Benson (1972) suggested that *Cletocythereis* could be antecedent to *Hermanites*, and this is supported by its occurrence in the Late Eoeene of Australia (McKenzie, 1979). It is clear that identification of derived eharaeters as a preliminary to drawing phylogenetie inferenees ean be rather subjective when the stratigraphie ranges of species have not yet been investigated fully. Even the v-shaped frontal sear, generally aecepted as a relatively primitive feature, is not a safe guide in the ease of *Cletocythereis*. Benson (1972) referred to "a partially divided v-shaped frontal sear", and eonsequently placed *Cletocythereis* early in the line of development from ancestral trachyleberids. Yet within the populations of Miocene *Cletocythereis* speeies deseribed hereunder, intraspeeifie variations in the shape and divisions of the frontal sear or sears are eonsiderable — ranging from a single v-shaped scar, through partially divided scars and two sears, one of whieh is v- or heart-shaped, to two or three more or less eireular sears. Of these variations, however, the single v-shaped frontal scar is by far the most eommon.

In spite of the neeessity for caution, I eoncur with Hartmann and Puri's placement (1974) of *Cletocythereis* in Trachyleberididae, beeause the v-shaped frontal scar is the most eommon. The classification of Liebau (1975), whieh puts not only *Cletocythereis*, but also sueh genera as *Oertliella* and *Agrenocythere* into Hemicytheridae eannot be supported using the eonservative muscle-sear eriterion.

Cletocythereis caudispinosa (Chapman and Crespin, 1928)

Pl. 1 figs 6, 7, 8, 9

Cythere caudispinosa Chapman and Crespin *in* Chapman et al., 1928: 125, pl. 9 figs 64a, b .— McKenzie, 1974: 160, pl. 1 fig. 4.

Oertliella caudispinosa. — McKenzie, 1981: 107.

'Oertliella' caudispinosa. — McKenzie and Peypouquet, 1984 : 293.

Cletocythereis caudispinosa. — Whatley and Downing, 1983: 382, pl. 7 figs 10, 11. — Warne, 1987: 442.

Cletocythereis cf. *caudispinosa*. — McKenzie et al., 1991: 172, pl. 8 fig. 14, pl. 9 fig. 6.

Figured specimens. NMV P134939 — Pl. 1 fig. 6; NMV P134940 — Pl. 1 fig. 7; NMV P134941 — Pl. 1 fig. 8; NMV P123327 — Pl. 1 fig. 9.
Dimensions. (P123327) LV L=0.67; H=0.39.
Material. 65 specimens from Clifton Bank and Hentys, near Hamilton. *C. caudispinosa* also occurs in the Wuk Wuk Marl at Bairnsdale in Gippsland; in the lower section of the Morgan Limestone at Blanchetown, SA; and in the Mannum Formation at the Mannum Pumping Station, SA. A related and possibly ancestral form occurs in the Tortachilla Limestone and the Blanche Point Marls of the Port Willunga area of SA (personal collections) and was noted by McKenzie et al. (1991).
Horizon and Age. Muddy Creek Marl, early Middle Miocene. If the specimens from the Wuk Wuk Marl and the Morgan Limestone are conspecific, they are also contemporaneous (Abele *in* Douglas and Ferguson, 1988; Lindsay, 1985).

Description. There is a distinct eye tubercle. Halfway along the dorsal margin a 'rim tooth' (McKenzie, 1974) or 'aussenzahn' (Malz, 1980) projects above the general line of the LV and in dorsal view overlaps the RV. Hinge strongly holamphidont with smooth simple teeth and a smooth median bar. Anterior margin finely denticulate and fused zone broader than at other parts of the margin. Approximately 20 simple, unbranched radial pore canals. Anterior marginal ridge thin, sharply defined and stands up normal to lateral surface of the valve. Ventral ridge continuous with anterior ridge, thin and also sharply defined, at least in specimens from Muddy Creek. Dorsal ridge less clearly defined than for *C. rastromarginata* (Brady, 1880) but a series of 3 well-developed subacuminate nodes gives a broken dorsal profile in lateral view.

Posterodorsal angle marked by development of a short spine, as remarked by Chapman et al. Muscle scars consist of 4 adductors in a near-vertical row, each scar obliquely aligned to the ventral margin. Dorsal and ventral scars short and rounded, the middle two scars are elongate and somewhat dumbbell-shaped. Frontal scars vary, but the commonest form is a small, circular scar, with a larger v- or heart-shaped scar below it in lateral view. In some specimens the larger frontal scar has the apex of the v pointing anteriorly, rather than ventrally. In juvenile forms, the larger frontal scar is more attenuated in shape, and the smaller dorsal scar may be absent.

Remarks. Chapman and Crespin's description of the holotype is not detailed. Unlike the type species, *Cletocythereis rastromarginata* (Brady, 1880), for which Benson (1972) illustrated and designated a lectotype, *C. caudispinosa* has not been redescribed.

Chapman and Crespin's description emphasised the acuminate spinose posterior, anterior and ventral ridges, and reticulation pattern. Although they stated that 'the aureole of the median area is not distinctly radiate', in some specimens the reticulation around the subcentral tubercle is very regularly developed, except directly ventral to the tubercle. In the figured specimen, the reticulation is marked by substantial 'celation' (Sylvester-Bradley and Benson, 1971) or intergrowths which tend to obscure the pattern (Pl. 11 fig. 1).

A possibly ancestral form from Eocene beds in South Australia differs from the Muddy Creek specimens in that the dorsal ridge has spines rather than nodes, the ventral ridge is not continuous with the anterior ridge, and the posterior spines are less well-developed. However, the acuminate posterior and reticulation strongly suggest *C. caudispinosa* rather than *C. rastromarginata*. Muscle scars were not observed in these specimens so a possible relationship with the genus *Oertliella* cannot be established, even though other morphological features such as the spinose dorsum suggest it.

Cletocythereis sp. cf. *C. rastromarginata* (Brady, 1880)

Pl. 1 fig. 10, Pl. 2 figs 1, 2

Cythere rastromarginata Brady, 1880 (partim, sensu Holden, 1967): 83, pl. 16 figs 1a–d (not figs 2a–d = *C. bradyi* Holden, 1967). — Puri and Hulings, 1976: 286, pl. 9 figs 10–14 [not 9 = *C. bradyi* Holden, 1967].
Bradleya rastromarginata. — Hornibrook, 1952: 17.
Cletocythereis rastromarginata. — Swain, 1963: 823. — Benson, 1972: 22–23, 28, 56, pl. 1 figs 1–4. — Hartmann, 1981: 108, pl. 5 figs 15, 16. — Yassini and Wright, 1988: 169, figs 6 – McKenzie et al., 1990: 20–21, pl. 6 fig. 9, pl. 8 figs 11, 12.
Cletocythereis cf. *rastromarginata*. — McKenzie, 1967: 95, pl. 13 figs 1–2, fig. 6b, figs 10a–b. — Hartmann, 1978: 96, pl. 6 fig. 16. — Hartmann, 1979: 234, pl. 6 figs 5–7. — Malz, 1980: 382. — Warne, 1987: 442. — McKenzie et al., 1991: 171, pl. 8 fig. 13, pl. 9 fig. 2.
Cletocythereis sp. — McKenzie, 1979: 91, pl. 2 figs 4, 5.

Figured specimens. NMV P134942 — Pl. 1 fig. 10; NMV P134943 — Pl. 2 fig. 1; NMV P134944 — Pl. 2 fig. 2.
Dimensions. (P134942) Male LV L=0.77; H=0.36.
Material. 48 specimens from Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Brief description. Elongate species of *Cletocythereis* with finely denticulate anterior and strongly denticulate posteroventral margin. Dorsal margin straight. Posterodorsal margin concave. Ventral margin slightly concave. Fine-ribbed reticulation, tending to concentric about

the subcentral tubercle. Strong ventral marginal rib.

Remarks. These specimens differ from the lectotypes figured by Puri and Hulings (1976) in being much less inflated and in lacking the nodes on the ventral ridge. Holden's (1967) resolution of the problem of alate and non-alate forms of *C. rastromarginata* (Brady) by treating them as separate species is correct (Malz, 1980). Since the specimens from Clifton Bank and Hentys are non-alate forms, they are referred to *C. rastromarginata.* Some variation occurs in the form of the anterior ridge but this is also evident from the figures in Benson (1972). Sexual dimorphism in terms of length/height ratios confirms Holden's division of Brady's original specimens into two species. Benson (1972) did not include an amended diagnosis to replace Swain's original description (1963) and, unfortunately, the material available to me is insufficient in quantity and quality to enable an amended diagnosis to be included.

Tribe **Veeniini** Puri, 1973

Dumontina Deroo, 1966

Discussion. This genus is not represented by any other described or figured species from Australian fossil or Recent faunas, except for one species listed by Warne (1987). However, hingement and *Cythereis*-like shape, with the trachyleberid muscle scar of ?*Dumontina cratis* sp. nov. suggest this genus. Erection of a new genus for this species and ?*Dumontina* sp. A may be warranted after further study.

?Dumontina cratis sp. nov.

Pl. 2 figs 6, 7, 8

Holotype. NMV P123218 — Hentys — Pl. 2 fig. 8.
Paratypes. NMV P123219 (not figured); NMV P134947 — Pl. 2 fig. 6; NMV P134948 — Pl. 2 fig. 7.
Dimensions. Holotype LV: L=0.73; H=0.38. Paratype (P123219) RV: L=0.64; H=0.35.
Material. 57 specimens, Clifton Bank (older samples only — 7 to 10) and Hentys, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Robust *Dumontina*-like species with strongly developed, finely-meshed reticulation and deep sulci in anterior and posterior.

Description. Valves strongly calcified and thick; dorsal and ventral margins straight; valve tapered posteriorly; anterior smoothly and broadly rounded; posterior rounded with slight angularity at extremity. Strong, stub-like denticulations on full anterior and posterior margins (where not broken or worn); denticulations continued along anteroventral and posteroventral margins. Thick marginal anterior and posterior marginal ribs, covered with nodules; these ribs separated from reticulated lateral surface of valves by deep sulci, with nodules protruding into them. Ornamentation of fine-meshed, flat ribs, bordering deep, relatively small fossae, which have a longitudinal trend in ventral half of valve; irregularly distributed on remainder. Sub-central tubercle marked by smaller or no fossae, scarcely protruding above valve surface. On some specimens, v-shaped frontal scar visible on external expression of tubercle. Prominent, clear eye tubercle at anterodorsal angle.

Hinge strongly holamphidont; anterior tooth in RV curved; median elements smooth in both valves. Inner lamella of moderate width in anterior and posterior, narrower ventrally. No vestibules. RPCs numerous (15–20 in anterior; 10–12 in posterior), unbranched; occasionally paired or grouped, generally single. Muscle scar pattern difficult to determine because of reticulation. V-shaped frontal scar distinct in some specimens, adductors not determined. Sexual dimorphism — males longer and shorter than females.

Etymology. L. *cratis* = a hurdle; a reference to the wickerwork appearance of the reticulation.

Affinities. ?*Dumontina cratis* sp. nov. differs from the type species *D. puncturata* (Bosquet, 1854) figured by Deroo (1966) in the absence of any marked dorsal marginal rib and the presence of denticulations. *D. puncturata* does not have the deep sulci which characterise ?*D. cratis* sp. nov.

?Dnmontina sp. A

Pl. 2 figs 9, 10

Figured specimens. NMV P1134949 — Pl. 2 fig. 9; NMV P123220 — Pl. 2 fig. 10.
Dimensions. (P123220) RV: L=0.63; H=0.32.
Material. 32 specimens, Clifton Bank (very rare) and Hentys, Muddy Creek Marl, early Middle Miocene.

Brief description. Reticulate *Dumontina*-like species with spines confined to posterior margin and denticulate anterior margin. Flat-surfaced muri bound small, deep fossae. Anterior furrow crossed by narrow ribs. Reticulation covers subcentral area. Marginal spines clavellate. U-shaped frontal scar is only scar which can be discriminated. Hinge holamphidont.

Remarks. Dimensions indicate that ?*Dumontina* sp. A is not an instar of ?*Dumontina cratis* sp. nov. although the reticulation is quite distinctive and suggests possible affinities with that species, from which ?*Dumontina* sp. A differs by the absence of the deep anterior sulcus, the marked posterior spinosity, and the greater taper posteriorly. The u-shaped frontal scar differs from the v-shaped scar of ?*D. cratis*. The holamphidont hinge is also less strongly developed than in ?*D. cratis* sp. nov.

Deltaleberis McKenzie, Reyment and Reyment, 1991

Deltaleberis warnei sp. nov.

Pl. 3 figs 1, 2, 3

Holotype. NMV P123224 — Pl. 3 fig. 2.
Paratypes. NMV P123223 (not figured); NMV P134950 — Pl. 3 fig. 1; NMV P134951 — Pl. 3 fig. 3.
Dimensions. Holotype RV: L=0.64; H=0.27 Paratype (P123223) LV: L=0.57; H=0.32.
Material. 43 specimens, Clifton Bank and Hentys, near Hamilton. (A closely related, and possibly ancestral, form in my collection also occurs in SA, in the early Late Eocene Tortachilla Limestone at the type section 'Uncle Tom's Cabin'.) Muddy Creek Mark, early Middle Miocene.

Diagnosis. Deltaleberis with broad transverse rounded ribs, posterior one marked by round, pitted depression; anterior by central constriction.

Description. Valves subequal; hyaline in fresh specimens. Subtrapezoidal in lateral view; elongate. Anterior broadly rounded; finely denticulate anteriorly; greatest length medially. Dorsal margin straight; posterodorsal cardinal angle approximately 135° ; posterodorsal margin straight. Posteroventral margin subrounded, with denticulations. Ventral margin slightly sinuous, concave medially. Lateral valve surface irregularly inflated in 2 transverse rounded ridges (variable from specimen to specimen). Subcentral swelling (not a tubercle). Posteroventral region compressed, bordered by rounded ridge.

Valve surface smooth on ridges (under high magnification very small pores irregularly distributed over these smooth surfaces); small punctae on other surfaces (Pl. 11 fig. 4). Punctae form clearly defined patterns giving sieve-like appearance to surface of valve. Eye tubercle indistinct and merged with transverse ridge. Muscle scars as for the genus. RPCs simple, unbranched — few (7–8) on anterior margin; more closely spaced on posteroventral margin (also 7–8). Normal pores widely scattered; simple. Line of concrescence and inner margin coincident except for anteroventral sector with small vestibule; fused zone broad anteriorly.

Hinge holamphidont, but not strongly so. Sexual dimorphism — males more elongate and less inflated than females.

Etymology. For Dr M. T. Warne, in recognition of his work on the ostracode faunas of southeastern Australia.

Affinities. The valve surfaces of *Deltaleberis warnei*, with their ornamentation a combination of smooth inflated ribs or ridges and finely punctate interareas, are very similar to those of the type species *Deltaleberis rugosapytta* McKenzie et al., 1991. *Deltaleberis warnei* sp. nov. differs from the type species in its more elongate shape, even in females, and pattern of transverse ribs. It differs from *D. delicata* McKenzie et al., 1993 in having a straight posterior margin, different rib pattern, and notably a different style of fine ornamentation (Pl. 11 fig. 4).

Alatahermanites Whatley and Titterton, 1981

?*Alatahermanites septarca* sp. nov.

Pl. 3 figs 4, 6

Holotype. NMV P123221 — Hentys — Pl. 3 fig. 4.
Paratypes. NMV P123222 (not figured); NMV P134952 — Pl. 3 fig. 6.
Dimensions. Holotype RV: L=0.85; H=0.40 Paratype (P123222) LV, instar: L=0.73; H=0.35
Material. 17 specimens, Hentys, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Medium to large (up to 1 mm) ?*Alatahermanites,* with strongly ponticulate, 7–arched, alar ventral ridge; prominent subcentral tubercle and pitted surface ornamentation.

Description. Valves subrectangular in lateral view; somewhat elongate because of reduction in height from anterior to posterior. Dorsal and ventral margins straight. Anterior broadly and evenly rounded with greatest length at mid-height; posterior angulate, with greatest extension below mid-height, posterodorsal margin slightly concave and posteroventral margin straight. Anterior very finely denticulate; posterior with 4 or 5 spines well-developed in ventral half. Anterodorsal cardinal angle moderately defined; posterodorsal cardinal angle more so. Prominent 'hinge' tubercle (cf. Treatise p. Q339) developed at the anterodorsal angle. No eye tubercle or interior eye sinus. A dorsal rib clearly developed from anterior of sulcus behind 'hinge' tubercle to its termination short of the

posterodorsal angle; subponticulate, with no apertures in the arches. A strongly-developed rib linking the 'hinge' tubercle with the dorsum through a loop not in contact with the subcentral tubercle — the loop outlining a deep sulcus. Ventral rib very strongly developed from the anteroventral margin to its culmination in a very prominent rounded knob, projecting substantially from the lateral surface of the valve. This rib ponticulate in form with seven clearly differentiated arches.

Ornamentation: fine pattern of pits covering lateral surface of valves, large arched ribs linking body of valve to dorsal, anterior and ventral margins. (In some specimens small pits cover all surfaces except ribs and tubercles.) Hinge strongly but modified holamphidont, with very large, stepped, anterior tooth and socket, narrow median bar and small posterior tooth right on cardinal angle in RV; LV corresponding but median groove not strongly marked. The unusual anterior tooth in the LV ('conical pessular' tooth of *Idiocythere*, cf. Treatise: Q339) present in adult specimens with hingeline intact.

Muscle scars not readily resolvable. Frontal scar single, distinctly U-shaped with long arms; adductors a row of 4 with dorsal smallest and middle 2 scars very elongate; ventral scar not distinguished easily because of inner curvature of muscle scar depression (subcentral tubercle). Inner margin and line of concrescence coincide. Radial pore canals numerous, straight and unbranched on anterior margin.

Etymology. From the Latin for the seven arches characterising the ventral ridge.

Affinities. ?Alatahermanites septarca sp. nov. differs from the type species *A. hastatus* Whatley and Titterton, 1981 in its ornament, which is ponticulate on both dorsal and ventral margins, and pitted on the lateral surface, rather than the 'very strong coarse reticulation' of *A. hastatus.* Although it shares the subrectangular shape of *Alatahermanites*, its posterior is distinctive in being strongly denticulate and somewhat caudate, and there is a strong 'hinge' tubercle which is not characteristic of *Alatahermanites. ?A. septarca* shares some characteristics with *Idiocythere* Triebel, 1958 in its pitted surface ornamentation and denticulate posterior but lacks the tapered shape of that genus. The modified holamphidont hinge, diagnostic of *Alatahermanites,* also shares a characteristic with *Idiocythere*, notably the additional anterior rim tooth in the LV. On balance, tentative placement in *Alatahermanites* is preferred.

Remarks. This species is only tentatively attributed to *Alatahermanites* because of some shared features with *Idiocythere.* This occurrence implies that *Alatahermanites* may range into the Middle Miocene. Although the specimens allow the erection of a new species, the details of the hinge structure and muscle scar pattern need to be clarified with better preserved material. Many of the specimens have damaged hinge lines.

Idiocythere Triebel, 1958

Idiocythere sp.
aff. *I. thalassea* McKenzie, Reyment and Reyment, 1991

Pl. 3 fig. 5; Pl. 11 fig. 5

Figured specimen. NMV P123361 — Pl. 3 fig. 5; Pl. 11 fig. 5.
Dimensions. LV L=0.63; H=0.32.
Material. 1 specimen, Clifton Bank, Muddy Creek, near Hamilton, Muddy Creek Marl, late Early Miocene.

Remarks. One valve possibly conspecific with *Idiocythere thalassea* McKenzie et al., 1991: pl. 9 fig. 9 occurs in the fauna from Clifton Bank, Sample 10. Its hingeline is broken.

Tribe **Incertae sedis** ('Australimoosellini' Howe and McKenzie, 1989.)

Mackencythere Malz and Ikeya, 1982

Mackencythere sp. A.

Pl. 3 fig. 7

Figured specimen. NMV P123360 — Pl. 3 fig. 7.
Dimensions. RV L=0.46; H=0.22.
Material. 3 specimens, Hentys on Grange Burn, Muddy Creek Marl, early Middle Miocene.

Remarks. These specimens belong to a species of *Mackencythere* with a narrow anterior ridge and two concentric posterior ridges, a complex reticulation of narrow rounded ribs, and a marginal, reticulated posterior flange. The muscle platform diagnostic of the genus is clearly marked. *M.* sp. A differs from the type species, *M. venata* (Brady), 1866 in the absence of a median ridge and a more rounded posterior. It differs from *M.* sp. 1 Warne, 1987 in its narrower anterior ridge, its finer reticulation and its rounded, reticulate posterior.

Arculacythereinae Hartmann, 1981

Arculacythereis Hartmann, 1981

Discussion. The use of *Arculacythereis* Hartmann, 1981 for the following species is based on

the distinctive thickening of the shell wall below and behind the anterior hinge elements on the interior of the valve, and the distinctive pattern of ornamentation. The former characteristic is shared by genera such as *Australimoosella* Hartmann, 1978, *Doratocythere* McKenzie, 1967, *Waiparacythereis* Swanson, 1969 and *Yassinicythere* Howe and McKenzie, 1989 (McKenzie, pers. comm. 1989). However, the ornamentation of these genera is quite different from that of *Arculacythereis*.

?Arculacythereis postdeclivis (Chapman, 1914)

Pl. 3 figs 8, 9, 10

Cythere postdeclivis Chapman, 1914: 39–40, pl. 7 figs 23a, b.

Cytheralison postdeclivis. — McKenzie, 1981: 106.

Figured specimens. NMV P123225 — Hentys — Pl. 3 fig. 8; NMV P134953 — Pl. 3 fig. 9; NMV P134954 — Pl. 3 fig. 10.

Dimensions. (P123225) RV: L=1.08; H=0.56; W=0.29.

Material. 17 specimens, Henlys and Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Large *?Arculacythereis* with posterior depression; thick shell; reticulation marked by a tendency for longitudinal rather than lateral alignments; bean-shaped valves with slight median 'waist' or narrowing, and divided frontal scar.

Description. Valves large, tumid, thick-walled and bean-shaped. Anterior broadly rounded and slightly recurved ventrally. Posterior also broadly rounded, with very slight caudal process in ventral half. Eye tubercle indistinct. Ornamentation of deep subcircular to oval or elongate fossae, bounded by broad, flat-surfaced muri. Reticulation pattern oriented vertically rather than laterally. Little evidence of subcentral tubercle on external surface of valves.

Muscle scars adjacent to, but not in, subcentral pit on interior surface of valves. Two frontal scars, subcircular and separate; dorsal smaller than ventral; 4 adductor scars, the dorsomedian in some specimens elongate, in others divided; ventromedian and ventral scars subequal and closely associated, or even conjoined so as to give appearance of only 3 adductors. Shell thickening below anterior hinge elements, in a slightly elongate ridge.

Hinge weakly holamphidont. Hinge clements smooth. Inner margin and line of concrescence coincident. RPCs numerous but difficult to distinguish. Sexual dimorphism — females shorter and higher than males. Juveniles with reticulation more marked, muri narrower than in adults; hinge hemiamphidont. Very large, indistinctly ornamented specimens common.

Affinities. ?Arculacythereis postdeclivis (Chapman, 1914) shows some affinities with *Lankacythere coralloides* (Brady, 1886) from which it differs in its more ovate fossae, the absence of the ear-shaped posterior ridge and the less distinct eye tubercle (Bhatia and Kumar, 1979). However, it is on the basis of its dorsal 'stub' or ridge that the species is tentatively assigned to *Arculacythereis* rather than to *Lankacythere*, since Bhatia and Kumar make no reference to such a feature in their diagnosis of the latter genus. *Lankacythere* has a trachyleberid v-shaped frontal scar as in other campylocytherinid genera, whereas these specimens have the hemicytherid divided frontal scar consisting of two subrounded scars. To retain the species in a trachyleberidine genus raises the significance of frontal scar configuration in Trachyleberididae and Hemicytheridae.

It is possible that the assignment of *?Arculacythereis postdeclivis* (Chapman, 1914) might be confirmed when further studies of the genera *Australimoosella* Hartmann, 1978, *Yassinicythere* Howe and McKenzie, 1989, *Doratocythere* McKenzie, 1967 and *Waiparacythereis* Swanson, 1969 have been completed. At present, the significance of the anterodorsal thickening of the shell below the anterior hinge elements is equivocal, since it is also a diagnostic feature of these genera.

Remarks. Chapman's original description is inadequate. Surface ornament, hinge development and muscle scar configuration vary substantially intraspecifically. Very large thick-shelled specimens often show considerable wear and abrasion. The muri are enlarged and the fossae small and shallow — in extreme cases the surface is almost without a pattern of ornament. Bhatia and Kumar (1979) referred to variations in the form and pattern of the muri, which they suggested may be ecological. The frontal scars are occasionally joined to form one *Grinioneis*-style scar; dorsomedian adductor frequently divided also.

Arculacythereis tatei sp. nov.

Pl. 3 figs 11, 12

Holotype. NMV P123266 — Hentys — Pl. 3 fig. 11.

Paratypes. NMV P123267 (not figured); NMV P134955 — Pl. 3 fig. 12.

Dimensions. Holotype RV: L=0.78; H=0.39. Paratype (P123267) LV: L=0.70; H=0.34.
Material. 36 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Arculacythereis species with reticulate/punctate ornamentation and distinct posteroventral compressed flange.

Description. Well-calcified subrectangular inflated valves, with maximum inflation on posteroventral area, bordering marked posteroventral flange. Dorsal margin straight; ventral margin slightly sinuous, subparallel to dorsal margin. Anterior very broadly rounded; posterior more narrowly rounded, with maximum lateral extension slightly above mid-height. Valve surface covered with indistinct pattern of rounded ribs, with punctae rather than fossae within the mesh of ribs. Larger, deeper fossae in arc parallel to anterior and posteroventral margins. Slight denticulations on posteroventral margin. No subcentral tubercle.

Hinge shows a thin, elongated tooth in RV. Median element appears to be smooth but difficult to determine. Only the u-shaped frontal scar visible; adductor pattern not known. Inner lamella broad in anterior, less so in posterior. No vestibules. RPCs clustered in groups of up to five; numerous; some branched. Interior of valve subdivided by swellings not matched by sulci on valve exterior. Very prominent dorsomedial projecting stub. Sexual dimorphism not evident. Juveniles show some evidence of slight sulci on external valve surface; dorsomedian stub well-developed.

Etymology. For Professor Ralph Tate who collected and described fossils from this locality in the late nineteenth century.

Affinities. Arculacythereis tatei differs from the type species *A. vacciformis* Hartmann, 1981 in having a straight dorsum, very slightly concave venter and no 'Feinskulptur', although the general pattern of ornamentation is similar. *A. tatei* is closer in shape to *A.* sp. Howe and McKenzie, 1989, but the latter is uniformly inflated, with no posteroventral flange.

Arculacythereis sp. aff. *A. thomasi* McKenzie, Reyment and Reyment, 1991

Pl. 4 figs 1, 2

Figured specimens. NMV P134956 — Pl. 4 fig. 1; NMV P123265 — Pl. 4 fig. 2.
Dimensions. (P123265) LV L=0.70; H=0.34.
Material. 1 specimen, Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Brief description. Arculacythereis species similar to *A. thomasi* McKenzie et al., 1991 but differing in its straight rather than slightly convex dorsal margin, more compressed posteroventral area, narrower posterior and dorsal depression or pit. Because the range of intraspecific variation in *A. thomasi* is not known, the assignment is tentative.

Arculacythereinidae

Arculacythereinid gen. indet. sp. A

Pl. 4 fig. 3

Figured specimen. NMV P123268 — Pl. 4 fig. 3; NMV P123269 (not figured).
Dimensions. (P123268) LV: L=0.85; H=0.43. (P123269) RV, juvenile: L=0.71; H=0.36.
Material. 11 specimens, Hentys only, Muddy Creek Marl, early Middle Miocene.

Brief description. Arculacythereinid with deep anterior furrow; strongly inflated valve and surface ornamentation consisting of primary swellings and ribs, with fine-ribbed secondary reticulation and micropunctate surface. Anterior furrow and irregularly inflated surface reminiscent of New Zealand species *Waiparacythereis joanae* and *Waiparacythereis caudata* Swanson, 1969. Caudal development minimal differing from clear posteroventral caudae of *Waiparacythereis* species. Posterior compressed and sharply divided from medial inflated section of valve. Muscle scars include a u-shaped frontal scar, group of 4 elongate adductors and large subrounded ventral mandibular scar. Flattened dorsomedial stub projecting into interior of valve (diagnostic of arculacytherinid group of genera). Unequivocal generic assignment not possible.

Tribe **Pterygocythereidini** Puri, 1957

?Pterygocythereis Blake, 1933

?Pterygocythereis sp. indet.

Pl. 13 fig. 7

Figured specimen. NMV P123362 — Pl. 13 fig. 7.
Dimensions. LV L=0.43; H=0.28.
Material. 1 specimen, Hentys on Grange Burn, Muddy Creek Marl, early Middle Miocene.

Remarks. This specimen is a juvenile but because of the strongly developed, broad, flat-topped spines and absence of perforations and

butresses in the ventral ridge is placed in ?*Pterygocythereis* rather than *Alataleberis* (McKenzie and Warne, 1986) or *Ponticulocythere* Dingle, 1981. The relationships of the genera *Alataleberis, Pterygocythereis* and *Alatacythere* were discussed by McKenzie and Warne (1986) where reference was also made to *Ponticulocythere* as a possible ancestor of *Alataleberis*. This juvenile does not provide clear evidence of any relationship with *Ponticulocythere*.

Tribe **?Pterygocythereidini** Puri, 1957

Alataleberis McKenzie and Warne, 1986

Alataleberis miocenica McKenzie and Warne, 1986

Pl. 4 figs 4, 5, 6

Alataleberis miocenica McKenzie and Warne, 1986: 38 figs 2d, 3n–r.

Figured specimens. NMV P134957 — Pl. 4 fig. 4; NMV P134958 — Pl. 4 fig. 5; NMV P123363 — Pl. 4 fig. 6.
Dimensions. (P123363) Carapace L=0.83; H=0.41; W=0.31.
Material. 32 specimens, Clifton Bank and Henlys near Hamilton, Muddy Creek Marl, early Middle Miocene.

Remarks. These specimens are clearly conspecific with those figured by McKenzie and Warne (1986) some of whose specimens came from the Clifton Bank locality. The figured specimen has a strongly developed eye tubercle, and regularly but sparsely distributed normal pores.

Hemicytheridae Puri, 1953

Hemicytherinae Puri, 1953

Tribe **Hemicytherini** Puri, 1953

Hemicythere Sars, 1925

'Hemicythere' lubrica sp. nov.

Pl. 4 figs 7, 8; Pl. 14 figs 2, 3

Holotype. NMV P123226 — Clifton Bank — Pl. 4 fig. 7, Pl. 14 fig. 2.
Paratypes. NMV P123227 — Pl. 4 fig. 8, Pl. 14 fig. 3; P123228 (Not figured).
Dimensions. Holotype RV: L=0.71; H=0.38. Paratype LV: L=0.70; H=0.41. Paratype Carapace: L=0.70; H=0.38; W=0.34.
Material. 154 specimens, Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Smooth, shiny-surfaced, subrectangular hemicytherid, with distinct posterodorsal and posteroventral protuberances and subcentral tubercle below mid-height.
Description. Valves thick-shelled; dorsal and ventral margins straight; anterior curved but not broadly rounded; posterior with blunt caudal process in ventral half. Posterodorsal margin slightly concave. Anterodorsal cardinal angle rounded, projecting slightly above the dorsum. A hinge-ear more marked in LV than RV.

Surface smooth and shiny, with strong rounded protuberances posterodorsally and posteroventrally; former more posteriorly located than latter. Subcentral tubercle below mid-height but not strongly developed. Valve surfaces with smoothed irregularities but neither ornamentation nor ribs. Normal pores scattered over surface, type not known. Few small denticulations on posteroventral margin. Eye tubercle indistinct.

Hinge strongly holamphidont; anterior tooth in RV stepped; median bar smooth. Anteromedian tooth in LV rounded. Sockets deep. Muscle scar pattern complex and variable within the species (Pl. 14 figs 2, 3). Holotype with 2 rounded frontal scars (some specimens have 3); 4 adductors in very oblique row on side of muscle scar pit; dorsal scar small, subrounded; 2 median scars clearly divided (undivided in some specimens); ventral scar slightly elongate.

Marginal zone relatively broad in anterior and posteroventral sector; narrow vestibules. Approximately 15–20 simple, unbranched RPCs on anterior margin; few on posterior. Normal pores not observed on holotype, but possibly simple, from evidence on other specimens. Juveniles more rounded in lateral view; hinge ears not developed; hinge merodont. Sexual dimorphism not observed.

Remarks. Although the generic assignment of this species to *Hemicythere* is uncertain, it undoubtedly belongs to the tribe Hemicytherini rather than to Aurilini (Hartmann and Puri, 1974). *Hemicythere* has been recently ignored as with other genera established when an abundant and distinctive group is initially tackled. Under these circumstances the generic diagnosis tends to be too all-embracing, although in the case of *Hemicythere*, Sars' diagnosis (1922–28) remains more precise than some contemporary ones. The type genus no longer serves as a catch-all for species better related to more recently erected genera (Van Morkhoven, 1962). This scenario occurs more than once in the Hemicytheridae, e.g. Hornibrook's (1952) *Quadracythere* and *Bradleya*.

Recently fewer species have been referred to *Hemicythere* s.s. Hazel (1967) refers to the 'subreniform shape, distinctive hingement and

muscle scars' as important features characterising its type species. The assignment of *'H.' lubrica* sp. nov. to the genus needs justification in view of its subrectangular shape and absence of ventral inflation. It does not look like a *Hemicythere* species. The muscle scar pattern of the holotype, same as that of the type species, varies within the population from Muddy Creek. On the other hand, hingement is typical. *'H.' lubrica* cannot be assigned to another genus (Hartmann and Puri, 1974) even though *Hemicythere* s.s. is characteristically a Northern Hemisphere cool temperate genus.

Etymology. Latin *lubricus* — slippery; a reference to the shiny surface of the valves.

Affinities. *'H.' lubrica* has no close affinities with other species of *Hemicythere*. *Tenedocythere nuda* McKenzie et al., 1991 is similar to *'H'. lubrica* in lateral view and size and may even be conspecific. However, an assignment to *Tenedocythere* cannot be sustained on the basis of general shape since I believe the ornamentation and the smooth posterior tooth in RV are diagnostic and *'H'. lubrica* has no ornamentation and a lobed posterior tooth. On the other hand, the muscle scar pattern is given greater weight in my assignment.

'Hemicythere' tenuicostata sp. nov.

Pl. 4 figs 9, 10; Pl. 5 fig. 1, Pl. 14 fig. 4

Holotype. NMV P123230 — Clifton Bank — Pl. 4 fig. 10, Pl. 14 fig. 4.
Paratypes. NMV P123229 (Not figured); P123231 (Not figured); P134959 — Pl. 4 fig. 9; P134960 — Pl. 5 fig. 1.
Dimensions. Holotype RV: L=0.66; H=0.39. Paratype (P123229) LV: L=0.64; H=0.38. Paratype Carapace (P123231): L=0.73; H=0.41; W=0.29.
Material. 50 specimens, mostly at Clifton Bank, but also rarely at Hentys, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Compressed, lightly-ridged hemicytherid, with narrow ventral flange, medially and posteriorly.

Description. Valves characteristic hemicytherid shape in lateral view, with broadly rounded anterior; slightly acuminate posterior, terminating in ventral half of valve; dorsal and ventral margins subparallel. Dorsal margin straight, with slight projections at anterodorsal and posterodorsal angles. Posterodorsal margin slightly convex and broken at midpoint by additional small projection, giving an angled profile. Ventral margin sinuous, with 2 or 3 small, widely separated denticulations towards posterior.

Surface of valves very lightly pitted in ventral half (very difficult to discern in worn specimens); narrow, horizontal ridges, very lightly developed except ventrally, and slightly radiate in the posterior. Parallel ventral ridges more marked; one ridge defining the slight ventral inflation of valves; otherwise valves compressed. No subcentral tubercle but muscle scars visible on exterior surface in some specimens. Weakly developed eye tubercle below anterodorsal cardinal angle.

Muscle scars — 4 adductors; dorsal and dorsomedian elongate (latter divided in some specimens); ventromedian and ventral scars subrounded and aligned obliquely to the trend of other adductors. Two subrounded frontal scars, ventral larger. Two clearly marked dorsal scars, anterior v-shaped, apex of v pointing anteriorly. Fulcral point between dorsal scars marked by opaque area (Pl. 14 fig. 4.)

Hinge strongly holamphidont. RV anterior tooth smooth and simple; posterior tooth narrow and blade-like, triangular in lateral view; large anteromedian socket; smooth median bar with distinct ventrally directed angulation at posterior end. LV anterior socket deep, with rounded retaining bar across ventral portion; posterior socket on posterodorsal margin, elongate and narrowed at ends; anteromedian tooth simple, smooth and rounded; median groove narrow and curved at posterior end round posterodorsal angle. Fused zone narrow, except anteriorly; inner margin and line of conerescence coincident throughout. RPCs difficult to determine. Normal pores numerous and open. Sexual dimorphism — females shorter and higher than males. No juveniles in this population.

Etymology. Latin *tenuis* — thin; *costa* — a rib; a reference to the fine, narrow ridges on the valves.

Affinities. *'H.' tenuicostata* has the characteristic hemicytherid shape and narrow ventral ridge. It differs from the type species *H. villosa* Sars, 1866 in being only lightly pitted and in its muscle scar pattern. As few Australian fossil species have been referred to *Hemicythere* (*H. tarakohensis* Hornibrook, 1952 appears to be a *Quadracythere*) *'H.' tenuicostata* has no close relationships with described species of this genus. It is markedly different in shape from *'H.' lubrica* sp. nov. Although *'H.' tenuicostata* has some points which link it to Hartmann's (1979) subgenus *Procythereis (Serratocythere)*, it cannot be placed in that taxon because its muscle scar pattern does not fit the 1–1–2–1(2) formula given

in Hartmann's diagnosis (1979); its shape is hemicytherid rather than aurilinid and it has a distinct, if small, caudal process, more noticeable in the RV. In addition, *Serratocythere* is diagnosed as foveolate ('punctate' in Sylvester-Bradley and Benson's 1971 terminology), whereas '*H.*' *tenuicostata* is only very lightly pitted.

'Hemicythere' sp. cf. *'H'. tenuicostata*

Pl. 5 fig. 2

Figured specimen. NMV P123364 — Pl. 5 fig. 2.
Dimensions. LV L=0.59; H=0.36.
Material. 22 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Remarks. This specimen is a *'Hemicythere'* similar to *'H'. tenuicostata,* but differing in more acuminate posterior, greater inflation of the valves and the posterior reticulation network.

Hemicytherid gen. et sp. indet.

Pl.13 fig. 8

Figured Specimen. NMV P123365 — Pl. 13 fig. 8.
Dimensions. LV L=0.32; H=0.17.
Material. 9 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Remarks. Although there is a characteristic ventral inflation and hemicytherid muscle scar pattern, these specimens are more elongate and acuminate than the *'Hemicythere'* species described above. Furthermore, the slightly irregular surface is punctate, rather than ridged. Assignment beyond family level is not possible.

Mackenzina gen. nov.

Type species. Mackenzina foveolata sp. nov.

Diagnosis. Hemicytherid with well-developed bifid posteroventral spine, pitted lateral surface and subacuminate cauda.

Etymology. For Dr K. G. McKenzie in recognition of his pioneering work on Australian Cenozoic ostracoda.

Remarks. Mackenzina differs from members of the Aurilini Puri, 1973. It is unlike *Mutilus* and *Aurila* in its muscle scar pattern and unlike *Pokornyella* in shape. Its double frontal scar suggests Hemicytherini Puri, 1953 and its prominent bifid spine together with other diagnostic features is regarded morphologically as warranting generic status.

Mackenzina foveolata sp. nov.

Pl. 5 figs 3, 4, 5, 6

Holotype. NMV P123235 — Hentys — Pl. 5 fig. 3.
Paratypes. NMV P123236 — Pl. 5 fig. 4; P123237 — Pl. 5 fig. 6; P134961 — Pl. 5 fig. 5.
Dimensions. Holotype RV: L=0.70; H=0.42. Paratype (P123236) LV: L=0.73; H=0.43. Paratype (P123237) RV, instar: L=0.62; H=0.36.
Material. 95 specimens, Hentys, on Grange Burn, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Mackenzina with bifid posteroventral spine, small equally spaced spines on the ventral side of cauda, and regularly pitted lateral surface.

Description. Subquadrate valves; dorsal and ventral margins parallel in LV; dorsal margin slightly curved in RV; anterior gently rounded; greatest length slightly below mid-height. Posterior with subacuminate cauda slightly above mid-height of valve in lateral view. Posteroventral margin straight and angled at 315°, with 2 or 3 short, broad spines. Outer margin and outline coincident in lateral view except where bifid spine projects slightly beyond margin. Valve closure straight in dorsal and ventral view, except for slight sinus in anterior RV. Bifid character of ventral spine clearly evident in ventral view. LV overlaps RV slightly at anterodorsal cardinal angle.

Ornamentation of regular small pits over lateral surface of valves, concentric to anterior margin, but not markedly linear over the rest. Pits on base of bifid spine. Row of larger fossae above ventral ridge anterior to spine. Anterior and posterior margins compressed as generally unornamented flange. Ventral ridge extending into bifid, bladelike spine at its posterior termination, with proximal and distal components of subequal size. Small denticulations on anterior margin of less abraded specimens. Subcentral tubercle slightly below midline and in anterior of valve; free of pits; not prominent; gentle swelling only. Eye tubercle clear, distinct and glassy; well below dorsal margin in lateral view.

Inner lamella broadest anteriorly, but generally narrow. Inner margin and line of concrescence coincident (i.e. no vestibules). RPCs numerous and unbranched — more apparent in juvenile specimens. Normal pores not observed because of adherent matrix.

Muscle scars — 2 subrounded frontal scars (fused in some specimens); 4 adductors in vertical row; ventromedian scar small and sub-

circular; other adductors elongate and oblique. Sexual dimorphism not detected. Hinge strongly holamphidont; RV with strong, peg-like anterior tooth; elongate triangular posterior tooth; anteromedian socket bounded ventrally by a ridge extending from the anterior tooth; median groove smooth. LV with deep anterior socket; shallower and slightly longitudinal posterior socket; median bar faintly crenulate. Juvenile specimens with pitting around subcentral tubercle; outer areas smooth; some RPCs branched; few RPCs on cauda; bifid spine clearly developed, more acute and pointed than in adults; valve margins thinner and more flange-like; A7 instar with merodont hinge; A8 with holamphidont hinge.

Etymology. Latin — foveola, a small depression (even though the depressions may be large enough in some specimens to warrant the designation 'punctae').

Remarks. M. foveolata sp. nov. is the only species attributed to *Mackenzina,* and is most nearly related to *Hemicythere* s.s. The ornamentation of *M. foveolata* raises the question of differentiating between a smooth pitted surface and one with a reticulation of muri. Such a question becomes one to be resolved by SEM micrographs. With the light microscope, the boundaries between pits or fossae and the surrounding muri, or valve surface are critical. If the boundaries are sharp and right-angled or acutely angled and if the intervening spaces between the pits/fossae are relatively flat, the surface can be described as 'pitted' (Sylvester–Bradley and Benson, 1971). If the boundaries are less precisely defined and the intervening spaces are seen to be continuous with the sides of the fossae, the surface is reticulated (Sylvester–Bradley and Benson, 1971). In the case of *M. foveolata* sp. nov. the former applies.

Each moult represents the complete expression of the genotype for that stage provided there is enough calcite available. Greater or lesser pitting or reticulation compared with that in the adult is indicative only of the pattern for the particular juvenile stage, unless there is insufficient ambient calcite available to allow full expression. Variation does not reflect loss of some shell material through development of more pits/fossae or addition of material through the development of more muri (Roer and Dillaman, 1984). Potential for these variations to provide some palaeoenvironmental information has not been investigated.

Tribe **Aurilini** Puri, 1973

Pokornyella Oertli, 1956

'Pokornyella' sp. indet.

Pl. 6 fig. 1

Figured specimen. NMV P123368 — Pl. 6 fig. 1.
Dimensions. RV L=0.67; H=0.45.
Material. 1 specimen, Clifton Bank on Muddy Creek, Muddy Creek Marl, early Middle Miocene.

Brief description. Uuniformly punctate '*Pokornyella*' with the size of punctae decreasing from centre to margins. Truncate caudal process in the ventral half of the posterior. Prominent eye tubercle.

Remarks. Because of some similarity in shape to *Neobuntonia batesfordiense,* the specimen is only tentatively assigned to *Pokornyella. 'Pokornyella'* sp. indet. differs from *Pokornyella australiae* McKenzie et al., 1991 in being punctate rather than reticulate. It differs from *Pokornyella* s.l. McKenzie, 1979, which is a punctate form, in its general shape, more elongate and distinctly caudate. The rarity of *Pokornyella* in these generally warm temperate to subtropical faunas is consistent with its preference for a cooler palaeoenvironment. Thus the report by McKenzie et al. (1991) of 83 from Bells Headland and Point Addis suggests some Late Oligocene cooling in south-eastern Australia. This isolated specimen is probably allochthonous.

Thaerocytherinae Hazel, 1967

Tribe **Thaerocytherini** Hazel, 1967

Hermanites Puri, 1955

Remarks. Hermanites was erected to include species from the United States and has remained a characteristic Western Hemisphere genus although its use for Eastern Hemisphere species was initially quite acceptable (Moos, 1965). Sissingh (1972) and Liebau (1975) revised European Trachyleberididae and Hemicytheridae, as a result of which species with similar external characteristics of valve shape and ornamentation formerly in *Hermanites* were reassigned to new genera. Sissingh (1972) erected *Tenedocythere* as a subgenus of *Quadracythere* on the basis of longitudinal ribbing, features of the hingement and RPCs. Liebau (1975) erected *Grinioneis* as a subgenus of *Cletocythereis,* with *Hermanites paijenborchiana* Keij, 1957 as type species. Both workers placed their genera in the Trachyleberididae in spite of difficulties in establishing a

diagnosis which incorporated frontal scars. As early as 1963 von Morkhoven recognised the potential confusion. *Hermanites* is used for species from this fauna where the original diagnosis covers their main characteristics. *Tenedocythere* and *Grinioneis* are excluded because the diagnostic characteristics of the Muddy Creek species do not fit satisfactorily.

Hermanites glyphica sp. nov.

Pl. 7 figs 3, 4, 5, 6, 7, 8; Pl. 12 fig. 4

Holotype. NMV P123249 — Hentys — Pl. 7 fig. 3.
Paratypes. NMV P123250 (Not figured); P123251 — Pl. 7 fig. 5; Pl. 12 fig. 4; P134968 — Pl. 7 fig. 4; P134969 — Pl. 7 fig. 6; P134970 — Pl. 7 fig. 7; P134971 — Pl. 7 fig. 8.
Dimensions. Holotype LV: L=0.92; H=0.59. Paratype (P123250) LV: L=0.97; H=0.59. Paratype (P123251) RV, instar: L=0.77; H=0.46.
Material. 426 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Large, thick-shelled *Hermanites* with coarse, rounded reticulation, developed only in the adult form.

Description. Valves large, heavy, thick-walled; coarse reticulation. Lateral surface of valves inflated and irregular; dorsal rib short and ill-defined. Anterior margin with numerous small denticulations, often abraded. Slight caudal process below mid-line of valve, fringed by 5–6 short spines in well-preserved specimens. Eye tubercle not prominent. Subcentral tubercle high, covered by reticulation, but not large in area. Posterodorsal termination of dorsal rib a blade-like process with 2 muri of reticulation. Ventral rib terminates posteriorly in blunt process. Blade-like protuberance on ventral closure (sinus). In dorsal view carapace arrow-shaped. Characteristic semi-circular pit below subcentral tubercle, bounded by muri. Behind rim of anterior margin a row of 6–7 fossae beginning anterior to eye tubercle. Second, less-well-defined row of fossae posterior to first row and separated from it by strong rounded rib. RPCs numerous along anterior margin (25–30 straight, unbranched and occasionally paired); 8–10 RPCs on caudal process. Line of concrescence and inner margin coincident.

Muscle scars in pit internally, expressed as subcentral tubercle externally; oblique row of 4 adductors (sometimes appearing as 3, see description of *'H.' lungulata*) — dorsal long, dorsomedian dumbbell-shaped and longest, ventromedian small and circular (in some specimens drawn out, ventral slightly more extended. Two subcircular frontal scars.

Hinge holamphidont; smooth median bar; posterior tooth smooth, blade-like and at 45° to the dorsal median ridge/groove. Sexual dimorphism not clearly established; females broad and short; males relatively longer and narrower. Shell material hyaline. No signs of 'spongeous' reticulation. Juveniles do not show the strong reticulation pattern, but have fine network over finely punctate surface (Pl. 12 figs 5, 6). Juveniles all males in this population.

Etymology. Greek, *glyphe* — a carving, with reference to the appearance of the heavy reticulation.

Affinities. H. bireticulata Al-Furaih, 1980 has 3 frontal scars and differs from *H. glyphica* in its curved anterodorsal profile, absence of processes at the ends of ribs, less regular anterior ornamentation and its three frontal scars. In other respects it is fairly similar. *H. soliporosa* Al-Furaih, 1980 and *H. tranquilis* Al-Furaih, 1980 are much less rectangular and have different patterns of reticulation. *H. fungosa* Butler, 1963 has no lateral rows in the reticulation. The *H. tschoppi* (Bold, 1946) plexus has different muscle scars, regularity of reticulation and size. *H. glyphica* differs from the type species, *H. reticulata* Puri, 1953, in its less well-developed subcentral tubercle, smooth median bar in the hinge and less well-developed cauda. *H. immodica* Al-Furaih, 1984 has no mediodorsal tubercle. *H. straba* Al-Furaih, 1983 is longer and less high, with less marked reticulation. I agree with Neale's (1975) comment that *H. volans* Neale, 1975 belongs in another genus. With *H. dameriacensis* Keij, 1958 the subcentral tubercle is clear of reticulation, unlike in the case of *H. glyphica* sp. nov.

'Hermanites' thomasi sp. nov.

Pl. 7 figs 9, 10; Pl. 8 figs 1, 2; Pl. 10 fig. 9; Pl. 12 figs 7, 8; Pl. 14 fig. 6

?*Grinioneis* sp. 1. — Warne 1987: 443, pl. 3 fig. 1.

Holotype. NMV P123242 — Clifton Bank — Pl. 7 fig. 9, Pl. 14 fig. 6.
Paratypes. NMV P123243, P123244 (Not figured); P134972 — Pl. 7 fig. 10; P134973 — Pl. 8 fig. 1, Pl. 12 fig. 7; P134974 — Pl. 8 fig. 2; P134992 — Pl. 10 fig. 9, Pl. 12 fig. 8.
Dimensions. Holotype LV, ♀: L=0.66; H=0.39. Paratype (P123243) RV, male: L=0.71; H=0.38. Paratype (P123244) Carapace: L=0.64; H=0.36; W=0.29.
Material. 471 specimens, Clifton Bank, Muddy Creek, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Small *Hermanites*-like, with well-defined subcentral tubercle and reticulation laterally radiate from it; prominent alate posteroventral process; posterodorsal spine.

Description. Valves small; LV overlapping RV slightly in anterior; dorsal and ventral margins subparallel, straight to slightly sinuous; anterior rounded; greatest lateral extension in ventral half with distinct acuminate caudal process. Three short spines on posteroventral margin; posterodorsal margin concave. Dorsal margin with small anterior 'hinge ear' on both valves. Eye tubercle distinct and clearly below dorsal margin.

Ornamentation a clear reticulation of broad rounded muri bounding narrow, deep fossae; reticular pattern laterally radiate from smooth, rounded subcentral tubercle. Muscle scars visible on external surface of tubercle. Strong ribbing on ventral surface of alar processes. Ventral rib strong. Anterior margin marked by rounded rib. Small dorsal rib terminated posteriorly by strong, projecting angular node.

Hinge holamphidont; median bar smooth. Muscle scar pattern (Pl. 14 fig 6.) a cluster of 3 frontal scars, all subcircular, 2 larger, with smaller one between. Obliquely vertical row of 4 adductor scars; dorsomedian clearly divided; posteromedian elongate. Two dorsal scars above main cluster. Muscle scar pattern substantially consistent throughout population.

Inner margin and line of concrescence coincident. Fused zone relatively narrow. RPCs and normal pores not observed. Sexual dimorphism marked; males longer and less high than females. No juveniles present in this population.

Etymology. For Dr G. A. Thomas, who assisted in the supervision of this project.

Remarks. Although the muscle scar pattern is consistent throughout the population and differs from the two frontal scars diagnostic for *Hermanites* s.s., *H. thomasi* is tentatively placed in this genus for reasons similar to those set out below for '*H.*' *lungulata*. The muscle scar pattern is characteristic of the auriline genera *Mutilus* and *Aurila* but the hingement of *H. thomasi* lacks the notched posterior tooth and stepped anterior tooth of aurilinids, and its shape in lateral view is quite unlike their ventrally inflated forms. The specimen figured by Warne (1987) is probably conspecific with '*H*'. *thomasi* but its frontal scar pattern rules out the trachyleberid *Grinioneis*. Although '*H*'. *thomasi* has a linear reticulation pattern, it is quite unlike Sissingh's (1972) figures of *Tenedocythere prava* (Baird, 1850), *T. mediterranea* Ruggieri, 1962 and *T. salebrosa* Uliczny, 1969 in that it has a subcentral tubercle free of reticulation, and its muri are somewhat flat-surfaced. Assignment to *Tenedocythere* is inappropriate.

There are some similarities to *Margocythere* McKenzie et al., 1991 but the absence of the eponymous broad margin, the smooth, rather than 'rugged' reticulation, and relatively small size rule out assignment to that genus. According to Hartmann and Puri (1974: 35) frontal scars are indeterminate between trachyleberids and hemicytherids but I place this species in Hemicytheridae, not only on the basis of frontal scars but also because of similarity to such non-trachyleberids as the bradleyine genera. On the basis of muscle scars alone, the species might be assigned to the Aurilini but it does not have auriline ventral inflation, nor the notched posterior and stepped anterior teeth of auriline hingement.

'*Hermanites*' *lungulata* (McKenzie, Reyment and Reyment, 1991)

Pl. 6 figs 9, 10; Pl. 7 figs 1, 2; Pl. 14 fig. 7

Bradleya lungulata McKenzie et al., 1991: 162, pl. 6 fig. 8, pl. 10 figs 9, 10.

'Bradleya' lungulata. — McKenzie et al., 1993: 113, pl. 7 fig. 13, pl. 8 fig. 19.

Figured specimens. NMV P123245 — Pl. 6 fig. 10, Pl. 14 fig. 7; P123246 (Not figured); P123247 — Pl. 7 fig. 1; P123248 (Not figured); P134966 — Pl. 6 fig. 9; P134967 — Pl. 7 fig. 2.

Dimensions. (P123245) RV: L=0.84; H=0.43. (P123246) LV: L=0.91; H=0.48. (P123247) Carapace: L=0.90; H=0.43; W=0.64. (P123248) LV, instar: L=0.66; H=0.35.

Material. 68 specimens, Hentys and Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Brief description. Medium to large *Hermanites*-like species with 'spongeous' or celated reticulation; regular lateral surface reticulation bounded by narrow, flat-surfaced muri; prominent subcentral tubercle, free of reticulation.

Affinities. This species is close to *H. (Grinioneis) paijenborchiana* (Keij, 1957) in terms of reticulation and shape, but specimens from Muddy Creek differ in having three subcircular frontal scars. It differs from other *Hermanites* as discussed below for *H. glyphica*, in having only small nodules at the ends of the dorsal and ventral ribs. It is also close to *Quadracythere*

quadrazea Hornibrook, 1952. It appears quite similar to *Limburgina quadrazea* (Hornibrook) (Benson, 1972: pl. 1 fig. 6), which specimen is quite large (L=0.93 mm), and lacks a cauda and the strong ventral ridge of *'Hermanites' lungulata.* Pl. 6 fig. 8 of McKenzie et al. (1991) differs from the other illustrated specimens in having reticulation on the subcentral tubercle, in its pattern of reticulation without clearly defined concentric sequence of reticules around the tubercle and in the rounded surfaces of the muri.

Remarks. *'H' .lungulata* is tentatively included in *Hermanites* because of its shape, caudal process, dorsal and ventral alate ventral ribs. However, its muscle scar pattern is somewhat anomalous in having three frontal scars (Muddy Creek specimens only) and two ventral adductors so closely associated that they sometimes appear as one undivided scar (Pl. 14 fig. 7). These variations are within the range of hemicytherids (Hartmann and Puri, 1974) and further underline the need for caution in using muscle-scar patterns as diagnostic at the generic level in "transitional" hemicytherids.

The use of the term 'divided' to describe a muscle scar is ambiguous. It is difficult to separate single, original adductor scars divided because of evolutionary, ecophenotypic or functional trends from separate scars fused. It is equally difficult to specify separate adductor scars even if closely associated. Divisions between components associated laterally are usually regarded as dividing a single scar, whereas divisions between components closely associated vertically are not. It is not clear from the literature whether the adductor muscle attachment points reflect the separation of fibres into clusters or not but these muscles tend to be separated vertically rather horizontally. In *'H' .lungulata,* division of the closely associated scars is vertical so that it would be generally regarded that the species had four adductor scars, the ventral two very closely associated or fused. Variation occurs intraspecifically at one location, as well as between locations.

Bradleya lungalata McKenzie et al., 1991 and *'Bradleya' lungulata* McKenzie et al., 1993 cannot belong to *Bradleya* because of their distinct cauda, flat-surfaced muri, radiate reticulation pattern, relatively small reticules and smooth subcentral tubercle, none of which fits Benson's (1972) diagnosis of Bradleyinae. Consequently, this species should be re-assigned to *Hermanites* s.l.

Bradleyinae Benson 1972

Spinobradleya McKenzie, Reyment and Reyment, 1991

Spinobradleya nodosa sp. nov.

Pl. 8 figs 3, 4, 5, 6

Holotype. NMV P123252 — Clifton Bank — Pl. 8 fig. 3.
Paratypes. NMV P123253, P123254 (Not figured); P134975 — Pl. 8 fig. 4; P134976 — Pl. 8 fig. 5; P134977 — Pl. 8 fig. 6.
Dimensions. Holotype LV: L=0.83; H=0.45 Paratype (P123253) RV: L=0.81; H=0.43. Paratype (P123254) LV, instar: L=0.63; H=0.36.
Material. 337 specimens, Hentys on Grange Burn, and Clifton Bank on Muddy Creek, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Subrectangular *Spinobradleya* with strongly developed blade-like dorsal and ventral ridges; finely divided reticulation with nodes developed at intersections of ridges; reticulation and nodes covering subcentral tubercle.

Description. Valves subrectangular, with dorsal and ventral margins parallel; anterior broadly rounded; posterior with small caudal process in ventral half; posterodorsal margin slightly concave. Dorsal margin in lateral view broken by division into 2 blade-like ridges. Ventral ridge developed posteriorly into alar process terminating in small node.

Ornamentation a small-meshed reticulation, with nodes at intersections. (Great intraspecific variation in the development of these nodes.) Reticulation and nodes continue over prominent subcentral tubercle. Anterior margin with ridge-like flange bearing small denticulations. Ornamentation developed on venter, and bounded by ridges and margins of alar process.

Muscle scars — 2 subcircular frontal scars, dorsal smaller; 4 adductor scars, dorsal ovate, remaining 3 elongate; ventromedian and ventral scars closely associated, but separate. Normal pores clearly visible on interior of valve (type unknown) — equally spaced and related to reticulation mesh. Line of concrescence and inner margin coincident. RPCs on anterior margin but not clearly visible.

Hinge strongly holamphidont, with anterior tooth in RV stepped. Median bar finely crenulate. Sexual dimorphism — males longer and less high than females. Juveniles develop spiny nodes before the reticulation mesh.

Etymology. Referring to the nodes on the muri of the reticulation.

Remarks. The development of nodes in the ornamentation and the muscle scar pattern are characteristic of this genus. *Spinobradleya nodosa* differs from the type species *S. acantha* McKenzie et al., 1991 with its interspine reticulation rather than separate spines; its more strongly developed subcentral tubercle and the absence of dorsal spines. It is more similar to *S. echinata* McKenzie et al., 1993 which has interspine reticulation but differs in not having the posterior flattening. *S. nodosa* is not placed in *Jugosocythereis* Puri 1957 in spite of the reticulation and nodes being noticeably developed on the subcentral tubercle. There is no development of longitudinal ridges or of the 'bridge' structure regarded as phylogenetically significant in *Jugosocythereis* by Benson (1972). The ridges on the subcentral tubercle which McKenzie (pers. comm. 1986) and Holden (1967) regarded as diagnostic of *Jugosocythereis* are not mentioned in the original diagnosis, but implied in the name from the Latin *jugum* = a yoke or ridge. Such ridges also occur in *Tenedocythere* Sissingh, 1972.

Bradleya Hornibrook, 1952 s.s.

Remarks. The original generic concept of Hornibrook was too broadly based to remain untouched. Subsequent refinement, particularly by Benson (1972), has enabled taxonomists to discriminate among this range of deep- and shallow-water hemicytherids and to establish species with important distinctive phylogenetic and/or palaeoecologic characteristics (Whatley et. al., 1983, 1984). As a result, the generic concept of *Bradleya* is now more precise than in many other Tertiary hemicytherid and trachyleberid genera. *Bradleya* species form a small consistent element in the fauna of the Muddy Creek Marl and this enables comparisons to be made both with southeastern Australia and more widely.

Bradleya* (*Bradleya*) *praemackenziei Whatley and Downing, 1983

Pl. 8 figs 7, 9; Pl. 13 fig. 2

Bradleya praemckenziei Whatley and Downing, 1983: 381, pl. 7 figs 7-9. — Warne, 1987: 443.

Bradleya morningtonensis McKenzie and Peypouquet, 1984: 301.

Figured Specimens. NMV P123369 — Pl. 8 fig. 7; P134979 — Pl. 8 fig. 9; P134993 — Pl. 13 fig. 2.

Dimensions. (P123369) LV L=0.80; H=0.43.

Material. 10 specimens. Muddy Creek at Clifton Bank and Hentys near Hamilton. *B. (B.) praemackenziei* also occurs in Fyansford Clay, the Sherwood Marl (M. T. Warne, pers. comm., 1985) and the Balcombe Clay (McKenzie and Peypouquet, 1984); in the Gellibrand Marl at Native Hut Creek, and Warrambine Creek in the Leigh R. area; in the Wuk Wuk Marls, Gippsland (characterised by a continuous median ridge) and in the Morgan Limestone at Blanchetown, SA (own collections). A related, and possibly ancestral form occurs in the Late Eocene Blanche Point Formation Perkana Member as defined in Lindsay (1985). A distinctive species in the older Tuketja Member of the same formation shows sufficient morphological similarities to *B. (B.) praemackenziei* and the related form in the Perkana Member referred to above to be investigated as part of the phylogeny of southeastern Australian bradleyines (McKenzie et al., 1991). Muddy Creek Marl, early Middle Miocene for the Hamilton specimens. Approximately the same age for those from the Fyansford Formation (Balcombe Clay), the Sherwood Marl and the Wuk Wuk Marls. Those from the Morgan Limestone may be younger.

Remarks. It is clear from Whatley and Downing's (1983) and McKenzie and Peypouquet's (1984) figures that their specimens are conspecific — they are from virtually the same locality and horizon.

Whatley and Downing (1983) found this species to be a substantial element in the Balcombian fauna from Fossil Beach, Mornington (30 individuals — 7% of total assemblage). In a smaller sample, McKenzie and Peypouquet (1984) stopped their count at 50 individuals — 15% of the assemblage. In the Muddy Creek Marl, *Bradleya* species contribute a much lower proportion, *B. (B.) praemackenziei* having only 12 confirmed specimens (0.1%). With two other species *Bradleya* contibutes only 40 specimens (0.4%). A feature of the specimens from Muddy Creek is the development of the posterior end of the ventral ridge into a flattened, spine-like process. The eye tubercle is well-developed as would be expected in a relatively shallow water form.

Some of the better preserved specimens show aggradation (sensu McKenzie and Peypouquet, 1984) but it is difficult to draw palaeoecological inferences from this because of the small number of specimens in the Hamilton sample and the difficulty of discriminating between partially aggraded specimens subject to abrasion in the post-depositional environment (possibly even remanie specimens) and those not showing aggradation per se.

Some specimens, only tentatively assigned to this species, have the eye tubercle lower than the dorsal margin in lateral view, with a narrow ridge above the tubercle. These also show an enlargement of alternate denticulations along the anterior margin into short spines. This may be more widespread but cannot be detected in the more abraded specimens. The dorsum of these specimens is often very discontinuous in lateral view.

All of these points indicate intraspecific variation only.

***Bradleya* (*Bradleya*) sp. cf. *B. kincaidiana* (Chapman)**

Pl. 8 figs 8, 10

Cythere kincaidiana Chapman, 1926: 132–133, pl. 10 figs 1a–c.

Figured Specimens. NMV P123370 — Pl. 8 fig. 10; P134978 — Pl. 8 fig 8.
Dimensions. (P123370) RV: L=0.84; H=0.43.
Material. 21 specimens, Hentys and Clifton Bank, on Grange Burn and Muddy Creek, Muddy Creek Marl, early Middle Miocene.

Brief description. Caudate species with clearly-defined dorsal ridge sweeping below small eye tubercle in anterior, and separate from, but paralleled by, ridge beginning at eye tubercle and continuous with strongly developed narrow ventral ridge. These ridges have a finely punctate/reticulate surface (Pl. 13 fig. 2). Posterior termination of ventral ridge a flattened spine. This characteristic spine develops to varying degrees in this species, and also in *B. (B.) praemackenziei* and is most prominently developed in some specimens of *Bradleya (B.)* sp. A (see below). Hence it should not be regarded as diagnostic at the species level. Ventral adductor scar apparently divided, but difficult to determine with certainty.

Remarks. The species is referred to *Cythere kincaidiana* Chapman, 1926 but with reservations because of the paucity of the material. The most notable feature of Chapman's species is the posterodorsal spine. This is missing from these specimens so it is appropriate to compare them with *B. (B.) kincaidiana* which they resemble in many other respects, rather than to regard them as conspecific, even though there is interspecific (and intraspecific) variability of the posteroventral spine. These specimens differ from *Bradleya regularis* McKenzie et al., 1991 in the undulating sweeps of the dorsal and ventral ridges, though the poor preservation of the latter species makes comparison difficult. They differ from *Bradleya dickbensoni* McKenzie et al., 1991 in their more caudate shape and smaller reticulation pattern. The absence of a central longitudinal ridge distinguishes them from *Quasibradleya* species.

***?Bradleya* (*Bradleya*) sp. A**

Pl. 9 fig. 1

Figured Specimen. NMV P123255 — Pl. 9 fig. 1.
Dimensions. RV: L=0.70; H=0.41.
Material. 7 specimens, Hentys and Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Brief description. Differing from *B. (B.)* sp. cf. *B. (B.) kincaidiana* in shape of valves in lateral view, which is closer to that of *B. (B.) praemackenziei*. Differ from latter species in presence of a median ridge in reticulation pattern. This pattern has a longitudinal trend in the dorsal half of the valve. The posteroventral termination of the ventral ridge is much less prominent than in either of the preceding species. The material is too limited for the erection of a new species, and the presence of a median ridge makes assignment to the subgenus *Bradleya* tentative.

***Bradleya* (*Quasibradleya*) Benson, 1972**

***Bradleya* (*Quasibradleya*) *pyxos* sp. nov.**

Pl. 9 figs 2, 3; Pl. 13 fig.3; Pl. 14 fig. 8

Quasibradleya sp. — McKenzie, 1979: 91–92, pl. 2 figs 6, 7.

Holotype. NMV P123257 — Clifton Bank — Pl. 9 fig. 2, Pl. 14 fig. 8.
Paratypes. NMV P123256, P123258 (Not figured); P134980 — Pl. 9 fig. 3, Pl. 13 fig. 3.
Dimensions. Holotype RV, male: L=0.76; H=0.36. Paratype (P123256) LV, male: L=0.73; H=0.38. Paratype (P123258) LV, female: L=0.77; H=0.42.
Material. 98 specimens, Clifton Bank and Hentys, near Hamilton, Muddy Creek Marl, early Middle Miocene. (The occurrence in borehole WLG38 in the South Australian Willunga Embayment recorded by McKenzie [1979] is from Early Miocene, N6.)

Diagnosis. Subrectangular *Quasibradleya* with well-developed ventral ridge, strongly developed anterior ridge linking with median ridge, anterior to subcentral tubercle, but does not continue towards the posterior.

Description. Valve subrectangular in lateral view. Anterior broadly and evenly rounded. Dorsal and ventral margins subparallel. Dorsum slightly convex in anterior half, ventral margin slightly convex overall. Posterior with small, rounded caudal process in ventral half, smoothly continuous with straight margin from posterodorsal angle. Caudal process more pronounced and angular in juvenile specimens. Lateral margins unbroken by projection of ornament or ridge.

Ornamentation of lateral surface of valves a complex reticulate pattern, with tendency to longitudinal rows of fossae. Strong, rounded anterior marginal ridge. Strong ventral ridge parallel to

ventral margin, thinner than anterior ridge, and more strongly developed in stratigraphically younger specimens. Valves strongly inflated except posteriorly — caudal area compressed. Well-defined median ridge linking anterior ridge with subcentral tubercle, but not continuing beyond. Dorsal ridge in anterior half of valve a continuation of rounded anterior ridge. From eye-tubercle to posterodorsal angle, dorsal ridge developed from reticulation immediately below eye-tubercle sinus, sweeping upward to form dorsal margin in posterior half of valve.

Greatest height through anterodorsal angle to ventral margin. Greatest length medially. Greatest width medially through subcentral tubercle. Inner lamella very broad anteriorly, with numerous straight unbranched RPCs. No vestibules. Normal pores not observed.

Hinge strongly holamphidont, with median bar and groove smooth. Muscle scar pattern — 2 subcircular frontal scars aligned obliquely to long axis of valve; 4 adductors in semicircular arc concave to anterior. Dorsal adductor large, kidney-shaped; dorsomedian adductor small; ventromedian adductor clearly divided; ventral adductor small (Pl. 14 fig. 8). Eye tubercle just below anterodorsal angle — variably preserved in the material available for study. No LV/RV overlap.

Sexual dimorphism not established. Later instars with more prominent caudal process and greater angularity in ridge pattern.

Affinities. McKenzie (1979) briefly referred to a *Quasibradleya* species from borehole WLG38 at depth 76.5m conspecific with *Q. pyxos*. Warne (1987) listed two *Quasibradleya* species from the Melbourne Trough. Of Hornibrook's bradleyine species (1952), *B. cunazea* and *B. dictyon* come closest morphologically to *B. (Q.) pyxos* but their reticulation patterns are quite different. *Quasibradleya janjukiana* McKenzie et al., 1991 is less caudate and quadrate in shape than *Bradleya (Quasibradleya) pyxos*. *Quasibradleya momitea* McKenzie et al., 1993 has a subrounded posterior, and a different reticulation pattern from this species.

Etymology. From the Greek *pyxos,* a box.

Remarks. This species is placed in Benson's subgenus *Quasibradleya* even though the diagnostic median ridge does not continue from the anterior beyond the subcentral tubercle. Benson's illustrated species (*B. (Q.) dictyonites, B. (Q.) prodictyonites* and *B. (Q.) paradictyonites*) are all noticeably more elongate than *Bradleya* s.s. The elongate *B. (Q.) pyxos* shares this characteristic, which, taken together with its partial median ridge, warrants placement in the subgenus *Quasibradleya.*

Quadracythere Hornibrook, 1952

Subgenus *Quadracythere* Hornibrook, 1952

Quadracythere (*Quadracythere*) *spica* Holden

Pl. 9 figs 4, 5, 6

Quadracythere spica Holden, 1976: F24, Pl.5 figs 22, 25.

Figured Specimens. NMV P134981 — Pl. 9 fig. 4; P123263 — Pl. 9 fig. 5; P134982 — Pl. 9 fig. 6; P123262, P123264 (Not figured).

Dimensions. (P123262) LV: L=0.83; H=0.50. (P123263) RV: L=0.84; H=0.48. (P123264) LV, instar: L=0.63; H=0.38.

Material. 957 specimens, Hentys and Clifton Bank, Muddy Creek Marl, early Middle Miocene.

Remarks. Holden (1976) tentatively linked his three species of *Quadracythere* from the Midway Island drillholes into an evolutionary sequence, beginning with *Q. (Q.) spica,* continuing with *Q. aequabilis* Holden, 1976 and ending with *Q. trijugis* Holden, 1976. He also suggested that marked variation in the posteroventral and posterodorsal tubercles is an ecophenotypic response (Holden, 1976: F24). Specimens of *Q. (Q.) spica* from the Muddy Creek Marl show evidence of these variations, but all are sufficiently similar to be one species. A range of instars from A6 to A8 are present with adult forms. *Q. (Q.) spica* is the most abundant species overall being the most abundant at Clifton Bank and the second most abundant at Hentys. It resembles Hornibrook's New Zealand *Quadracythere* species and is closest to *Q. mediaruga* Hornibrook, 1952, differing in the absence of the median ridge. The age of the Midway Island specimens is given as Lower Miocene, allowing time for probable migration westwards across the Pacific. *Quadracythere singletoni* McKenzie et al., 1991 lacks the longitudinal development of ribs and the prominent posterodorsal 'ear' characteristic of *Q. (Q.) spica.*

Hornibrookellina subgen. nov.

Type species. Hornibrookellina hentyensis sp. nov.

Diagnosis. Quadracythere with subrectangular valves in lateral view; posterodorsal margin not markedly caudate; shell surface strongly reticulate with no median ridge, but dorsal and ventral ribs developed to a greater or lesser extent.

Muscle scar pattern variable, but upper adductor scars undivided, and 2 frontal scars subcircular in form.

Remarks. This subgenus has been erected because of disparities between *Hornibrookella* (sensu Al-Furaih, 1977) and *Quadracythere (Hornibrookella)* Moos, 1965 s.s. The latter was erected on the basis of differences of the LV, hinge features and muscle scars from the original genus. *Quadracythere* s.s. has been used less than it might had not Hornibrook's (1952) inclusion of 11 rather widely different species extended its variability beyond present taxonomic acceptability. Material of *Quadracythere* s.s. in this fauna provides scope for a resolution of the problems associated with diagnosis and placement of *Hornibrookella* and other quadracytherid species which do not fit readily into the existing taxonomy.

The subgenus *Q. (Hornibrookella)* was erected to include distinctly quadracytherid species, including *Q. anna* (Lienenklaus, 1894) as type species. Subsequently Al-Furaih (1975, 1977) rejected Moos's diagnostic muscle scar features because he was able to show that intraspecific (and even RV and LV) variation occurred. Instead, Al-Furaih (1977) elevated *Hornibrookella* to genus level with a diagnosis focussed on shape, ridge and reticulation pattern, eye- and subcentral-tubercles and hinge. The last three characteristics are not diagnostic but are shared with *Quadracythere* s.s. To establish a genus (as distinct from a subgenus) on the basis of valve shape and a single characteristic of the reticulation pattern is debatable.

Furthermore, Al-Furaih's concept of *Hornibrookella*, thus defined, does not clearly accommodate its type species which has a definite posterodorsal extension with evidence of relatively large denticulate projections. In fact, all the species figured by Moos (1965) — *Q. (H.) anna, Q. (H.) macropora gamma,* and *Q. (H.) vahrenkampi* — share this shape, whereas the species figured by Al-Furaih (1975, 1977, 1980) and by Siddiqui (1971) have a less well-defined posterodorsal extension. If one were to look for confirmation of Al-Furaih's concept of *Hornibrookella* in eye- and subcentral-tubercles and hinge, one would find it difficult to differentiate between *Hornibrookella* and *Quadracythere* s.s.

It is clear that Moos's (1965) subgenus *Q. (Hornibrookella)* and Al-Furaih's (1977) concept of it differ, if not on muscle scar patterns, then on shape, since species of the latter are longer and less high than the characteristic quadracytherid. Both Al-Furaih and Siddiqui failed to describe muscle scar patterns of the species they included in *Hornibrookella* because of poor preservation or because they made only general statements (Al-Furaih, 1983). However, because the material fits Al-Furaih's group and because its muscle scar pattern is distinct from those of the Moos group and is consistent in occurrence, a separate subgenus can be erected for them. This leaves *Q. (Hornibrookella)* as originally diagnosed by Moos (1965) for at least *Q. (H.) anna* (Lienenklaus, 1894) (type species), *Q. (H.) macropora macropora* (Bosquet 1894), *Q. (H.) macropora gamma* Moos, 1965 and *Q. (H.) vahrenkampi* Moos, 1965.

The following species are referred to the new subgenus:

Q. (Hornibrookellina) cyclifossata, Q. (H.) cyclopea, Q. (H.) cuspidata, Q. (H.) divergens, Q. (H.) epicelis, Q. (H.) posterisella (All Al-Furaih, 1977);

Q. (Hornibrookellina) abdulrazzaqi Al-Furaih, 1983;

Q. (Hornibrookellina) platybomus, Q. (H.) directa, Q. (H.) subquadra, sp. A. (All Siddiqui, 1971); and

Q. (Hornibrookellina) hentyensis sp. nov.

The other species listed by Siddiqui *Q. (Hornibrookella) arcana* (Lubimova and Guha, 1960) is retained in the Moos subgenus because of its shape. *Hornibrookella (?) currimundria* McKenzie et al., 1993 is also retained in *Hornibrookella* because its shape and reticulation are allied to those of the type species.

Quadracythere* (*Hornibrookellina*) *hentyensis sp. nov.

Pl. 9 figs 7, 8, 10; Pl. 10 fig. 1; Pl. 13 fig. 4; Pl. 14 fig. 9

Holotype. NMV P123260 — Hentys — Pl. 9 fig. 7, Pl. 14 fig. 9.

Paratypes. NMV P123259 — Pl. 9 fig. 10; P134983 — Pl. 9 fig. 8; P134985 — Pl. 10 fig. 1, Pl. 13 fig. 4; P123261 (Not figured).

Dimensions. Holotype LV: L=0.95; H=0.53. Paratype (P123259) LV: L=0.90; H=0.48. (P123261) Paratype RV, instar: L=0.73; H=0.40.

Material. 185 specimens, Hentys on Grange Burn, at Yulecart, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Thick-shelled subrectangular *Q. (Hornibrookellina)* having subpolygonal semi-regular reticulation with narrow muri covering lateral surface of valves. Large depression posterior to the eye tubercle.

Description. Valves subrectangular in lateral view, with dorsal and ventral margins virtually parallel. Dorsal margin in LV straight; in RV with slight anterodorsal hinge-ear (van Morkhoven, 1962). Anterior broadly rounded, with narrow flange. Posterior margin with weakly developed caudal process, more evident in LV than RV. Anterior and posterior cardinal angles rounded. Carapace inflated posteriorly in dorsal and ventral views. No marginal denticulations.

Ornament a cellular reticulation of subpolygonal, flat-surfaced narrow muri defining deep fossae. Dorsal ridge less prominent than ventral ridge. Ventral ridge marked posteriorly by narrow rib. Subcentral tubercle covered by reticulation pattern. Little suggestion of longitudinal or lateral ridges. Fossae posterior to eye-tubercle fused into large depression. In ventral view, cellular pattern of reticulation well-developed.

Inner lamella moderately broad in anterior and posteroventral sections. No vestibules. Numerous simple, unbranched RPCs, concentrated in anterior and posteroventral sections. Hinge strongly holamphidont, with smooth anterior and posterior teeth in RV; median element crenulate, with anterior end having a large, rounded tooth in LV, and with posterior end of median element flared into small rounded lobe. Normal pores not identifiable on exterior surface because of adherent matrix.

Muscle scars a subvertical row of 4 undivided adductors; 2 subcircular or slightly elongate frontal scars, and 2 small mandibular scars. Dorsal and dorsomedian adductor scars elongate; ventral and ventromedian adductor scars compressed, giving the appearance of a single, but divided, larger scar. (Pl. 14 fig. 9 and discussion above). Eye tubercle distinct and rounded. No conspicuous overlap of valves; line of valve closure in dorsal view straight. Sexual dimorphism evident — males longer and less high than females. Specimens of the 7th and 8th instars occur with adults. No distinctive juvenile features.

Affinities. Alocopocythere Siddiqui, 1971 and *Omaniella* Zawawi, 1985 nomen nudum share some characteristics with this subgenus, but the single v- or j-shaped frontal scar removes them from Hemicytheridae using conservative criterion. Howe and McKenzie (1989) suggested that *Alocopocythere*, which has been reassigned from Echinocytherideinae to Cytherettidae, may be transitional to some *Neocytheretta*. It seems likely, however, that *Quadracythere (Hornibrookella)* Moos, 1965, *Q. (Hornibrookellina)* subgen. nov., and *Omaniella* nomen nudum are transitional forms with shared morphology. Further investigations of the phylogeny of *Quadracythere* s.s., its subgenera, and these other genera will be necessary to distinguish clearly between them.

Of the 18 species of *Q. (Hornibrookella)* and *Q. (Hornibrookellina)* described and figured up to 1989, only *Q. (Hornibrookella) macropora* (Bosquet, 1984) ranges above the Oligocene. Most are confined to the Palaeogene. In terms of valve shape in lateral view and general pattern of ornamentation, *Q. (Hornibrookellina) hentyensis* sp. nov. comes closest to *Q. (H.) posterisella* (Al-Furaih, 1977) from which it differs in having a much less pronounced cardinal angle and a reticulation pattern which does not extend to the posteroventral margin. *Q. (H.) hentyensis* sp. nov. resembles through its cellular ornamentation the seven species described by Al-Furaih (1977, 1983) and *Q. (H.)* sp. A of Siddiqui (1971) but differs in valve shape, in details of ornamentation, and in having undivided adductor muscle scars and distinctive frontal scars.

Moos (1965), in diagnosing the subgenus *Q. (Hornibrookella),* and Al-Furaih (1975), in redescribing the type species *Q. (H.) anna,* drew attention to the variable muscle scar pattern, even within one species, so that it is unwise to use it as a diagnostic feature unless its consistency can be established with a hypodigm (Simpson, 1940) of at least 20 specimens. In the case of *Q. (H.) hentyensis* sp. nov. no such variation was evident in a hypodigm of 24 adult specimens (in the original collection — 20 more specimens added since then), or in a possibly conspecific population from the Wuk Wuk Marl of Gippsland (own unpublished data). To establish the phylogenetic relationships of these species, and of the genera and subgenera *Quadracythere* s.s., *Q. (Hornibrookella), Q. (Hornibrookellina)* and *Omaniella* nomen nudum, it is likely that classification by ornamentation pattern proposed by Liebau (1971) and Neale (1975) with modifications suggested by Al-Furaih (1977) will be valuable.

Etymology. From the locality 'Hentys' on Grange Burn, near Hamilton.

Remarks. This is the first record of the subgenus *Q. (Hornibrookellina)* in Australia. An undescribed species of the related subgenus [*?Q. (Hornibrookella)*] of Janjukian age, from Castle Cove (Upper Glen Aire Clays) also exists (McKenzie, 1985, pers. comm.). Similar forms (*Hornibrookella* sp. 1 Warne, 1987 and *Horni-*

brookella sp. 2 Warne, 1987) also occur in the Melbourne Trough in the Fyansford Clay at the Batesford Quarry, a formation of equivalent age to the Muddy Creek Marl. McKenzie et al., (1991) described and figured three species of *Hornibrookella*. Of these, *H. flexicostata* is dealt with under *Chapmanella* gen. nov. below; *H. aggradata* is not a *Hornibrookellina* because of its arched dorsum, caudate posterior and thickened ribs and *Hornibrookella* sp. (McKenzie et al., 1991: Pl. 6 fig. 7, Pl. 10 fig. 15) is possibly a *Hornibrookellina*, which differs from *H. hentyensis* in its anterior 'hinge ear' and its caudate posterior, especially marked in the specimen figured in Pl. 10 fig. 15.

Q. (Hornibrookellina) hentyensis sp. nov. occurs only at Hentys on Grange Burn and is not found in any of the samples from Clifton Bank. The species is part of the biocoenose, as juveniles of at least three instars occur with the adults. The juveniles tend to be a little less rectangular and more tapered posteriorly. Whatley and Downing (1983) did not record *Quadracythere* s.s. or its subgenera from their Balcombian locality, probably because deeper water conditions prevailed, as indicated by a fauna in which *Krithe nitida* was the most abundant species. *Q. (Hornibrookellina)* cf. *hentyensis* was also recorded from the Wuk Wuk Marl on the Mitchell River, Gippsland (Neil, 1985; unpublished data — Geol. Surv. Vic. Locality No. GSV–F31).

Urocythereidinae Hartmann and Puri, 1974

Ambostracon Hazel, 1962

'Ambostracon' recta sp. nov.

Pl. 5 figs 7, 8, 9, 10; text-fig. 3

Holotype. NMV P123270 — Clifton Bank — Pl. 5 fig. 10, text-fig. 3.
Paratypes. NMV P123271 — Pl. 5 fig. 9; P134962 — Pl. 5 fig. 7; P134963 — Pl. 5 fig. 8.
Dimensions. Holotype LV: L=0.54; H=0.28. Paratype (P123271) RV: L=0.52; H=0.29.
Material. 89 specimens, Clifton Bank only, (not present at Hentys), Muddy Creek Marl, early Middle Miocene.

Diagnosis. Small, subquadrate *Ambostracon*-like species with noded dorsal ridge having prominent posterodorsal termination.

Description. Valves subquadrate in outline; slightly tapered. Anterior broadly rounded; dorsal margin with anterodorsal hinge ear, and slightly arched in RV; dorsal margin of LV with greatest height at anterodorsal cardinal angle; ridged section of valve surface projects posterodorsally as slight arch beyond otherwise straight line of margin. Posterior marked by subacuminate cauda in ventral half. Ventral margin almost straight. Ornamentation — noded rib oblique to dorsal margin from below eye tubercle to posterodorsal angle; narrow anterior ridge; concentric noded anterior and anteroventral rib; discontinuous noded ventral rib; sharply-edged wedge-shaped termination to posterodorsal lateral surface. Subcentral tubercle not strongly developed. Eye spots below anterodorsal angle of valve. Margins without denticulations except for 2 small denticles on posteroventral margin.

Hinge strongly holamphidont. LV median bar slightly crenulate on margin. Teeth on RV smooth. Posterior tooth and socket at posterodorsal angle and extended linearly around that angle. Muscle scar pattern of 3 frontal scars, 1 small and anterior to 2 larger ones; adductor scars subdivided in a distinctive array (text-fig. 3). Inner lamella moderately broad anteriorly; narrower posteroventrally. RPCs numerous, simple and straight. Normal pores not observed.

Etymology. From the L. *rectus,* right, perpendicular to the base, straight — a reference to the unusually quadrate appearance of this species.

Remarks. The species is only tentatively assigned to *Ambostracon* because of the absence of ribbed, reticulated ornamentation. McKenzie (1967) referred to *Ambostracon* species as "characterized externally by an ornament of heavy ribs and intermediate reticulations". However, its muscle scars, eye spot and hingement fall within the genus. It differs from *A. pumila* (Brady, 1866) in its more elongate shape and absence of ornamentation referred to above. Some figured species of *Ambostracon* (*A.? fredbrooki* Milhau, 1993; *A.* cf. *A. pumila* (Brady, 1866) in Swanson (1979) show little of the pattern of ornamentation referred to in Hazel's (1962) diagnosis but I stress its significance by only tentatively referring this relatively unornamented species to the genus. I agree with Dingle (1992), who regarded *Ambostracon* as a senior synonym of *Patagonacythere* Hartmann, 1962, some characteristics of which are shared by *'A.' recta.* The absence of the diagnostic areas of attachment of the inner lamella ('pillar structures') rules out assignment of *'A.' recta* to *Caudites.*

Chapmanella gen. nov.

Type species. Cythere flexicostata Chapman, 1914.

Diagnosis. Urocythereinid usually with 3 frontal

scars; a thick, rounded, marginal anterior ridge; ornamentation of longitudinal, celated, coarse ribs, and distinct caudal process in ventral half of the posterior.

Etymology. For Frederick Chapman who described the type species.

Remarks. Chapmanella shares some characteristics with *Urocythereis* Ruggieri, 1950, namely its muscle scar pattern, heavily calcified valves and strong and celated pattern of ornamentation. However, it differs in its longitudinal ribbing and its more distinct cauda.

Chapmanella flexicostata (Chapman, 1914)

Pl. 10 figs 2, 3, 4, 5, 6, 7, 8; Pl. 13 figs 5, 6

Cythere flexicostata Chapman, 1914: 35–36, pl. 7 figs 14a, 14b. — McKenzie, 1974: 160.

(?Bradleyini) gen. C, *flexicostata* (Chapman). — Warne, 1987: 443.

Hornibrookella flexicostata. — McKenzie et al., 1991: 159-160, pl. 10 fig. 11.

Figured specimens. NMV P123371 — Pl. 10 fig. 7; P134986 — Pl. 10 fig. 2; P134987 — Pl. 10 fig. 3; P134988 — Pl. 10 fig. 4, Pl. 13 fig. 6; P134989 — Pl. 10 fig. 5; P134990 — Pl. 10 fig. 6; P134991 — Pl. 10 fig. 8; P134994 — Pl. 13 fig. 5.
Nominate Specimens. NMV P123232; P123233; P123234.
Dimensions. (P123371) Male LV instar: L=0.41; H=0.22. (P123232) RV: L=0.76; H=0.42. (P123233) LV: L=0.74; H=0.41.
Material. 236 specimens, Clifton Bank and Hentys, Muddy Creek Marl, early Middle Miocene. Also recorded by McKenzie et al., 1991 from Late Oligocene to Middle Miocene, and by Warne, 1987, Early Middle to Late Miocene.

Description. In lateral view, subquadrate valves, tapered posteriorly. Dorsal and ventral margins straight in LV; dorsal margin slightly convex in RV. (Some specimens show a slight 'hinge-ear' at the anterodorsal cardinal angle in LV.) Carapace blunt arrow shape in dorsal view. Blunt caudal process in ventral half of posterior, with 3 or 4 short, peg-like spines. (Two rows of spines superimposed in some specimens.) Anterior broadly rounded, with greatest lateral extension in ventral half; numerous small denticulations — usually very abraded in the population studied. Anterior bounded by rounded, substantial ridge, continuous along ventral margin, but tapered off at anterodorsal angle. Dorsal and ventral ridges terminated posteriorly by blunt, rounded spines. (This condition may be due to abrasion in the Muddy Creek Marl specimens; Chapman's holotype is well-preserved.) Posterodorsal margin concave.

Ornamentation a series of 6 or 7 distinct lateral ribs, more or less continuous from anterior to posterior; generally sinuous and flat-surfaced. (Specimens show a wide range of rib types from sharp-edged and narrow, through rounded, to broad and flat-surfaced — Pl. 13 figs 5, 6). Dorsal ribs sharply angled below eye tubercle; ribs slightly subparallel from subcentral tubercle in posterior half of valve; rib pattern variable between specimens. Valve surface between ribs not visible because of adherent matrix. Short rib on venter not continuous with lateral ribs. Eye tubercle present in both valves; prominent, glassy and slightly below dorsal margin.

Hinge strongly holamphidont; RV anterior tooth rounded; posterior tooth lobed; median bar smooth. LV socket deep and rounded. Inner margin and line of concrescence coincident; fused zone broad anteriorly, less so posteriorly. RPCs numerous, simple and unbranched on anterior margin; less numerous on cauda and ventral margin. Normal pores visible in valve interior; numerous and aligned in channels between ribs; not observed externally; type unknown.

Muscle scars visible on subcentral tubercle externally (in some specimens). Internally, muscle scar pattern of 3 small, subcircular frontal scars in a triangular configuration; an oblique row of 4 adductors — dorsal subrounded, dorsomedian clearly divided, ventromedian elongate, ventral ovate to subrounded. (Some intraspecific variation occurs but the pattern described is by far the most common.)

Sexual dimorphism not established with the specimens from any one sample; intraspecific variation in length/height ratios within the total population may be due to sexual dimorphs. Juveniles — A7 and A8 instars; rib pattern established, but ribs fine and threadlike (Pl. 13 fig. 6); normal pores more evident externally. Hinge merodont.

Remarks. In view of the inadequacy of Chapman's description I give a full description including the muscle scar pattern which was not known to Chapman.

The characteristics referred to above constitute a clearly differentiated set which cannot readily be incorporated in any other genus of the subfamily. If the celation of the ribbing (which is the most distinctive feature) is due to an ecological response a population without such celation may be discovered. In that event, *Chapmanella* might have to be synonymised with *Urocythereis*. McKenzie et al. (1991) figured a specimen (Pl. 10 fig. 11) which is very similar to that figured in Pl. 10 fig. 7, and assigned it to *Hornibrookella*

without discussion. For the reasons set out above, their specimens would have to be included in the new genus *Chapmanella*.

Hemicytheridae incertae sedis

Neobuntonia Hartmann, 1981

Emended diagnosis. In addition to the characters listed by Hartmann, a muscle scar pattern (Pl. 14 fig. 5) of 4 adductors, subrounded or elongate; the central 2 adductors alongside each other, rather than in a subvertical alignment. Two subrounded frontal scars, the dorsal larger — vertically aligned. In some cases, dorsomedian adductor elongate, ventromedian rounded, with alignment tending to oblique rather than horizontal. Juvenile forms show considerable variation.

Remarks. Since the muscle scars were not diagnosed by Hartmann, conspecific Recent specimens from beach sand at Robe, SA, were examined. Characteristic hemicytherid scars were found and they formed essentially the same pattern as in the fossil population from Hentys and Clifton Bank. By the criteria discussed in connection with '*Hermanites' lungulata* (McKenzie et al., 1991) the two median scars would be classified as a divided scar were it not for their subrounded, and hence quite separate, configuration. Consequently, Hartmann's diagnosis has been amended to include the muscle scar pattern, and the genus is assigned to the tribe Hemicytherini.

Neobuntonia batesfordiense (Chapman, 1910)

Pl. 6 figs 2, 3, 4; Pl. 14 fig. 5

Cytheropteron batesfordiense Chapman, 1910: 300–301, Pl. 2 figs 7a–c. — Chapman 1914: 45, Pl. 8 fig. 36.

Cytheropteron batesfordiense var. *aculeata* Chapman, 1914: 46, Pl. 8 fig. 37.

Neobuntonia siebertorum Hartmann, 1981: 115, text figs 38–46, Pl. 8 figs 6–9.

Figured Specimens. NMV P123366 — Pl. 6 fig. 2, Pl. 14 fig. 5; NMV P123367 — Pl. 6 fig. 3; P134964 — Pl. 6 fig. 4.
Dimensions. (P123366) RV: L=0.92; H=0.59 ; (P123367) RV L=0.90; H=0.60.
Material. 130 specimens, Hentys and Clifton Bank, near Hamilton, Muddy Creek Marl, early Middle Miocene.

Remarks. Examination of Chapman's types of *Cytheropteron batesfordiense* Chapman, 1910 and *C. batesfordiense aculeata* Chapman, 1914 indicated that the subspecies is not warranted. Spines in some specimens is considered intraspecific variation. Examination of paratypes of *Neobuntonia siebertorum* Hartmann, 1981 found no major morphological differences between the specimens from the Miocene deposits and the Recent species. The only differences could be attributed to effects of differential preservation of the fossil specimens (e.g. foveolation of the surface was sometimes obscured). Consequently, Hartmann's species has been placed in synonymy with the Miocene species. The species is placed in *Neobuntonia,* although there are no records from the intervening period.

Neobuntonia sp. indet.

Pl. 6 fig. 5

Figured Specimen. NMV P123238 — Pl. 6 fig. 5.
Dimensions. RV: L=0.90, H=0.58.
Material. 1 specimen, Clifton Bank on Muddy Creek, Muddy Creek Marl, early Middle Miocene.

Brief description. Neobuntonia somewhat more elongate than *N. batesfordiense*. Posterior acutely rounded without caudal process. No marginal denticulations. Surface clearly foveolate, as distinct from fossil specimens of *N. batesfordiense* where foveolation is weak, and sometimes not evident in poorly preserved material.

Notocarinovalva gen. nov.

Type species. Notocarinovalva yulecartensis sp. nov.

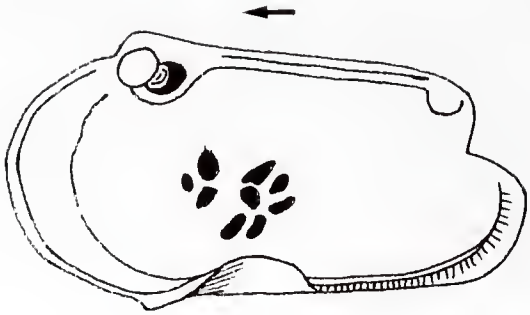
Other species. Neobuntonia airella McKenzie et al., 1991.

Diagnosis. Carinate hemicytherid with marked posterodorsal cardinal angle, and flat venter.

Etymology. Greek, *notos*, south, and *Carinovalva.*

Remarks. The type species is similar in external appearance to the type species of *Carinovalava* Sissingh, 1973 (*C. keiji* [Sissingh, 1973]), hence the generic name *Notocarinovalva*. However, significant differences between *Carinovalva* and *Notocarinovalva* include frontal muscle scars and hinge structure and lead me to assign the genus to Hemicytheridae rather than to Trachyleberididae in which Sissingh placed *Carinovalva.* The only other related species is *N. airella* (McKenzie et al., 1991).

Malz (1981a) suggested that the acceptance of a world-wide distribution of particular species and genera on the basis of external similarities is frequently in error, because separate evolutionary lines of development can be proved. It is possible that the external similarities between *Carinovalva* Sissingh *and Notocarinovalva* gen. nov.



Text-figure 3. *'Ambostracon' recta* sp. nov. NMV P123270 RV int. and muscle scars. x 100

may be due to convergent evolution, since the muscle scar patterns place the genera in different families. I believe that the external similarities of *Notocarinovalva* and *Carinovalva,* coupled with their basic difference in muscle scar pattern at the family level lend weight to this hypothesis.

Notocarinovalva yulecartensis sp. nov.

Pl. 6 figs 6, 7, 8

Holotype. NMV P123240 — Hentys — Pl. 6 fig. 6.
Paratypes. NMV P123239 — Pl. 6 fig. 8; P123241 (Not figured); P134965 — Pl. 6 fig. 7.
Dimensions. Holotype RV: L=0.71; H=0.39. Paratype (P123239) LV: L=0.71; H=0.39. Paratype (P123241) Carapace: L=0.73; H=0.43; W=0.45.
Material. 73 specimens, Hentys and Clifton Bank (rare), near Hamilton, Muddy Creek Marl, early Middle Miocene.

Diagnosis. Notocarinovalva with foveolate surface, small blunt ventral caudal process and small anterior vestibule.

Description. Valves tending to hemi-elliptical in lateral view and subequal in size. Dorsal and ventral margins straight. Anterior broadly rounded. Posterior margin slightly concave, with ventral termination marked by slight, subrounded caudal extension in line with ventral margin, and bearing some small denticulations in well-preserved specimens. Valves inflated ventrally in characteristic hemicytherid form, but bounded by rounded carinate ridge. Venter flat and broad with greatest width medially. Small anteroventral denticulations (visible only in well-preserved specimens). Small eye tubercle below valve margin at anterodorsal angle. Surface of valves foveolate in all but anterior and venter. Marginal reticulation ventrally and posteroventrally. No subcentral tubercle. Hinge strongly holamphidont in adult specimens; lophodont in juveniles. RV anterior tooth smooth; RV posterior tooth elongate; median element smooth. LV complementary.

Adductors a subvertical row of 4 individual scars — dorsomedian elongate; lower 2 scars closely associated. Two (or rarely 3) subcircular and subequal frontal scars. Muscle scars visible on exterior of valves. Small anterior vestibule. Fused zone relatively narrow. RPCs straight, unbranched and numerous only in anterior. Few thick, unbranched RPCs along ventral carina. Normal pores not observed. Sexual dimorphism not observed.

Etymology. From Yulecart, the locality in which Hentys and Clifton Bank are situated.

Affinities. Neobuntonia airella McKenzie et al., 1991 is similar to *Notocarinovalva yulecartensis* gen. et sp. nov. and should be placed in *Notocarinovalva* because it has both the marked posterodorsal cardinal angle and the flat venter diagnostic of the genus. *N. airella*, however, differs from *N. yulecartensis* in its large shallow punctations, and its less elongate shape.

Remarks. The main reason for placing *Notocarinovalva* in the Hemicytheridae is the double frontal scar. The holamphidont hinge, which lacks the special features in the hingement of *Yajimaina*, is similar to that of *Carinovalva* as figured in Sissingh (1973). See also comments on the genus.

Conclusion

The ostracode faunas of which these species form a part are dominated by the hemicytherids, though there is also a substantial representation of xestoleberids, loxoconchids, cytherurids and bairdiids. The trachyleberids and bythocytherids form a smaller proportion of the total. The prime purpose of this monograph is taxonomic, since it is on the basis of an adequate taxonomy that studies of palaeoecology and evolutionary development must be based. Other taxonomic papers are planned, to be followed by palaeoecological studies.

Acknowledgments

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References

Al-Furaih, A.A.F., 1975. On *Hornibrookella anna* (Lienenklaus). *A Stereo-Atlas of Ostracod Shells* 2(3): 211–214.

Al-Furaih, A.A.F., 1977. Cretaceous and Palaeocene species of the ostracod *Hornibrookella* from Saudi Arabia. *Palaeontology* 20(3): 483–502.

Al-Furaih, A.A.F., 1980. *Upper Cretaceous and Lower Tertiary Ostracoda (Superfamily Cytheracea) from Saudi Arabia.* University Libraries, University of Riyadh: Riyadh, Saudi Arabia. 211 pp.

Al-Furaih, A.A.F., 1983. Paleocene and Lower Eocene Ostracoda from the Umm er Radhuma Formation of Saudi Arabia. *University of Kansas, Paleontological Contributions* 107: 1–10.

Benson, R.H., 1972. The *Bradleya* problem, with descriptions of two new psychrospheric ostracode genera, *Agrenocythere* and *Poseidonamicus* (Ostracoda, Crustacea). *Smithsonian Contributions to Paleobiology* 12: 1–138.

Berggren, W.A., Kent, D.V. and Flynn, J.J., 1985. Paleogene geochronology and chronostratigraphy. Pp. 211–260 in: Snelling, N.J. (ed.) *Geochronology and the Geological Record.* Special Papers, Geological Society of London.

Bhatia, S.B. and Kumar, S., 1979. Recent Ostracoda from off Karwar, west coast of India. Pp. 173–178 in: Krstic, N. (ed.) *Proceedings of the VII International Symposium on Ostracodes — Taxonomy, Biostratigraphy and Distribution of Ostracodes.* The Serbian Geological Society: Beograd.

Carter, A.N., 1978. Phosphatic nodule beds in Victoria and the late Miocene–Pliocene eustatic event. *Nature* 276: 258–259.

Chapman, F., 1910. A study of the Batesford limestone. *Proceedings of the Royal Society of Victoria.* n.s. 22(2): 264–314.

Chapman, F., 1914. Description of new and rare fossils obtained by deep boring in the Mallee. Part III: Ostracoda to fishes. With a complete list found in the borings. *Proceedings of the Royal Society of Victoria.* n.s. 27(1): 28–71.

Chapman, F., 1926. Geological notes on *Neumerella,* and the section from Bairnsdale to Orbost. *Proceedings of the Royal Society of Victoria.* n.s. 38: 125–142.

Chapman, F. and Crespin, I., 1928. The Sorrento Bore, Mornington Peninsula, with a description of new or little known fossils. *Records of the Geological Survey of Victoria* 5(1): 1–195.

Deroo, G., 1966. Cytheracea (Ostracodes) du Maastrichtien de Maastricht (Pays-Bas) et des regions voisines; résultats stratigraphiques et paléontologiques de leur étude. *Mededelingen van de Geologische Stichting* C, 2(2) [Uitgevers Maatschappij 'Ernest van Aelst', Maastricht.]

Douglas, J.A. and Ferguson, J.A. (eds), 1988. *Geology of Victoria.* Victorian Division, Geological Society of Australia. 664 pp.

Gill, E.D., 1957. The stratigraphical occurrence and palaeoecology of some Australian marsupials. *Memoirs of the National Museum of Victoria* 21: 135–203.

Hartmann, G., 1978. Die Ostracoden der Ordnung Podocopida G.W. Mueller, 1894 der tropisch-subtropischen Westkuste Australiens (zwischen Derby im Norden und Perth im Suden). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 75: 64–219.

Hartmann, G., 1979. Die Ostracoden der Ordnung Podocopida G.W. Mueller, 1894 der warm-temperierten (antiborealen) West- und Sudwestekuste Australiens (zwischen Perth im Norden und Eucla im Suden). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 76: 219–301.

Hartmann, G., 1981. Die Ostracoden der Ordnung Podocopida G.W. Mueller, 1894 der subtropisch-tropischen Ostkuste Australiens (zwischen Eden im Suden und Heron Island im Norden). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 78: 97–149.

Hartmann, G. and Puri, H.S., 1974. Summary of neontological and paleontological classification of Ostracoda. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 70: 7–73.

Hazel, J.E., 1967. Classification and distribution of the Recent Hemicytheridae and Trachyleberididae (Ostracoda) off northeastern North America. *United States Geological Survey, Professional Paper* 564: 1–49.

Holden, J.C., 1967. Late Cenozoic Ostracodes from the drowned terraces in the Hawaiian Islands. *Pacific Science* 21(1): 1–50.

Holden, J.C., 1976. Late Cenozoic Ostracoda from Midway Island drill holes. *United States Geological Survey, Professional Paper* 680–F: F1–F40, 17 pls.

Hornibrook, N. de B., 1952. Tertiary and Recent Marine Ostracoda of New Zealand. *New Zealand Geological Survey, Palaeontological Bulletin* 18: 1–82.

Howe, H.V. and McKenzie, K.G., 1989. Recent marine Ostracoda (Crustacea) from Darwin and northwestern Australia. *Northern Territory Museum of Arts and Sciences. Monograph Series* 3: 1–50.

Howe, H.V., Sylvester-Bradley, P., van den Bold, X. and Reyment, R.A., 1961. Family Trachyleberididae. In: Moore, R.C. (ed.), *Treatise on Invertebrate Paleontology*. Part Q. Arthropoda 3, Crustacea — Ostracoda. Geological Society of America and University of Kansas Press: New York and Lawrence.

Liebau, A., 1975. Comment on the supragenerie taxa of the Trachyleberididae s.n. (Ostracoda, Cytheracea). *Neues Jahrbuch Geologie Palaeontologie Abhandlungen* 148(3): 353–379.

Lindsay, J.M., 1985. Aspects of South Australian Tertiary foraminiferal biostratigraphy, with emphasis on studies of *Massilina* and *Subbotina*. *Special Publications, South Australian Department of Mines and Energy* 5: 187–231.

Mallett, C.W., 1977. *Studies in Victorian Tertiary foraminifera: Neogene planktonic faunas. Parts 1 and 2*. Unpublished Ph.D. thesis, University of Melbourne.

Malz, H., 1980. *Cletocythereis* Swain, 1963 (Ostracoda); besondere Merkmale und geographische Verbreitung ihrer Artung. *Senckenbergiana Lethaea* 60(4/6): 381–397.

Malz, H., 1981. *Yajimaina* n. gen., eine fernoestliche *Carinovalva* — Verwandte (Ostracoda; Trachyleberidinae). *Mitteilungen Bayerischen Staatssammlung für Palaeontologie und historische Geologie* 21: 65–72.

McKenzie, K.G., 1967. Recent Ostracoda from Port Phillip Bay, Victoria. *Proceedings of the Royal Society of Victoria*. n.s. 80(1): 61–106.

McKenzie, K.G., 1974. Cenozoic Ostracoda of southeastern Australia, with the description of *Hanaiceratina* new genus. *Geoscience and Man* 6: 153–182.

McKenzie, K.G., 1979. Notes on Ostracoda from Willunga Embayment boreholes WLG38, WLG40, and WLG42. In: Cooper, B.J. (ed.), *Eocene and Miocene stratigraphy of the Willunga Embayment. Geological Survey of South Australia, Reports of Investigations* 50: 90–101.

McKenzie, K.G., 1981. Chapman's 'Mallee Bores' and 'Sorrento Bore' Ostracoda in the National Museum of Victoria, with the description of *Maddocksella* new genus. *Proceedings of the Royal Society of Victoria*. n.s. 93: 105–107.

McKenzie, K.G. and Bonaduce, G., 1991. Partial redescriptions of some Trachyleberididae and Hemicytheridae from the Bay of Naples: comparisons, and a re-appraisal of trachyleberidid — hemicytherid classification. *Program and Abstracts: Eleventh International Symposium on Ostracoda, Warrnambool*: p. 60.

McKenzie, K.G. and Peypouquet, J.-P., 1984. Oceanic palaeoenvironment of the Miocene Fyansford Formation from Fossil Beach, Mornington, Victoria, interpreted on the basis of Ostracoda. *Alcheringa* 8(4): 291–303.

McKenzie, K.G. and Warne, M.T., 1986. *Alataleberis* new genus (Crustacea, Ostracoda) from the Tertiary of Victoria and South Australia. *Proceedings of the Royal Society of Victoria* 98(1): 31–40.

McKenzie, K.G., Reyment, R.A. and Reyment, E.R., 1990. Pleistocene and Recent Ostracoda from Goose Lagoon Drain, Victoria and Kingston, South Australia. *Bulletin of the Geological Institutions of the University of Uppsala* n.s. 16: 1–46.

McKenzie, K.G., Reyment, R.A. and Reyment, E.R., 1991. Eocene–Oligocene Ostracoda from South Australia and Victoria, Australia. *Revista Espanola de Paleontologia* 6(2): 135–175.

McKenzie, K.G., Reyment, R.A. and Reyment, E.R., 1993. Eocene Ostracoda from the Browns Creek Clays at Browns Creek and Castle Cove, Victoria, Australia. *Revista Espanola de Paleontologia* 8(1): 75–116.

Moos, B., 1965. Die Ostracoden-Fauna des Unteroligozäns von Bunde (Bl. Herford-West, 3817) und einige verwandte jüngere Arten (Ostr., Crust.) I. *Quadracythere (Hornibrookella)* n. subg., *Pokornyella, Hemicythere, Hermanites. Geologisches Jahrbuch* 82: 593–630.

Morkhoven, F.P.C.M. van, 1962. *Post-Palaeozoic Ostracoda: Their Morphology, Taxonomy and Economic Use. Part 1: General*. Elsevier: Amsterdam. 204 pp.

Morkhoven, F.P.C.M. van, 1963. *Post-Palaeozoic Ostracoda: Their Morphology, Taxonomy and Economic Use. Part 2: Generic Descriptions*. Elsevier: Amsterdam. 478 pp.

Neale, J.W., 1959. *Normanicythere* gen. nov. (Pleistocene and Recent) and the division of the ostracod family Trachyleberididae. *Palaeontology* 2(1): 72–93.

Neale, J.W., 1975. The ostracod fauna of the Santonian Chalk (Upper Cretaceous) of Gingin, Western Australia. *Special Papers in Palaeontology* 16: 1–81.

Neil, J.V., 1992. *Taxonomy and palaeoecology of the ostracode fauna of the Middle Miocene Muddy Creek Marl, southwestern Victoria*. Unpublished M.Sc. thesis, University of Melbourne. 267 pp., 22 pls, 9 tables, 6 text-figs.

Pokorny, V., 1955. Contribution to the morphology and taxionomy of the subfamily Hemicytherinae Puri, 1953

(Crustacea: Ostracoda). *Acta Universitas Carolinae, Geologica* III: 3–34.

Pokorny, Vl., 1957. The phylomorphogeny of the hinge in Podocopida (Ostracoda: Crustacea) and its bearing on the taxionomy. *Acta Universitas Carolinae, Geologica* III: 3–22.

Pokorny, Vl., 1964. The taxonomie delimitation of the subfamilies Trachyleberidinae and Hemicytherinae (Ostracoda, Crustacea). *Acta Universitas Carolinae, Geologica* III: 275–284.

Puri, H.S., 1957. Stratigraphy and zonation of the Ocala Group. *Florida Geological Survey Bulletin* 38: 1–248.

Puri, H.S. and Hulings, N.C., 1976. Designation of lectotypes of some ostracods from the Challenger Expedition. *Bulletin of the British Museum (Natural History) Zoology* 29: 249–315, 27 pls, 14 text-figs.

Reeckmann, S.A., 1974. *The geology and environmental analysis of the Tertiary seqnence at Muddy Creek, and Grange Burn, Hamilton, Victoria.* Unpublished B.Sc.(Hons.) thesis, University of Melbourne.

Roer, R. and Dillaman, R., 1984. The structure and calcification of the crustacean cuticle. *American Zoologist* 24: 893–909.

Ruggieri, G., 1962. Gli ostracodi marini del Tortoniano, Sicilia Centrale. *Palaeontographia Italica* 56 (n.s. 26) *Memoir* 2: 1–68.

Scott, M., 1974. *Ornate Ostracoda from the Victorian Tertiary.* Unpublished M.Sc. thesis, Macquarie University.

Siddiqui, Q.A., 1971. Early Tertiary Ostracoda of the family Trachyleberididae from West Pakistan. *Bulletin of the British Museum (Natural History), Geological Supplement* 9: 1–98.

Simpson, G.G., 1940. Types in modern taxonomy. *American Journal of Science* 238: 413–431.

Sissingh, W., 1972. Late Cenozoic Ostracoda of the South Aegean Island Arc. *Utrecht Micropaleontological Bulletins* 6: 1–187.

Sissingh, W., 1973. *Carinovalva* new genus (Ostracoda), and comments on the ostracode genus *Lixouria* Uliczny (1969). *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen* (B) 76: 143–147.

Swain, F.M., 1963. Pleistocene Ostracoda from the Gubik Formation, Arctic Coastal Plain, Alaska. *Journal of Paleontology* 37(4): 798–834.

Swanson, K.M., 1969. Some Lower Miocene Ostracoda from the Middle Waipara district, New Zealand. *Transactions of the Royal Society of New Zealand, Earth Sciences* 7(3): 33–48.

Sylvester-Bradley, P. and Benson, R.H., 1971. Terminology for surface features in ornate ostracodes. *Lethaia* 4: 249–286.

Triebel, E., 1958 Zwei neue Ostracoden-Gattungen aus dem Lutet des Pariser Beckens. *Senckenbergiana Lethaea* 39: 105–117.

Uffenorde, H., 1981. Ostracoden aus dem Oberoligozän und Miozän des unteren Elbe-Gebietes (Niedersachsen und Hamburg, NW-Deutsches Tertiärbecken). *Palaeontographica* (A) 172: 103–198.

Warne, M.T., 1987. Lithostratigraphical associations of the ostracode fauna in the marine Neogene of the Port Phillip and Western Port Basins, Victoria, southeastern Australia. Pp. 435–445 in: McKenzie, K.G. (ed.), *Shallow Tethys 2.* Balkema: Rotterdam.

Whatley, R., Harlow, C.J., Downing, S.E. and Kesler, K.J., 1983. Observations on the origin, evolution, dispersion and ecology of the genera *Poseidonamicus* Benson and *Bradleya* Hornibrook. Pp. 492–509 in: Maddocks, R.F. (ed.), *Applications of Ostracoda.* University of Houston Geosciences.

Whatley, R. and Downing, S.E., 1983. Middle Miocene Ostracoda from Victoria, Australia. *Revista Espanola de Micropaleontologia* 15(3): 347–407.

Whatley, R., Downing, S.E., Kesler, K. and Harlow, C.J., 1984. New species of the ostracod genus *Bradleya* from the Tertiary and Quaternary of DSDP sites in the southwest Pacific. *Revista Espanola de Micropaleontologia* 16: 265–298.

Whatley, R.C. and Titterton, R., 1981. Some new Recent podocopid Ostracoda from the Solomon Islands southwest Pacific. *Revista Espanola de Micropaleontologia* 13: 157–170.

Yajima, M., 1978. Quaternary Ostracoda from Kisarazu near Tokyo. *Transactions and Proceedings of the Paleontological Society of Japan* n.s. 112: 371–409.

Yassini, I. and Jones, B.G., 1987. Ostracoda in Lake Illawarra: Environmental factors, assemblages and systematics. *Australian Journal of Marine and Freshwater Research* 38: 795–843.

Yassini, I. and Wright, A.J., 1988. Distribution and ecology of Recent ostracodes (Crustacea) from Port Hacking, New South Wales. *Proceedings of the Linnaean Society of New South Wales* 110: 159–174.

Zawawi, T., 1986? Ostracoda from Oman. Unpublished M.Sc. thesis. Macquarie University, Sydney.

Plate captions

The specimens are housed in the invertebrate palaeontology collections of the Museum of Victoria, and are identified by numbers prefixed by the letters NMV P.

The following abbreviations are used: RV, right valve; LV, left valve; C, carapace; F, female; M, male; J, juvenile; ext., external; int., internal. Sample numbers for Clifton Bank are referred to in the introduction. 'Hentys' is the locality name for the bulk sample from Grange Burn (Fig. 1). Localities for the specimens are given as either Clifton Bank or 'Hentys'. The stratigraphic level of samples from Clifton Bank is given in Fig. 2. The Early - Middle Miocene boundary is between planktonic foraminiferal zones N8 and N9. In some cases, the stratigraphic level of specimens from the Clifton Bank samples is not known.

Magnifications are given for each photograph.

Plate 1

1. *?Trachyleberis robustus* (Yassini and Jones, 1987) RV ext. NMV P123216 Clifton Bank,

Sample 5 (Middle Miocene) x 65
2. *?Trachyleberis robustus* (Yassini and Jones, 1987) RV ext. NMV P134937 Clifton Bank, Sample 8 (late Early Miocene) x 90
3. *?Trachyleberis robustus* (Yassini and Jones, 1987) C dorsal NMV P134938 Clifton Bank, Sample unknown (Middle Miocene) x 60
4. *?Actinocythereis* sp. A LV ext. NMV P123221 Clifton Bank, Sample 3 (Middle Miocene) x 65
5. *?Actinocythereis* sp. A JRV ext. NMV P134939 "Hentys" (early Middle Miocene) x 80
6. *Cletocythereis caudispinosa* (Chapman and Crespin, 1928) RV ext. NMV P134939 'Hentys' (early Middle Miocene) x 90
7. *Cletocythereis caudispinosa* (Chapman and Crespin, 1928) RV ext. NMV P134940 Clifton Bank, Sample 10 (late Early Miocene) x 90
8. *Cletocythereis caudispinosa* (Chapman and Crespin, 1928) RV ext. NMV P134941 'Hentys' (early Middle Miocene) x 90
9. *Cletocythereis caudispinosa* (Chapman and Crespin, 1928) LV ext. NMV P123327 'Hentys' (early Middle Miocene) x 90
10. *Cletocythereis* sp. cf. *C. rastromarginata* (Brady, 1880) LV ext. NMV P134942 Clifton Bank, Sample 10 (late Early Miocene) x 90

Plate 2

1. *Cletocythereis* sp. cf. *C. rastromarginata* (Brady, 1880) C ventral NMV P134943 Clifton Bank, Sample 5 (Middle Miocene) x 90
2. *Cletocythereis* sp. cf. *C. rastromarginata* (Brady, 1880) LV int. NMV P134944 'Hentys' (early Middle Miocene) x 90
3. *?Ponticocythereis* sp. aff. *P. manis* Whatley and Titterton, 1981 RV ext. NMV P134945 'Hentys' (early Middle Miocene) x 75
4. *?Ponticocythereis* sp. aff. *P. manis* Whatley and Titterton, 1981 RV ext. NMV P134946 Clifton Bank, Sample 9 (late Early Miocene) x 75
5. *?Ponticocythereis* sp. aff. *P. manis* Whatley and Titterton, 1981 RV ext. NMV P123217 'Hentys' (early Middle Miocene) x 75
6. *?Dumontina cratis* sp. nov. RV int. NMV P134947 Clifton Bank, sample unknown Middle Miocene) x 90
7. *?Dumontina cratis* sp. nov. JMRV ext. NMV P134948 Clifton Bank, Sample 4 (Middle Miocene) x 90
8. *?Dumontina cratis* sp. nov. LV ext. Holotype NMV P123218 'Hentys' (early Middle Miocene) x 65
9. *?Dumontina* sp. A JLV ext. NMV P134949 'Hentys' (early Middle Miocene) x 120
10. *?Dumontina* sp. A RV ext. NMV P123220 'Hentys' (early Middle Miocene) x 80

Plate 3

1. *Deltaleberis warnei* sp. nov. RV int. NMV P134950 Clifton Bank, Sample 10 (late Early Miocene) x 90
2. *Deltaleberis warnei* sp. nov. MRV ext. Holotype NMV P123224 Clifton Bank, Sample 10 (late Early Miocene) x 90
3. *Deltaleberis warnei* sp. nov. FRV ext. NMV P134951 Clifton Bank, Sample 8 (late Early Miocene) x 100
4. *?Alatahermanites septarca* sp. nov. RV ext. Holotype NMV P123221 'Hentys' (early Middle Miocene) x 65
5. *Idiocythere* sp. aff. *I. thalassea* McKenzie, Reyment and Reyment, 1991 LV ext. NMV P123361 Clifton Bank, Sample 9 (late Early Miocene) x 85
6. *?Alatahermanites septarca* sp. nov. JRV ext. NMV P134952 Clifton Bank, Sample unknown (Middle Miocene) x 100
7. *Mackencythere* sp. A RV ext. NMV P123360 'Hentys' (early Middle Miocene) x 120
8. *?Arculacythereis postdeclivis* (Chapman, 1914) LV ext. NMV P123225 Clifton Bank, Sample 10 (late Early Miocene) x 50
9. *?Arculacythereis postdeclivis* (Chapman, 1914) JRV ext. NMV P134953 'Hentys' (early Middle Miocene) x 100
10. *?Arculacythereis postdeclivis* (Chapman, 1914) RV ext. NMV P134954 Clifton Bank, Sample 10 (late Early Miocene) x 55
11. *Arculacythereis tatei* sp. nov. RV ext. Holotype NMV P123266 Clifton Bank, Sample 2 (Middle Miocene) x 75
12. *Arculacythereis tatei* sp. nov. LV ext. NMV P134955 'Hentys' (early Middle Miocene) x 80

Plate 4

1. *Arculacythereis* sp. aff. *A. thomasi* McKenzie, Reyment and Reyment, 1991 RV ext. NMV P134956 'Hentys' (early Middle Miocene) x 80
2. *Arculacythereis* sp. aff. *A. thomasi* McKenzie, Reyment and Reyment, 1991 LV ext. NMV P123265 Clifton Bank, Sample 10 (late Early Miocene) x 85
3. Arculacythereinid gen. indet. sp. A LV ext. NMV P123268 'Hentys' (early Middle Miocene) x 65
4. *Alataleberis miocenica* McKenzie and Warne, 1986 JRV int. NMV P134957 Clifton Bank, Sample 4 (early Middle Miocene) x 80
5. *Alataleberis miocenica* McKenzie and Warne, 1986 JRV ext. NMV P134958 Clifton Bank,

Sample 4 (early Middle Miocene) x 80
6. *Alataleberis miocenica* McKenzie and Warne, 1986 C from LV side NMV P123363 Clifton Bank, Sample 5 (Middle Miocene) x 75
7. *'Hemicythere' lubrica* sp. nov. RV ext. Holotype NMV P123226 Clifton Bank, Sample 10 (late Early Miocene) x 75
8. *'Hemicythere' lubrica* sp. nov. LV int. NMV P123227 Clifton Bank, Sample 10 (late Early Miocene) x 75
9. *'Hemicythere' tenuicostata* sp. nov. MRV ext. NMV P134959 Clifton Bank, Sample 8 (late Early Miocene) x 90
10. *'Hemicythere' tenuicostata* sp. nov. LV ext. Holotype NMV P123230 Clifton Bank, Sample 8 (late Early Miocene) x 85

Plate 5

1. *'Hemicythere' tenuicostata* sp. nov. RV int. NMV P134960 Clifton Bank, Sample 4 (early Middle Miocene) x 90
2. *'Hemicythere'* sp. cf. *'H.' tenuicostata* sp. nov. LV ext. NMV P 123364 Clifton Bank, Sample 10 (late Early Miocene) x 90
3. *Mackenzine foveolata* gen. et sp. nov. RV ext. Holotype NMV P123235 'Hentys' (early Middle Miocene) x 90
4. *Mackenzina foveolata* gen. et sp. nov. LV ext. NMV P123236 'Hentys' (early Middle Miocene) x 90
5. *Mackenzina foveolata* gen. et sp. nov. JLV ext. NMV P134961 'Hentys' (early Middle Miocene) x 100
6. *Mackenzina foveolata* gen. et sp. nov. JRV int. NMV P123237 'Hentys' (early Middle Miocene) x 100
7. *'Ambostracon' recta* sp. nov. FRV ext. NMV P134962 Clifton Bank, Sample 10 (late Early Miocene) x 120
8. *'Ambostracon' recta* sp. nov. MRV int. NMV P134963 Clifton Bank, Sample 9 (late Early Miocene) x 120
9. *'Ambostracon' recta* sp. nov. FRV ext. NMV P123271 Clifton Bank, Sample 10 (late Early Miocene) x 75
10. *'Ambostracon' recta* sp. nov. MLV ext. Holotype NMV P123270 Clifton Bank, Sample 10 (late Early Miocene) x 100

Plate 6

1. *Pokornyella* sp. indet. RV ext. NMV P123368 Clifton Bank, Sample 10 (late Early Miocene) x 85
2. *Neobuntonia batesfordiense* (Chapman, 1914) FRV ext. NMV P123366 Clifton Bank, Sample 3 (Middle Miocene) x 60
3. *Neobuntonia batesfordiense* (Chapman, 1914) MRV ext. NMV P123367 Clifton Bank, Sample 10 (late Early Miocene) x 60
4. *Neobuntonia batesfordiense* (Chapman, 1914) JRV ext. NMV P134964 'Hentys' (early Middle Miocene) x 80
5. *Neobuntonia* sp. indet. RV ext. NMV P123238 Clifton Bank, Sample 9 (late Early Miocene) x 60
6. *Notocarinovalva yulecartensis* gen. et sp. nov. RV ext. Holotype NMV P123240 'Hentys' (early Middle Miocene) x 85
7. *Notocarinovalva yulecartensis* gen. et sp. nov. JRV ext. NMV P134965 'Hentys' (early Middle Miocene) x 90
8. *Notocarinovalva yulecartensis* gen.et sp. nov. LV int. NMV P123239 'Hentys' (early Middle Miocene) x 75
9. *'Hermanites' lungulata* (McKenzie, Reyment and Reyment, 1991) JMLV ext. NMV P134966 Clifton Bank, Sample 3 (Middle Miocene) x 80
10. *'Hermanites' lungulata* (McKenzie, Reyment and Reyment, 1991) RV ext. NMV P123245 'Hentys' (early Middle Miocene) x 65

Plate 7

1. *'Hermanites' lungulata* (McKenzie, Reyment and Reyment, 1991) C dorsal NMV P123247 'Hentys' (early Middle Miocene) x 50
2. *'Hermanites' lungulata* (McKenzie, Reyment and Reyment, 1991) LV int. NMV P134967 Clifton Bank, Sample 8 (early Middle Miocene) x 65
3. *Hermanites glyphica* sp. nov. LV ext. Holotype NMV P123249 'Hentys' (early Middle Miocene) x 65
4. *Hermanites glyphica* sp. nov. FRV ext. NMV P134968 Clifton Bank, Sample 4 (early Middle Miocene) x 70
5. *Hermanites glyphica* sp. nov. JRV ext. NMV P123251 'Hentys' (early Middle Miocene) x 75
6. *Hermanites glyphica* sp. nov. C ventral NMV P134969 Clifton Bank, Sample 10 (late Early Miocene) x 70
7. *Hermanites glyphica* sp. nov. RV int. NMV P134970 Clifton Bank, sample unknown (Middle Miocene) x 70
8. *Hermanites glyphica* sp. nov. JLV ext. NMV P134971 'Hentys' (early Middle Miocene) x 80
9. *'Hermanites' thomasi* sp. nov. FLV ext. Holotype NMV P123242 Clifton Bank, Sample 10 (late Early Miocene) x 80
10. *'Hermanites' thomasi* sp. nov. MRV ext. NMV P134972 Clifton Bank, Sample 5 (Middle Miocene) x 90

Plate 8

1. *'Hermanites' thomasi* sp. nov. FRV ext. NMV P134973 Clifton Bank, Sample 5 (Middle Miocene) x 90
2. *'Hermanites' thomasi* sp. nov. LV int. NMV P134974 Clifton Bank, Sample 10 (late early Miocene) x 90
3. *Spinobradleya nodosa* sp. nov. LV ext. Holotype NMV P123252 Clifton Bank, Sample 10 (late Early Miocene) x 65
4. *Spinobradleya nodosa* sp. nov. MRV ext. NMV P134975 Clifton Bank, Sample 3 (Middle Miocene) x 80
5. *Spinobradleya nodosa* sp. nov. JRV ext. NMV P134976 Clifton Bank, Sample 10 (late Early Miocene) x 90
6. *Spinobradleya nodosa* sp. nov. JRV ext. NMV P134977 Clifton Bank, Sample 10 (late Early Miocene) x 120
7. *Bradleya (Bradleya) praemackenziei* Whatley and Downing, 1983 LV ext. NMV P123369 'Hentys' (early Middle Miocene) x 75
8. *Bradleya (Bradleya)* sp. cf. *B. kincaidiana* (Chapman, 1926) JRV ext. NMV P134978 'Hentys' (early Middle Miocene) x 90
9. *Bradleya (Bradleya) praemackenziei* Whatley and Downing, 1983 JLV ext. NMV P134979 Clifton Bank, Sample 7 (Early Middle Miocene) x 65
10. *Bradleya (Bradleya)* sp. cf. *B. kincaidiana* (Chapman, 1926) RV ext. NMV P123370 Clifton Bank, Sample 10 (late Early Miocene) x 75

Plate 9

1. *Bradleya (Bradleya)* sp. A MRV ext. NMV P123255 'Hentys' (early Middle Miocene) x 85
2. *Bradleya (Quasibradleya) pyxos* sp. nov. MRV ext. Holotype NMV P123257 Clifton Bank, Sample 10 (late Early Miocene) x 75
3. *Bradleya (Quasibradleya) pyxos* sp. nov. JLV ext. NMV P134980 'Hentys' (early Middle Miocene) x 80
4. *Quadracythere (Quadracythere) spica* Holden, 1976 FLV ext. NMV P134981 Clifton Bank, Sample 3 (Middle Miocene) x 70
5. *Quadracythere (Quadracythere) spica* Holden, 1976 RV ext. NMV P123263 'Hentys' (early Middle Miocene) x 65
6. *Quadracythere (Quadracythere) spica* Holden, 1976 JLV ext. NMV P134982 Clifton Bank, Sample 10 (late Early Miocene) x 80
7. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. FLV ext. Holotype NMV P123260 'Hentys' (early Middle Miocene) x 65
8. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. RV ext. NMV P134983 'Hentys' (early Middle Miocene) x 80
9. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. JRV int. NMV P134984 'Hentys' (early Middle Miocene) x 100
10. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. MLV ext. NMV P123259 'Hentys' (early Middle Miocene) x 65

Plate 10

1. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. JRV ext. NMV P134985 'Hentys' (early Middle Miocene) x 90
2. *Chapmanella flexicostata* (Chapman, 1914) C ventral NMV P134986 Clifton Bank, Sample 4 (Middle Miocene) x 80
3. *Chapmanella flexicostata* (Chapman, 1914) MRV int. NMV P134987 Clifton Bank, Sample 4 (Middle Miocene) x 80
4. *Chapmanella flexicostata* (Chapman, 1914) JRV ext. NMV P134988 'Hentys' (early Middle Miocene) x 100
5. *Chapmanella flexicostata* (Chapman, 1914) MRV ext. NMV P 134989 Clifton Bank, Sample 10 (late Early Miocene) x 80
6. *Chapmanella flexicostata* (Chapman, 1914) RV ext. NMV P134990 'Hentys' (early Middle Miocene) x 80
7. *Chapmanella flexicostata* (Chapman, 1914) JMLV ext. NMV P123371 'Hentys' (early Middle Miocene) x 130
8. *Chapmanella flexicostata* (Chapman, 1914) RV ext. NMV P134991 Clifton Bank, Sample 4 (Middle Miocene) x 80
9. *'Hermanites' thomasi* sp. nov. FLV ext. NMV P134992 Clifton Bank, Sample 10 (late Early Miocene) x 100
10. *Spinobradleya nodosa* sp. nov. JLV ext. NMV P134993 Clifton Bank, Sample 4 (Middle Miocene) x 100

Plate 11

[All figures show detail of surface ornament at higher magnification.]

1. *Cletocythereis caudispinosa* (Chapman and Crespin, 1928) NMV P123327 'Hentys' (early Middle Miocene) x 400
2. *?Ponticocythereis* sp. aff. *P. manis* Whatley and Titterton, 1981 NMV P123217 'Hentys' (early Middle Miocene) x 375
3. *?Dumontina cratis* sp. nov. JMRV NMV P134948 Clifton Bank, Sample 4 (Middle Miocene) x 220
4. *Deltaleberis warnei* sp. nov. NMV P123224

Clifton Bank, Sample 10 (late Early Miocene) x 400
5. *Idiocythere* sp. cf. *I. thalassea* Detail of subcentral tubercle area NMV P123361 Clifton Bank, Sample 9 (late Early Miocene) x 250
6. *?Arculacythereis tatei* sp. nov. NMV P123266 Clifton Bank, Sample 10 (late Early Miocene) x 800
7. *?Arculacythereis tatei* sp. nov. NMV P134994 Clifton Bank, Sample 10 (late Early Miocene) x 450
8. *Alataleberis miocenica* McKenzie and Warne, 1986 NMV P134995 Clifton Bank, Sample 4 (Middle Miocene) x 800

Plate 12

1. *Mackenzina foveolata* gen. et sp. nov. NMV P134961 'Hentys' (early Middle Miocene) x 350
2. *Mackenzina foveolata* gen. et sp. nov. JLV NMV P134961 'Hentys' (early Middle Miocene) x 1100
3. *Neobuntonia batesfordiense* (Chapman, 1914) NMV P123366 Clifton Bank, Sample 10 (late Early Miocene) x 350
4. *Hermanites glyphica* sp. nov. NMV P123251 'Hentys' (early Middle Miocene) x 225
5. *Hermanites glyphica* sp. nov. NMV P134996 'Hentys' (early Middle Miocene) x 600
6. *Hermanites glyphica* sp. nov. NMV P134997 'Hentys' (early Middle Miocene) x 675
7. *'Hermanites' thomasi* sp. nov. NMV P134973 Clifton Bank, Sample 4 (Middle Miocene) x 800
8. *'Hermanites' thomasi* sp. nov. NMV P134992 Clifton Bank, Sample 4 (Middle Miocene) x 350

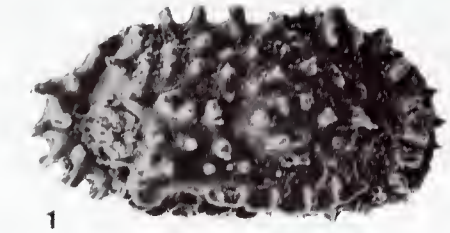
Plate 13

1. *'Hermanites' thomasi* sp. nov. Detail of subcentral tubercle NMV P134992 Clifton Bank, Sample 4 (Middle Miocene) x 350
2. *Bradleya (Bradleya) praemackenziei* Whatley and Downing, 1983 NMV P134993 Clifton Bank, Sample 4 (Middle Miocene) x 675
3. *Bradleya (Quasibradleya) pyxos* sp. nov. NMV P134980 'Hentys' (early Middle Miocene) x 350
4. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. NMV P134985 'Hentys' (early Middle Miocene) x 350
5. *Chapmanella flexicostata* (Chapman, 1914) NMV P134994 'Hentys' (early Middle Miocene) x 350
6. *Chapmanella flexicostata* (Chapman, 1914) NMV P134988 Clifton Bank, Sample 4 (Middle Miocene) x 350
7. *?Pteroygocythereis* sp. indet. LV ext. NMV P123362 'Hentys' (early Middle Miocene) x 120
8. Hemicytherid gen. et sp. indet. ?JLV ext. NMV P123365 Clifton Bank, Sample 7A (early Middle Miocene) x 160

Plate 14

Figures show muscle scar patterns, except where otherwise noted.

1. *?Trachyleberis robustus* (Yassini and Jones, 1987) NMV P123216 x 160
2. *'Hemicythere' lubrica* sp. nov. NMV P123226 x 300
3. *'Hemicythere' lubrica* sp. nov. NMV P123227 x 300
4. *'Hemicythere' tenuicostata* sp. nov. NMV P123229 x 400
5. *Neobuntonia batesfordiense* (Chapman, 1910) x 200
6. *'Hermanites' thomasi* sp. nov. NMV P123242 x 250
7. *'Hermanites' lungulata* (McKenzie, Reyment and Reyment, 1991) NMV P123245 x 225
8. *Bradleya (Quasibradleya) pyxos* sp. nov. NMV P123257 x 275
9. *Quadracythere (Hornibrookellina) hentyensis* subgen. et sp. nov. NMV P123260 x 200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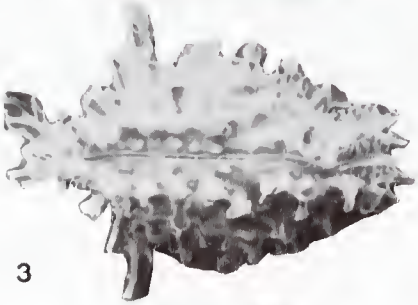
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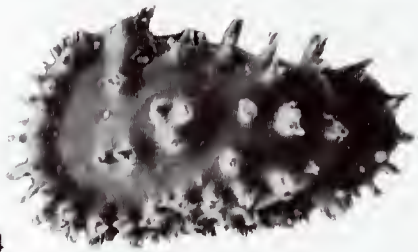
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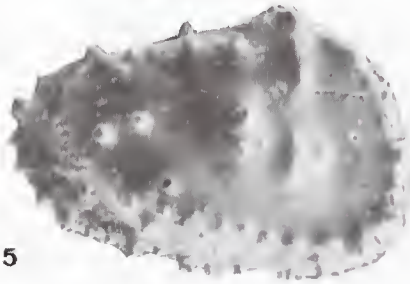
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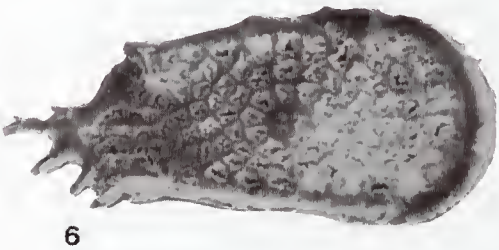
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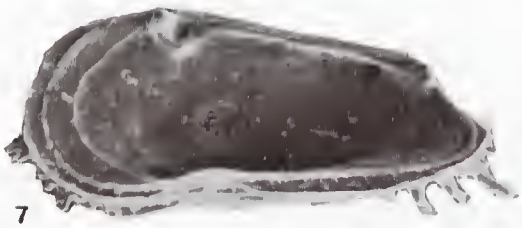
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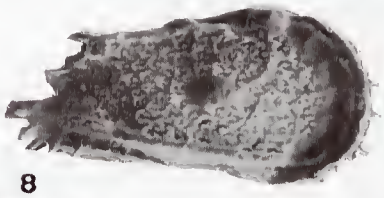
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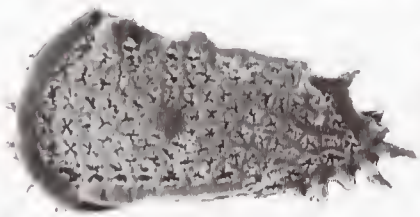
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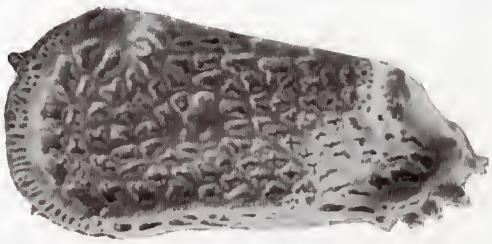
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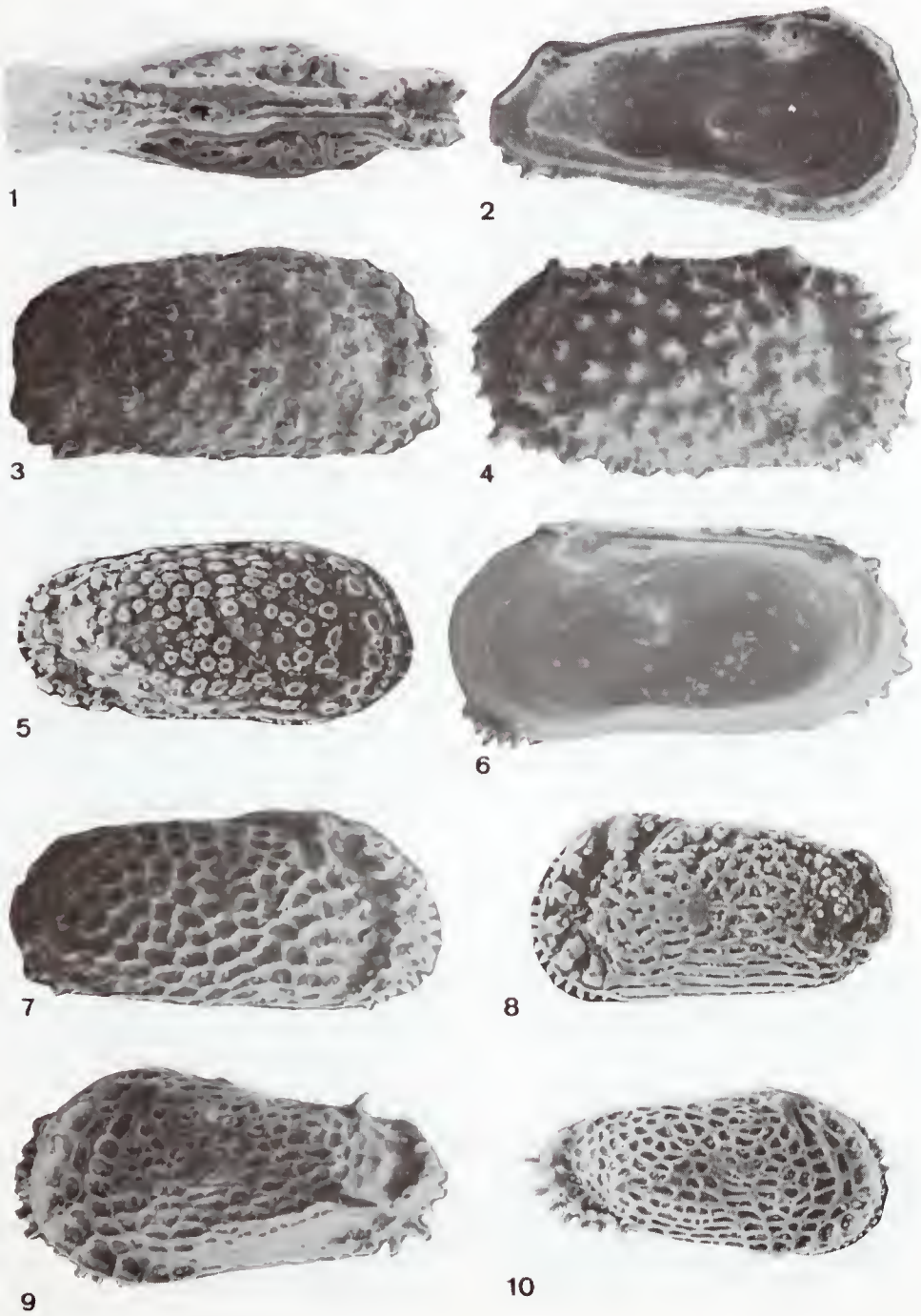
PLATE I



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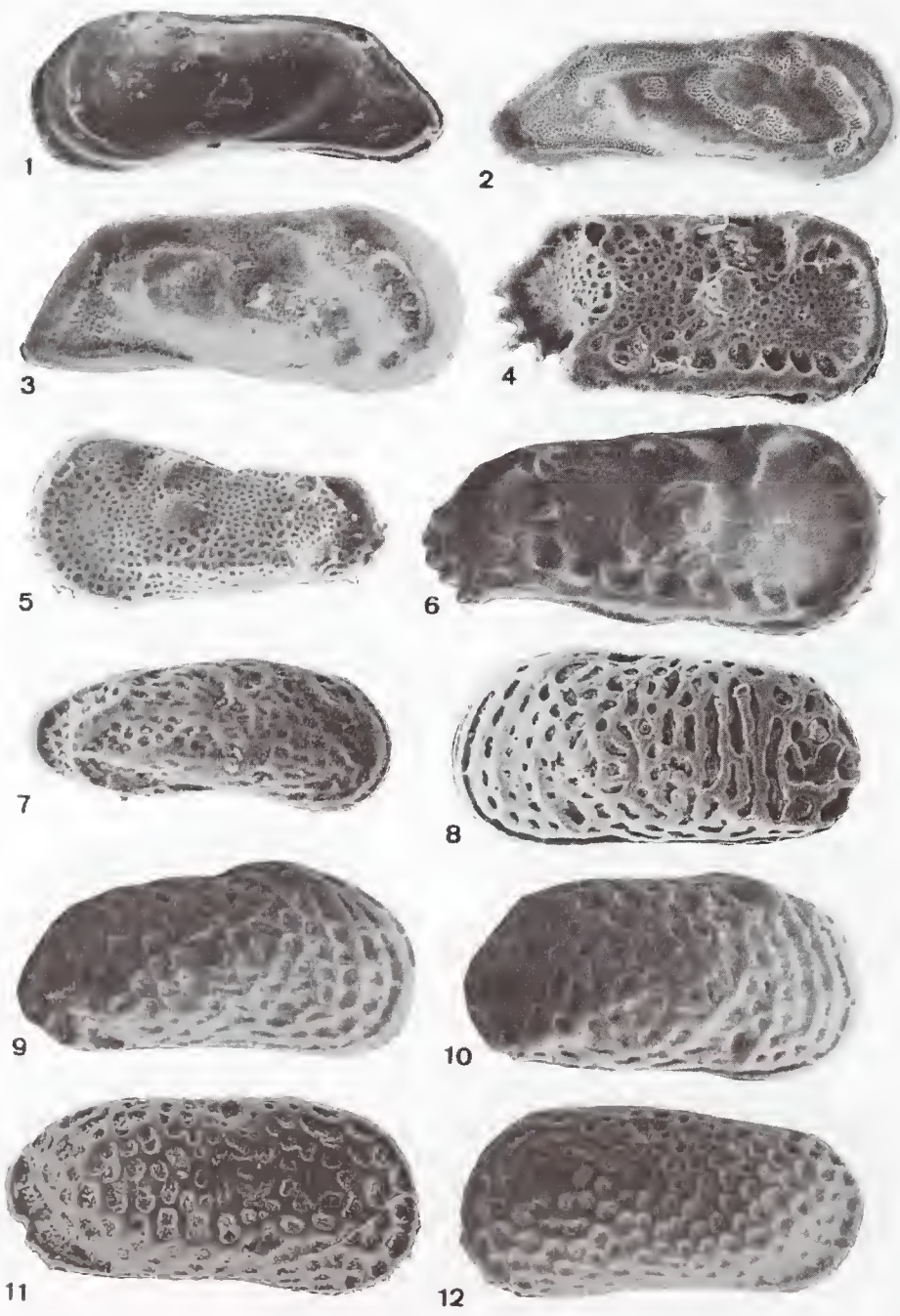

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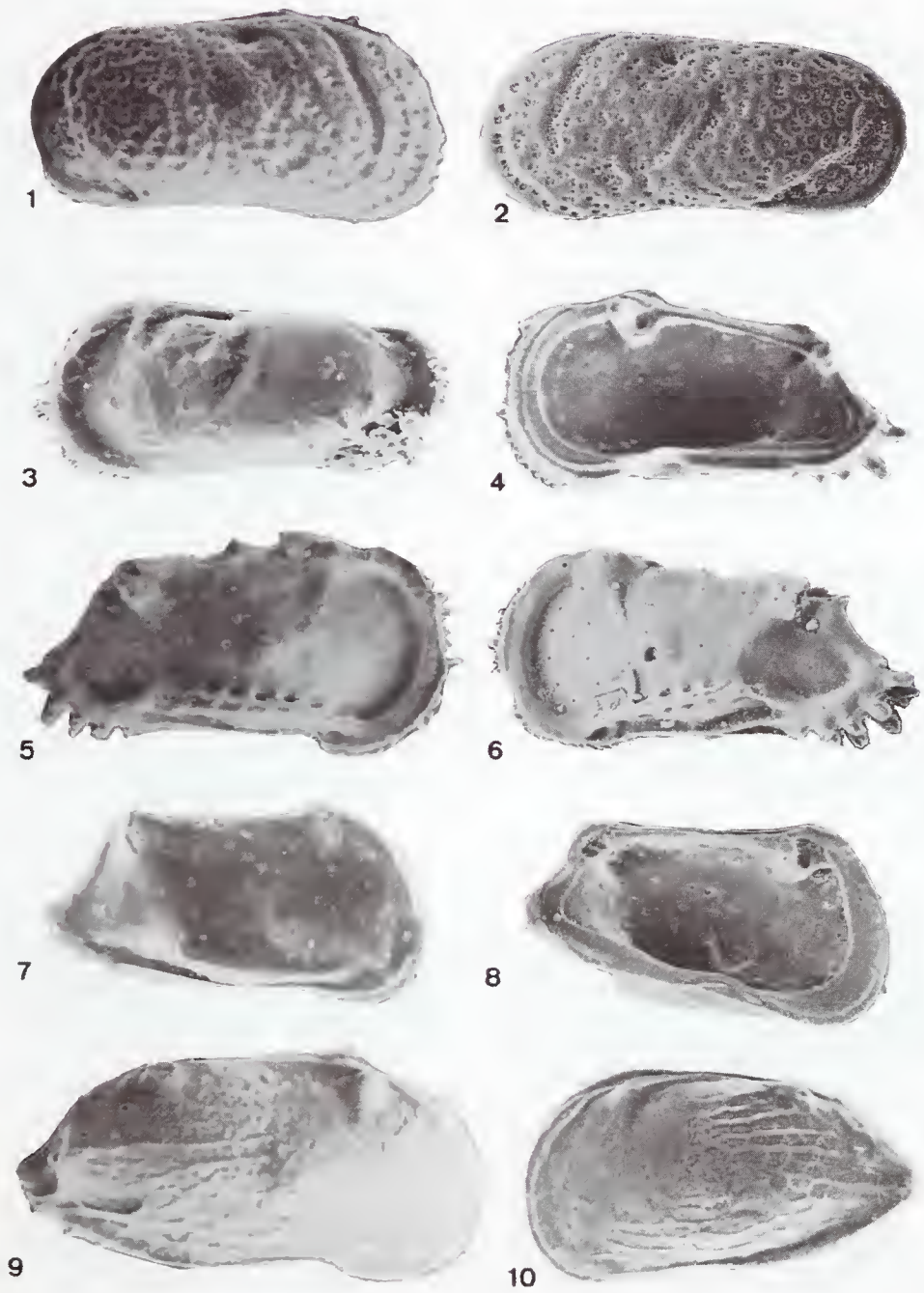

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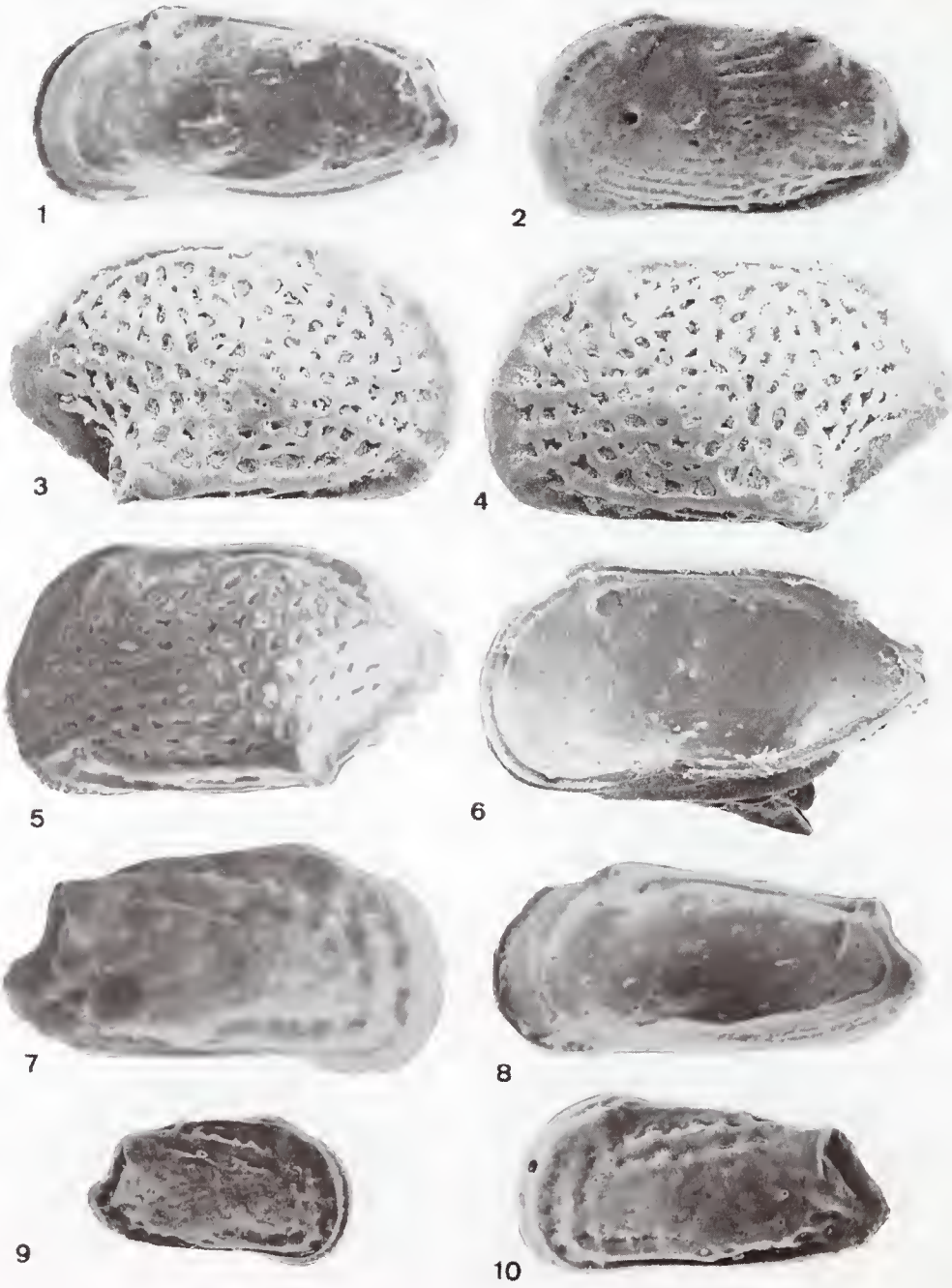

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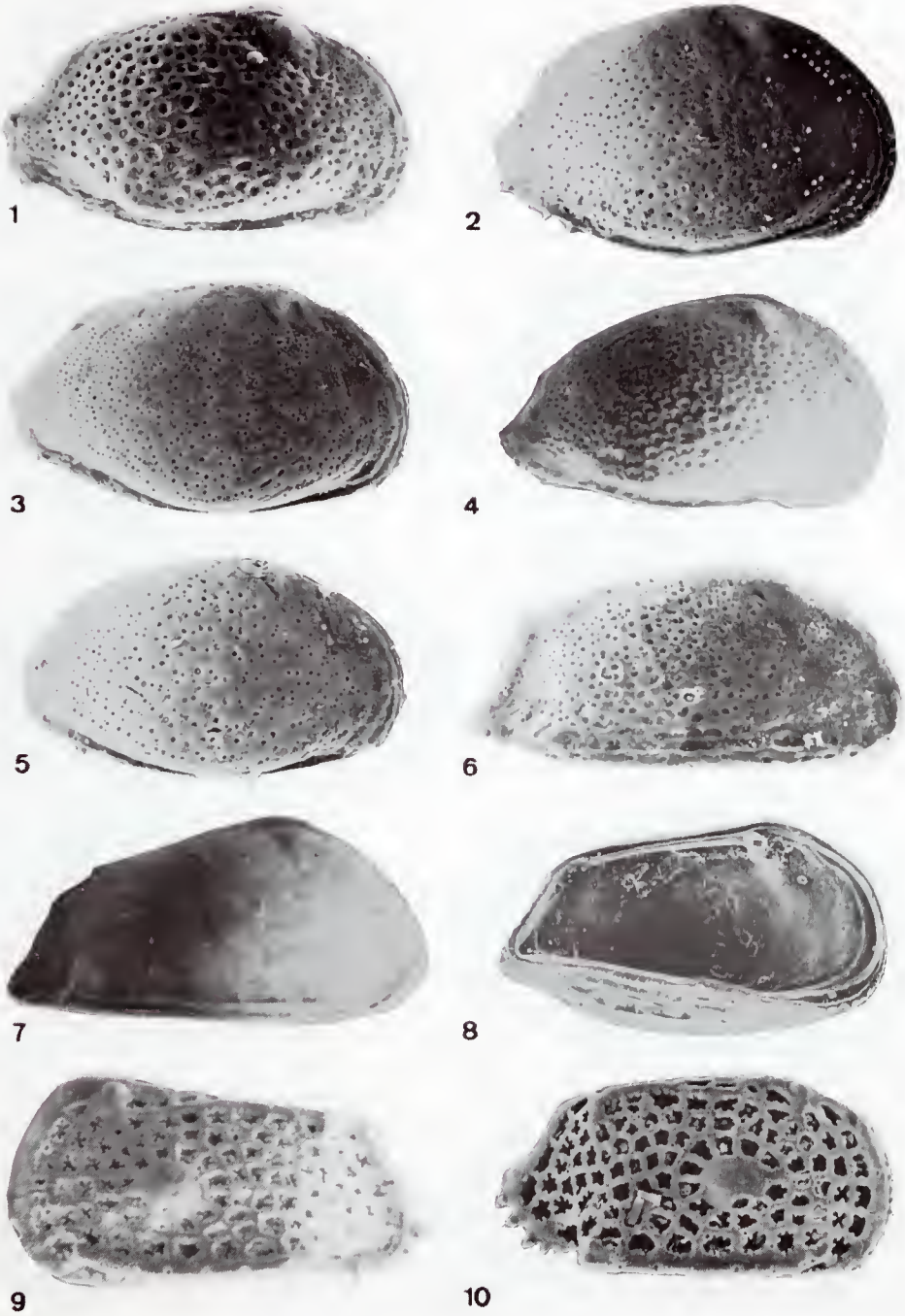

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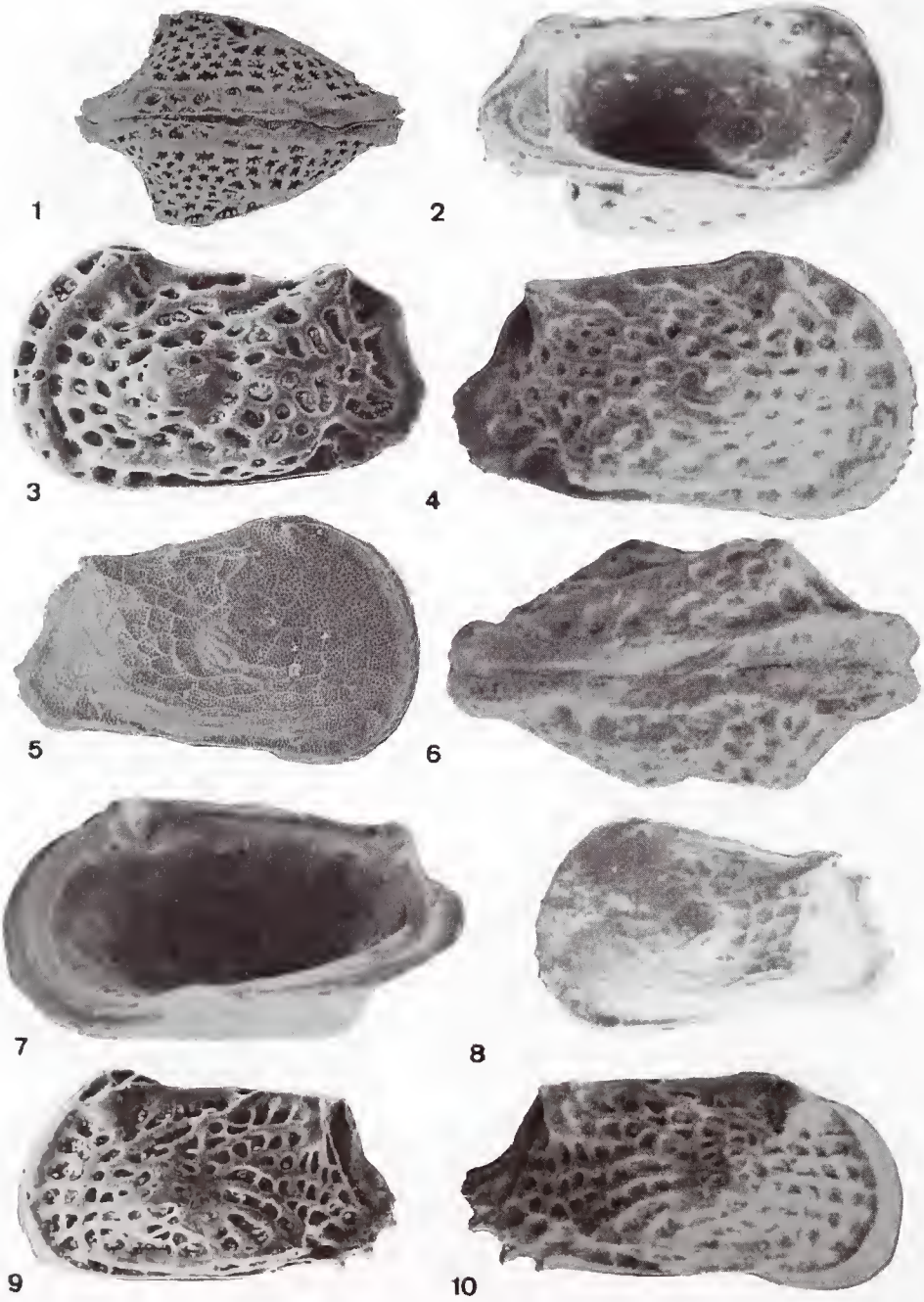

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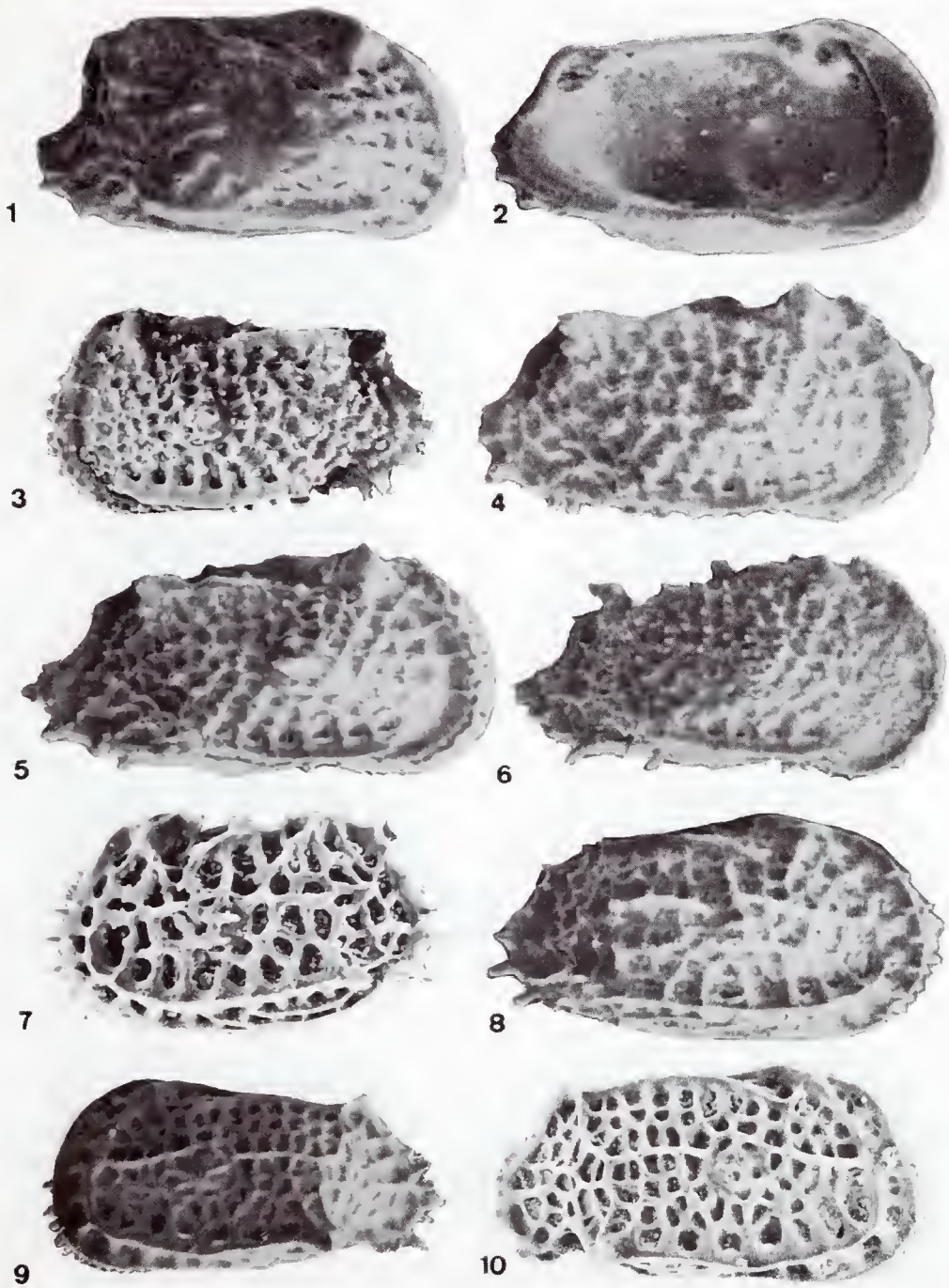

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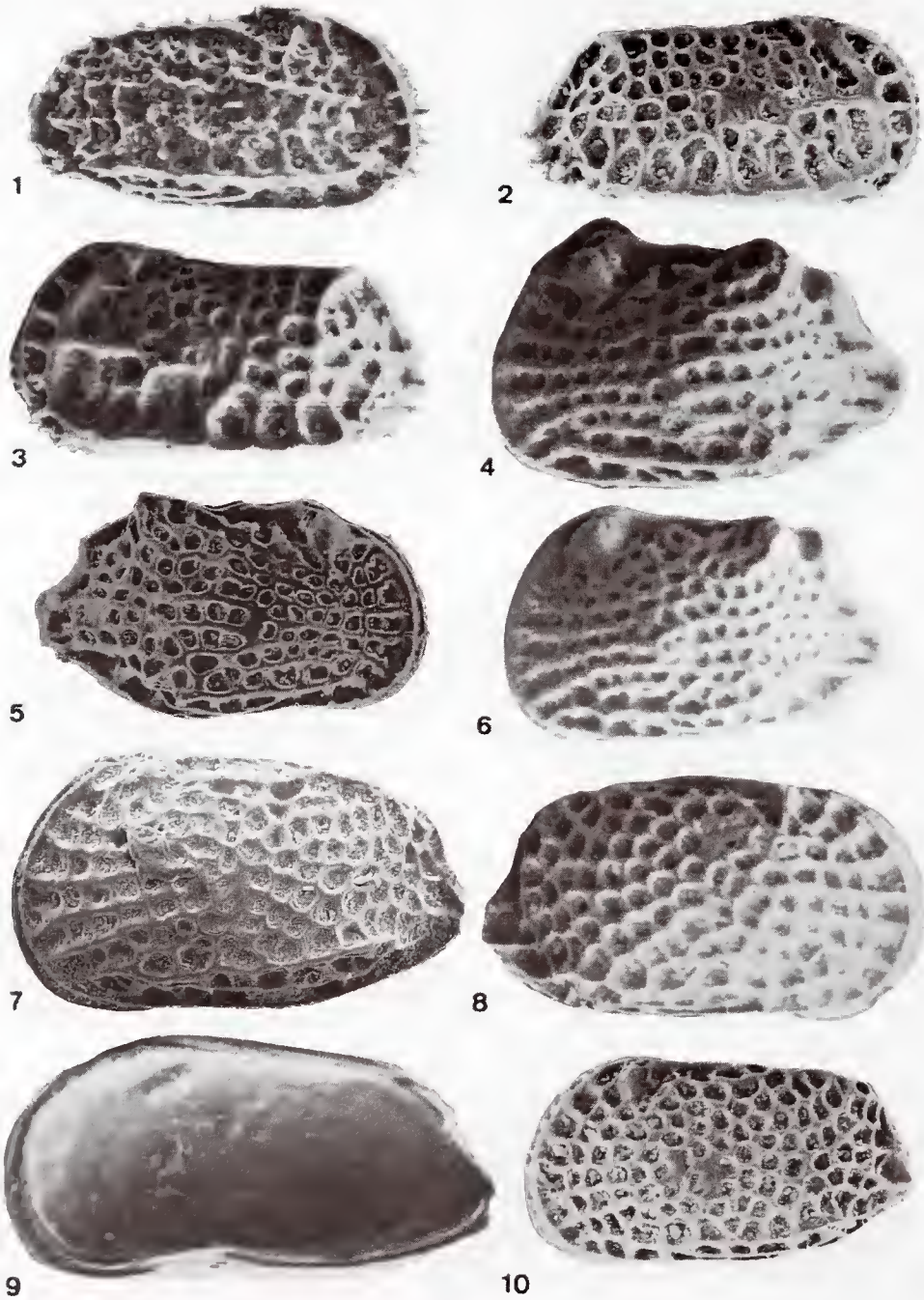

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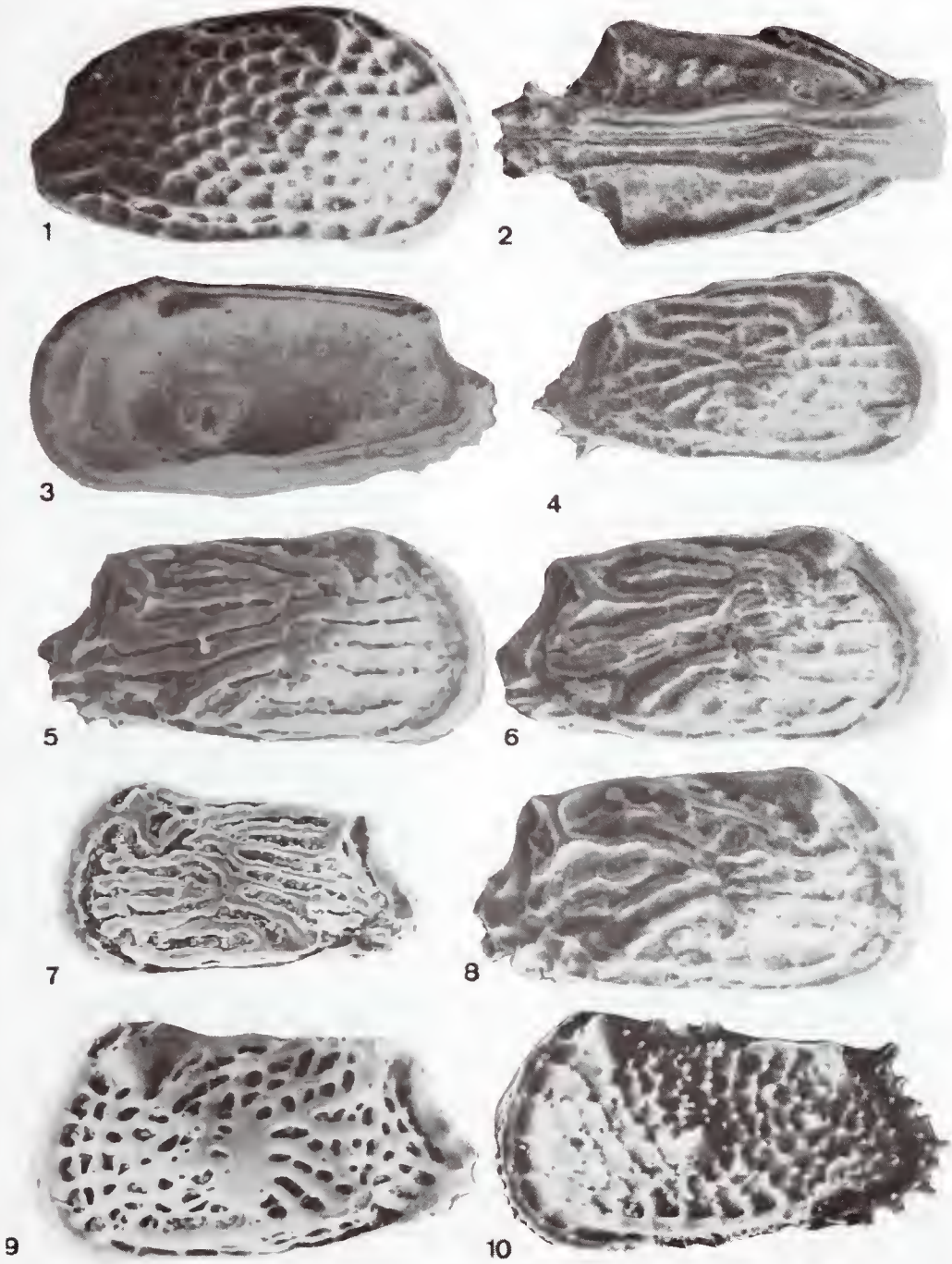

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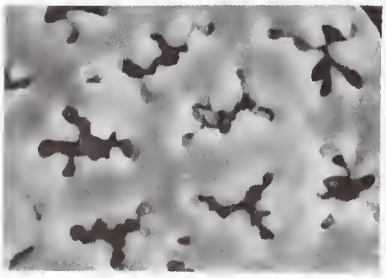
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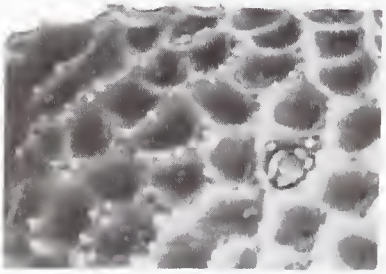
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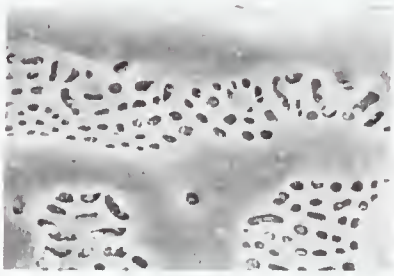
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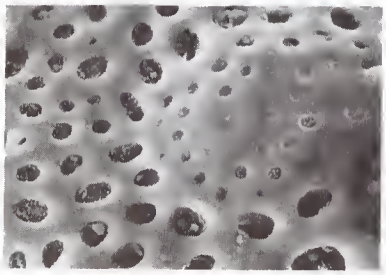
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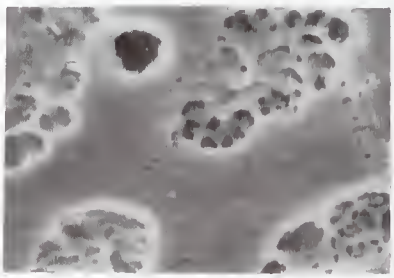
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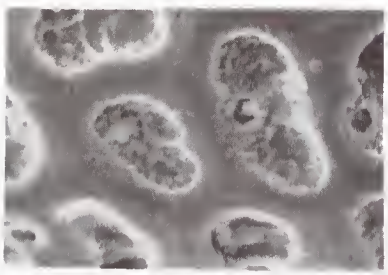
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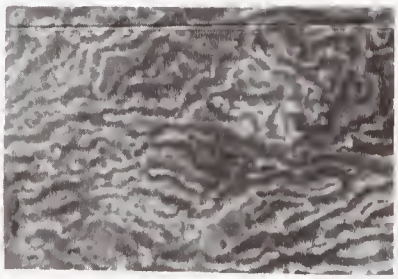
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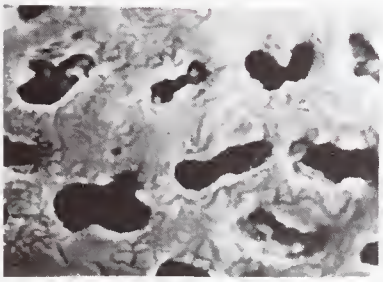
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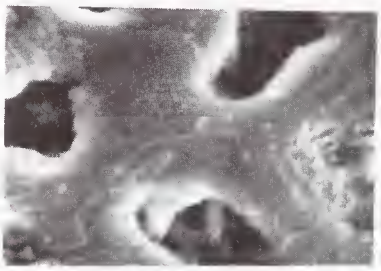
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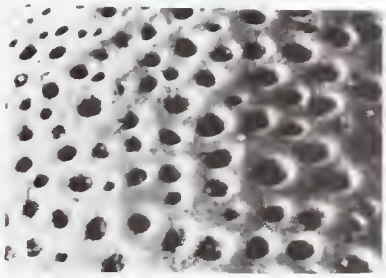
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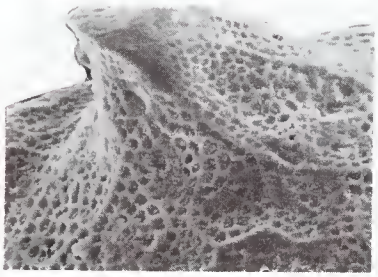
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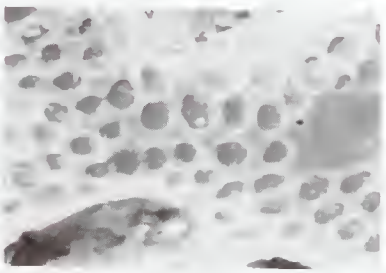
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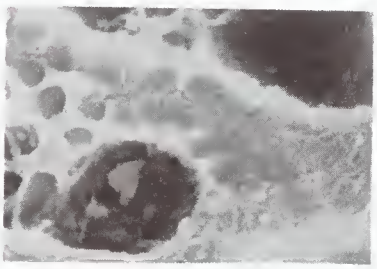
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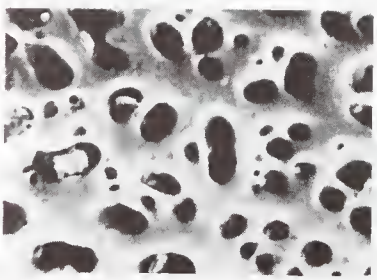
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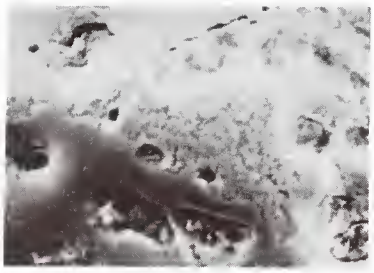
PLATE 12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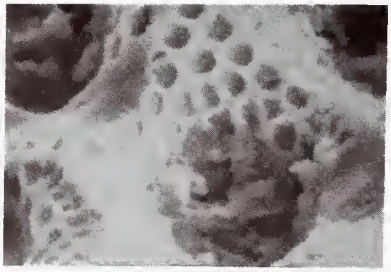
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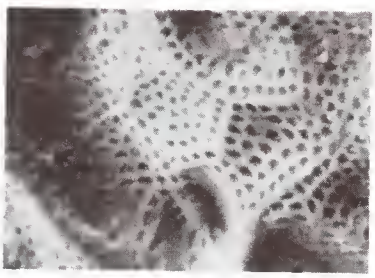
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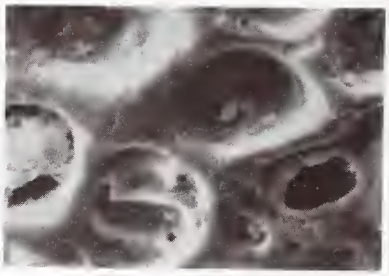
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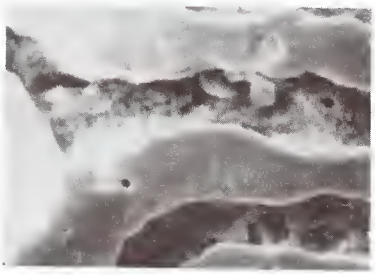
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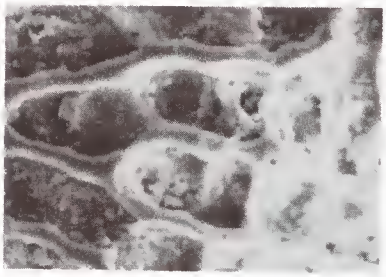
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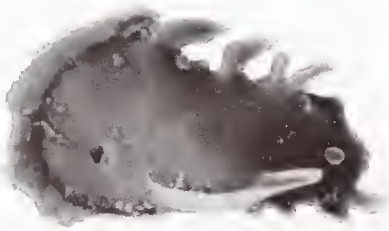
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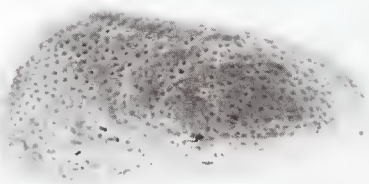
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PLATE 13

PLATE 14