

Eocene molluscs from the Merlinleigh Sandstone, Carnarvon Basin, Western Australia

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ABSTRACT – Sixteen species of molluscs are described from the Late Eocene Merlinleigh Sandstone, Carnarvon Basin, Western Australia. The assemblage, a random thanatocoenose, is dominated by bivalves (11 species) and a cephalopod, with a few gastropod specimens. All primary shell carbonate — calcite or aragonite — is replaced by silica. The assemblage is distinctive in composition, resembling no other known from the Australian Eocene. Terrestrial plant material, all silicified, is associated with the marine fossils, consistent with a depositional environment of the energised sandy littoral, subject to river flood discharge. At a height of +280 to 300 m AHD, the formation compares closely with others of similar age in southwestern Australia, which also consist of a combination of marine and terrestrial fossil material. Faunal affinities with the southern Australian Eocene were weak; an apparent Tethyan-Indo-Southwest Pacific influence is present, possibly with a weak endemic element. The taxonomy of the nautiloid *Aturia clarkei* is discussed.

KEYWORDS: new species, fossils, Tethyan-Indo-Southwest Pacific influence, silicification, *Aturia*.

INTRODUCTION

This paper continues studies by the authors (Darragh and Kendrick 1980, 2000, 2008) on the Eocene molluscan faunas of southern and western Australia, herein with regard to the most northerly of these, from the Merlinleigh Sandstone, eastern Carnarvon Basin (Playford et al. 1975 and references; Cockbain 1981). The formation is a thin (up to 15 m), transgressive, poorly cemented, silicified quartz sandstone with subordinate siltstone and conglomerate, exposed discontinuously between the Gascoyne and Lyndon Rivers, near the northern margin of the Yilgarn Block (Johnstone et al. 1973), with the most productive outcrops located in and adjacent to the Kennedy Range. At the type section (24°18'50"S, 115°11'10"E), located at a mesa 1.6 km ESE of the abandoned Merlinleigh Station homestead, the formation is 9.1 m thick. The formation unconformably overlies Permian units and is overlain in turn by either Tertiary laterite or by a conspicuous aeolian dune field of possible Quaternary age.

Fossil material, invariably silicified, occurs mainly as surface float on and below erosion scarps and comprises, at present knowledge, foraminifers, colonial corals, bryozoans, hydrozoans, molluscs, fossil wood

(some teredine-bored) and other terrestrial plant remains, likewise silicified (Teichert 1944; Pulley 1959; Brunnschweiler 1962; Cockbain 1981; McNamara and Scott 1983; Haig and Mory 2003). Other than the nautiloid *Aturia clarkei* Teichert, 1944, molluscs from the Merlinleigh Sandstone have thus far remained undescribed, notwithstanding their ready collection and often excellent preservation. However, the gastropods and nautiloids, in particular, have undergone moderate to severe mechanical abrasion and transportation. All bivalves of whatever facies (teredines excepted) are known only from single, disarticulated valves. As a whole, the material forms a randomly disassociated death assemblage.

This assemblage of molluscs and that from the Kalbarri area sandstone differ from the other known Late Eocene faunas of Australia, as none of the others represents a shallow water fauna inhabiting a sandy substrate (Darragh and Kendrick 2008). Somewhat similar types of facies are known in the late Tertiary.

MATERIAL

The study material has been drawn from the

palaeontological collections of the Western Australian Museum (WAM), Museum Victoria (NMV) and the E. de C. Clarke Earth Sciences Museum, The University of Western Australia (UWA). The registration numbers of Western Australian Museum animal fossil specimens accessed before June 1959 bear the prefix G and subsequently are prefixed by the last two digits of the current year of registration; those of plant specimens are prefixed by P and the last two digits of the current year of registration.

Most of this material represents five collection events, all from Western Australia, as follows:

1. Collection of C. Teichert. From east side of Kennedy Range, 1.3 miles (2.1 km) north of Merlinleigh homestead, Carnarvon Basin, W.A.
UWA 21406 – holotype of *Aturia clarkei* Teichert, 1944
UWA 21407a–e – paratypes of *A. clarkei*. Paratypes UWA 21407a & b missing, November 2008
2. Collection of R. Savage and W.D.L. Ride, 5–7.ix.1967. Merlinleigh Station, from and adjacent to type section of Merlinleigh Sandstone.
Map ref. Kennedy Range 312973. WAM 69.274–69.290.
3. Collections by the present authors:
 - i. 10.iv.1969. Lyndon Station, three miles (c. 5 km) WNW from Ebra Well, surface float. Map ref. Winning Pool 289063. WAM 70.1693, 70.1694.
 - ii. 13.iv.1969. Surface float on sides of mesa 1.6 km ESE from Merlinleigh Station homestead (= type section of Merlinleigh Sandstone). Map ref. Mount Sandiman LU 175087. WAM 70.1665–70.1677. NMV P314122–314134, P31429–314297, 314894–314896.
 - iii. 13.iv.1969. Surface float on side of mesa c. 200m N of type section of Merlinleigh Sandstone. WAM 70.1678–70.1692.
4. Collections by the present authors with K.J. McNamara, 31.viii–1.ix.1979.
 - i. Side of breakaway 1.5 km E of old Merlinleigh station homestead; 200 m N of type section mesa, Merlinleigh Sandstone. Map ref. Mount Sandiman LU 175087. WAM 79.2856–79.2887. P.79.46–P.79.50. NMV P314290–314293, 314306, 315059.
 - ii. Merlinleigh Station. Side of escarpment 0.8 km N from type section mesa, Merlinleigh Sandstone. Map ref. Kennedy Range 312975. WAM 79.2889–79.2891. P.79.42, P.79.43. The type locality for *Banksia archaeocarpa* McNamara and Scott, 1983.
 - iii. Merlinleigh Station. Side of escarpment immediately S of track 1.5 km NNE of old Merlinleigh homestead. Map ref. Kennedy Range 312977. WAM 79.2892–79.2898. P.79.51. P314294–314297.
 - iv. Mt Sandiman Station. Small mesa 2 km SE of type section of Merlinleigh Sandstone. Site is close to boundary with Merlinleigh Station. Map ref. Kennedy Range 314974. WAM 79.2902. P.79.53. P315054.
 - v. Mt Sandiman Station. Hill 1 km and 120° from type section mesa of Merlinleigh Sandstone. Float on northern hill slopes. Map ref. Kennedy Range 313974. WAM 79.2899, 79.2900. P.79.52.
5. Collections by present authors with K. Ayyasami (Geological Survey of India), 8,9.ix.1996.
 - i. Eroded lower slope of mesa 1.6 km ESE of old Merlinleigh homestead. Map ref. Mt Sandiman (1:100,000 sheet) LU 176087. WAM 97.1–97.8, P.97.1–P.97.6. NMV P314112–314121, P315512.
 - ii. Erosion slope 1.5 km NNE of old Merlinleigh homestead; between 0.4 km and 0.1 km N of pass. Map ref. Mt Sandiman (1:100,000 sheet) LU 165111. WAM 97.9–97.12, P.97.7. NMV P314294–7.
 - iii. Other records, some, possibly all, of which may be manuports.
6. Two fragments of an *Aturia* shell from an Aboriginal campsite on Eudamullah Station, said to have been bought there from Merlinleigh. Presented by A. Snell and accessed 14.ii.1942. WAM G16008.
7. Four shell fragments of *Aturia* from 'surface of valley containing Bangemall goldmine'. Presented by M. Greening and accessed October 1966. WAM 66.1008–66.1011.
8. Two shell fragments of *Aturia* found on Moogooree Station by Mrs F.S. Dodds. Accessed 9.xii.1977. WAM 78.641–2.
9. Part of an *Aturia* shell retaining a remnant of its outer layer, found by J. Glass in the Kennedy Range. Presented via the Geraldton Regional Museum and accessed 24.viii.1988. WAM 88.849.

AGE AND CORRELATION

A Miocene age for the Merlinleigh Sandstone was initially proposed by Teichert (1944), after Chapman and Crespin (1934), from the shared presence of the nautiloid *Aturia clarkei* Teichert with the Pallinup Formation (= Plantagenet Beds) of the Bremer Basin, which with the Kennedy Range Tertiary strata were subsequently correlated by Glaessner (1955) with the Late Eocene Tortachilla Limestone and Blanche Point Formation of the St Vincent Basin. From a study of the fibulariid echinoids, Brunnschweiler (1962) favoured an Eocene ('Late Cuisian or Lutetian') age for the formation. Further, from the presence of foraminifers *Maslinella chapmani* Glaessner and Wade, *Operculina* sp., *Crespinina kingscotensis* Wade and *Rotalia* sp.,

TABLE 1 All molluscan taxa known from the Merlinleigh Sandstone, listed in taxonomic order together with the total numbers of each examined.

BIVALVIA	Total specimens
<i>Cucullaea</i> sp. cf. <i>C. adelaidensis</i> Tate, 1886	2
<i>Glycymeris</i> sp. cf. <i>G. cainozoica</i> (Tenison Woods, 1877)	99
<i>Spondylus</i> sp. cf. <i>S. gaderopoides</i> McCoy, 1876	2
Pectinid, genus and species undetermined	1 frag.
' <i>Ostrea</i> ' sp.	1
<i>Chama</i> sp.	23
<i>Miltha</i> sp.	2 frags
<i>Venericardia capricornia</i> sp. nov.	61
<i>Periglypta weegeeree</i> sp. nov.	4
<i>Dosinia</i> (<i>Kereia</i>) <i>numerosissima</i> sp. nov.	121
Teredinid, genus and species undetermined	10
GASTROPODA	
<i>Tugali?</i> sp.	5
<i>Turbo</i> (<i>Euninella</i>) sp. cf. <i>T. (E.) hamiltonensis</i> Harris, 1897	3
<i>Vasum</i> sp.	1
<i>Zelandiella?</i> sp.	1
CEPHALOPODA	
<i>Aturia clarkei</i> Teichert, 1944	78

Cockbain (1981) confirmed a Late Eocene age for the Merlinleigh Sandstone, correlated in part with the Late Eocene Giralia Calcarenite of the Carnarvon Basin, the latter deposited under 'open ocean conditions'.

The nearshore features of the Merlinleigh Sandstone are matched by others of similar age and elevation in southwest Australia, as has been noted by Johnstone et al. (1973). An example of this, hitherto unreported, has been recognized in an exposure of the Plantagenet Group located on a low divide between the Gordon and Pallinup Rivers, 13 km ENE of Tambellup (34°02'S, 117°38'E). Lithologies present include (a) a dark brown, conglomeratic, coarse-grained sandstone with impressions of marine bivalves and (b) a pallid, fine-grained spongolite with impressions of terrestrial vegetation (WAM records). Contour maps of the area (Martinup SW 1:25,000 series) show that the site lies at or very close to +300 m AHD.

DEPOSITIONAL ENVIRONMENT

Plant debris in the Merlinleigh Sandstone includes araucarian cones, proteaceous leaves, wood, a *Banksia* frutescence and other material (McLoughlin and Hill 1996). This, in close association with an assortment of marine fossils dominated by disarticulated bivalves from a shallow sandy infaunal habitat, indicates a depositional environment featuring 'local rivers in flood, depositing

the poorly sorted sands and the plant material close to a marine sand bar' (McNamara and Scott 1983: pp. 186–187). The presence of rare very worn and damaged specimens of a turbinid gastropod and limpet are indications of transport of specimens from some distant rocky or hard ground habitat. The *Aturia* specimens suggest strandings on a shallow beach exposed to the open ocean; the extensive damage to almost all the specimens, particularly to the body chamber, suggests some kind of predation at sea involving large fish or cetaceans.

SYSTEMATIC PALAEOLOGY

Class Bivalvia Linnaeus, 1758

Family Cucullaeidae Stewart, 1930

Genus *Cucullaea* Lamarck, 1801

Cucullaea sp. cf. *C. adelaidensis* Tate, 1886

Figures 1G, H, K

cf. *Cucullaea adelaidensis* Tate, 1886: 144, plate 11, figures 14a, b.

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 97.1, one LV. WAM 97.9, one RV. NMV P314302,

marginal fragment of LV. NMV P314113, fragment of LV. Total of one LV, one RV and fragments.

DESCRIPTION

Valves of about normal size for genus, possibly less than fully mature; robust, obliquely trapezoidal, inflated, longer than high; umbones prominent, strongly incurved, orthogyrous; LV apparently more inflated and with a more elevated, prominent umbo than RV. Lateral teeth parallel to dorsal margin, not descending; ventral margin of LV strongly internally crenulate, RV apparently less so. Sculpture finely, closely radiate with subordinate commarginals, that appear to be finer on LV. Myophoric flange present (LV); adductor scars commarginally ridged; ligament with two grooves.

DIMENSIONS

	Length	Height	Inflation
WAM 97.1 LV	43.2	37.5	16.3
WAM 97.9 RV	44.4	35.8	14.4

REMARKS

The limited available material, consisting of single left and right valves representing different individuals, is, in general features (size, sculpture etc), similar to *Cucullaea adelaidensis* Tate (type series illustrated by Singleton 1932: 304, plate 26, figures 21–24; Ludbrook 1965:102, plate 4, figures 11–15) from 'glauconitic sands, Adelaide [= Kent Town] bore', now assigned to the Blanche Point Formation. Tate's species is also recorded from the Late Eocene Upper Browns Creek Clay of Victoria (Darragh 1985:111). Decalcified moulds of a species of *Cucullaea* (WAM 89.312, WAM 89.313) resembling *C. adelaidensis* and the present species are known from the Pallinup Formation near Mount Barker, Western Australia.

Small discrepancies in shell proportions and some other features are noted in the study material from Merlinleigh. Their significance, if any, remains to be clarified.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Glycymerididae Newton, 1916

Genus *Glycymeris* da Costa, 1778

Glycymeris sp. cf. *G. cainozoica* (Tenison Woods, 1877)

Figures 1B, C

cf. *Cucullaea cainozoica* Tenison Woods, 1877: 111.

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 69.281 (4 valves), 70.1667 (1), 70.1668 (9), 70.1684 (1), 79.2856 (4), 79.2893 (8), 97.2 (5), 97.10 (2); NMV P314115 (7), P314131 (4), P314292 (21), P314294 (9), P314298 (14). Total of 99 single valves.

DESCRIPTION

Of medium size for genus, subcircular, slightly longer than high; umbo orthogyrous, moderately inflated, beak small, slightly elevated, a little anterior of centre, margin rounded anteriorly, subangulate and slightly extended posteriorly. Ligamental area narrow, with 4–14 insertion grooves, the anterior series being the greater. Hinge with two prominent, subhorizontal series with the posterior the larger, median teeth very fine. Hinge encroached upon by expansion of ligamental area. Internal margin strongly crenulate from anterior to posterior extremities. Anterior adductor scar subcircular, bordered by a groove; posterior adductor scar D-shaped, bordered by low myophoral flange; both scars commarginally ridged. External sculpture of numerous very fine radial costellae, arranged in groups of six and seven, the groups offset by slightly deeper, wider grooves; weak intercostal, commarginal striae visible on some specimens.

DIMENSIONS

	Length	Height	Inflation
WAM 70.1667 RV	26.9	25.3	8.9
WAM 70.1668 LV	34.0	33.7	13.5
WAM 79.2856 RV	28.6	26.3	8.2

REMARKS

The study material, which provides the earliest record for the genus from Western Australia, has some resemblance to *Glycymeris cainozoica* (Tenison Woods, 1877) from the Early Miocene Freestone Cove Sandstone of Table Cape, near Wynyard, northern Tasmania and which has been recorded from the Late Eocene to Middle Miocene (Chapman and Singleton 1925: 20–22 plate 1, figures 1–4, plate 4, figures 1–3; Ludbrook 1965: 87; Ludbrook 1967: 65, plate 1, figures 7–12) of southeastern Australia.

The sculpture of Merlinleigh specimens is very similar to that of topotypes of Tenison Woods' species but these latter seem to have more teeth than do specimens of equal size in the present material; Merlinleigh specimens are very slightly trigonal in shape and are more produced on the posterior flank, compared with specimens (including topotypes) of *G. cainozoica* from southeastern Australia, which are more roundly equilateral in outline.

Though not uncommon on weathered outcrops around Merlinleigh, the present species is known only from single valves, often broken and/or much abraded. Comparison of a size-range of well-preserved specimens from Merlinleigh would clarify relations with the Tenison Woods species, which are for the present deferred.

The spelling of the specific name by Tenison Woods as *cainozoica* has been assumed to be a printing error for *cainozoica* by all subsequent authors and in terms of Article 33.3.1 of the *International Code of Zoological Nomenclature* (Fourth edition) the latter spelling is maintained.

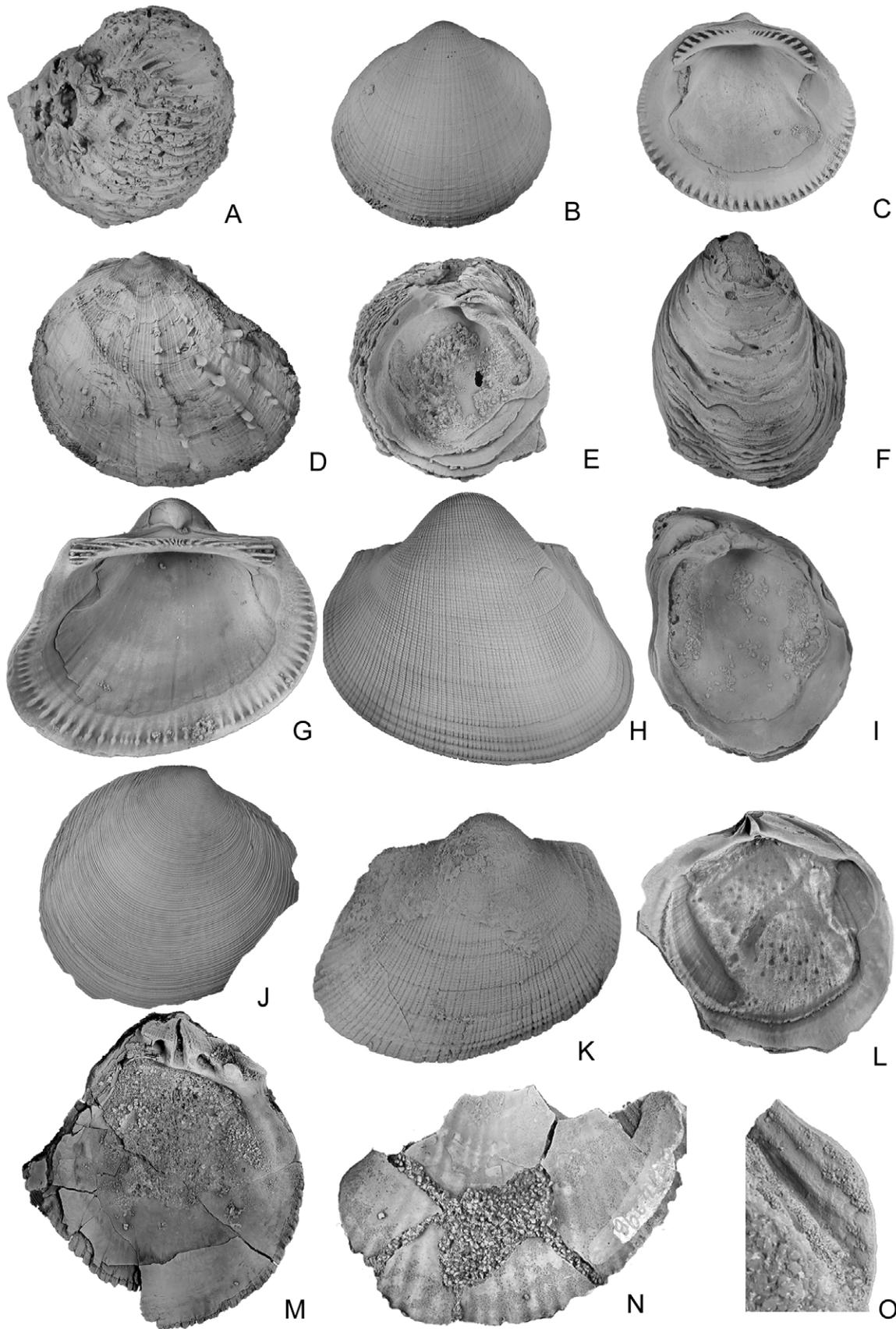


FIGURE 1 A, E, F, I, *Chama* sp.: A, E, WAM 97.3 (x 0.9); F, I, WAM 97.3 (x 0.8); B, C, *Glycymeris* sp. cf. *G. cainozoica* (Tenison Woods, 1877): B, C, WAM 70.1667 (x 1.3); D, M, *Spondylus* sp. cf. *S. gaderopoides* McCoy, 1876: D, NMV P314116 (x 0.9); M, WAM 69.282 (x 0.8); G, H, K, *Cucullaea* sp. cf. *C. adelaidensis* Tate, 1886: G, H, WAM 97.1 (x 1.1); K, WAM 97.9 (x 1.1); J, L, *Miltha* sp.: J, L, NMV P314122 (x 1.0); N, O, Pectinid, genus and species undetermined: N, O, NMV P314298 N (x 1.3), O (x 3.4).

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Spondylidae Gray, 1826**Genus *Spondylus* Linnaeus, 1758*****Spondylus* sp. cf. *S. gaderopoides* McCoy, 1876**

Figures 1D, M

cf. *Spondylus gaderopoides* McCoy, 1876: 27, plate 38, figures 1a–d.

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 69.282 LV. NMV P314116 LV. Total of two specimens.

DESCRIPTION

The specimens to hand are of small size both for the genus and for McCoy's species. LV irregularly convex, rounded anteriorly and extended posteriorly; beak small, projecting slightly above short and weakly alate dorsal margin. Externally (LV) there are ten larger radial costae, bearing prominent, erect scales; the intercostal spaces have five to seven finer costellae and are crossed by coarse, commarginal growth lines. Ligament is internal, in a deep, elongate resilifer, on each side bounded by isodont crura; where preserved, internal margin moderately crenulate; adductor scar obscured.

DIMENSIONS

	Length	Height	Inflation
WAM 69.282 LV	c. 54	63 (est.)	-
NMV P314116 LV	52.6	48	15 (est.)

REMARKS

Since its description by McCoy (1876) from the Oligocene of Bird Rock Bluff, Torquay (Otway Basin), *S. gaderopoides* has been recorded from numerous Middle Eocene to Middle Miocene sources across southern Australia (Tate 1886:121; 1899:275; Lowry 1970: 66, 107, figures 20, 27E, 28; *S. sp. cf. S. gaderopoides* McCoy, Darragh and Kendrick, 1980: 15, figure 4 A, B). Specimens with sculpture very similar to that of specimen NMV P314116 (Figure 1D) occur in the Middle-Upper Tortachilla Limestone of the St Vincent Basin (NMV collection) and, further west, the species occurs in the Wilson Bluff and Abrakurrie Limestones and the Colville Sandstone of the Eucla Basin. Small specimens attributable to this variable species occur in the Eocene Pallinup Formation and Nanarup Limestone of the Bremer Basin (Darragh and Kendrick 1980 and WAM collection). The present specimens extend these confirmed or provisional records northward into the Carnarvon Basin.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Pectinidae Rafinesque, 1815**Genus and species undetermined**

Figures 1N, O

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. NMV P314298, fragmentary single valve.

DESCRIPTION

Little remains of the specimen beyond the internal surface extending to the ventral margin and to either the anterior or posterior margin of a medium sized pectinid. The valve is rather flat with numerous simple, wide radial costae, about as wide as the interspaces. Two very small, visible areas of the external surface show simple radial costae.

DIMENSIONS

The specimen has a length of 43 mm. Estimated original length c. 48 mm.

REMARKS

The simple style of ribbing, so far as can be observed, resembles that of the LV of the *flindersi* form of *Talochlamys eyrei* (Tate, 1886), a widespread species across southern Australia from Aldingan to Longfordian (Beu and Darragh 2000: 101–106, Figures 31B, C, E, G, I; 32G; 33A–E; 34A–G). The identity of this, the sole known pectinid from the Merlinleigh Sandstone, awaits the collection of further, better preserved material.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Ostreidae Rafinesque, 1815**'*Ostrea*' sp.**

Figures 2F, J, L

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. NMV P314124. 1 LV.

DESCRIPTION

A single, small, ostreiform LV, partly overlain on inner and outer surfaces by silicified sandstone. The valve is worn, higher than wide and showing evidence of an elongate, partly infilled attachment area. The resilifer is shallow and triangular; catachomata present on anterior dorsal margin.

DIMENSIONS

	Length	Height	Inflation
NMV P314124	25 (est.)	33	12 (est.)

REMARKS

The specimen is poorly preserved and reliable identification even to generic rank is questionable.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Chamidae Lamarck, 1809**Genus *Chama* Linnaeus, 1758*****Chama* sp.**

Figures 1A, E, F, I

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 70.1686 (3 specimens), 79.2858 (1), 97.3 (2), 97.4 (5). NMV P314126 (5), P314174 (4), P314301 (3). Total of 23 specimens.

DESCRIPTION

Up to normal size for genus, thick and robust, mostly somewhat abraded, irregular in shape, subcircular to dorsoventrally elongate in outline, inequivalve, LV the larger, internally concave with small umbonal attachment area; valves weakly coiled with prosogyrous umbones, bordered on posterior flanks by shallow radial depressions. Sculpture foliaceous, of irregular strength and spacing, on which a weak, close, radial microsculpture is occasionally visible. Hinge of LV with large, horizontal, blade-like, weakly serrate tooth; RV with weak corresponding socket; ligamental area of LV arched. Anterior adductor scar of RV very elongate, much higher than wide; posterior adductor scar of RV wider and shorter than anterior scar, D-shaped. Adductor scars in LV matching in size and shape.

DIMENSIONS

	Length	Height	Inflation
WAM 97.3a RV	38.5	49.3	19.5
WAM 97.3b LV	36.3	49.4	19.0

REMARKS

Chama lamellifera Tenison Woods, 1877, originally described from the Early Miocene of Table Cape, Tasmania, ranges from Late Eocene to Bairnsdalian and is smaller and much more thinly shelled than the study material, with a finer commarginal and radial sculpture. It appears to be confined to the Otway and St Vincent Basins (Ludbrook 1955: 46; Darragh 1985: 111).

In its robust form and shape the Merlinleigh species has some resemblance to *Chama ruderalis* Lamarck, 1819 (Recent Australia and Late Miocene to Pleistocene New Zealand (Beu 2006: 217, figure 16), and to *C. subgigas* d'Orbigny, 1850, Lutetian, Paris Basin.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Lucinidae Fleming, 1828**Genus *Miltha* H. and A. Adams, 1857*****Miltha* sp.**

Figures 1J, L, 3E

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. NMV P314122. Two fragmentary RVs.

DESCRIPTION

Small for genus, subcircular, a little shortened (also broken) anteriorly; umbo prosogyrous, beak short, directed anteriorly; margin convexly rounded behind beak, slightly concave immediately anterior to beak. Sculpture of fine, regular, closely-set commarginal costae, with a prominent radial groove extending from beak to posterior margin of disc. Ligament recessed, set upon a broad hinge plate; cardinals two, bifid. Anterior adductor scar elongate (20 x 5 mm), close to pallial line; posterior adductor scar ovate (11 x 7 mm). Pallial line entire, strongly defined; internal margin, where retained, smooth.

DIMENSIONS

	Length	Height	Inflation
NMV P314122 RV	39.3	37.3	7.3

REMARKS

Australian records of the genus *Miltha* have been confined hitherto to the Miocene and Pliocene of the Eucla, St Vincent, Otway and Gippsland Basins (Ludbrook 1969; Beu and Darragh 2001). The present material extends the geographic and stratigraphic ranges of the genus to the Late Eocene of the Carnarvon Basin.

We here report the recognition of specimens of a species of *Miltha* from the Pliocene-Pleistocene 'Older' Ascot Formation of the Perth Basin (Playford et al. 1975; Kendrick et al. 1991). Being entirely subsurface, all material from the formation has been acquired by percussion drilling and sludge pump extraction from water bores and in the case of *Miltha* specimens, is fragmentary. The best specimens (WAM 94.1029, 98.507, 00.354), of undoubted generic provenance, are from bores in the West Gingin district, c. 70 km N of Perth. Other relevant localities are Canning Vale, Pinjar and Thornlie, all located in the eastern part of the metropolitan Perth Basin. Specific determination of this Ascot Formation material is deferred. It appears to be distinct from *M. hamptonensis* Ludbrook from the Roe Calcarenite.

In New Zealand, *Miltha* is recorded from the Early Paleocene (Wangaloan) to Late Pliocene (Waipipian) (Beu and Maxwell 1990).

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

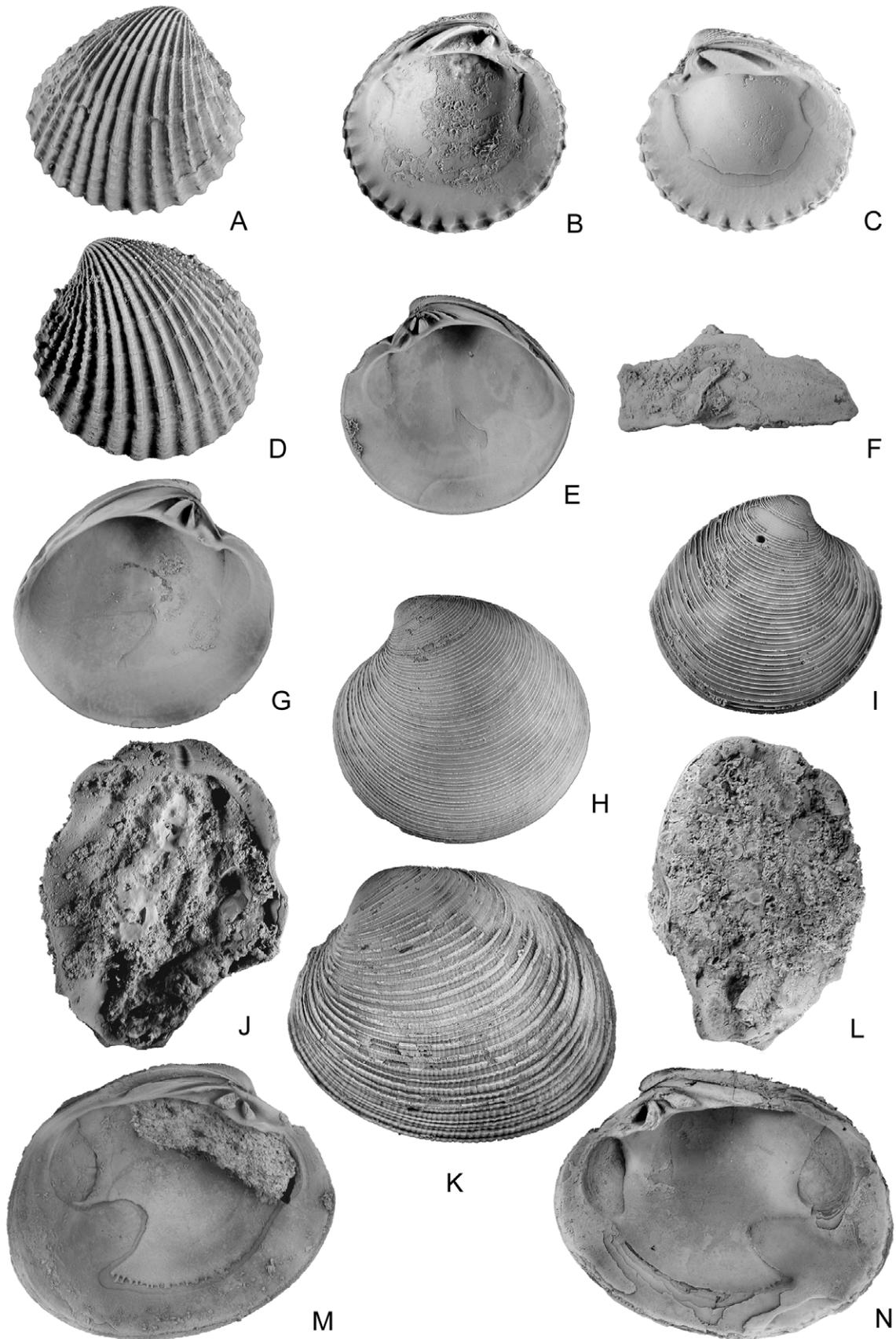


FIGURE 2 A, B, C, D, *Venericardia capricornia* sp. nov.: A, C, WAM 79.2857b (x 2.1) paratype; B, D, WAM 78.2857a (x 2.1) holotype; E, G, H, I, *Dosinia (Kereia) numerosissima* sp. nov.: E, I, WAM 97.6d (x 1.2) paratype; G, H, WAM 97.6a (x 1.2) holotype; F, J, L, '*Ostrea*' sp.: F, J, L, NMV P314124, F (x 1.2), J, L (x 1.2); K, M, N, *Periglypta weegeeree* sp. nov.: K, M, WAM 79.2860b (x 0.8) holotype; N, WAM 79.2889 (x 0.8) paratype.

Family Carditidae Fleming, 1828**Genus *Venericardia* Lamarck, 1801*****Venericardia capricornia* sp. nov.**

Figures 2A–D, 3C, D

MATERIAL EXAMINED*Holotype*

Australia: Western Australia: WAM 79.2857a LV, from Kennedy Range. 1.5 km E of abandoned Merlinleigh homestead (type section of Merlinleigh Sandstone). Mount Sandiman LU 175087.

Paratypes

WAM 79.2857b–f 2LVs 3RVs. NMV P315512 RV.

Other material

WAM 70.1669 (2 specimens), 70.1685 (6), 97.4 (5), NMV P314112 (6), P314128 (9), P314293 (11), P314296 (3), P314305 (11). Total of 61 single valves.

DESCRIPTION

Up to medium size for genus, usually (present material) less so, robust, roundly subquadrate in outline, slightly higher than long; umbones prosogyrous, beaks incurved; with 22–26 strong, sharp, radial costae, which expand relative to the interspaces with growth; radials crossed by commarginal growth striae, producing weak scales. Ligament submarginal, narrow; lunule small, deeply set. Anterior adductor scar narrow, elongate, exceeding in length the posterior scar, which is ovate in profile. Pallial line between scars prominent. Internal margins strongly crenulate, corresponding to the costal interspaces.

Hinge with cardinals only, three in each valve; LV with long, thin posterior tooth with narrow groove along crest, a small triangular central tooth and a weak or obsolete anterior cardinal; RV with reduced, triangular cardinal, prominent, strong, elongate, triangular central cardinal and a long, thin, posterior cardinal. Laterals obsolete.

DIMENSIONS

	Length	Height	Inflation	Costae
WAM 79.2857a LV, holotype	17.5	18.0	6.7	25
WAM 79.2857b RV, paratype	16.1	16.1	6.4	24
WAM 79.2857c LV, paratype	16.9	18.5	7.1	22
WAM 79.2857d LV, paratype	17.7	17.1	6.3	21+
WAM 79.2857e RV, paratype	17.3	17.5	7.1	22
WAM 79.2857f RV, paratype	17.0	17.9	7.0	22
NMV P315512 RV, paratype	33.3	31.2	11.6	26

REMARKS

The species lacks any known congener in the Australasian Tertiary and its affinities would appear to lie in all probability with the carditids of the tropical — Tethyan Paleogene, such as *Venericardia imbricata* (Gmelin), the type species of the genus, from the

Lutetian of the Paris Basin. The hinge of the present species is very similar to that of *V. imbricata*.

The genus *Venericardia* has been utilized in the past to accommodate small carditids from the Tertiary of southern Australia and New Zealand, such as '*Cardita*' *latissima* Tate (Darragh and Kendrick 1980, 2000 for synonymy). This and other such taxa, which have much more prosogyrous umbones and more prominent spines and scales, seem better located generically as *Glyptoactis* (*Fasciculocardia*) (Darragh and Kendrick 2008: 226).

The specific name recognizes the proximity of the Kennedy Range to the Tropic of Capricorn.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Veneridae Rafinesque, 1815**Genus *Periglypta* Jukes-Brown, 1914*****Periglypta weegeeree* sp. nov.**

Figures 2K, M–N, 3F, G

MATERIAL EXAMINED*Holotype*

Australia: Western Australia: WAM 79.2860b LV, from Kennedy Range, Western Australia. West side of erosion scarp 1.5 km E of old Merlinleigh homestead and c. 200m N of type section of Merlinleigh Sandstone. Map ref. Kennedy Range 312974.

Paratypes

WAM 79.2860a RV; 79.2889 RV.

Other material

WAM 70.672, fragmentary LV; 70.1688, RV. NMV P314123, 3 fragments; P314120, 1 fragment; P314304, 1 fragment. Total of 4 single valves and 6 (single) fragments.

DESCRIPTION

Up to normal size for genus, robust, roundly subquadrate, longer than high, strongly prosogyrous, beak incurved; lunule shallow, defined by an incised border; escutcheon more evident on LV where there is a distinct radial groove; sculpture of prominent, close, commarginal lamellae, slightly recurved dorsally and crenulated by numerous, fine, close-set radial costellae; internal margin of valves smooth. Pallial sinus wide, rounded. Adductor scars ovate, higher than long.

DIMENSIONS

	Length	Height	Inflation
WAM 79.2860b LV holotype	62.5	52.0	19.2
WAM 79.2860a RV paratype	55.5	50.0	18.0
WAM 79.2889 RV paratype	63.0	54.5	19.5

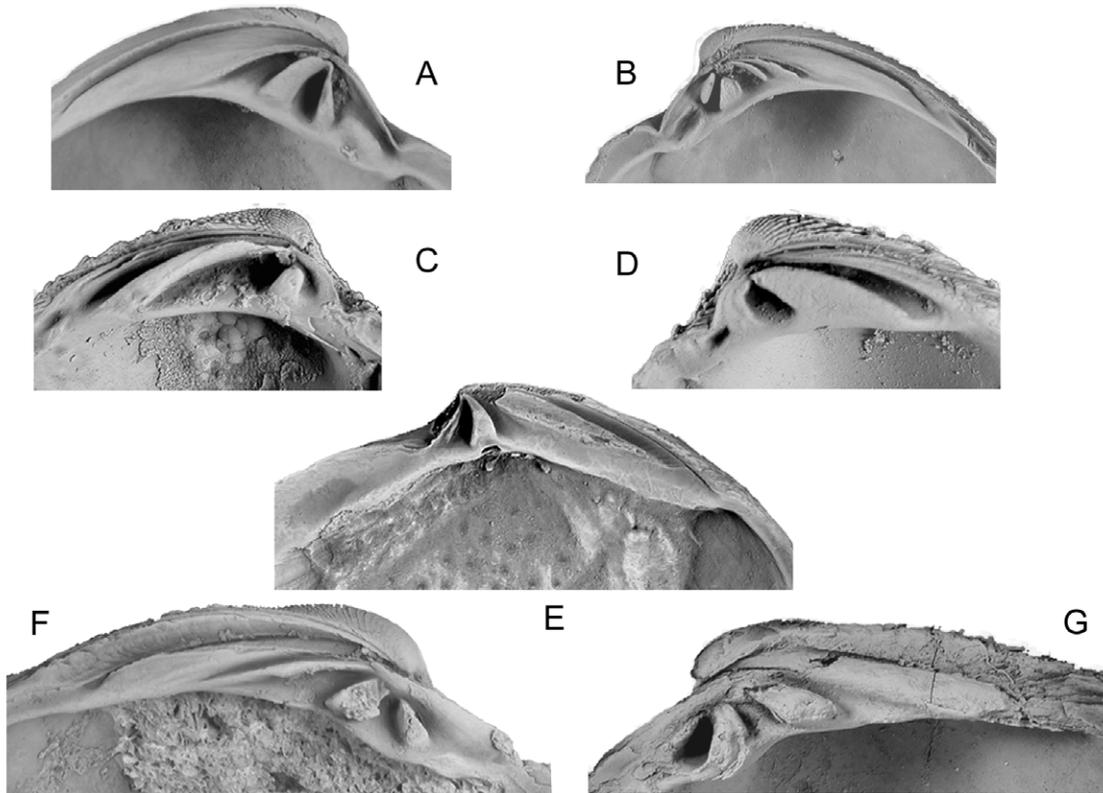


FIGURE 3 A, B, *Dosinia (Kereia) numerosissima*, sp. nov.: A, WAM 97.6a (x 2.7) holotype; B, WAM 97.6b (x 2.7) paratype; C, D, *Venericardia capricornia* sp. nov.: C, WAM 79.2857a (x 3.6) holotype; D, WAM 79.2857b (x 3.6) paratype; E, *Miltha* sp.: E, NMV P314122 (x 2.3); F, G, *Periglypta weegeeree*, sp. nov.: F, WAM 79.2860b (x 1.8) holotype; G, WAM 79.2889 (x 1.8) paratype.

REMARKS

This is the first record for the genus in the Tertiary of Australia, though species are not uncommon in the living fauna of northern Australia. Records of fossil species are not common, so the stratigraphic distribution of the genus is poorly known. *Periglypta miocenica* (Michelotti, 1847) recorded from the Early to Middle Miocene of Europe and North Africa (Freneix et al. 1987 and references therein) may be the oldest occurrence for the genus hitherto. The present species is slightly more elongate and less subquadrate in comparison with the extant *Periglypta puerpera* (Linnaeus, 1771) from tropical waters in northern Australia.

A related and superficially similar genus, *Proxichione* Iredale, 1929, occurs in the Tertiary of southern Australia from the Late Oligocene to Recent (Darragh 2010). Species of *Proxichione* have a large, angular, pallial sinus and lack the prominent groove present on the escutcheon of species of *Periglypta*.

The species name is derived from an expression of the Yamatji (indigenous) language of the district of origin, which may be translated as 'weegeeree' or 'long time ago'.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Genus *Dosinia* Scopoli, 1777

Subgenus *Kereia* Marwick, 1927

Dosinia (Kereia) numerosissima sp. nov.

Figures 2E, G-I, 3A, B

MATERIAL EXAMINED

Holotype

Australia: Western Australia: WAM 97.6a, LV, from Kennedy Range, W.A. Eroded lower slope of mesa 1.6 km ESE of site of abandoned Merlinleigh homestead (type section of Merlinleigh Sandstone). Mount Sandiman LU 176087. Collected K. Ayyasami and G.W. Kendrick, 8.ix.1996.

Paratypes

WAM 97.6 b-l, 5LVs, 6RVs; P315513 LV, P31554 RV. From the type locality.

Other material

WAM 69.285 (2), 70.1670 (2), 70.1671 (see Remarks), 70.1687 (5), 79.2861 (4 + fragments), 97.7 (1), 97.11 (1). NMV P314114 (27), P314132 (17), P314307 (9), P314134 (26), P314295 (5), P314295 (5), P314290 (1). Total of 121 single valves.

DESCRIPTION

Up to median size for genus and subgenus,

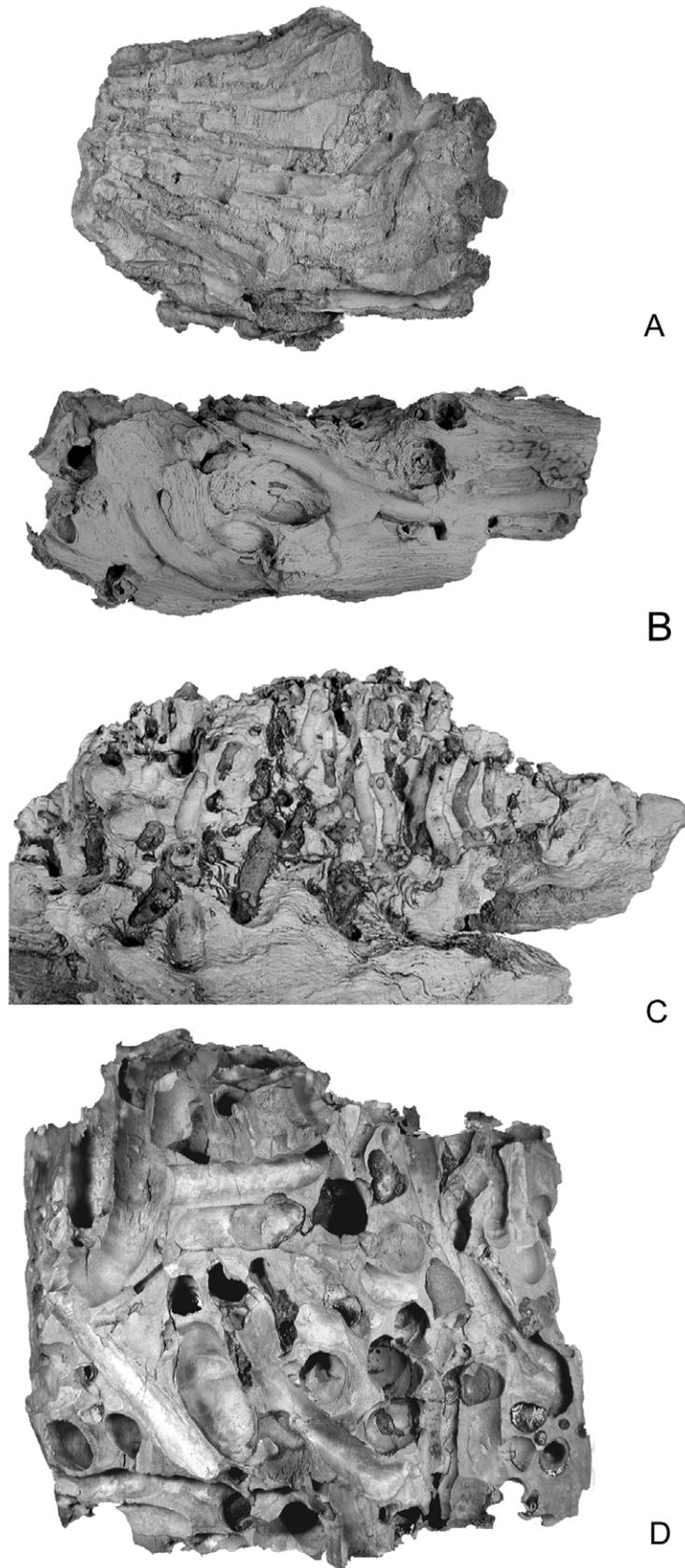


FIGURE 4 A, B, C, D, Teredinid genus and species undetermined: A, WAM P79.51b (x 0.9); B, WAM P79.51a (x 0.8); C, WAM P69.6c (x 1.3); D, NMV P315054 (x 0.6).

subcircular, about as high as long, with pronounced, somewhat inflated (with growth), prosogyrous umbones and incurved beaks; lunule small, recessed; escutcheon wide, occupying most of dorsal margin. Sculpture of numerous well developed, thin, commarginal lamellae, increasing in height with growth. Hinge plate short, robust, ligament sunken, occupying most of hinge plate. Hinge of LV with short A11, narrow 2a, robust 2b and extended, narrow 4b; RV with short A1, short narrow 3a, robust 1 and bifid 3b. Pallial sinus small, often obscured by sediment. Internal margin smooth.

DIMENSIONS

	Length	Height	Inflation
WAM 97.6a LV, holotype	33.3	32.9	10.6
WAM 97.6d RV, paratype	30.2	29.4	9.4
WAM 97.6f RV, paratype	32.9	32.6	9.6
WAM 97.6g LV, paratype	28.5	28.2	9.3
WAM 97.6k RV, paratype	35.5	35.7	11.2
NMV P315513 LV, paratype	31.3	29.3	9.0
NMV P315514 RV, paratype	34.5	34.2	10.5

REMARKS

The genus and subgenus are known from most of the southern Australian Tertiary strata, beginning with *Dosinia (Kereia) imparistriata* Tate, 1887 from the Late Eocene of South Australia (Tate 1887: 162, plate 14, figure 11). The sculpture of Tate's species features irregularly spaced, incised lines, not the regularly spaced lamellae of the Merlinleigh species, and the two taxa appear to be specifically distinct. Compared with *D. (K.) densilineata* Pritchard, 1896 from the Late Oligocene — Early Miocene of Victoria and Tasmania, *Dosinia (Kereia) numerosissima* sp. nov. is higher than long and less prosogyrous; the hinge is higher and more triangular and the sculpture, though similar, is a little coarser. The hinge of the Merlinleigh species is very similar to that of *D. (K.) johnstoni* Tate, 1887 from the Late Miocene-Early Pliocene of Victoria but the former has a coarser sculpture and more robust shell.

No congener of the present species is as yet known from the Middle/Late Eocene of the Bremer and Eucla Basins.

The entire sample of the present species comprises single valves, attesting to substantial post-mortem reworking of what was very probably an infaunal sediment dweller. A single exception to this circumstance is revealed by specimen WAM 70.1671, from the type section of the formation, comprising part of the conch of an *Aturia* measuring about 12 x 6 x 4 cm, the sedimentary infilling of which contains abundant, juvenile, paired valves of this venerid species, all evidently representing a single generational cohort. A randomly chosen specimen from these juveniles measured 4.8 x 4.6 x 2.2 mm.

The study material shows very limited evidence of predation: WAM 97.7, a fragmentary LV, shows a bevelled naticiform borehole on the umbo. Paratype 97.6b shows a small unsuccessful non-naticiform borehole, likewise located on the umbo.

The specific name refers to the abundance of the species in the study material.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Teredinidae Rafinesque, 1815

Teredinid, genus and species undetermined

Figures 4A–D

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM G10023 (2 specimens), P.69.6 (2), 70.1677 (1), P79.51 (2), P.97.6 (1); NMV P315054 (2). Total of 10 pieces of fossil wood with probable teredine tube infillings.

DESCRIPTION

See Remarks.

REMARKS

Fossil wood and diverse other remains of terrestrial vegetation (McNamara and Scott 1983) occur not infrequently in weathered residues from the Merlinleigh Sandstone, on and below erosion slopes of the Kennedy Range. Occasional specimens of such wood feature boreholes of teredine form, sometimes in abundance, subcircular in cross-section and infilled with silica and with borehole diameters ranging from about 1 to 13 mm. The smaller tubes (c. 2 mm) usually retain longitudinal septa but, in the study material, appear to lack other diagnostic features. Thus the holes and their siliceous infilling cannot be assigned to any taxon beyond the familial level.

DISTRIBUTION

Merlinleigh Sandstone. Late Eocene.

Class Gastropoda Cuvier, 1797

Family Fissurellidae Fleming, 1822

Genus *Tugali* Gray in Dieffenbach, 1843

Tugali? sp.

Figures 5G–I

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 70.1689 (1 specimen); NMV P314118 (1), P314125 (2 + fragment). Total of four shells and fragment.

DESCRIPTION

Shell patelliform, oval, longer than wide; apex moderately raised, cap-like, at one-third of length from posterior margin; sculpture of 57–65 strong radial costae, about as wide as interspaces and crossed by

irregular growth ridges; margin smooth. Muscle scar usually conspicuous, horse-shoe shaped and opening anteriorly.

DIMENSIONS

	Length	Width	Height	Ribs
WAM 70.1689	31.9	23.0	10.8	57
NMV P314125	30.4	25.2	11.1	45
NMV P314118	34.1	23.5	(obscured by matrix)	c. 55

REMARKS

The apical areas and margins of all specimens to hand are either abraded or concealed by sediment so that the description must remain incomplete. No specimen shows an anterior notch, as has been noted for *Tugali cicatricosa* A. Adams recorded by Ludbrook (1956: 9–10) from the Middle Miocene Dry Creek Sands and Recent, Port Lincoln, South Australia. A high rib count and a greater width relative to length distinguish the present species from congeners cited by Ludbrook (1956) from the St Vincent Basin.

The shells are not unlike those of *Clypidina* but no internal groove has been observed. Subject to re-evaluation based upon better preserved material, this would appear to be the earliest record for *Tugali* in the Australasian Region. In New Zealand, the genus is recorded first in the Waitakian (Early Miocene) (Beu and Maxwell 1990).

Small patelliform gastropods from the Albany district (Pallinup Formation) and Quagering Beds of the Northcliffe area attributed respectively to *Cellana* and *Nacella* (?) *jutsoni* (Chapman and Crespín, 1934) (Darragh and Kendrick 2000: 30, figure 4 L, N) are not unlike the present species though possibly with fewer ribs. Clarification of their relationship requires access to further, better preserved material.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Turbinidae Rafinesque, 1815

Genus *Turbo* Linnaeus, 1758

Subgenus *Euninella* Cotton, 1939

Turbo (*Euninella*) sp. cf. *T. (E.) hamiltonensis* Harris, 1897

Figures 5A–F, L

cf. *Turbo hamiltonensis* Harris, 1897: 274, plate 8, figures 3a–c.

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. WAM 79.2862 (1 abraded specimen, NMV P314119 (1 broken specimen, 1 operculum), P314127 (1 broken operculum),

P314129 (2 columellar fragments). Total of two incomplete shells, one complete operculum and fragments.

DESCRIPTION

Shell robustly turbinata with about five convexly-graduate whorls; aperture continuous, expanded over anomphalous columella, internally grooved. Sculpture of spire spirally lirata, the posterior lirae strongly beaded with some fine lirae against the anterior suture; last whorl with well developed beading on anterior lirae. Operculum spiral, oval, flat internally, smooth and convex externally.

DIMENSIONS

The aperture of WAM 79.2862 has a transverse diameter of c. 29 mm and a height of c. 24 mm. The operculum of NMV P314119 measures 15.6 x 12.8 x 4.8 mm.

REMARKS

The limited material to hand is poorly preserved and inadequate for specific determination but seems to agree reasonably well with *Euninella* Cotton (type species *Turbo gruneri* Philippi, 1846), considered by Williams (2007, table 1) to be a 'probably valid' subgenus of *Turbo* Linnaeus, 1758. Compared with specimens of *T. (E.) hamiltonensis* Harris, 1897 from the Balcombian Muddy Creek Formation of the Otway Basin, the Merlinleigh species differs in its more rounded whorls, best shown on WAM 79.2862, and by the traces of beading on the basal lirae.

Opercula and a fragmentary shell, comparable to the present material, have been recovered from the Pallinup Formation, Bremer Basin (Darragh and Kendrick 2000: 39, 40, figures 5L–M, O). Clarification of the identity of this turbinid material awaits the collection of better preserved material.

In a cladistic comparison of turbinid generic lineages, Williams (2007, figure 4) suggests a Miocene origin for *Euninella* within her Tropical Clade 5 component, all derived from the genus *Turbo*. Subject to confirmation, these turbinid records from Western Australia may extend the stratigraphic range of *Euninella* back from Miocene to Late Eocene.

OCCURRENCE

Merlinleigh Sandstone. Pallinup Formation? Late Eocene.

Family Turbinellidae Swainson, 1835

Genus *Vasum* Röding, 1798

Vasum sp.

Figure 5M

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. NMV P314300. One specimen (fragment).

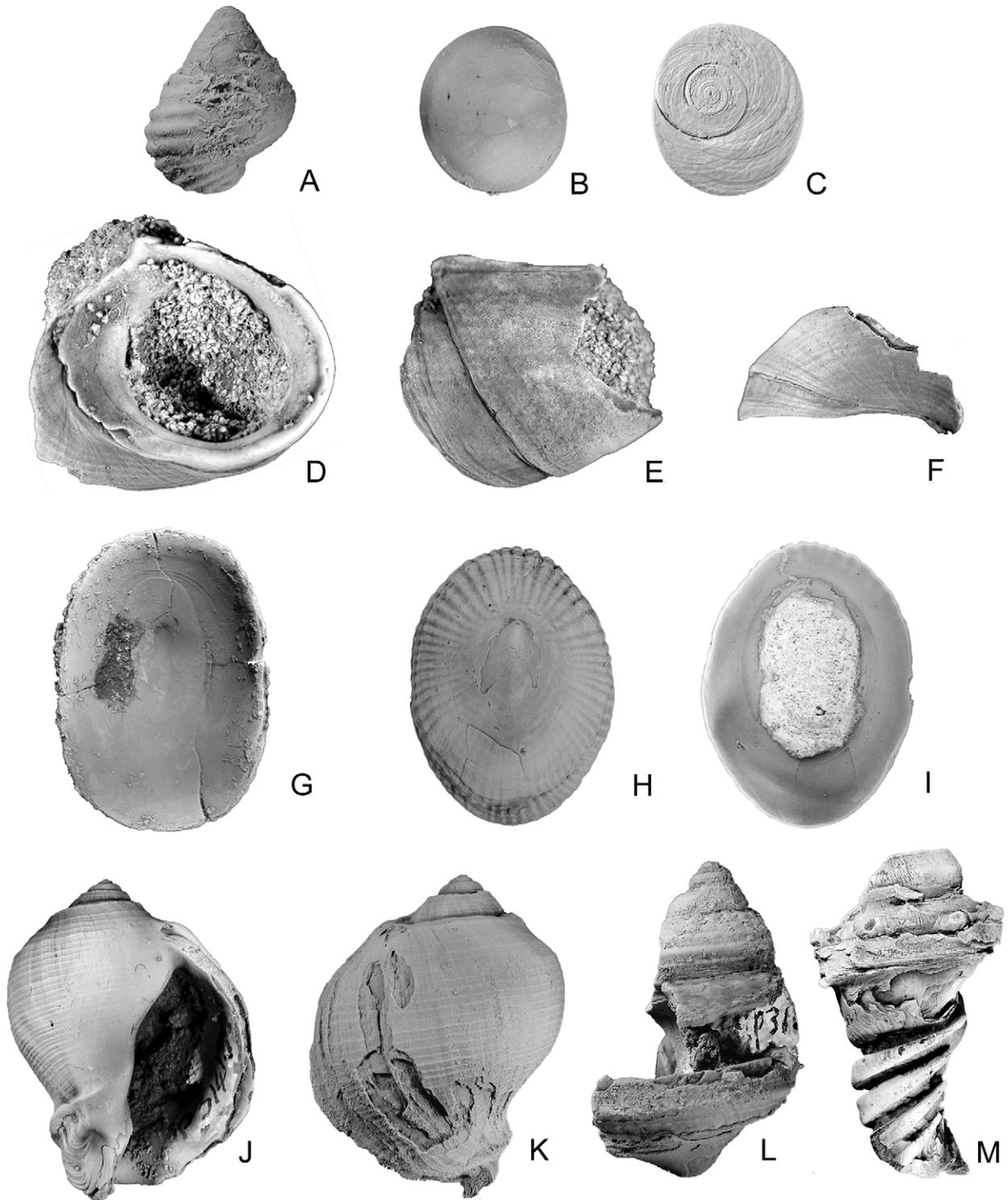


FIGURE 5 A, B, C, D, E, F, L, *Turbo (Euninella)* sp. cf. *T. (E.) hamiltonensis* Harris, 1897: A, NMV P314308 (x 4.5); B, C, NMV P314119 (x 1.8); D, E, F, WAM 79.2862 (x 1.2); L, NMV P314119 (x 1.9); G, H, I, *Tugali?* sp.: G, NMV P314118 (x 1.2); H, I, WAM 70.1689 (x 1.3); J, K, *Zelandiella?* sp.: J, K, NMV P314130 (x 1.9); M, *Vasum* sp.: M, NMV P314300 (x 0.9).

DESCRIPTION

The specimen is part of a robust, biconic/fusiform shell with strongly spinose, spaced tubercles on the shoulder of the last whorl; a few thin spiral lirae can be seen below the suture. Four very strong columellar plaits are flattened at the top and extend to the upper turns of the columella.

DIMENSIONS

In its fragmentary condition, the specimen has a height of 55 mm, width 31.5 mm. When intact, it would have been the largest gastropod known to date from the Merlinleigh Sandstone.

REMARKS

Meaningful comparison with other taxa is not possible but what little remains of the specimen bears some resemblance in shape to *Vasum humerosum* Vaughan, 1896, Late Eocene, N. America (Vokes 1966: 4, plate 1, figure 1). This is the first record of the genus from the Eocene of Australia. It is a characteristic tropical genus, being represented in the fauna of northern Australian seas, but with a single relative – *Vasum (Altivasum) flindersi* (Verco) – living in southern and south western waters (Wilson 1994).

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Family Buccinidae Rafinesque, 1815**Genus *Zelandiella* Finlay, 1926*****Zelandiella?* sp.**

Figures 5J–K

MATERIAL EXAMINED

Australia: Western Australia: Kennedy Range. NMV P314130 (1). P314291 is a badly worn and decorticated specimen that might be of this genus.

DESCRIPTION

Shell of four spire whorls and one smooth, flattened protoconch whorl, the latter coiled with the axis of the shell. Spire whorls low, rapidly expanding, each succeeding whorl almost enveloping the previous; five lirae visible on the penultimate whorl and about 40 fine lirae on last whorl; whorls slightly flattened at posterior suture, latter becoming channelled with growth. Outer lip slightly sinuous posteriorly; columella twisted, short with deeply-notched anterior canal; siphonal fasciole well developed, bounded posteriorly by a prominent, sharp cord.

DIMENSIONS

	Height	Max. diameter	No. whorls
NMV P314130	26.7	19.7	5

REMARKS

This species is assigned to the genus *Zelandiella* with some doubt, as it has little resemblance to most of the taxa included in that genus, which have high spires and coarse longitudinal costae or tubercles. An exception is *Z. fatua* Finlay, 1926 (Middle Miocene, New Zealand, Beu and Maxwell, 1990, Plate 30, figures c, d), which the Merlinleigh species does resemble in size, in its low spire, presence of spiral lirae and lack of costae. The Merlinleigh species differs from *Z. fatua* by having a much lower spire and much finer spiral lirae. If correctly assigned, the geographic range of the genus is extended to Australia and the stratigraphic range to Late Eocene. In New Zealand the genus ranges from Early Oligocene to Early Pliocene.

OCCURRENCE

Merlinleigh Sandstone. Late Eocene.

Class Cephalopoda Cuvier, 1797**Family Aturiidae Chapman, 1857****Genus *Aturia* Bronn, 1838*****Aturia clarkei* Teichert, 1944**

Figures 6A–J

Aturia cf. *A. ziczac* (Sowerby) Miller and Crespin, 1939: 80, plate 14, figure 1; text figures 1, 2.

Aturia clarkei Teichert, 1944: 79, plate 15, figures 1–4; plate 16, figures 1, 2: text figure 2; Glaessner, 1955: 354, plate 34, figure 2, plate 35, fig 3, text figures 1–3; Darragh and Kendrick, 2008: 220, figures 1.18, 1.19.

Aturia clarkei attenuata Teichert and Cotton, 1949: 255, plate 21.

Aturia sp. Haig and Mory, 2003, figures 3Q–R.

MATERIAL EXAMINED

Holotype

Australia: Western Australia: Kennedy Range. UWA 21406 from east side of Kennedy Range, on track, 1.3 miles (2.1 km) north of breakaway leading up to Merlinleigh Homestead.

Paratypes

UWA 21407a–e. From type locality (a–b not seen 16 September 2009).

Other material

(Merlinleigh Sandstone only). WAM G1008 (2 specimens), 64.35 (1 specimen), 66.1007–9 (3 specimens), 66.1011 (1 specimen), 69.277 (4 specimens) 69.287 (1 specimen) 69.288 (1 specimen associated with wood), 69.289 (4 specimens, 69.701–2 (2 specimens), 70.913 (5), 70.1378 (1 specimen), 70.1674 (1 specimen) 70.1676 (1 specimen), 70.1690–1 (2 specimens), 70.1693 (1 specimen) 78.639–42 (8 specimens), 79.286 (1 specimen), 79.2864–5 (2 specimens), 79.2894–6 (3

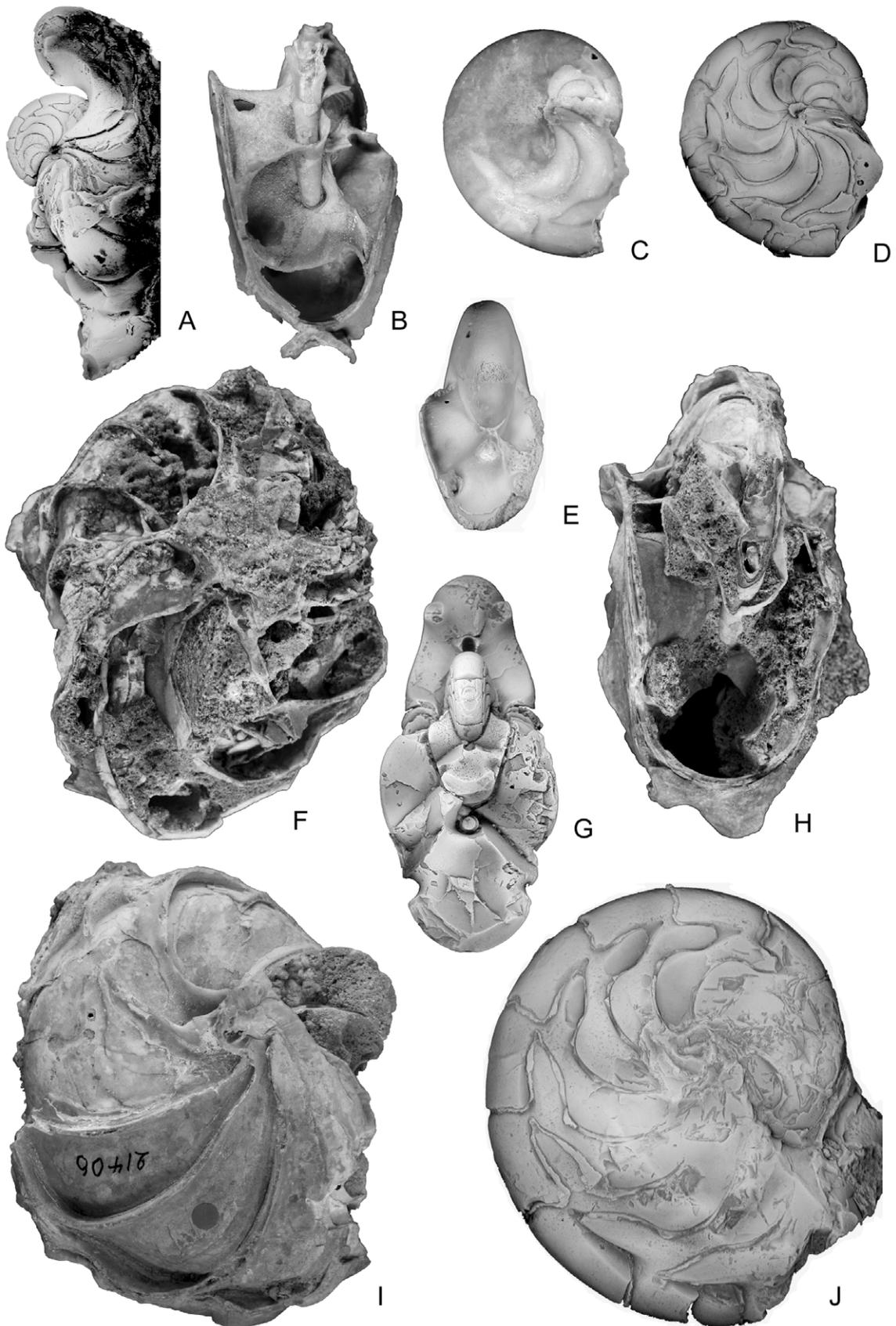


FIGURE 6 A, B, C, D, E, F, G, H, I, J, *Aturia clarkei* Teichert, 1944: A, G, WAM 64.35 (x 0.8); B, WAM 79.2866g (x 0.8); C, E, WAM 70.1691 (x 0.8); D, WAM 78.639a (x 0.8); F, H, I, UWA 21406 (x 0.8) holotype ; J, WAM 78.643 (x 0.8).

specimens), 79.2900 (1 specimen) 79.2902 (1 specimen), 83.2449 (3 specimens), 87.474 (1 specimen), 88.849 (1 specimen), 97.1 (1 specimen). NMV P314306 (4 specimens), (P314894 (1 specimen), P314895 (1), P314896 (2 specimens), P315053 (3 specimens).

DESCRIPTION

The study material, including the type series, is on the whole poorly preserved and fragmentary, revealing little more than a cursory indication of the salient features of the species. When intact, the shell would have attained a diameter of up to c. 300 mm, being smooth, involute, compressed and broadly rounded across the venter; umbilicus closed; about 10–11 camerae per volution, frequently exposed by attrition of the outer shell layer. Suture almost flat across venter with a narrow, asymmetrical, pointed lateral lobe, a broadly rounded, asymmetrical lateral saddle and a wide, shallow umbilical lobe.

The holotype is a fragmentary internal replication, bordered by the siphuncle and devoid of any portion of the outer surface or aperture. The maximum measurable diameter of this specimen is 100 mm, consistent with a diameter of c. 300 mm or more) when intact.

Of the paratype series UWA 21407 a–e, specimens a and b were not seen on 16 September 2009; specimen c is noteworthy for the retention of part of the external shell surface near the aperture (right side), something of a rarity in the study material as a whole.

DIMENSIONS

	Max. diameter	Width
UWA 21406, holotype	100	42
WAM 70.1691	44.0	23.5
WAM 78.639a	45.5	22.0
WAM 64.35	72.0	31.5
WAM 78.643	84.0	31.0
WAM 78.2886g	-	38.0

REMARKS

Aturia had a virtually cosmopolitan distribution in the Eocene. In explaining this, Chirat (2000) has argued that, because of their unique siphuncular morphology, the shells, after death, probably drifted for very long distances, so that the number of true bio-species compared with recorded taxa is probably quite small. Many 'species' appear to have been erected for reasons of geographical separation or dispersal and from minor morphological differences or based on few specimens, poorly preserved. We have noted at least 22 names that have been proposed for Eocene 'species' of *Aturia* (Kummel 1956) and have priority over *A. clarkei* and it seems highly probably that Teichert's name will prove to be a junior subjective synonym of one of these.

The earliest available names for Eocene species appear to be *Aturia ziczac* (J. Sowerby, 1812) and *A. alabamensis* (Morton, 1834). Judging from illustrations, *A. clarkei* appears to be very close in morphology to both of them

but, without being able to compare good specimens, we are unable to state at present with any certainty whether the latter is a synonym of either of the former, if indeed the former represent one or two separate species or whether *A. clarkei* is a synonym of any of the other recorded taxa. In view of this uncertainty, we retain Teichert's name for the time being. As Chirat (2000) has pointed out, the genus is in need of revision, something we are not in a position to undertake at present.

In the Middle to Late Eocene of Western Australia, specimens of *A. clarkei* are not uncommon, usually as small or broken specimens or as siliceous internal casts. This fact, together with the character of the Merlinleigh Sandstone, is in accord with Chirat's (2000) comments that many occurrences (of *Aturia*) represent shoreline strandings – the shells having been transported by ocean currents over greater or lesser distances from their original habitats. All but a very few Merlinleigh specimens show substantial shell fragmentation, consistent with a high degree of predation prior to stranding and burial.

OCCURRENCE

Australia only. Otway Basin: Clifton Formation (reworked). St Vincent Basin: Tortachilla Limestone. Bremer Basin: Pallinup Formation. Southern Carnarvon Basin: Merlinleigh Sandstone (type); unnamed sandstone (Kalbarri). Middle-Late Eocene.

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