The brachiopod fauna of the Plio-Pleistocene Ascot Formation, Perth Basin, Western Australia

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Abstract – Three new species of terebratulide brachiopods *Cancellothyris ascotensis* sp. nov., *Megerlina irenae* sp. nov. and *Megerlina dorothyae* sp. nov. are described from the Ascot Formation, Perth Basin, Western Australia. The fauna also includes the previously described terebratulid species *Anakinetica recta* Richardson, 1991 and *Anatida gnangarensis* Richardson, 1991. The loop of *A. gnangarensis* is described for the first time. Three further species, *Austrothyris grandis* (Tenison-Woods 1865), *Magellania flavescens* (Lamarck 1819) and an indeterminate are also described. The presence of these species in the southwest of Western Australia during the Plio-Pleistocene provides further evidence of the importance of the Leeuwin Current to the distribution of marine invertebrates.

INTRODUCTION

Sediments collected from various bore holes in the Ascot Formation along the coastal plain west of the Darling Scarp in the Perth Basin, Western Australia (Figure 1) have yielded a relatively sparce brachiopod fauna. Richardson (1991) has described two species, *Anatida gnangarensis* Richardson, 1991 and *Anakinetica recta* Richardson, 1991 from this fauna. These are redescribed herein. *Austrothyris grandis* (Tenison-Woods 1865) and *Magellania flavescens* (Lamarck 1819) are recorded for the first time from the Formation. Three new species, *Cancellothyris ascotensis* sp. nov., *Megerlina irenae* sp. nov. and *M. dorothyae* sp. nov. are described. A species of indeterminate genus is also described. This is the earliest record of the genus *Megerlina* and of *Magellania flavescens* from Australia.

Geology

The Ascot Formation consists of 'fine to very coarse, grey to yellow-brown quartz sands with subordinate carbonate and less frequently quartzose calcarenites' (Kendrick *et al*. 1991). These generally fine upwards and contain well preserved marine invertebrates including the brachiopods described below. Some bones, teeth and phosphatic nodules have been reworked from the underlying Osborne Formation (Kendrick *et al*. 1991). The lateral extent of the formation in any direction is unknown.

Kendrick *et al*. (1991) interpreted the formation as 'representing a sequence of depositional events along the neritic inner shelf, associated with a progressively prograding shoreline.' The age of the Formation decreases from east (Late Pliocene) to the west (Early Pleistocene) (Figure 2). The Ascot Formation overlies the Albian-Cenomanian Osborne Formation unconformably and is separated by minor transitional units (Balme 1980) from the overlying Bassendean Sands and Guildford Formation (Low 1971; Playford and Low 1972). There was a major regression at the end of the Ascot Formation deposition (Kendrick *et al*. 1991).

The two members of the Ascot Formation can be separated biostratigraphically by the molluscs present. The older eastwards Ascot assemblage contains the arcoid bivalve *Cucullaea* and the janthinid gastropod *Hartungia* confirming the age as Pliocene (Kendrick *et al*. 1991). Neither of these two genera are found in the younger westwards member of the formation and it is regarded as Early Pleistocene (Kendrick *et al*. 1991). Planktonic foraminifera from the older member are regarded as Pliocene in age (Mallett 1982). Mallett (1982) also suggested that the temperature during deposition was similar ("neither significantly colder, at least as warm") to that presently experienced along the south western margin of Australia. The presence of phosphatic nodules, quartz sand and the lack of carbonate deposits suggests that the temperature may actually have been much cooler than at present (McNamara, personal communication). The brachiopods herein described occur in both the Pliocene and Pleistocene deposits with some overlap as mentioned below.

METHODS AND MATERIAL

The specimens examined have been primarily
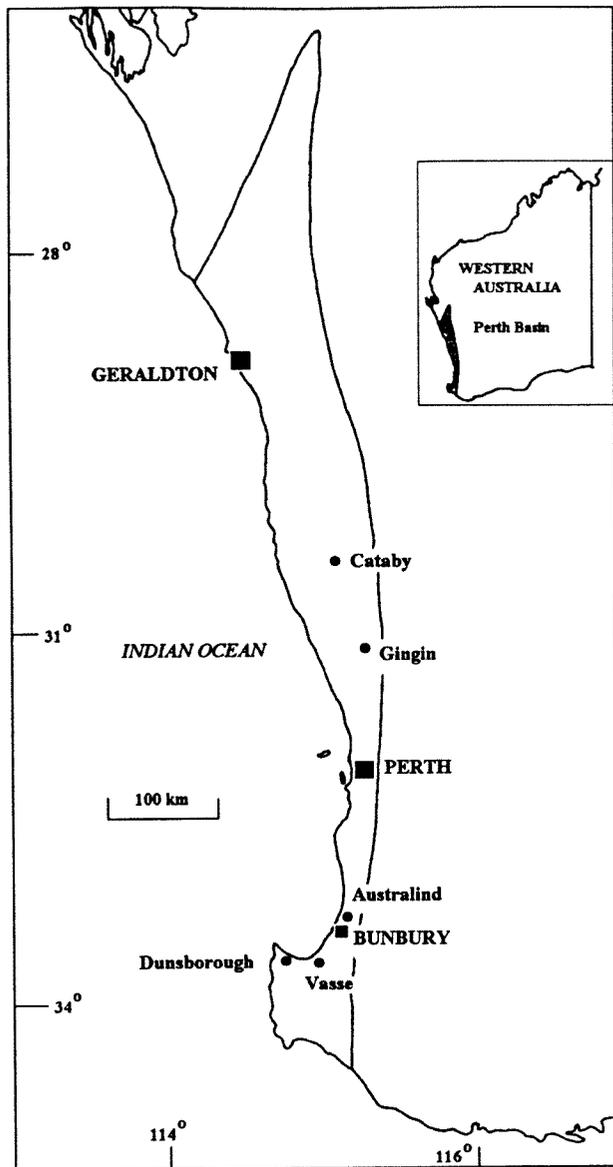
Figure 1 Extent of the Ascot Formation in the Perth Basin, Western Australia.

collected by G. W. Kendrick, J. G. Hastings, V. A. Ryland and a number of others including J. Neil, F. Page, E. O'Driscoll, F. Iley, B. R. Wilson, L. J. Gray and A. D. Allen and K. Morgan from the Geological Survey of Western Australia. The specimens are housed in the Western Australian Natural History Museum Collection. The specimens were all measured to an accuracy of 0.1 mm using digital calipers. Specimens were coated with ammonium chloride whitening agent prior to photography.

SYSTEMATIC PALAEONTOLOGY

Phylum Brachiopoda Dumeril, 1806

Subphylum Rhynchonelliformea Popov, Bassett, Holmer & Laurie, 1993

Order Rhynchonellida Kuhn, 1949

Suborder Terebratellidina Muir-Wood, 1955

Superfamily Terebratuloidea Gray, 1840

Family Cancellothyrididae Thomson, 1926

Subfamily Cancellothyridinae Thomson, 1926

Genus *Cancellothyris* Thomson, 1926

Type Species
Terebratula cancellata Koch, 1843.

Cancellothyris ascotensis sp. nov.
Figure 5 H–L

Diagnosis
Non bifurcating costae; incipient folding; narrow symphytium; rectangular socket teeth.

Material Examined

Holotype
WAM 86.1606 Jupp's Bore, West Gingin, Ascot Formation, Perth Basin, Late Pliocene.

Paratypes
WAM 78.172, 590, 1147, 3117 Paulik's Bore, Jandakot, Ascot Formation, Perth Basin, Early Pleistocene.

Description
External. Shell small to medium-sized, 2.2 to 15.3 mm long. Pyriform. Biconvex. Width greatest anterior to mid-length, 75% of shell length. Surface capillate (6 ribs per mm at mid-length), not bifurcating. Costae increasing in number after each major growth line. Ridges wider than troughs. Finely and densely punctate. Cardinal margin curved; lateral margin convex with respect to ventral valve; anterior commissure incipiently paraplicate (shell distorted). Umbo short, beak suberect, slightly labiate. Foramen mesothyridid, large (13% of shell length). Palintrope and symphytium very narrow. Deltidal plates conjunct, triangular, meeting at apex.

Internal. Ventral Valve: Hinge teeth rectangular, slightly convex towards dorsal valve, slightly swollen bases. Pedicle collar narrow, complete.

Dorsal Valve. Outer socket ridge thin. Sockets a narrow trench. Inner socket ridge thin and joins upward curved outer hinge plate. These are fused with crural base. Cardinal area very delicate, wide, with little thickening towards lateral margin. Cardinal process small, subcircular striated cup, 7% shell length.

Remarks
The lack of bifurcation of the ribs is significant in
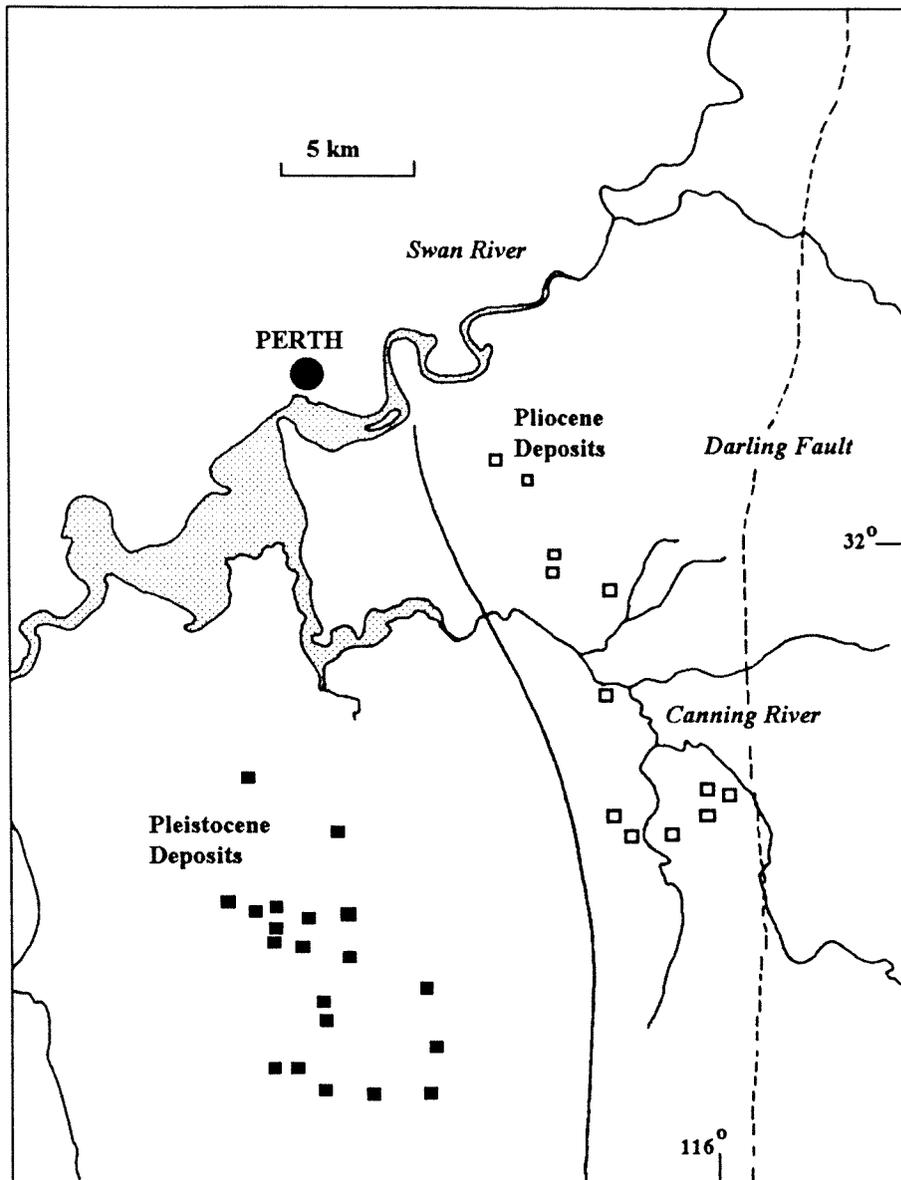
Figure 2   Division of the Pliocene and Pleistocene sections of the Ascot Formation in the Perth metropolitan area, Perth Basin, Western Australia (adapted from Kendrick *et al.* 1991).

this species. There is an increase in number of ribs and these appear after each of the major distinct growth lines. There is no indication of bifurcation of individual ribs.

Richardson (1971) placed *Terebratulina flindersi* Chapman, 1913 and *Terebratulina scoulari* Tate, 1880 in the genus *Cancellothyris*. This is accepted here as the deltidal plates on these species are conjunct whereas in *Terebratulina* they are disjunct. The new species differs from *C. flindersi* described from Mallee Bore of Late Eocene age in South Australia, in that it is longer, lacks bifurcation of the ribbing and lacks spines at the lateral margins (Chapman 1913). *C. scoulari* described from the Late Oligocene to Early Miocene of South Australia (Tate 1880) differs in that the socket teeth are tapered in contrast to the rectangular teeth in *C. ascotensis*.

Moreover, it has a clear deep sulcus which is lacking in *C. ascotensis* and the ribs repeatedly bifurcates which does not occur in *C. ascotensis*. *C. hedleyi* (Finlay 1927) is a recent species described from southern Australian and South Pacific waters (Foster 1989). It has a wide symphytium, unlike the narrow symphytium of *C. ascotensis*. It also has bifurcating costae and a clear sulcus in the dorsal valve, features not found in *C. ascotensis*. *C. platys* Brunton and Hiller, 1990 is a recent species described from the western coast of South Africa. It is very similar to *C. ascotensis* but is larger and has a well developed pedicle collar which is free anteriorly. *C. ascotensis* has a narrow sessile pedicle collar. An undescribed extant *Cancellothyris* from Dunsborough, Western Australia also lacks bifurcating costae but has a wider symphytium, a
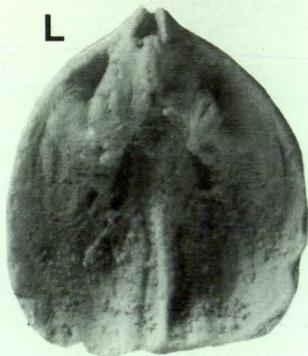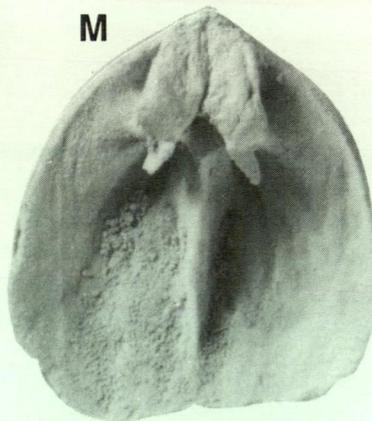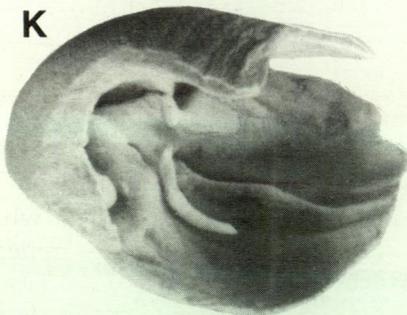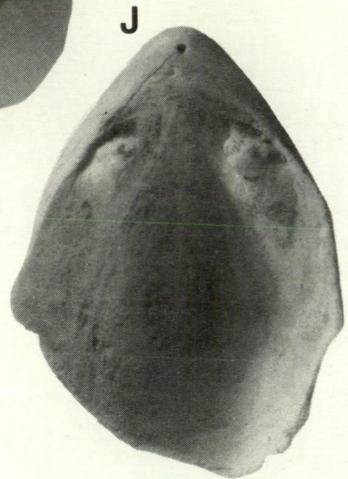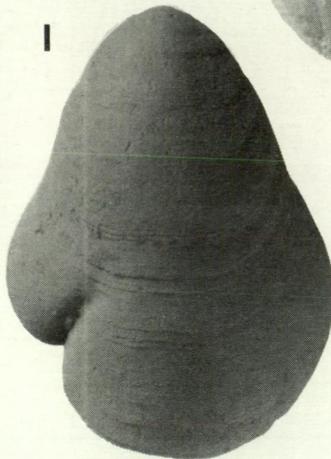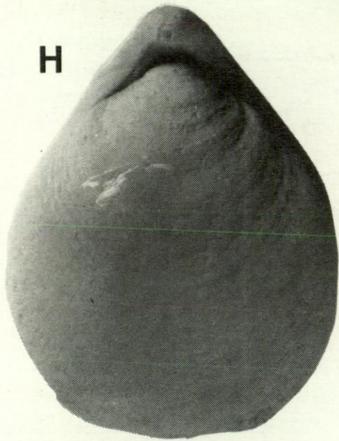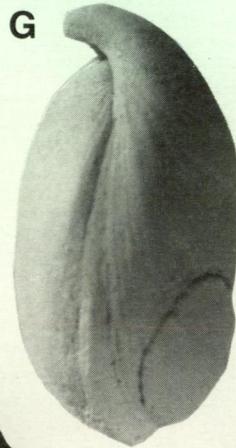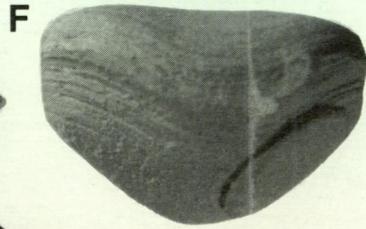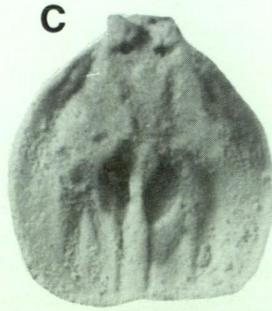
rectangular foramen and is more labiate than *C. ascotensis*.

Etymology

This species is named after the Ascot Formation.

Superfamily Terebratelloidea King, 1850

Family Terebratellidae King, 1850

Subfamily Anakineticinae Richardson, 1991

Genus *Anakinetica* Richardson, 1987

Type Species

Terebratella cumingii Davidson, 1852.

Anakinetica recta Richardson, 1991
Figure 3 A–E

1991 *Anakinetica recta* Richardson: 33, figure 1. G–L.

Material Examined

Holotype

WAM 90.241 Paulik's Bore, Jandakot, Ascot Formation, Perth Basin, Early Pleistocene.

Paratypes

WAM 90.242-246 Paulik's Bore, Jandakot, Ascot Formation, Perth Basin, Early Pleistocene.

Other Material

Ascot Formation, Perth Basin, Late Pliocene:

WAM 81.218 Number 1 Bore, Redcliffe State School; 86.965, 974 Iley's Bore Number 1; 86.1260, 1414 Iley's Bore number 2, Banjup; 87.183 Iley's Bore number 4 bore; 80.1092 Western Mining Corporation, Cataby; 64.5 number 5 bore, Gnangara; 66.918 number 8 bore, Gnangara; 77.921,922 Rando's Bore number 1; 77.1425, 1653, 1863, 1864, 2077, 2926, 3210 Rando's Bore number 2, Thornlie; 83.2411 Humfrey's Bore; 85.1009 Cameron's Bore; 94.1280 Larsen's Bore, West Gingin; 74.1008 Gray's Bore, Gosnells.

Ascot Formation, Early Pleistocene:

WAM 84.1273 Argentiers Bore, Canning Vale; 86.413 Iley's Bore, Forrestdale; 67.702 Adrian's Nursey Bore; 70.997 Schafer's Bore; 70.1754 Poletti's Bore; 75.1016,1025 Exploratory Bore; 71.141, 74.176, 376, 816, 76.255, 472, 706, 864, 947, 1081, 1123, 1163, 1223, 1252, 1408, 90.241-246 Paulik's Bore, Jandakot; 75.807 West Pinjarra.

Description

Exterior. Shell subcircular to ovate from 1.4 to 12 mm long. Biconvex, depth 35% to 49% shell length, ventral valve deeper than dorsal valve in majority of specimens. Width greatest at or anterior to mid-length, 66% to 98% shell length. Growth lines clearly visible, punctae very fine and dense. Cardinal margin gently curved to nearly straight, distinct umbo in dorsal valve; lateral valve edge bevelled to round, margin concave with respect to ventral valve; anterior valve edge bevelled, anterior commissure unisulcate. Umbo strong; beak truncated, straight to incipiently suberect; beak ridge sharp to gently rounded. Foramen small in large specimens, 3% shell length, permesothyridid. Palintrope high, wide, concave, symphytium straited longitudinally.

Interior. Ventral valve. Hinge teeth triangular up curved, grooved at union with lateral margin, heavily buttressed to margin; no dental plates. Pedicle trough narrow between thickened lateral margin walls. Adductor muscle scars short, kidney-shaped, separated by low septum.

Dorsal valve. Outer socket ridges insignificant. Sockets triangular, no roof. Inner socket ridge fused to crural base and swollen, buttressed to valve floor. Narrow shallow groove between crural base and swollen united hinge plates which form a raised septalium. Crura thin, convergent. Median septum curved upward anteriorly, low posteriorly uniting at base to septalium, thin. Remnants of loop on anterior of median septum comprised of two connecting bands, one lower than the other. Anterior adductor muscle scars short, elongate kidney-shaped, deep. Valve floor thickened. Cardinal process a deep small depression within thin extensions of inner socket ridge.

Remarks

The material studied contained the type specimens and 324 others. The greatest width appears to be at the mid-length in the more elongate specimens but posterior to it in the more sub-circular specimens. The dorsal valves are very convex exteriorly. When standing alone, they are asymmetrically balanced, with the thickened

◄ **Figure 3** A–E, *Anakinetica recta* Richardson, 1991. **A**, **B**, WAM 90.241. **A**, lateral view; **B**, dorsal valve view. Both x 5. **C**, WAM 96.245, dorsal valve interior x 6; **D**, WAM 96.246, ventral valve interior x 4; **E**, WAM 72.2055, anterior commissure x 5. **F–N**, *Adnatida gnangarensis* Richardson, 1991. **F–H**, WAM 94.247, holotype. **F**, anterior commissure; **G**, lateral view; **H**, dorsal valve view. All x 3. **I**, WAM 64.5a, ventral valve view x 3 (note the indentation); **J**, WAM 94.249, ventral valve interior x 3; **K**, WAM 64.5b, dorsal valve interior x 3; **L**, WAM 94.248, dorsal valve interior x 3; **M**, WAM 64.5c, dorsal valve interior x 4; **N**, WAM 64.5d, dorsal valve interior x 2.

posterior weighed downwards, the thin anterior upwards. Many specimens are broken towards the anterior where there is no lateral thickening. The concentric growth lines are clearly visible and close together. Curvature of the dorsal valve varies from strongly convex to almost flat. This curvature is not size dependent, as both the larger (up to 12 mm) and the smallest (2 mm) can be deeply curved or nearly flat. Those that are flattest are more subcircular. The foramen is very small and does not change size greatly with ontogeny being 15% (0.3 mm diameter) of shell length in small specimens and 3% (0.4 mm in diameter) of shell length in the largest. The beak ridges are roundly sharp, and the beak gives the appearance of being notched where the foramen cuts the ridge. The specimens range over both the older and younger Ascot Formation and thus range from Late Pliocene to Early Pleistocene in age (Kendrick *et al.* 1991).

Genus *Adnatida* Richardson, 1991

Type Species
Magasella deformis Tate, 1880.

Adnatida gnangarensis Richardson, 1991
Figure 3 G–N

1991 *Adnatida gnangarensis* Richardson: 41, figure 5A–F.

Material Examined

Holotype
WAM 90.247 Mines Department Bore N° 5, Gnangara, Ascot Formation, Perth Basin, Late Pliocene.

Paratypes
WAM 90.248, 249 Mines Department Bore N° 5, Gnangara, Ascot Formation, Perth Basin, Late Pliocene.

Other Material
WAM 64.5, 90.247 Mines Department Bore N° 5, Gnangara; 73.132 Kowalski's Bore, Gosnells; 77.1425 Rando's Bore, Thornlie, Ascot Formation, Perth Basin, Late Pliocene.

Description
Exterior. Shell 2 mm to 20 mm long. Ovate. Biconvex, dorsal valve flatter than ventral valve, depth to 56% shell length. Widest at mid-length or anterior to it, width to 71% shell length. Growth lines numerous, distinct, punctae fine and dense. Cardinal margin relatively narrow to 30% shell length, stongly curved; lateral valve edge rounded, lateral margin sigmoidal; anterior commissure edge bevelled, margin unisulcate. Beak sharp, incurved; beak ridges rounded. Foramen small, 2% shell length, permesothyridid. Symphytium high, triangular, concaved.

Interior. Ventral valve. Hinge teeth deltiodont with posterior vertical groove and swollen bases, strongly butressed to margin. Semicircular recess between teeth and valve floor. Pedicle trough very narrow. Adductor muscle scars elongated thin kidney-shaped. Thin low median septum arising at mid-length and extending to anterior margin.

Dorsal valve. Outer socket ridges wide. Socket ovate, floor swollen, strongly thickened to valve base. Inner socket ridges fused to swollen crural base and overhanging socket slightly. Septalium indististinguishable from swollen crural bases. Cardinal area united with thin cleavage to septum. Median septum blade like, bifurcates narrowly posteriorly. Crural process high, slightly converging, triangular with sharp point. Loop 71% of shell length, teloform (Magellaniiform) and terminates just posterior to anterior commissure, covered in calcite crystals. Connection with septum obscured. Anterior adductor muscle scars large elongate, either side of median septum.

Remarks
The genus *Adnatida* has also been described from the Eocene of South Australia (Richardson 1991). All specimens of *Adnatida gnangarensis* came from bores of Late Pliocene in age (Kendrick *et al.* 1991). One specimen has a deep cleft antereolaterally primarily on the ventral valve resulting in a "dimple". This may be the result of differential growth after attack or due to being "squeezed" between substrate elements.

Subfamily Terebratellinae King, 1850

Genus *Austrothyris* Allan, 1939

Type Species
Waldheimia gambierensis Thomson, 1918.

Austrothyris grandis (Tenison-Woods, 1865)
Figure 4 A–F

1865 *Waldeimia grandis* Tenison-Woods: 2, plate I, figure A–B.

1876 *Waldeimia gambierensis* R. Etheridge junior: plate II, figures 4 a–d.

1880 *Waldheimia grandis:* Tate: 152–153, plate XI, figures 3–4.

1927 *Magellania grandis:* Thomson: 301.

1939 *Austrothyris grandis:* Allan: 239–240, plate XXIX, figures 1–3, plate XXX, figure 4.
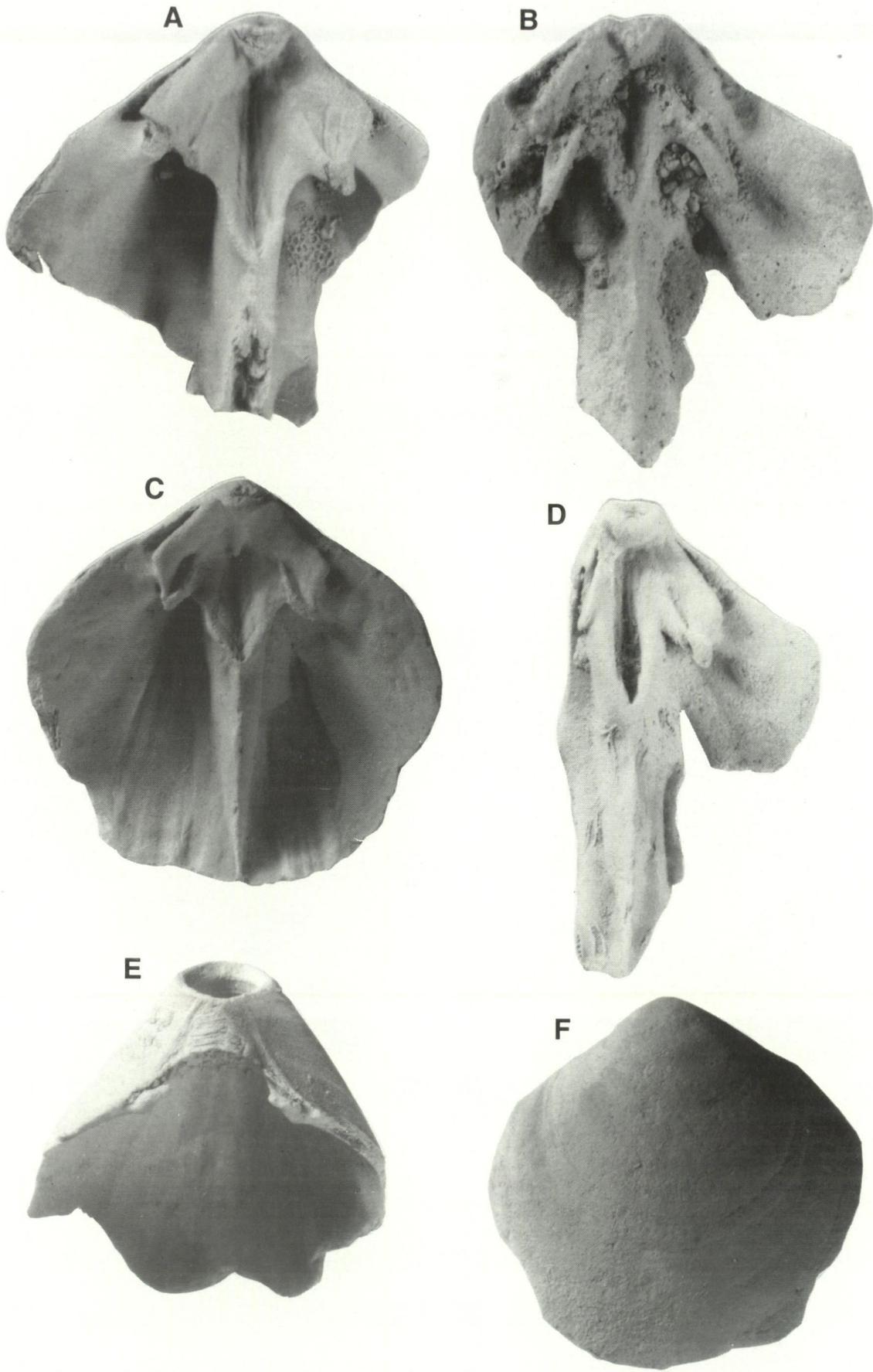
Figure 4   A–F, *Austrothyris grandis* (Tenison-Woods, 1865). **A**, WAM 76.1038a, dorsal valve interior x 3.5; **B**: WAM 76.1038b, dorsal valve interior x 3.5; **C**, **F**, WAM 71.887a. **C**, dorsal valve interior; **F**, dorsal valve exterior. Both x 2.5. **D**: WAM 76.1038c, dorsal valve interior x 3.5; **E**: WAM 76.1038d, ventral valve interior x 3.
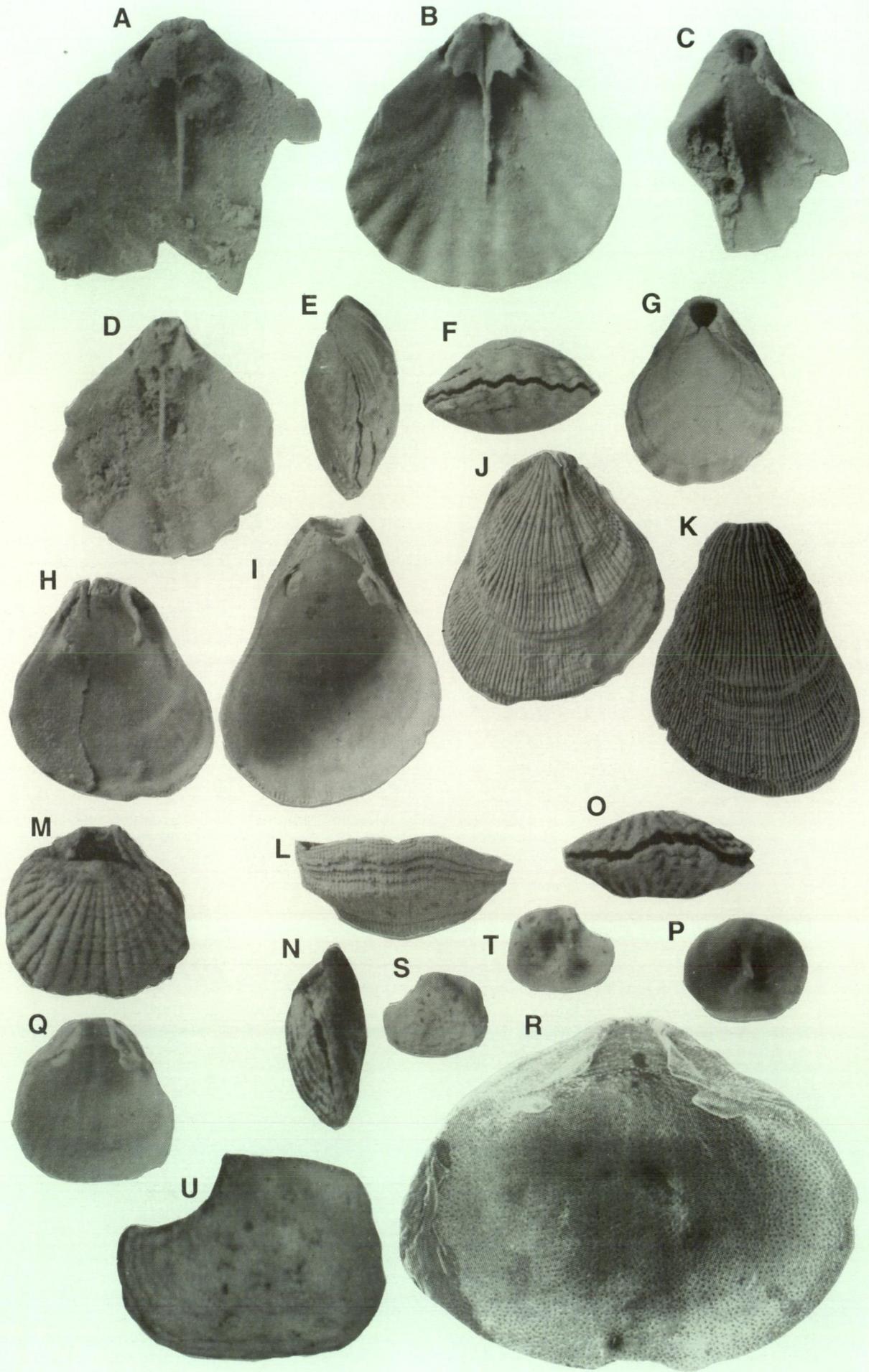
Material Examined

WAM 86.1605 Jupp's Bore, West Gingin; 73.179 Kowalski's Bore, Gosnells, Ascot Formation, Perth Basin, Late Pliocene.

WAM 71.887 Thompson Lake; 73.220 Australind; 76.256, 948, 949, 1038, 1040, 77.3798, 78.2775 Paulik's Bore, Jandakot; 72.1388, 1728, 2054, 2056, 2267 Cement Works Bore, Jandakot, Ascot Formation, Perth Basin, Early Pleistocene.

Description

Exterior. Incomplete specimens, shell medium-sized (greatest part 22 mm long). Biconvex. Smooth, growth lines distinct, finely and densely punctate. Cardinal margin curved with deeper curve under umbo. Umbo stout; beak straight to slightly suberect; beak ridges rounded. Foramen large (18% of greatest length available), mesothyridid, circular, beveled. Deltidal plates conjunct; palintrope narrow, convex; symphytium striated horizontally, ridges on either edge.

Interior. Ventral valve. Pedicle collar sessile, complete, does not extend into valve. Hinge teeth roundly rhombic, pointing posteriorly, leading edge slightly curved, concave, flush with lateral margin, no dental plates and bases not swollen. Adductor muscle scars kidney-shaped depressions either side of a low ridge.

Dorsal valve. Outer socket ridges thin and curve inwards to form dart with inner socket ridges over socket. Socket narrow, triangular. Shell thickened under socket. Inner socket ridge and hinge plate fused, curve slightly towards socket. Join between outer hinge plate and crural base "V" shaped, fused to hinge plates and traceable to posterior of shell. Crural process triangular shape, crest inner most. Median septum thick at base posteriorly, thins anteriorly, crest sharp. Posteriorly bifurcates, joining inner hinge plates to form septalium. Cardinal process a flattened cup, protruberant and angled towards ventral valve. Swollen rounded base of cardinal process extending into septalium. Anterior adductor muscle scars triangular, sharp apex posteriorly, curved base anteriorly. No complete loop observed.

Remarks

Although the median septum does not appear to run fully into the septalium, there is a small ridge half way into the septalium in some specimens. This may be consistent with either the median septum or the cardinal process support. The specimens are consistent with the descriptions of *A. grandis* in all other respects. *Austrothyris grandis* was described from the Early Miocene of South Australia (Allan 1939). A small specimen (3.3 mm long) has a clear septalium and the septum rises at the anterior end which is just anterior to the midline. The deltidal plates are disjunct at this stage.

Genus *Magellania* Bayle, 1880

Type Species

Terebratula flavescens Lamarck, 1819.

Magellania flavescens (Lamarck, 1819)
Figure 5 A–G

1819 *Terebratula flavescens* Lamarck: 246.

1819 *Terebratula dentata* Lamarck: 246.

1835 *Terebratula australis* Quoy and Gaimard: 551, plate 85 figures 1–5.

1835 *Terbratula recurva* Quoy and Gaimard: 554, plate 85, figures 10–11.

1847 *Terebratula spadae* Aradas: 237.

1850 *Waldheimia australis*: King: 145, plate 20, figures 10–12.

1852 *Waldheimia flavescens*: Davidson: 64, figures 6–7.

1859 *Waldheimia australis*: Hancock: 791–869, plates 52–59, 62, 63.

1860 *Terebratula (Waldheimia) flavescenes*: Reeve: plate 1.

1876 *Waldheimia flavescenes*: Tenison-Woods: 57.

1880 *Waldheimia flavescenes*: Davidson: 41, plate 3, figures 10–12.

1880 *Magellania flavescenes*: Bayle: 240.

1886 *Waldheimia flavescenes*: Davidson: 41–49, plate 7, figures 6–19, text figures 3–8.

1902 *Waldheimia flavescenes*: Hedley: 289.

◀ **Figure 5**   A–G, *Magellania flavescens* (Lamarck, 1819). A, WAM 76.257a, dorsal valve interior x 4; B: WAM 77.2675, dorsal valve interior x 4; C, WAM 76.257b, ventral valve interior x 5: D, WAM 76.257c, dorsal valve interior x 5; E–G, WAM 78.3116. E, lateral view; F, anterior commissure; G, dorsal valve view. All x 4. H–L, *Cancellothyris ascotensis* sp. nov. H–L, WAM 86.1606a holotype. H, dorsal valve interior x 3; I, ventral valve interior x 3.5; J, dorsal valve exterior x 3.5; K, ventral valve exterior x 3.5; L, anterior commisssure x 3.5. M–R, *Megerlina irenae* sp. nov. M–O, WAM 86.1604, holotype. M, dorsal valve view; N, lateral view; O, holotype, anterior commissure. All x 7; P, WAM 70.1629a, paratype, dorsal valve interior x 7; Q, WAM 86.1604, paratype, ventral valve interior x 7; R, WAM 70.1629b, (SEM) ventral valve interior x 17. S–U, *Megerlina dorothyae* sp. nov. S–U, WAM 71.1536. S, dorsal valve exterior x 8; T, dorsal valve interior x 8; U, dorsal valve exterior x 20.

1910 *Magellania flavescenes*: Verco: 96.

1927 *Magellania flavescenes*: Thomson: 294–295, figures 5, 8, 9, 19c, 102.

1939 *Magellania australis*: Allan: 234–235, plate 30, figure 6.

1939 *Magellania flavescenes*: Allan: 235–236, plate 30, figure 7.

1939 *Magellania iredalei* Allan: 236–237, plate 30, figure 5.

1974 *Magellania flavescenes*: Foster: 123–125, plate 11, figure 8, plate 19, figures, 15–16, plate 23. figures 5–5, text figure 3 part 25, text figure 31. C–D

Material Examined

WAM 71.1537 Bushell's Bore, Kewdale, Ascot Formation, Late Pliocene.

WAM 70.1738 Poletti's Bore; 73.325, 510 Cement Works Bore; 74.817, 75.1267, 76.257, 473, 1039, 1960, 77.4233, 78.591, 1146, 1479, 2199, 3116, 79.845, 1080, 1980 Paulik's Bore, Jandakot; 77.2675 Murdoch, Ascot Formation, Perth Basin, Early Pleistocene.

WAM 86.277 Buayanyup drain, Vasse, Perth Basin, Middle Holocene.

Description

Exterior. Shell small to medium-sized, 3 to 12 mm long (largest specimens incomplete). Subtriangular to ovate. Biconvex, dorsal valve flatter than ventral valve Widest anterior to mid-length. Finely and densely punctate, punctae oval. Shell ribbed, extending from posterior margin; ribs wide, 6% of shell length, troughs as wide as ribs, some ribs bifurcate anterior to mid-length. Dorsal valve sulcus anterior to mid-length. Cardinal margin strongly curved; lateral margin convex towards ventral valve, crenulate anterior to mid-length; anterior commissure unisulcate, crenulate (2 crests per mm). Umbo truncated; beak suberect, beak ridges rounded. Foramen large, 14% of shell length, mesothyridid. Deltidal plates triangular and disjunct. Lip over dorsal valve.

Interior. Ventral valve. Pedicle collar narrow, sessile. Hinge teeth unclear, wide, no dental plates.

Dorsal valve. Outer socket ridge thin. Inner socket ridge, slightly curved over socket. Socket triangular with no roof. Outer hinge plate, crural base and inner hinge plate fused. Vertical ribbing exists along union of inner socket ridge with outer hinge plate. Crural base extends posteriorly as slight rise. Crura divergent. Inner hinge plates join bifurcating median septum in cardinal third of posterior section. Median septum extends just beyond mid-length; crest to base thin, not swollen. septalium, sockets and cardinal process form a platform over posterior section of valve. Cardinal process with protruberant lip, projects towards ventral valve,

trilobed, lamella parallel to trilobed edge producing folded pattern. Loop incomplete.

Remarks

The disjunct deltidal plates are not characteristic of the genus. Richardson (1994) says the deltidal plates are "invariably conjunct". However, Bitner (1996) illustrated a disjunct specimen of *M. antarctica*. The fusion of the plates may well be a feature of later ontogeny. Unfortunately no specimens of large ventral valves or cojoined valves are available. The species is known from the present day waters of south eastern and south western Australia. This is the earliest record of the species.

Family Kraussinidae Dall, 1870

Genus *Megerlina* Deslongchamps, 1884

Type Species

Kraussia lamarckiana Davidson, 1852.

Megerlina irenae sp. nov.
Figure 5 M–R

Material Examined

Holotype

WAM 86.1604a, Jupp's Bore, West Gingin, Ascot Formation, Perth Basin, Late Pliocene.

Paratypes

WAM 86.1604b, Jupp's Bore, West Gingin, Ascot Formation, Perth Basin, Late Pliocene. WAM 70.1629a and b, 70.1409, 78.2683, 4062, 79.507 Paulik's Bore, Jandakot Ascot Formation, Perth Basin, Early Pleistocene.

Other Material

Ascot Formation, Perth Basin, Late Pliocene:
WAM 71.1597 Bushell's Bore, Kewdale.
Early Pleistocene.
WAM 76.1478, 78.2774, 3469, 4063, 79.263, 378, 1081 Paulik's Bore, Jandakot.

Diagnosis

Shell wider than long; costae not bifurcating; dorsal valve with wide sulcus; ventral valve with medial ridge;

Description

Exterior. Shell small to 4 mm long by 4.5 mm wide by 2 mm deep. Subrectangular. Widest at mid-length; Shell costate, ribs same width as troughs, 5 ribs per mm. Growth lines distinct, densely punctate. Cardinal margin straight to nearly so (megathyrid); lateral margin straight; anterior commissure crenulate, unisulcate to paraplicate,

sulcus 30% shell length. Umbo short, wide; beak suberect; beak ridges sharp. Foramen large, 21% shell length, mesothyridid. Deltidal plates present, disjunct. Pseudodeltidium concaved.

Interior. Ventral valve. Hinge teeth rectangular, converging towards dorsal valve, sharp on upper margin with swollen bases. Pedicle collar extends width of umbo, striated vertically. Median rise extending from posterior to mid-length. Shell thin, translucent and punctae clear.

Dorsal valve. Hemispherical and very deep. Outer socket ridge indistinct from lateral margin. Inner socket ridges upcurved forming the roof of socket. Socket cylindrical, slight with slight swelling at base of sockets. Cardinal process indistinct from posterior margin. Socket ridges and cardinal process curve towards valve floor meeting at bifurcating median septum to form thin shallow septalium. Median septum extends two thirds of shell length from the posterior margin then rises up anteriorly to bifurcate into two diverging processes.

Remarks

Megerlina irenae differs from *M. pisum* (Lamarck 1819) found in the waters off the eastern coast of South Africa in possessing a median ridge in the ventral valve, a feature lacking in *M. pisum* (Hiller 1986). *M. levis* Hiller, 1979, described from the Late Pleistocene deposits on the Zululand coast, lacks any radial ornamentation (Hiller 1979). *M. davidsoni* (Velain, 1877) described from shallow water, St Paul Island in the Southern Ocean differs from *M. irenae* in having a longer beak, a narrower sulcus (Cooper 1981) and lacking the median ventral ridge found in *M. irenae*. Cooper (1973) also described a extant species of *Megerlina* from the Southern Ocean. This species has outer hinge plates which are concave, thick and unite with the median septum (Cooper 1973), unlike *M. irenae*. Moreover it does not have the median ridge present in the ventral valve found in *M. irenae*. *M. striata* Jackson, 1952, an extant species from the Cape of Good Hope, is large attaining 14.1 mm in length. The ribs are bifurcate and the socket ridges are stout (Jackson 1952). This differs from *M. irenae* which is small (up to 4 mm), with ribs that do not bifurcate and slender socket ridges, the outer ridge indistinguishable from the lateral margin. *M. capensis* (Adams and Reeve 1850) an extant species also from the Cape of Good Hope is twice the size of the largest *M. irenae*, is longer than wide and has bifurcating costae (Jackson 1952). *M. lamackiana* (Davidson 1886–88) an extant species described from Port Jackson, New South Wales, has a wide hinge plate lacking in *M. irenae*.

Etymology

The species is named in honour of my wife Irena.

Megerlina dorothyae sp. nov.
Figure 5 S–U

Material Examined

Holotype
WAM 71.1536 Bushell's Bore, Kewdale, Ascot Formation, Perth Basin, Late Pliocene.

Diagnosis

Small *Megerlina* without costation, thickened sockets, shell thickened, large depression for muscle scars.

Description

Exterior. (Dorsal valve only). Shell small to 2 mm long by 2.5 mm wide. Convex with medial sulcus. Finely punctate; growth lines distinct with no costation. Cardinal margin nearly straight. Shell relatively thick.

Interior. Outer socket ridges thick. Inner socket ridges curved upwards to form incomplete socket roof. Shell thickened laterally along socket area. Median septum bifurcates posteriorly forming a narrow septalium. Septum rises anteriorly and bifurcates. Laminar on either side of septum. Interior margin of shell slopes away from septum. Two large (50% shell length) anterior adductor muscle scars either side of septum posteriorly. Median septum and muscle scars in a thickened walled depression, 70% shell length. Cardinal process insignificant.

Remarks

This single specimen is similar to *M. irenae* in general shape. However, it lacks costation, as does *M. levis* Hiller, 1979, but the sockets are comparatively thicker and the overall thickened shell and depression housing the septum and muscle scars is distinctive.

Etymology

Named in honour of my mother Dorothy.

THE SIGNIFICANCE OF THE BRACHIOPOD DISTRIBUTION IN THE PERTH BASIN

The distribution of the Cenozoic brachiopods in the Perth Basin is summarised in Table 1. The most abundant species collected is *Anakinetica recta* Richardson, 1991, which comprises some 73% of the total number of specimens. *A. recta*, *Austrothyris grandis*, *Cancellothyris ascotensis* and *Megerlina irenae* have been found in both the Late Pliocene and Early Pleistocene sections of the Ascot Formation (Kendrick *et al.* 1991). *Magellania flavescens* is also found throughout the Ascot Formation, and also extends into the Holocene. It's distribution pattern indicates a greater frequency in the Early

Table 1   Distribution of species in the Ceozoic deposits of the Perth Basin shown as a percentage of all brachiopod specimens found.

Species	Late Pliocene	Early Pleistocene	Holocene
Anakinetica recta	24.90	48.11	
Adnatida gnangarensis	7.55		
Austrothyris grandis	1.32	5.28	
Magellania flavescens	0.38	5.66	0.18
Cancellothyris ascotensis	1.32	0.75	
Megerlina irenae	0.38	3.39	
Megerlina dorothyae	0.18		

Pleistocene than in the Late Pliocene. This is the only species described from the Ascot Formation that is extant. *Megerlina dorothyae* and *A. gnangarensis* have only been recorded from the Late Pliocene. *A. recta, A. grandis,* and *M. irenae* are all more prevalent in the Early Pleistocene than in the Late Pliocene. *C. ascotensis* is more prevalent in the Late Pliocene than in the Early Pleistocene. Larger specimens tend to be very poorly preserved, many being broken, and shell pieces confused with those of bivalves. This may have implications in the diversity percentages.

Austrothyris grandis was described from the Early Miocene of South Australia (Allan 1939) and is present in the Early Miocene Abrakurrie Limestone of the Eucla basin, Western Australia. The genus *Adnatida* has been described from the Eocene of South Australia (Richardson 1991). The genus *Anakinetica* has been described from the Late Oligocene of Victoria, the Early Miocene of Victoria and South Australia (*A. breva*) and the Pliocene of Victoria (*A. tumida*) (Richardson 1991). *A. breva* is also present in the Early Miocene Abrakurrie Limestone of the Eucla Basin, Western Australia. The presence of genera common to earlier formations in southern Australia suggests that the oceanic temperatures during the Late Pliocene and Early Pleistocene of the Perth Basin were possibly similar to those in the Eucla, St Vincent and Otway Basins which ranged from 14°– 19° (James and Bone 1991). However, the presence of phosphatic nodules in the Ascot formation suggests the temperature was cooler than the southern Australian basins mentioned above. This, with the presence of genera *Austrothyris, Adnitida* and *Anakinetica* in the Ascot Formation, Perth Basin can best be explained by a hiatus in the Leeuwin Current. Cooler waters moving south to north with no interruption from the southerly flowing Leeuwin Current could have possibly allowed for the northward migration of the genera.

Brachiopods appear to be less influenced by temperature than by substrate (Richardson 1997). *Anakinetica breva* and *Adnatida deformis* are found in bryozoal limestone deposits whereas the Ascot

Formation consists of 'fine to very coarse, grey to yellow-brown quartz sands with subordinate carbonate and less frequently quartzose calcarenites' (Kendrick *et al.* 1991). This may account for the difference in the species.

Magellania flavescens could have evolved on the western coast of Australia and the have been dispersed in an easterly direction, to appear along the southern coast in Recent times. The mechanism for this distribution would most likely be the Leeuwin Current which is known to have been influential in the distribution of echinoids (McNamara 1999) and large warm water foraminifera (McGowran *et al.* 1997).

The reduced number of specimens compared to other deposits may be due to temperature, but as mentioned, temperature is not believed to have been a limiting factor (Richardson 1997). Kendrick (pers comm) suggests that the Ascot Formation is shallow inshore shelf with several regressional episodes indicated. This is believed to have been a high photic zone with seagrasses. This is supported by the presence of the bryozoan *Densipora*. Large seagrass attaching foraminifers are conspicuously absent, possibly because of the lower temperature which is suggested by the presence of phosphate nodules. The lack of significant numbers of brachiopods may therefore be due to a higher light intensity than would normally allow them to proliferate.

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