AUSTRALASIAN TERTIARY BRACHIOPODA. THE SUBFAMILY ANAKINETICINAE NOV.

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Four new endemic brachiopod genera (*Adnatida, Aliquantula, Elderra, Pilkena*) and seven new species (*Anakinetica breva, A. recta, A. tumida, Magadinella hamiltonensis, Pilkena compressa, Adnatida gnangarensis* and *Elderra toorlooensis)* are described from Tertiary bryozoan sands in Victoria, South Australia and Western Australia. The taxa are included in the new subfamily Anakineticinae which is erected for those Australian and New Zealand genera formerly included in the Magadinae.

WITH the exception of the Terebratellidae (subfamilies Terebratellinae, Anakineticinae nov., Bouchardiinae and Magadinae), Cainozoic articulate brachiopod families are cosmopolitan in distribution. Cainozoic members of the Terebratellidae are unknown in the northern and western hemispheres but are the principal components of the Recent brachiopod faunas in Australia, New Zealand, South America and Antarctica. In these areas, brachiopods are not rare members of the benthos, as they appear to be in other parts of the world.

The subfamily Anakineticinae nov. is an exclusively southern subfamily which apparently evolved in the biogenic sands of New Zealand and Australia during the Oligocene and Miocene. In New Zealand, a drastic reduction in the extent of shallow marine shelf environments by Late Miocene time (MacKinnon 1987) resulted in the disappearance of brachiopods specialised for these regimes, and both anakineticinid genera from that area (*Magadina, Rhizothyris*) are now extinct. In contrast, the stability of the Australian region has provided a virtually continuous record (Eocene to Recent) of anakineticinids specialised for bryozoan sands. Present day communities living in the bryozoan sands of the Australian shelf replicate those found in the Tertiary bryozoan sands, and the two communities are sometimes found in juxtaposition, as in southern Victoria, for example, where cliffs of the Aire coast border shelf waters.

Living anakineticinid species have been described in a series of papers (see Richardson 1987) which show that they are widely distributed in relation to latitude, longitude and depth, and that they possess a variety of adaptations for life in shifting bryozoan sands. These species have given a new insight into the structure and function of the pedicle, showing that it is not analagous to a stalk or stem but is a variable appendage used either to tether or to move individuals in soft sediments. Differences in the pedicle system and therefore in substrate relationships are reflected in overall shape and size, as well as in the beak and cardinalia.

Erection of a new subfamily for the Australian and New Zealand genera previously included in the Magadinae leaves the latter subfamily with four European Cretaceous genera, three of which are little known. The Australasian genera have been transferred to the Anakineticinae because they differ from *Magas*, the type genus of the Magadinae, in distribution of thickening, beak type, and in the form of the posterior surface of the cardinal process. The distribution of thickening in *Magas* indicates that the dorsal valve would have been uppermost in life and the ventral valve in contact with the underlying substrate (chalk), in contrast with the opposite orientation of austral genera. The posterior surface of the cardinal process of *Magas* is small and cup-shaped whereas in the genera attributed to the Anakineticinae it is prominent and distinctive in shape, with lateral vertical or near-vertical wings flanking a median horizontal surface (trefoil). Steinich (1968) and Johansen (1987) have remarked on the similarities between *Magas chitoniformis* and *Dalliglas nobilis* (Dallinidae) which they can separate only on the composition of the loop and density of punctae. Both *Magas* and *Dalliglas* exhibit adult loops at an early stage of the developmental sequence which is characteristic of terebratellacean families (Richardson 1975). Family position can be determined only from the patterns of resorption evident in intermediate stages, not from early or late stages of development. Adult

loop pattern therefore does not define the family position of *Magas* which may prove to be a member of the Dallinidae

Discussion of the evolutionary derivation of members of the Anakineticinae will be included in a forthcoming paper on Australian Terebratellidae.

The material described herein is housed in the collections of the South Australian Museum (SAM), the Western Australian Museum (WAM), and the Museum of Victoria (NMV).

SYSTEMATICS

Superfamily TEREBRATELLACEA King, 1850
Family TEREBRATELLIDAE King, 1850
Subfamily ANAKINETICINAE nov.

Diagnosis. Posteriorly thickened smooth Terebratellidae with permesothyrid foramen; cardinalia consisting of socket ridges, crural bases, and a cardinal process with trefoil posterior surface.

Genera included. Anakinetica Richardson, 1987; *Adnatida* nov.; *Aliquantula* nov.; *Australiarcula* Elliott, 1959; *Elderra* nov.; *Magadina* Thomson, 1915; *Magadinella* Thomson, 1915: *Parakinetica* Richardson, 1987; *Pilkena* nov.; *Pirothyris* Thomson, 1927; *Rhizothyris* Thomson, 1915.

Distribution. Cretaceous–Recent; Australia, New Zealand.

Comments. All anakineticinid genera are posteriorly thickened with a permesothyrid foramen. They differ from one another primarily in the cardinalia: in the extent of thickening of the hinge platform, in the presence of hinge pits or of a hinge trough and, if the latter is present, in its extent.

Differential thickening is a reliable indicator of free life in living forms and a permesothyrid foramen of an inert, non-muscular pedicle (Richardson 1981a); i.e. individuals that are pediculate but are neither tethered nor fixed to the underlying substrate. The presence of a hinge trough or of pits is associated with different actions of the pedicle (Richardson 1987). In the former, the action of pedicle muscles rotates the pedicle or the shell (depending on the mass of substrate bonded with the pedicle); in the latter they push the pedicle in and out of its housing, the beak. Rotatory action is associated with a bonded pedicle and attachment of the dorsal pedicle muscles to a hinge trough. In/out action is associated with a free pedicle and attachment of dorsal adjustor muscles to a pair of posterior hinge pits.

A hinge trough is characteristic of four of the genera and may (1) extend the full length of the platform (*Magadina*), (2) be restricted to its anterior section as a result of enlargement of the inner socket ridges and cardinal process (*Magadinella, Elderra*), or (3) be restricted to its posterior region (*Aliquantula*) by enlargement of the crural bases. Genera with hinge pits may differ in the position of the hinge platform relative to the valve surface and in shell shape and beak form, differences which, in members of living genera (*Anakinetica, Parakinetica*), are related to direction of movement and to the disposition of the pedicle processes.

Neither hinge trough nor pits are evident on the hinge platform of species of *Adnatida*. The absence of any area for attachment of the dorsal pedicle adjustor muscles is a likely indicator of atrophy or loss of the pedicle system, as are the small foramen and incurved beak also seen in these species. They would have been free-lying forms without any capacity to move and similar to some of the populations of *Neothyris lenticularis* described by Chapman & Richardson (1981) and Richardson (1981b). Species within each genus are distinguished on consistent differences in size and shape, on loop pattern, and on details of the hinge platform. Loop pattern is linked with the space available within the mantle cavity. In shells of small size and heavy thickening (*Magadina, Anakinetica recta*) the adult loop is at an early stage in the developmental sequence; i.e. with a ventral ring and wide descending branches separately attached to a high median septum. A long reflected loop without septal attachments is found in *Aliquantula* and *Elderra*, genera of moderate size and having the hinge platform smaller in relation to valve area than in *Anakinetica* and *Magadinella*. The loop is rarely recovered in its entirety but its parts and their relationship are evident during dissection.

Several Japanese species are difficult to distinguish from Australian anakineticinids. The Miocene species *Tanakura tanakura* Hatai, 1936, for example, was included by me (Richardson 1987) in the Magadinae because of its similarity to species of *Anakinetica*. The Pliocene–Recent species *Nipponithyris nipponensis* Yabe & Hatai, 1934 is also very similar to *Aliquantula insolita*. However, the adult loop of *N. nipponensis* displays double lateral connecting bands (Richardson 1975), showing that it is a member of the Dallinidae. The development

and adult loop of *T. tanakura* are unknown but the short median septum carries no evidence of connecting bands, indicating that a long reflected loop would have been present. Since a loop of this type is found as the ultimate developmental stage in all families and, since no other members of the Terebratellidae have been described from Japan, it is possible that *Tanakura* is also a dallinid genus, and the similarities in shape, size, beak and cardinalia are thus considered homeomorphies resulting from the occupation of sediments of similar type. Hatai (1940) described *T. tanakura* from coarse grained sandstones consisting of fragments of marine organisms and *N. nipponensis* from a shelf substrate of sand and shell fragments.

Genus **Anakinetica** Richardson, 1987

Type species. Terebratella(?) Cumingii Davidson, 1852 from the Recent of Australia.

Other species. Terebratula compta Sowerby, 1845; *A. breva* sp. nov.; *A. recta* sp. nov.; *A. tumida* sp. nov.

Occurrence. Australia; Oligocene to Recent.

Diagnosis. Sulcate. Beak suberect to straight; beak ridges sharp; symphytium wide, flat; cardinal margin straight or nearly straight. Hinge platform with posterior pits for attachment of dorsal adjustor muscles. Loop with ascending and descending branches separate or fused and with lateral connecting bands.

Comments. Species of *Anakinetica* lack a hinge trough for attachment of the dorsal adjustor muscles. The solid hinge platform, formed by fusion of the socket ridges, crural bases, and the anterior surface of the cardinal process (Richardson 1987), contains two pits which flank the posterior surface of the cardinal process. In the living species *A. cumingii* and also in *Parakinetica stewarti*, these pits serve as the sites of attachment of the dorsal adjustor muscles, and it is inferred that the pedicle of all fossil species included in the genus likewise would have been free and would have functioned in similar ratchet-like fashion.

Species of *Anakinetica* differ externally in size, outline, beak length, curvature of the cardinal margin, and in strength of sulcation. Internally they differ in the length and height of the septum, stage of loop development, and in details of the hinge platform. Two of these features appear to be linked. A short septum and a more advanced loop stage (with thin lateral connecting bands) are found in *A. compta* and *A. breva*. A long septum and wide connecting bands occur together in *A. tumida* and *A. recta*. The components of the hinge platform are fused but identifiable in *A. breva* and *A. tumida* but are not identifiable in *A. compta* and *A. recta*.

Key to species of *Anakinetica*

(based on external features only)

1. Beak length $< 0.2 \times$ valve length ..... *A. breva*
— Beak length $> 0.2 \times$ valve length 2
2. Cardinal margin curved, beak straight ..... *A. recta*
— Cardinal margin straight or nearly straight, beak suberect 3
3. Outline trapezoid, greatest width posterior to mid-length .. *A. tumida*
— Outline ovate, greatest width at mid-length; anterior commissure strongly sulcate ..... *A. compta*

Anakinetica compta (Sowerby in Strezlecki, 1845)

Fig. 1A–F

Terebratula compta Sowerby in Strezlecki 1845: 297, pl. 19, fig. 4

Terebratella compta.—Tenison-Woods 1865: 2, pl. 2, fig. 4a–e.

non *Terebratella compta.*—Etheridge 1876: 19–20, pl. 2, fig. 5a–d [= *Magadinella woodsiana* (Tate, 1880)].

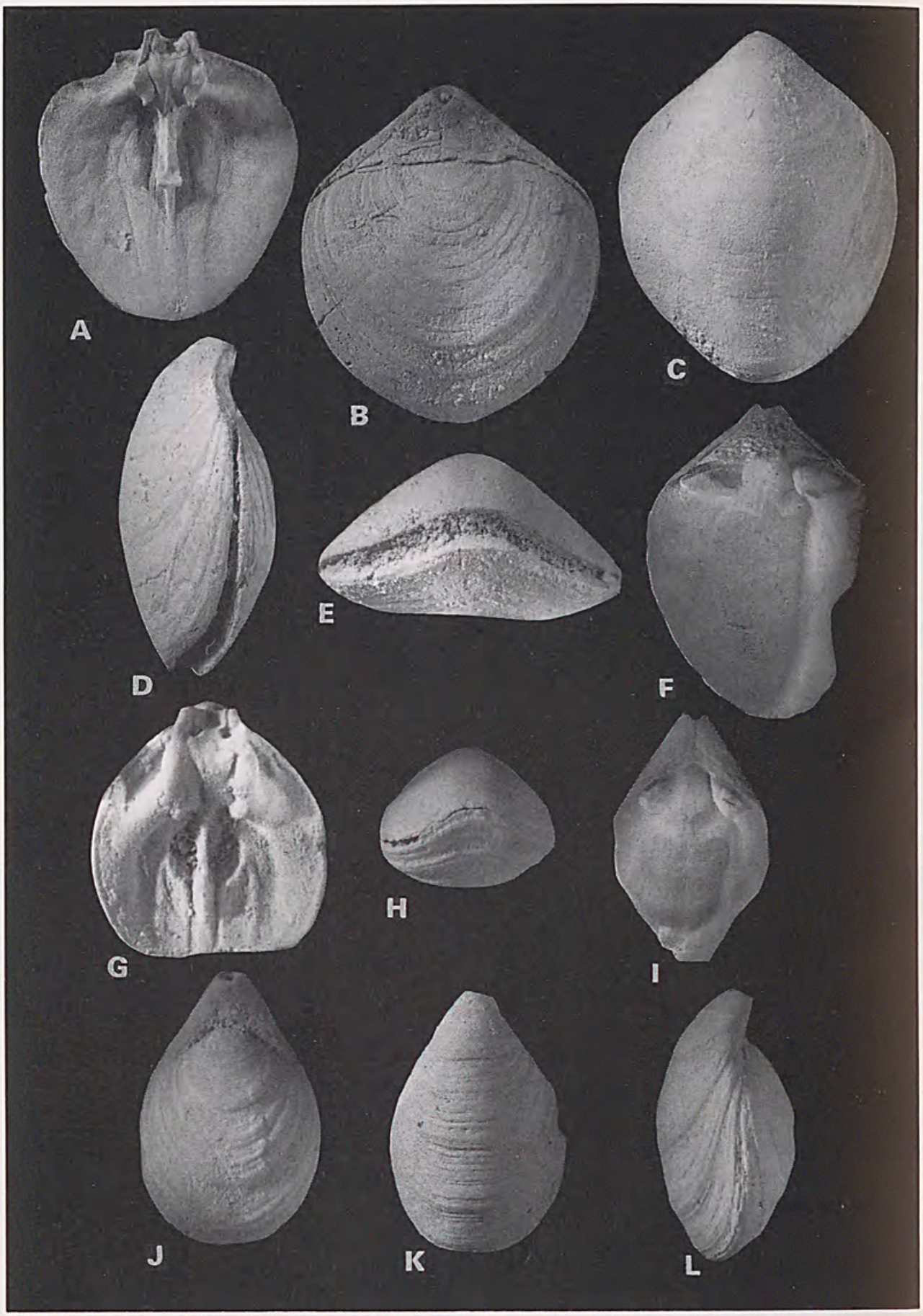
non *Magasella compta.*—Tate 1880: 162–163, pl. 10, fig. 6a–e [= *A. breva* sp. nov.].

Magadina compta.—Thomson 1915: 399, fig. 10

Type material. See comments.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P86974	18.8	15.0	14.9	8.9
NMV P3748	19.3	14.8	14.8	9.0
NMV P86973	17.9	13.6	12.9	8.9
NMV P58903	17.8	13.6	13.8	8.9
NMV P134239	18.5	14.9	15.5	8.2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Description. Outline subquadrate, greatest width at or slightly posterior to mid-length; dorsal valve with flattened umbo; anterior commissure deeply and narrowly sulcate. Beak suberect; cardinal margin straight; symphytium wide, flat to gently concave. Hinge platform wedge-shaped, almost square with indented posterior margin; surface relief low; posterior surface of cardinal process large, lateral surfaces lining posteriorly projecting socket ridges. Medium septum thick, low, terminating mid-length of valve. Loop with thin lateral connecting bands. Hinge teeth triangular in outline. Beak interior and lateral walls heavily thickened, leaving round tunnel for pedicle.

Comments. Sowerby (in Strezlecki 1845) described *Terebratula compta* on the basis of specimens collected from "an elevated beach at Port Fairy" on the Cape Otway coast, Victoria. Tate (1880) noted that "Strezlecki mistook our Older Tertiary deposits for Post Tertiary beaches". Port Fairy (if considered as synonymous with Point Fairy) contains no Tertiary outcrops although they occur inland in this general area. In 1865, Tenison-Woods referred specimens collected at Mount Gambier and Portland to *T.compta* and his figures agree with those of Sowerby. The Natural History Museum, London, where some of Sowerby's material is deposited, has no record of *T. compta*. The specimens described and figured herein were collected from the Mount Gambier Limestone (Janjukian, Upper Oligocene) at Portland, Victoria. Since no problem exists in the identification of Sowerby's species, and in accordance with Article 75 (b)(ii) of the International Code of Zoological Nomenclature, it is not considered necessary to designate a neotype.

Anakinetica recta sp. nov.

Fig. 1G–L

Name. From Latin *rectus* (straight), in reference to the beak.

Type material. Holotype WAM 90.241 and paratypes WAM 90.242–90.246, NMV P134722, from Frank Paulik's Bore (Lot 6, depth unknown), Jandakot, Western Australia.

Other horizons and localities. Western Australia. Jandakot: Adrian's Nursery Bore at 38.4 to 39.3 m; Schafer's Bore (Lot 415) at 40.6 m; Cement Works Bore at 33.6 to 33.7 m; Poletti's Bore No. 2 (Lot 7) at 39.6 to 41.1 m; Gnangara Bore No. 8 at 77.8 m. Gosnells: Kowalski's Bore (Lot 1) at 28.4 to 29.6 m. All material cited is housed in the Western Australian Museum.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
WAM 90.241	9.9	8.1	7.7	4.8
WAM 90.242	9.1	7.6	6.6	4.8
WAM 90.243	9.3	7.2	6.1	4.8
WAM 90.244	9.1	7.7	6.6	5.0
NMV P134722	8.9	6.9	6.4	3.7

Description. Outline elongate-ovate with greatest width at mid-length. Beak straight, symphytium slightly concave, cardinal margin curved. Hinge platform outline trapezoidal; posterior ends of socket ridges blunt, projecting slightly beyond posterior margin of valve; boundaries of components of platform not identifiable. Median septum extending slightly beyond mid-length of valve, high anteriorly. Loop with ascending and descending branches separate, attachments to septum wide. Hinge teeth triangular in outline. Lateral walls and beak interior heavily thickened, leaving round tunnel for pedicle.

Comments. Dr G. Kendrick (pers. comm.), Western Australian Museum, considers the age of the bores to be Pliocene to Early Pleistocene.

Anakinetica tumida sp. nov.

Fig. 2A–F

Name. From Latin *tumidus* (swollen), in reference to the cardinalia.

Type material. Holotype NMV P17329 and paratypes NMV P17330, P17331, P134203–P134207, from the Brighton Sands, Cheltenham Member (Cheltenhamian, Pliocene), Beaumaris, Victoria.

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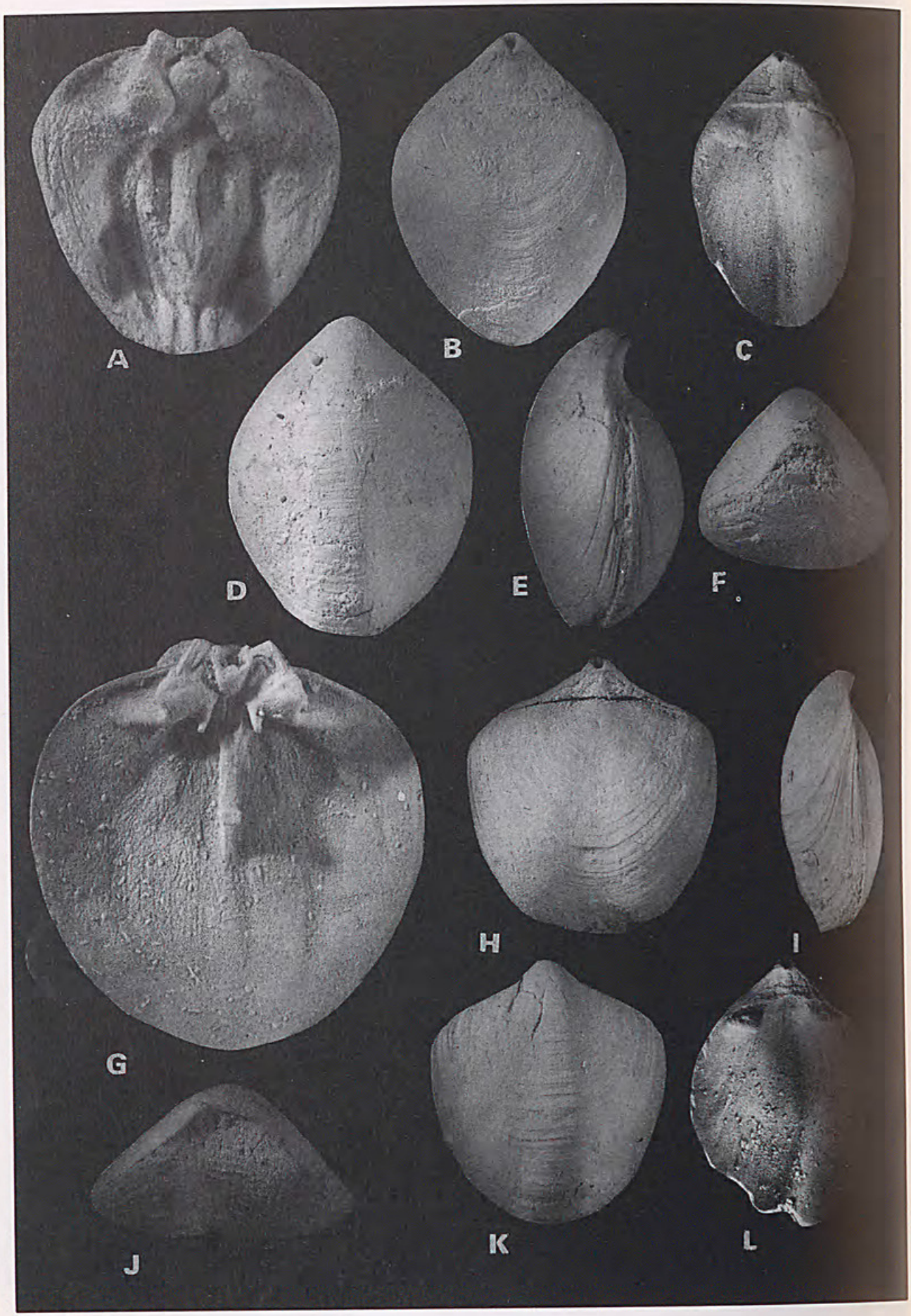
Fig. 1. A–F, *Anakinetica compta* (Sowerby, 1845). A, NMV P86984, dorsal interior, × 2.5. B–E, NMV P86974, dorsal, ventral, lateral, anterior (ventral valve uppermost) views, × 2.5. F, NMV P134202, ventral interior, × 2.5. G–L, *Anakinetica recta* sp. nov. G, paratype WAM 90.245, dorsal interior, × 5. H, J–L, holotype WAM 90.241, anterior (ventral valve uppermost), dorsal, ventral, and lateral views, × 4. I, paratype WAM 90.246, ventral interior, × 4.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Measurements. (In mm).

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P17329	16.8	13.2	12.4	9.2
NMV P17203	16.6	13.2	11.6	7.9
NMV P17204	17.1	13.4	12.4	9.2
NMV P17205	15.1	12.0	11.4	7.8
NMV P17206	15.0	11.9	10.8	8.1
NMV P17207	16.3	12.9	11.9	8.6

Description. Outline trapezoidal with greatest width posterior to mid-length; unequally biconvex, ventral valve deeper than dorsal valve, with median carina and steep lateral slopes; dorsal valve with flattened umbo and shallow median sulcus; anterior commissure narrowly sulcate. Beak suberect; cardinal margin straight; symphytium wide. Hinge platform outline trapezoidal; socket ridges, crural bases and anterior surface of cardinal process fused but identifiable. Median septum long, high anteriorly. Loop with ascending and descending branches having separate attachments to septum. Hinge teeth triangular in outline. Beak interior and lateral walls heavily thickened, leaving round tunnel for pedicle.

Comments. A. tumida closely resembles the Recent species *A. cumingii*. In *A. tumida* the cardinal margin is typically straight and variants with a slightly curved margin are rare, whereas the cardinal margin of *A. cumingii* varies from slightly to moderately curved. The ventral valve of *A. tumida* is always more strongly convex than the dorsal valve; in *A. cumingii* the valves are commonly equal in biconvexity. Fusion of the elements of the cardinalia appears to occur at a later stage in *A. tumida* than in *A. cumingii*; one dorsal valve of the former, 9 mm in length, exhibits medial fusion of the crural bases but not with the anterior surface of the cardinal process, so that a small posterior hinge trough is present at this stage.

Anakinetica breva sp. nov.

Fig. 2G–L

Magasella compta.—Tate 1880: 162–163, pl. 10, fig. 6a–e [non *Anakinetica compta* (Sowerby in Strezlecki, 1845)].

Name. From Latin *brevus* (short), in reference to the beak length.

Type material. Holotype NMV P17348, paratypes NMV P17349, P17350, P134213–P1234216, from the Point Addis Limestone (Janjukian, Upper Oligocene), Aireys Inlet, Victoria.

Other horizons and localities. South Australia. Mannum Formation (Lower Miocene): River Murray cliffs at Mannum. Victoria. Fyansford Formation (Longfordian, Lower Miocene): North Belmont Quarry, Geelong. Puebla Formation (Longfordian Lower Miocene): Jan Juc Point, mouth of Spring Creek, Torquay. Scutellina Limestone (Longfordian, Lower Miocene): Jan Juc, Torquay. All material cited is housed in the Museum of Victoria.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P17348	18.0	15.8	14.9	9.1
NMV P134213	18.6	15.5	15.6	9.7
NMV P134214	17.7	15.6	16.0	9.4
NMV P134215	17.4	15.4	14.4	9.0
NMV P134216	16.1	14.0	12.8	8.6

Description. Outline ovate, greatest width slightly posterior to mid-length. Dorsal valve almost plane, umbo flattened with median sulcus. Anterior commissure deeply and narrowly sulcate. Beak suberect; cardinal margin straight. Hinge platform short, length approximately 3 mm in dorsal valve 15 mm long; outline trapezoidal; anterior surface of cardinal process prominent, fused dorsally. Median septum short, terminating posterior to mid-length. Loop with thin lateral connecting bands. Hinge teeth triangular in outline. Lateral walls and beak interior moderately thickened.

Magadinella Thomson, 1915

Type species. Magasella Woodsiana Tate, 1880 from the Upper Oligocene to Middle Miocene of Australia.

Other species. M. mineuri Richardson, 1987; M. hamiltonensis sp. nov.

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Fig. 2. A–F, *Anakinetica tumida* sp. nov. A, paratype NMV P17330, dorsal interior, × 4. B, D–F, holotype NMV P17329, dorsal, ventral, lateral, and anterior (ventral valve uppermost) views, × 3. C, paratype P17331, ventral interior, × 3. G–L, *Anakinetica breva* sp. nov. G, paratype NMV P17349, dorsal interior, × 4. H–K, holotype NMV P17348, dorsal, lateral, anterior (ventral valve uppermost) and ventral views, × 2.25. L, paratype NMV P17350, ventral interior, × 2.5.

Occurrence. Australia; Upper Oligocene, Miocene, Recent.

Diagnosis. Sulcate. Beak erect to nearly straight; beak ridges sharp; symphytium wide; hinge line slightly to strongly curved. Hinge platform with shallow hinge trough, variable in size; cardinal process with swollen anterior process. Loop with ascending and descending branches fused anteriorly.

Comments. The diagnosis of the genus given by Richardson (1987) has been slightly modified following study of the two Tertiary species. The beak of the Recent species *Magadinella mineuri* is one-fifth to one-sixth the shell length, the symphytium is slightly concave without a median ridge, the cardinal margin is strongly curved, and the cardinalia occupy approximately one-third to one-quarter the length of the dorsal valve. In size and convexity *M. mineuri* and *M. woodsiana* are similar, but the cardinal margin of *M. woodsiana* may be slightly to strongly curved, a median ridge is variably developed on the symphytium, and the hinge platform is shorter relative to dorsal valve length. *M. hamiltonensis* is smaller, not heavily thickened, and the beak, hinge platform, and septum are all shorter than in the other two species.

Magadinella woodsiana (Tate, 1880)

Fig. 3A–F

Magasella Woodsiana Tate 1880: 163–164, pl. 10, fig. 3a–d.—Tate 1899: 256–257.

Magasella compta.—Pritchard 1896: 142–143 [part-tim., non *Anakinetica compta* (Sowerby in Strezlecki, 1945)].

Magadinella woodsiana.—Thomson 1915: 400–402, fig. 13a–c.—Thomson 1927: 277–278, fig. 92a–c.

Type material. Syntypes SAM T886A–K, M, N, from Morrundi, River Murray, South Australia. Horizon unknown.

Other horizons and localities. South Australia. Mount Gambier Limestone (Janjukian, Upper Oligocene): Mount Gambier. Victoria. Calder River Limestone (Janjukian, Upper Oligocene): Wilks' Localities 3 and 4, Aire coast. Point Addis Limestone (Janjukian, Upper Oligocene): Point Addis; Aireys Inlet; Kawarren. Sandford Limestone (Janjukian, Upper Oligocene): quarry on south side of Runymede Road, Sandford. All material cited is housed in the Museum of Victoria.

Measurements. (In mm; specimens from the Point Addis Limestone.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P17341	21.8	18.6	17.2	11.2
NMV P134223	18.0	14.0	12.1	9.9
NMV P134224	18.4	15.0	12.4	10.8
NMV P134225	17.1	14.7	11.2	11.1
NMV P134226	19.2	15.6	10.9	10.0
NMV P134227	17.4	13.9	11.5	9.8

Description. Outline variable, pyriform to ovate (narrowly to broadly) with maximum breadth at mid-length or farther forward; moderately to strongly biconvex. Beak nearly straight to suberect, one-quarter to one-eighth ventral valve length; symphytium flat to slightly concave, median longitudinal ridge variably developed; cardinal margin slightly to strongly curved. Hinge platform with hinge trough between medial borders of fused crural bases and socket ridges; cardinal process anterior surface variable in size, confined to posterior area or extending to posterior border of platform, not fused dorsally. Septum low, blade-like anteriorly, crest rounded posteriorly. Loop with ascending and descending branches fused anteriorly, separate posteriorly.

Comments. M. woodsiana is found in greatest abundance in the Point Addis Limestone. The preceding description is based on examination of hundreds of specimens from a single horizon and supplements Tate's description of the species from Morrundi, an area from which additional material is probably not obtainable.

Magadinella hamiltonensis sp. nov.

Fig 3G–L

Name. From the type locality.

Type material. Holotype NMV P134228 and paratypes NMV P134229–P134233, P134241, P134242, from the Muddy Creek Marl (Balcombian, Middle Miocene), Muddy Creek, Hamilton, Victoria.

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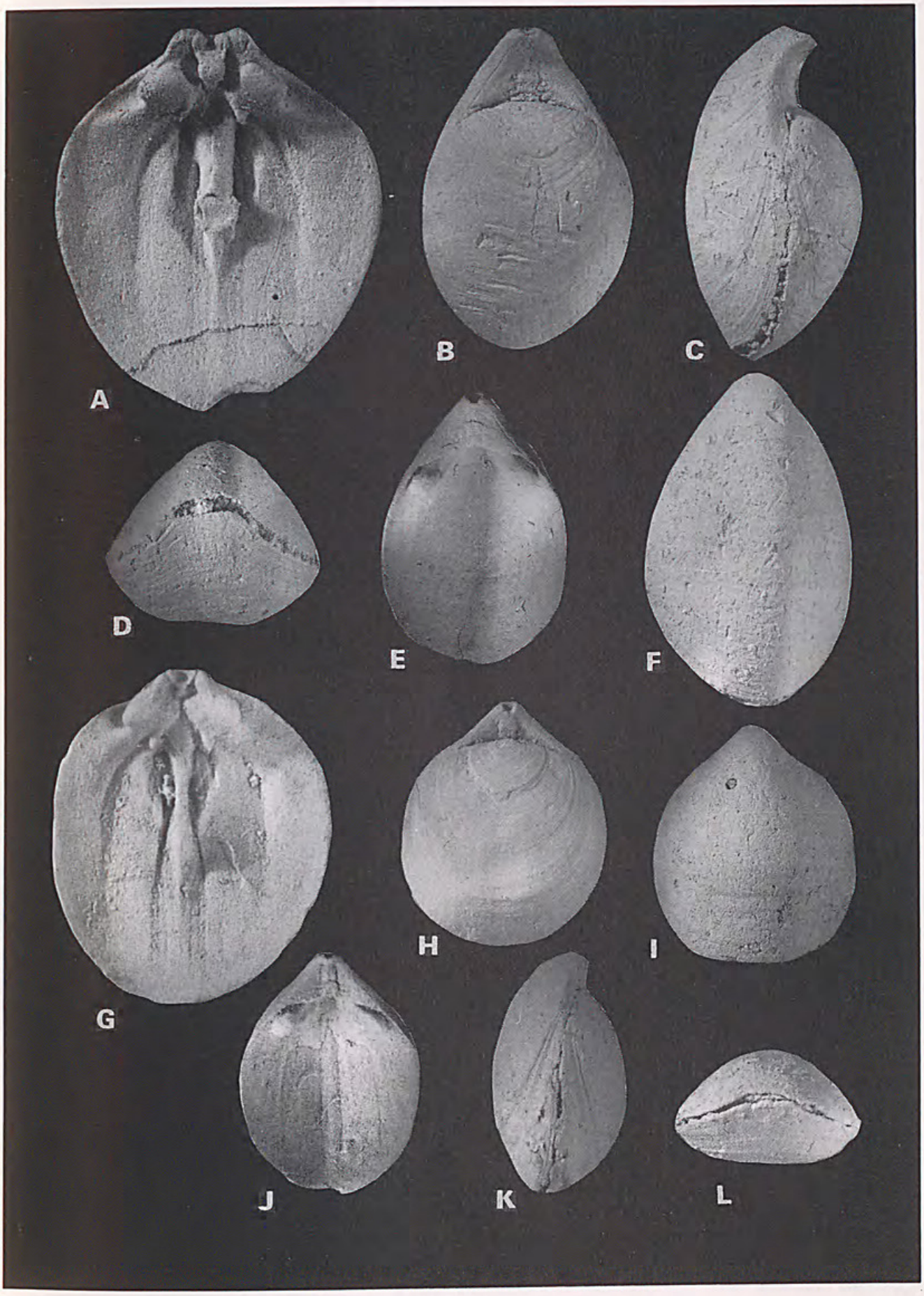
Fig. 3. A–F, *Magadinella woodsiana* (Tate, 1880). A, NMV P134210, dorsal interior, × 3.5. B–D, F, NMV P17341, dorsal, lateral, anterior (ventral valve uppermost) and ventral views, × 2.5. E, NMV P134211, ventral interior, × 2.25. G–L, *Magadinella hamiltonensis* sp. nov. G, paratype NMV P134229, dorsal interior, × 5.5. H, I, K, L, holotype NMV P134228, dorsal, ventral, lateral and anterior (ventral valve uppermost) views, × 3.4. J, paratype P134230, ventral interior, × 3.4.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Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P134228	11.0	9.0	8.6	5.6
NMV P134231	10.3	8.9	8.6	5.6
NMV P134232	10.1	8.7	8.6	5.4
NMV P134230	10.7	8.9	8.2	5.7
NMV P134241	9.3	7.8	7.4	4.8
NMV P134242	8.4	7.6	6.5	3.9

Description. Outline ovate; moderately biconvex. Anterior commissure slightly sulcate. Beak nearly straight, approximately one-fifth of valve length; symphytium slightly concave with median longitudinal ridge; cardinal margin gently curved. Hinge platform with wide, shallow hinge trough; anterior surface of cardinal process slightly variable in size, not extending beyond posterior half of platform. Septum extending to mid-length of valve, high anteriorly. Loop with ascending and descending branches fused anteriorly.

Elderra gen. nov.

Name. From the Aboriginal (handsome). Gender feminine.

Type species. Elderra toorlooensis sp. nov. from the Miocene of Australia.

Diagnosis. Sulcate. Beak suberect, beak ridges sharp; symphytium with median and lateral ridges; cardinal margin curved. Hinge platform with hinge trough. Loop without septal connecting bands.

Comments. Elderra contains only one species which is similar in many features to variants of species included in *Magadinella*, but which is notably less variable in size, shape, beak characters, and in the extent of thickening of the cardinalia. Essential distinguishing features are the loop stage and the ridges which demarcate the borders of the symphytium.

Elderra toorlooensis sp. nov.

Fig. 4A–F

Name. From the type locality.

Type material. Holotype NMV P17351 and paratypes NMV P17352, P17353, P86845, P134217–P134220, from the Gippsland Limestone, Bairnsdale Limestone Member (Bairnsdalian, Middle Miocene), Toorloo Creek, Lakes Entrance, Victoria.

Other horizons and localities. Victoria. Gippsland Limestone, Wuk Wuk Marl Member (Batesfordian–Bairnsdalian, Lower–Middle Miocene): lower beds, Skinner's; lower and upper beds, Drier's. Gippsland Limestone, Bairnsdale Limestone Member (Bairnsdalian, Middle Miocene): Pound Swamp; shaft on Rosehill Farm. Tambo River Formation (Mitchellian, Upper Miocene): cliffs on left bank of Tambo River, Swan Reach; cutting near Toorloo Arm. Unknown Tertiary formation: oil shaft dump, Lakes Entrance. All material cited is housed in the Museum of Victoria.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P17351	33.1	29.0	25.9	16.8
NMV P134217	29.8	25.7	22.7	16.3
NMV P134218	31.1	27.2	22.6	15.7
NMV P134219	19.8	26.2	22.5	15.1
NMV P134220	29.5	25.1	21.0	17.7

Description. Outline ovate, biconvex. Anterior commissure gently sulcate. Symphytium slightly concave, with median ridge and lateral ridges at junctions of symphytium and palintropes. Hinge platform trapezoidal in outline; socket ridges projecting posteriorly beyond umbo as two pointed processes, fused anteriorly with swollen crural bases; hinge trough extending length of platform, deeper posteriorly; cardinal process with slightly bulbous anterior surface. Septum short, base thick, crest sharp.

Comments. Little morphological variation is evident in specimens from the environs of Toorloo Creek and the Tambo and Mitchell Rivers. The specimens collected from an oil shaft dump at Lakes Entrance are smaller in size and slightly narrower in outline with stronger curvature of the cardinal margin, features which alone do not justify taxonomic separation.

Adnatida gen. nov.

Name. From the Latin *adnatus* (united), in reference to the components of the cardinalia. Gender feminine.

Type species. Magasella deformis Tate, 1880 from the Eocene of Australia.

Other species. A. gnangarensis sp. nov.

Diagnosis. Sulcate. Beak pointed, erect, foramen small; symphytium concave; beak ridges and cardinal margin curved. Hinge platform heavily thickened without hinge trough or pits, with posterior surface of cardinal process only identifiable structure.

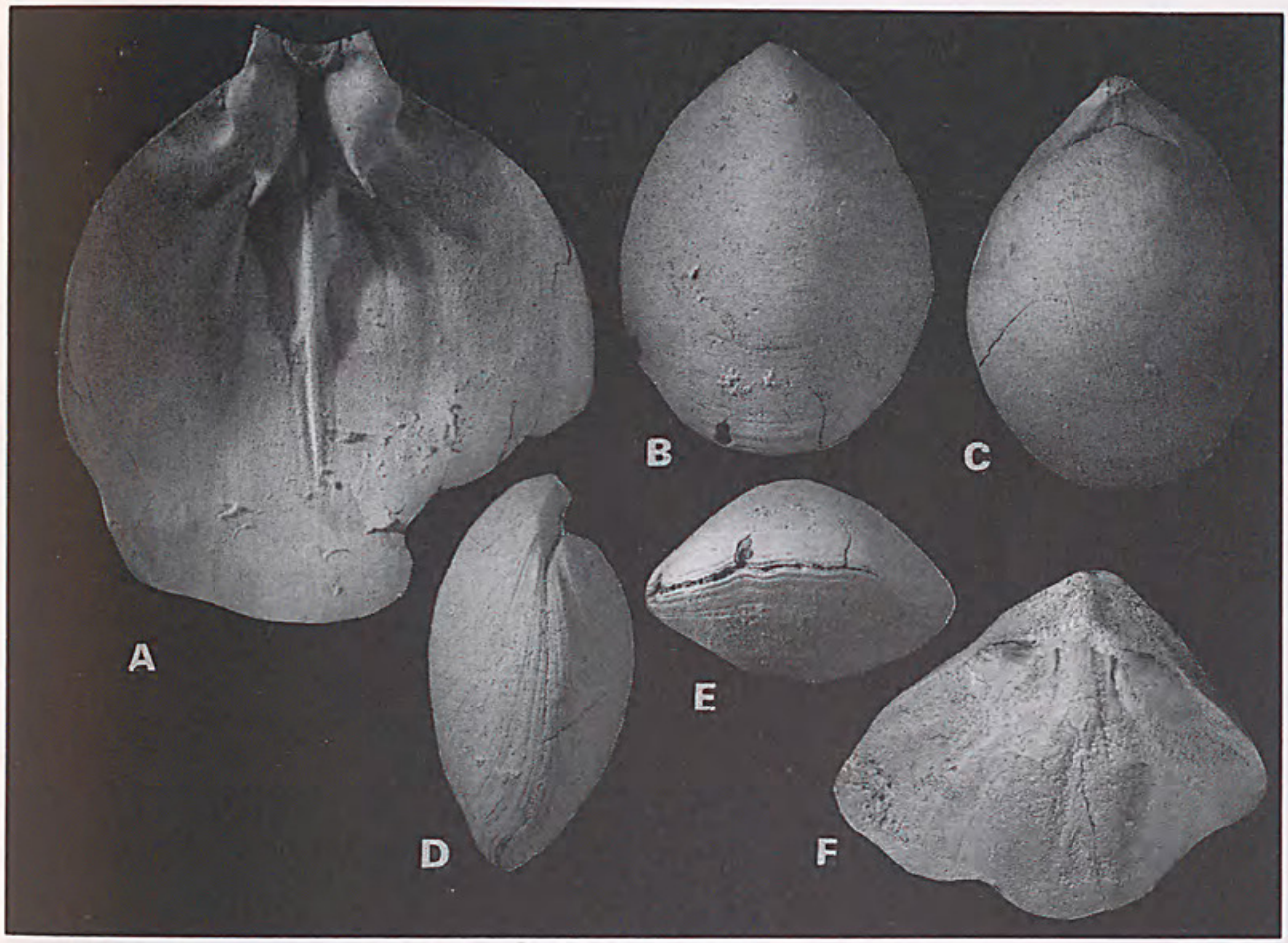


Fig. 4. A–F, *Elderra toorlooensis* sp. nov. A, paratype NMV P17352, dorsal interior, × 2.6. B–E, holotype NMV P17351, dorsal, ventral, lateral and anterior (ventral valve uppermost) views, × 1.25. F, paratype NMV P17353, ventral interior × 1.7.

Comments. The heavily thickened hinge platforms of the two species included in *Adnatida* appear to contain no sites for muscle attachment other than the posterior surface of the cardinal process (attachment surface of the diductor muscles). The absence of a hinge trough or pits, together with the small erect beak and tiny foramen, are indicators of an atrophied pedicle system and a free-lying existence. The appearance of the hinge platform suggests that a lifestyle characteristic of species of *Anakinetica* would have preceded loss of pedicle function in the species of *Adnatida*.

The species of *Adnatida* may be differentiated externally by the curvature of the cardinal margin (moderate in *A. deformis*, strong in *A. gnangarensis*), degree of sulcation (moderate in *A. gnangarensis*, strong in *A. deformis*), shape (broadly ovate in *A. deformis*, pyriform in *A. gnangarensis*) and in the pronounced convexity of the dorsal valve of *A.deformis*. The loop of neither species has been preserved, but the condition of the septum suggests that the loop of *A. deformis* would show ascending and descending branches, whereas that of *A. gnangarensis* would have fused branches with thin, lateral connecting bands.

Adnatida deformis (Tate, 1880)

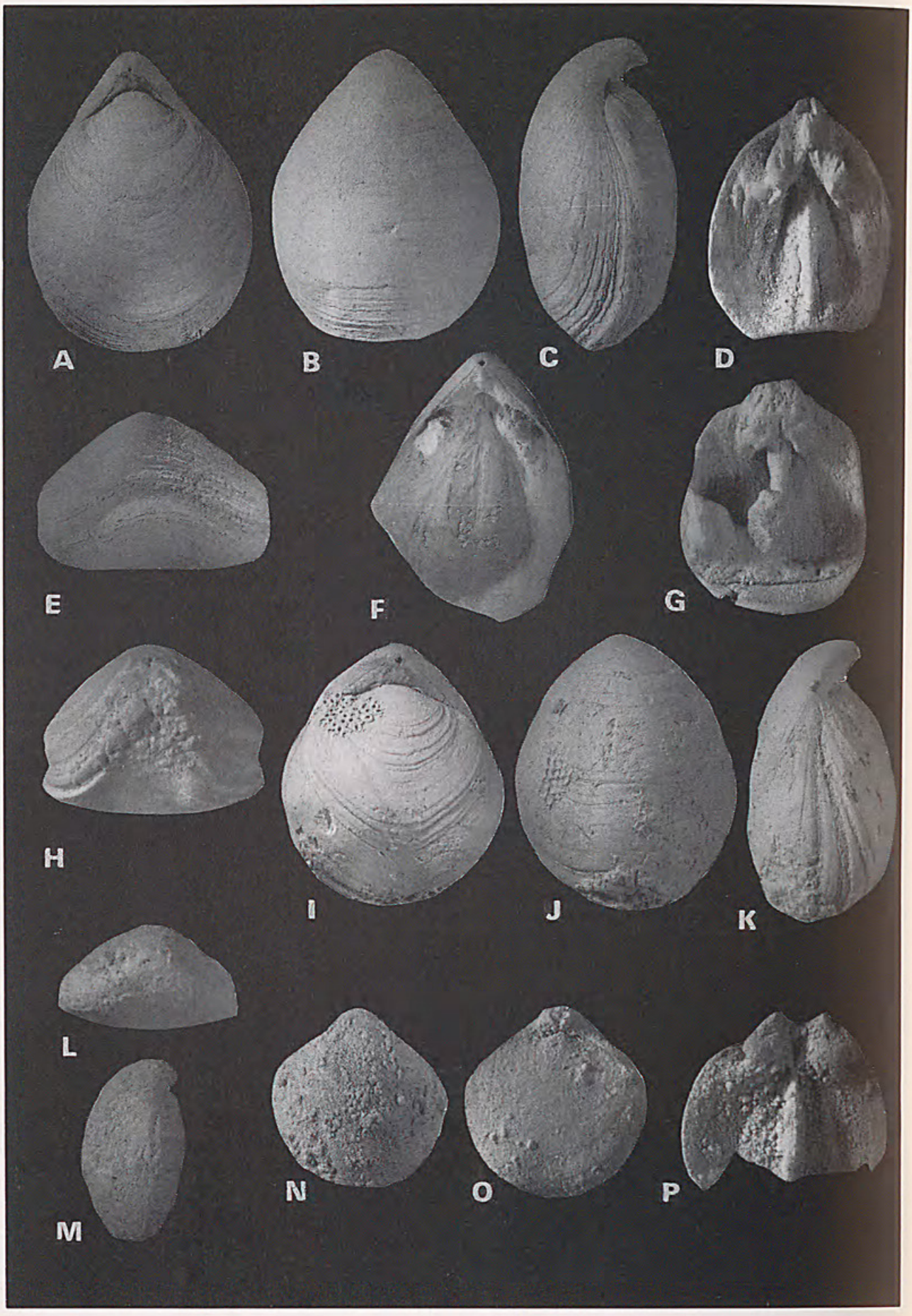
Fig. 5G–K

Magasella deformis Tate 1880: 165–166, pl. 10, fig. 5a–c.

Magadina(?) deformis.—Thomson 1927: 267.

Type material. Five syntypes, SAM T888A–E, from the Tortachilla Limestone (Eocene), Maslin Bay, Aldinga, South Australia.

Description. Length of figured specimen (Fig. 5H–K) 11.7 mm, breadth 9.2 mm, depth 6.6 mm. Strongly sulcate. Outline broadly ovate, greatest width just anterior to mid-length. Symphytium slightly concave; cardinal margin slightly curved. Hinge platform almost circular in outline; posterior surface of cardinal process roughened, slightly lower than surrounding plat-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form. Septum terminating anterior to mid-length, high anteriorly, posterior segment with blunt crest. Loop unknown.

Adnatida gnangarensis sp. nov.

Fig. 5A–F

Name. From the type locality.

Type material. Holotype WAM 90.247 and two paratypes WAM 90.248, 90.249 from the Western Australian Mines Department Bore No. 5, 44.2 to 46.3 m (Pliocene to Lower Pleistocene), Gnangara, Western Australia.

Description. Length of holotype 18.1 mm, breadth 13.4 mm, depth 9.0 mm. Moderately sulcate. Outline pyriform, greatest width just anterior to mid-length. Symphytium concave, cardinal margin strongly curved. Hinge platform outline elongately triangular; cardinal process with lateral segments of posterior surface incurved, rim and presumed anterior surface elevated above surrounding fused elements; anterior border indented at union with septum. Septum terminating anterior to mid-length, crest bladelike. Loop unknown.

Magadina Thomson, 1915

Type species. Magadina browni Thomson, 1915 from the Miocene of New Zealand.

Other species. M. clifdenensis Finlay, 1924; *M. thomsoni* Finlay, 1924; *M. waipariensis* Thomson, 1915; *Magasella lunata* Tate 1899.

Occurrence. Australia, New Zealand; Oligocene–Miocene.

Comments. Thomson's diagnoses (1915, 1927) included Australian species now referred to *Anakinetica* (*compta, cumingii*), *Bouchardiella* (*cretacea*), and *Parakinetica* (*deformis*). The only Australian species now included in the genus is *M. lunata. Magadina* is distinguished from other members of the subfamily in the presence of a deep hinge trough extending the full length of the platform, and in the absence of any medial fusion of the crural bases and/or the anterior surface of the cardinal process.

Magadina lunata (Tate, 1899)

Fig. 5L–P

Magasella lunata Tate 1899: 256, pl. 8, fig. 3, 3a.
(?) *Magadina lunata.*—Thomson 1927: 276.

Type material. Holotype SAM T1724A from Croydon Bore at 122 to 375 m (Miocene), Adelaide, South Australia.

Other horizon and locality. South Australia. Mannum Formation (Lower Miocene): quarry at Mannum. Material housed in the Museum of Victoria.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
SAM T1724A	7.1	6.3	6.9	3.8
NMV P134235	6.9	5.7	7.2	4.1
NMV P134236	7.2	6.1	7.0	4.3
NMV P134237	7.1	6.2	6.6	4.3
NMV P134238	5.6	4.8	6.2	2.8

Description. Outline nearly circular; unequally biconvex, dorsal valve nearly plane. Anterior commissure broadly sulcate. Beak suberect, short; deltidial plates conjunct; cardinal margin slightly curved. Hinge platform wide, short; crural bases and socket ridges fused, hinge trough wide, deep; cardinal process small, not projecting into hinge trough. Septum terminating just anterior to mid-length of valve, high anteriorly. Loop with ascending and descending branches separate.

Comments. The Tate Collection in the Department of Geology, University of Adelaide, contains a card with five specimens (T1724A–E) labelled *Magasella lunata.* Only one of these specimens, T1724A, possesses all the external features described and figured by Tate (1899). This specimen is plano-convex with anterior sulcation, a permesothyrid foramen, fused concave deltidial plates, and a curved cardinal margin. The remaining specimens are also plano-convex and sulcate but they display different beak characters (a hypothyrid foramen, rudimentary deltidial plates, and a nearly straight cardinal

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Fig. 5. A–F, *Adnatida gnangarensis* sp. nov. A–C, E, holotype WAM 90.247, dorsal, ventral, lateral and anterior (dorsal valve uppermost) views, × 2.5. D, paratype WAM 90.248, dorsal interior × 2.5. F, paratype WAM 90.249, ventral interior, × 2.5. G–K, *Adnatida deformis* (Tate, 1880). G, NMV P134212, dorsal interior, × 3.5. H–K, NMV P134240, anterior (ventral valve uppermost), dorsal, ventral and lateral views, × 3.5. L–P, *Magadina lunata* (Tate, 1899). L–O, NMV P134235, anterior (ventral valve uppermost), lateral, ventral and dorsal views, × 4. P, NMV P87579, dorsal interior, × 5.

margin) and were referred to *Malleia portlandica* by Richardson (1973b). The above description of the species is based on specimens collected in the Mannum Formation.

M. lunata is smaller in size than the New Zealand species. The largest specimen of *M. lunata* is 7.2 mm in length; the largest specimen of *M. browni* from the Museum of Victoria's collection is 13.3 mm. *M. lunata* resembles *M. clifdenensis* in beak and cardinal margin, both of which are shorter than in *M. browni*. The hinge platform of *M. lunata* differs from that of New Zealand species in its greater width and in the socket ridges, which are less strongly convergent and project beyond the margin of the valve for approximately half their lengths.

Pilkena gen. nov.

Name. From the Aboriginal *pilkena* (different). Gender feminine.

Type species. Pilkena compressa sp. nov. from the Oligocene of Australia.

Diagnosis. Sulcate. Beak nearly straight, beak ridges sharp; symphytium with low median ridge; cardinal margin slightly curved. Hinge platform with posterior pits for attachment of dorsal adjustor muscles. Loop long, reflected, without septal connecting bands.

Comments. The hinge platform of *Pilkena* is similar to that of *Anakinetica* in the absence of a hinge trough and the presence of posterior pits for attachment of the dorsal adjustor muscles. *Pilkena* is distinguished from *Anakinetica* by the more advanced loop and by the position of the hinge platform relative to the valve surface. The hinge platform of *Pilkena* does not extend beyond the margin of the dorsal valve, so that the tip of the dorsal umbo is visible. In addition, the posterior surface of the cardinal process is steeply inclined, and consequently both the posterior surface and the posterior pits face posteroventrally rather than ventrally as in *Anakinetica*. These features indicate that substrate relationships would differ in some respect from *Anakinetica*.

Pilkena compressa sp. nov.

Fig. 6A–F

Name. From the Latin *compressus* (compressed).

Type material. Holotype NMV P3629 and paratypes NMV P3627–P3633, P134221 from the Gellibrand Marl (Janjukian, Upper Oligocene), 1.6 km west of Sherbrooke River, near Port Campbell, Victoria.

Additional locality. Jan Juc Formation (Janjukian): Bird Rock Cliffs, Torquay, Victoria.

Measurements. (In mm.)

Specimen	Total length	Dorsal valve length	Breadth	Depth
NMV P3629	27.2	22.4	20.1	9.9
NMV P3627	28.6	24.3	22.6	9.8
NMV P3631	27.3	23.0	20.4	10.3
NMV P3632	25.2	21.8	20.0	9.8
NMV P3628	20.8	18.2	14.9	7.2

Description. Outline ovate, shallowly biconvex, ventral valve carinate, dorsal valve sulcate. Symphytium flat with median ridge. Cardinal platform outline triangular with broad anterior base narrowing to posterior apex; central rounded area (presumed anterior surface of cardinal process) bordered laterally by socket ridges, posterolaterally by pits and posteriorly by posterior surface of cardinal process. Median septum short, thick, with blade-like ventral edge, without traces of connecting bands. Teeth triangular, base almost flush with edge of valve, walls not excessively thickened.

Aliquantula gen. nov.

Name. From Latin *aliquantulus* (small), in reference to the foramen.

Type species. Waldheimia(?) insolita Tate, 1880 from the Eocene of Australia.

Diagnosis. Weakly sulcate. Beak suberect, foramen small; beak ridges sharp; cardinal margin curved. Hinge platform with small posterior hinge trough; swollen crural bases fused or almost fused medially; socket ridges not projecting beyond umbo; cardinal process small, discrete. Loop without septal connecting bands.

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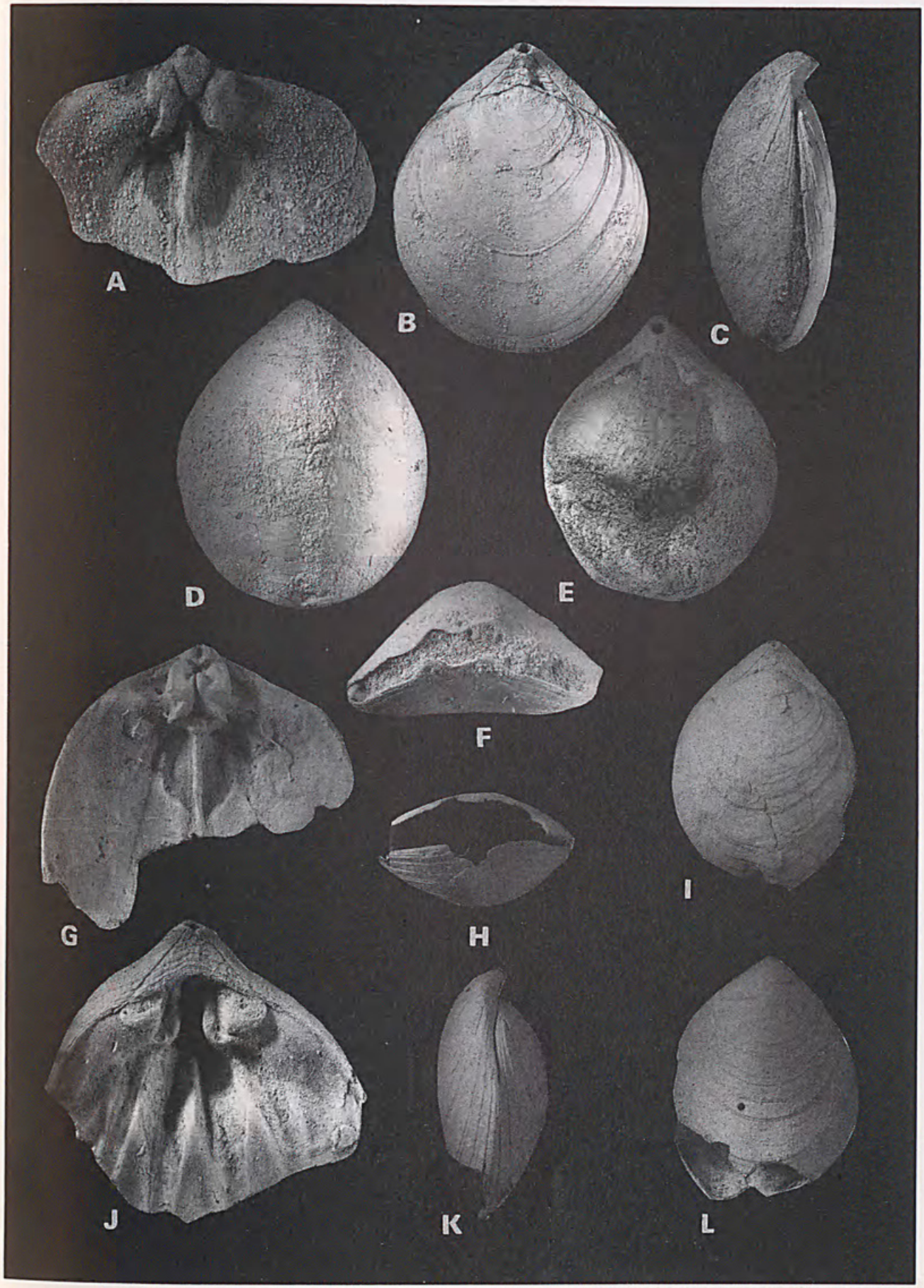
Fig. 6. A–F, *Pilkena compressa* sp. nov. A, paratype NMV P3630, dorsal interior, × 2.5. B–D, F, holotype NMV P3629, dorsal, lateral, ventral and anterior (ventral valve uppermost) views, × 1.8. E, paratype NMV P3633, ventral interior, × 1.5. G–L, *Aliquantula insolita* (Tate, 1880). G, NMV P134775, dorsal interior, × 2.3. H, I, K, L, NMV P134774, anterior (ventral valve uppermost), dorsal, lateral and ventral views, × 1.3. J, NMV P134776, ventral interior, × 2.3.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Comments. The partial to total infilling of the hinge trough is one of the characteristic features of members of the Anakineticinae. *Magadinella* and young individuals of *Anakinetica* and *Parakinetica* show that reduction in size and/or total infilling of the hinge trough is the result of enlargement of the cardinal process (anterior surface) which fuses anteriorly with the crural bases. *Aliquantula* shows a different mode of infilling, with swollen crural bases which may be fused medially but which do not fuse with the cardinal process. As a result, a tiny posterior hinge trough is delimited. In characters of the cardinalia, *Aliquantula* closely resembles the Japanese genus *Nipponithyris*, but the latter differs in beak characters and in loop pattern.

Aliquantula insolita (Tate, 1880)

Fig. 6G–L

Waldheimia(?) insolita Tate 1880: 151–152 (partim.), pl. 9, fig. 6b.
Magellania insolita Tate 1899: 282 (partim.).
(?) *Stethothyris(?) insolita* Thomson 1927: 282.

Type material. Syntypes SAM T908A–E, G, H, from the Tortachilla Limestone (Eocene), Maslin Bay, Aldinga, South Australia.

Other horizons and localities. South Australia. Blanche Point Marl (Eocene): Maslin Bay, Aldinga. Victoria. Castle Cove Limestone (Lower Oligocene): Castle Cove (Wilks' locality No.5); mouth of Johanna River. Browns Creek Clay (Eocene): Browns Creek, Aire River district. Browns Creek Clay, greensand member (Eocene): Hamilton Creek, Aire River district. Material cited is housed in the Museum of Victoria.

Description. Length of figured specimen (Fig. 6 H–I, K–L) 28.8 mm, dorsal valve length, 25.4 mm, breadth 22.1 mm, depth 12.4 mm. Outline ovate, biconvex. Anterior commissure slightly sulcate. Hinge platform outline ovate; socket ridges incurved, not projecting beyond valve margin; crural bases fused with anterior halves of socket ridges; posterior hinge trough small, deep; cardinal process almost circular in outline, anterior surface slightly swollen. Septum short, blade-like, without loop attachments. Ventral valve interior with heavily thickened posterolateral walls, beak cavity reduced to narrow tunnel. Hinge teeth irregular in outline, overlying heavy lateral thickenings in posterior region of valve immediately anterior to beak.

Comments. Of Tate's syntypes, specimen SAM T908A has previously been referred to *Aldingia furculifera* by Richardson (1973a).

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