Pentamerid Brachiopods from the Lower Silurian (Wenlock) Canberra Formation, A.C.T., Australia

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Pentamerid brachiopods are rare in the Wenlock-age Canberra Formation, but re-examination of old collections held by Geoscience Australia revealed the presence of four recognisable taxa, described here. The gypiduline *Ascanigypa glabra* (Mitchell) was originally described from Yass, northwest of Canberra, and has since been recorded from areas farther south; the latter records are revised. The pentamerides are *Apopentamerus clarkei* Strusz, *Kirkidium (Kirkidium) canberrense* sp. nov., and *Rhipidium (Pararhipidium) oepiki* sp. nov.

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Key words: *Apopentamerus*, *Ascanigypa*, brachiopods, Canberra, *Kirkidium*, *Rhipidium (Pararhipidium)*, Silurian, Wenlock.

INTRODUCTION

The geology of the city of Canberra is well known as a result of extensive work by the Engineering Geology group of the former Commonwealth Bureau of Mineral Resources, based largely on temporary exposures, and is structurally complex (see Henderson and Matveev 1980). Öpik (1958), who was the first to compile a relatively detailed account, recognised a sequence of rocks ranging in age from Late Ordovician to Early Devonian. The Ordovician strata have been dated using the graptolites identified by Öpik, but these are uncommon and have not been formally described. Unconformable on the Ordovician rocks are two sedimentary units, the Black Mountain Sandstone and the State Circle Shale (See Fig. 1). The former is unfossiliferous, and was thought by Öpik to be of Ordovician age, but has since been shown to be conformable with the State Circle Shale (Crook et al. 1973; Henderson 1973; Strusz and Jenkins 1982). The latter has been dated by its sparse graptolite fauna as late Llandovery in age.

Unconformably overlying these Llandovery strata is a thick and complex sequence of sedimentary and interfingering acid volcanic rocks of Wenlock age (for detailed age discussion, see Strusz and Percival 2018, and Percival and Zhen 2017). Öpik (1958) divided this into a number of discrete formations making up the Canberra Group, but because it has since been recognised that these units are largely unmappable in Canberra's complex and poorly outcropping geology, the Group is now referred to as the Canberra Formation. At the base of the formation is a discontinuous layer of ferruginous quartz-rich sandstone, Öpik's Camp Hill Sandstone. He noted the presence in this sandstone (now a Member of the Canberra Formation) of 'a shelly fauna with corals, brachiopods, and trilobites. Notable is the pentamerid brachiopod *Rhipidium*, previously known only from the Lower Silurian of north-eastern North America.'

While Öpik's collections were incorporated in the then Bureau of Mineral Resources collections during 1980-1981, not long prior to his death in January 1983, only the first of the studies of Canberra brachiopod faunas published in the 1980s (Strusz 1982, 1984, 1985) contained a very limited pentameride component, and the localities involved in that paper had not been available to Öpik. Pentameride brachiopods are uncommon or absent in most collections from Canberra, and fossil preservation (other than the material used in Strusz 1982, from the Walker Volcanics) is generally poor. Moreover, the mudstones prevalent in the Canberra Formation have been subjected to significant compression, leading

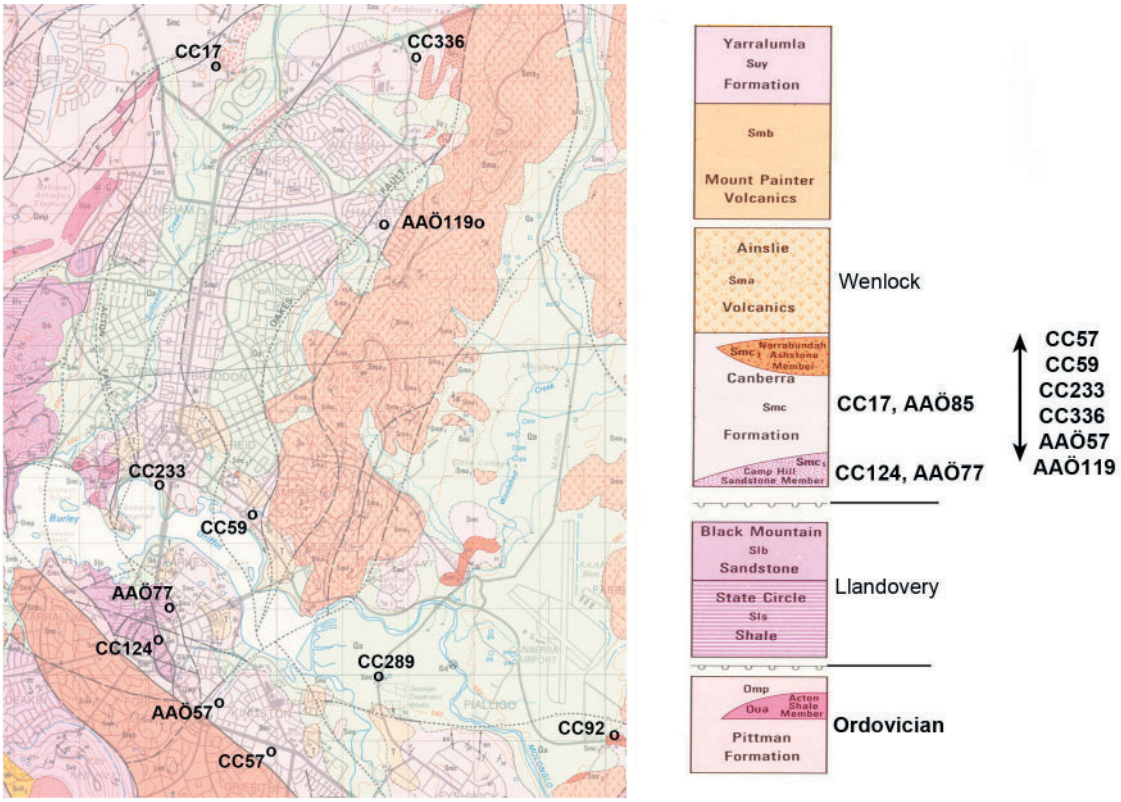

Figure 1. Modified portions of Henderson & Matveev (1980), showing the positions of the pentamerid localities on the geological map. Their distribution is also plotted against the stratigraphic column - only CC17, CC124 and AAÖ77 are reasonably well constrained.

to moderate to strong distortion. It is only now, following revision of the Yass faunas, description of a comparatively well preserved fauna excavated near Canberra airport (Strusz 2011), and a study of the coeval fauna in the Delegate River Mudstone at Quidong (Strusz and Percival 2018), that a proper investigation is possible.

Öpik's identification of *Rhipidium* in the Camp Hill Sandstone Member has proved correct, the material being good enough to recognise it as a new species of the subgenus *R. (Pararhipidium)* Boucot and Johnson, 1979. Accompanying this is the retziellide *Retziella* (very similar to that in the Delegate River Mudstone), atrypides, encrinuride trilobites, and unidentifiable corals. Scattered across a number of localities in the Canberra Formation are the pentamerids *Kirkidium (Kirkidium) canberrense* sp. nov. and *Apopentamerus clarkei* Strusz 2011, and the gypidulide *Ascanigypa glabra* (Mitchell 1921). The last-named was originally described from the Silverdale Formation at Yass, northwest of Canberra, and has subsequently been recognised at Quidong (Strusz and Percival 2018). Poorly preserved specimens from the Cappanana Formation east of Cooma (Strusz 2013) previously tentatively assigned to *A. clarkei*, are now identified as *A. glabra*.

SYSTEMATIC PALAEONTOLOGY

The classification followed is that in the Treatise on Invertebrate Paleontology, part H, volume 4 (Kaesler 2002); all references to authorship above the generic level will be found therein, and so are not repeated here.

All material used in this study is registered in the Commonwealth Palaeontological Collection, held by Geoscience Australia, Canberra (number prefix CPC). It was collected by staff of the former Commonwealth Bureau of Mineral Resources (now Geoscience Australia), and by Armin Öpik in his own time. Much unpublished material from Canberra and its surrounds is stored by Geoscience Australia under original locality numbers. A detailed list of the localities referred to herein is appended to the end of this paper.

Order PENTAMERIDA Schuchert and Cooper, 1931
Suborder PENTAMERIDINA Schuchert and Cooper, 1931
Superfamily PENTAMEROIDEA M'Coy, 1844
Family PENTAMERIDAE M'Coy, 1844
Genus *Kirkidium* Amsden Boucot and Johnson, 1967

Type species

Pentamerus knightii J. Sowerby, 1813. Aymestry Limestone Formation, Shropshire, England. Early Ludlow (Gorstian).

Remarks

I follow Bassett (1977:20) in the spelling of the specific name, taking note of his reference to the final ruling in ICZN Opinion 297 that the original spelling should be retained. This is also the usage of Cocks (2008).

Kirkidium (Kirkidium) Boucot and Johnson, 1967

Diagnosis

Strongly ventribiconvex non-trilobate pentameride, coarsely costate, with relatively long incurved ventral beak and palintrope; long ventral median septum and discrete subparallel hinge plates (new, after Boucot et al. in Kaesler, 2002).

Kirkidium (Kirkidium) canberrense sp. nov.
Fig. 2

Synonymy

Kirkidium? sp. Strusz and Percival 2018: 110, Fig. 18

Type material

Holotype CPC44243, paratypes CPC44238-44242, 44244-44253, locality AAÖ119.

Other material

CPC44230-44237, locality CC59; CPC44254?, locality CC233.

Distribution

Canberra Formation, Canberra; Delegate River Mudstone, Quidong, southern NSW.

Diagnosis

Species of *Kirkidium (Kirkidium)* with ventral median septum extending between 1/2 and 3/4 valve length and supporting small spondylium, and narrow outer hinge plates.

Description

Shell moderately to strongly ventribiconvex, at least 30 mm long, thickness about 2/3 length. Outline variable, from elongate suboval to elongate pyriform with greatest width anterior to mid-length, width about 3/5 to 4/5 length. Ventral umbo long, beak pointed, moderately incurved and well clear of dorsal beak; palintrope smooth, clearly separated from outer valve surface; delthyrium large, partly closed by dorsal beak; no visible deltidium. Dorsal umbo low, beak pointed, erect to slightly incurved. Ribs coarse, sharply rounded to angular, 6-8 in 10 mm at a radius of 20 mm, generally simple but occasionally bifurcate. There is a faint ventral sulcus anteriorly in some shells.

Ventral interior with thin, posteriorly high median septum extending beyond mid-length to as much as 3/4 valve length, and supporting small spondylium. Dorsal internal structures not well preserved. Discrete weakly divergent inner hinge plates extend to about 1/4 valve length, with distinct myophragm between anterior ends; outer hinge plates small, junction with inner hinge plates tightly but smoothly curved.

Remarks

The Canberra specimens are rather small, but in both external and ventral internal structure agree with specimens of similar size from the Delegate River Mudstone at Quidong, tentatively assigned to *Kirkidium* by Strusz and Percival (2018, p. 110, Fig. 18). The Quidong form includes larger specimens - up to about 62 mm long.

In outline, based on a plot of data from published illustrations, this species is a typical *Kirkidium* - very variable, but generally pyriform in outline and about as wide as long in smaller shells, becoming more elongate as size increases. Only *K. (K.) alaskense* (Kirk and Amsden, 1952) differs from this pattern in staying nearly as wide as long in large shells. Alexander (1948), Lamont (1965) and Bassett (1979) have noted the strong variability in outline of the type species *K. (K.) knightii*, but greater consistency in its internal structure - a very long ventral median septum supporting a long spondylium (much longer than in the Canberra species). Sapelnikov (1972) redescribed and illustrated a number of species from the Urals and the Tien-shan. *Kirkidium (K.) vogulicum* (Verneuil, 1845), as figured also by Johnson et al. (1976), is very close to *K. (K.) knightii*; according to Sapelnikov it differs only in greater variability in internal structure, so they could be conspecific. *Kirkidium (K.) pseudobiloculare* (Sapelnikov, 1961) is distinctive in having a very short ventral median septum, supporting only apically a very long and narrow spondylium. Internally closer

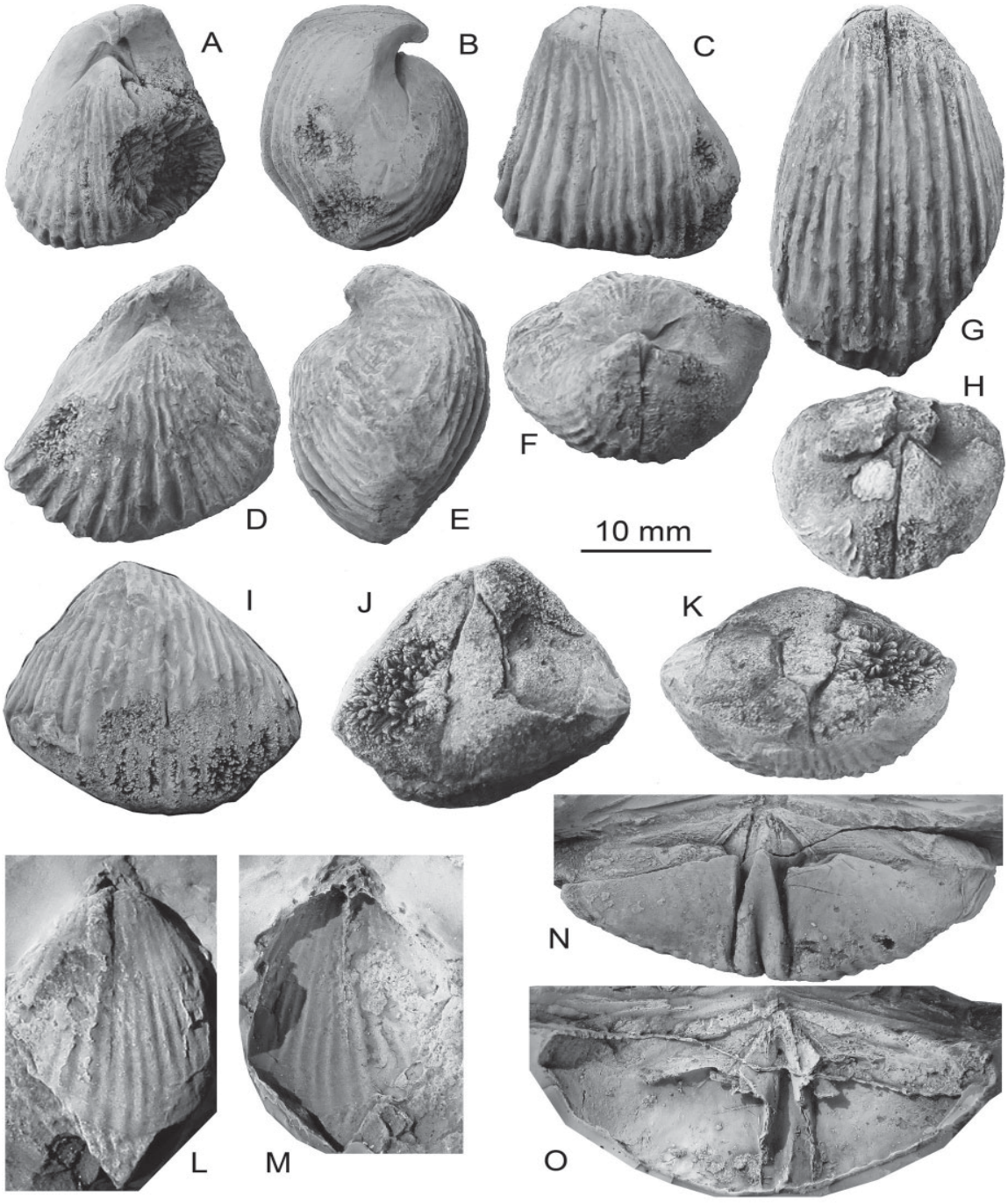

Figure 2. A-M, *Kirkidium* (*Kirkidium*) *canberrense* sp. nov., Canberra Formation, Wenlock; A-C, holotype CPC44243, locality AAÖ119, slightly worn shell in dorsal, lateral and ventral views; D-F, paratype CPC44248, worn shell in dorsal, lateral and posterior views, the last showing small spondylium and supporting septum; G-H, paratype CPC44244, worn elongate shell in ventral and posterior views; I-K, paratype CPC44249, heavily worn shell in ventral, posterior (ventral valve above) and postero-ventral views, showing cross-section of spondylium, and small teeth; L-M, CPC44234, locality CC59, incomplete ventral valve internal mould and latex cast. N-O, ?*K.* (*K.*) *canberrense*, CPC44254, locality CC233, umbonal region of large dorsal valve internal mould and latex cast, showing relatively large outer hinge plates, narrow dental sockets, and prominent myophragm.

to *K. (K.) canberrense* is *K. (K.) laqueatiformis* (Sapelnikov, 1961), which is described as having a low septum only 1/6 to 1/4 the valve length, apically supporting a narrow spondylium which rarely extends forward much beyond the mid-length - i.e. a shorter septum and longer spondylium than in the Canberra species. Moreover, in Sapelnikov's species the outer hinge plates are very wide, and there is a distinct ctenophoridium.

CPC44254 (Figs 2N-O) is a larger, but badly crushed, dorsal internal mould which appears to be elongate oval in outline. The posterior end is better preserved than in the type specimens, with a prominent curved palintrope, relatively larger outer hinge plates, and somewhat longer subparallel inner hinge plates separated anteriorly by a strong myophragm. Initially thought to be *Rhipidium (Pararhipidium)* (see below), the elongate oval outline argues against that. The stronger inner hinge plates and coarser ribs are more like those of *K. (K.) canberrense*, to which it is here tentatively assigned as a gerontic individual.

Kirkidium (Kirkidium?) sp. indet.
Fig. 3

Figure 3. *Kirkidium* (*Kirkidium*?) sp. indet. CPC44293, locality CC124, Camp Hill Member, Canberra Formation; Wenlock. Damaged ventral valve internal mould showing large pointed beak, large spondylium, and anterior end of median septum.

Material

CPC44293, locality CC124.

Discussion

A single large but incomplete and damaged ventral internal mould from locality CC124 is pyriform in outline, with a well developed spondylium and the trace of a long median septum. It differs from other specimens from that locality, here assigned to *Rhipidium (Pararhipidium),* in its coarser costae and prominent spondylium. The costae are as in *K. (K.) canberrense*, but the spondylium is much larger, and the beak is erect rather than strongly incurved. In these respects it more closely resembles *K. (K.) knightii*, which is known from elsewhere in New South Wales (Etheridge 1892), but this single specimen is insufficient for confident specific identification.

Genus *Apopentamerus* Boucot and Johnson, 1979

Type species

Apopentamerus racinensis Boucot and Johnson, 1979. Racine Dolomite, Wenlock, Wisconsin, U.S.A.

Diagnosis

Smooth non-lobate pentamerid, moderately to strongly biconvex with ventral valve usually deeper than dorsal valve; outline transversely oval to pyriform; ventral median septum long, supporting narrow spondylium; inner hinge plates subparallel, long, their junction with outer hinge plates smooth, without flanges (Strusz 2011).

Apopentamerus clarkei Strusz, 2011
Fig. 4

Synonymy

Apopentamerus clarkei Strusz, 2011: 37-39, Fig. 5, cum syn.

non cf. *Apopentamerus clarkei* Strusz; Strusz 2013:9-10, Fig. 7.

Diagnosis

Large strongly pyriform ventribiconvex *Apopentamerus* with prominent ventral beak, long ventral median septum, narrow spondylium, very long subparallel inner hinge plates (Strusz 2011)

Material

CPC44255-44257, locality CC57; CPC44258, locality CC92; CPC44259, locality CC336; CPC44260, locality AAÖ85.

Distribution

Canberra Formation including Camp Hill Sandstone Member.

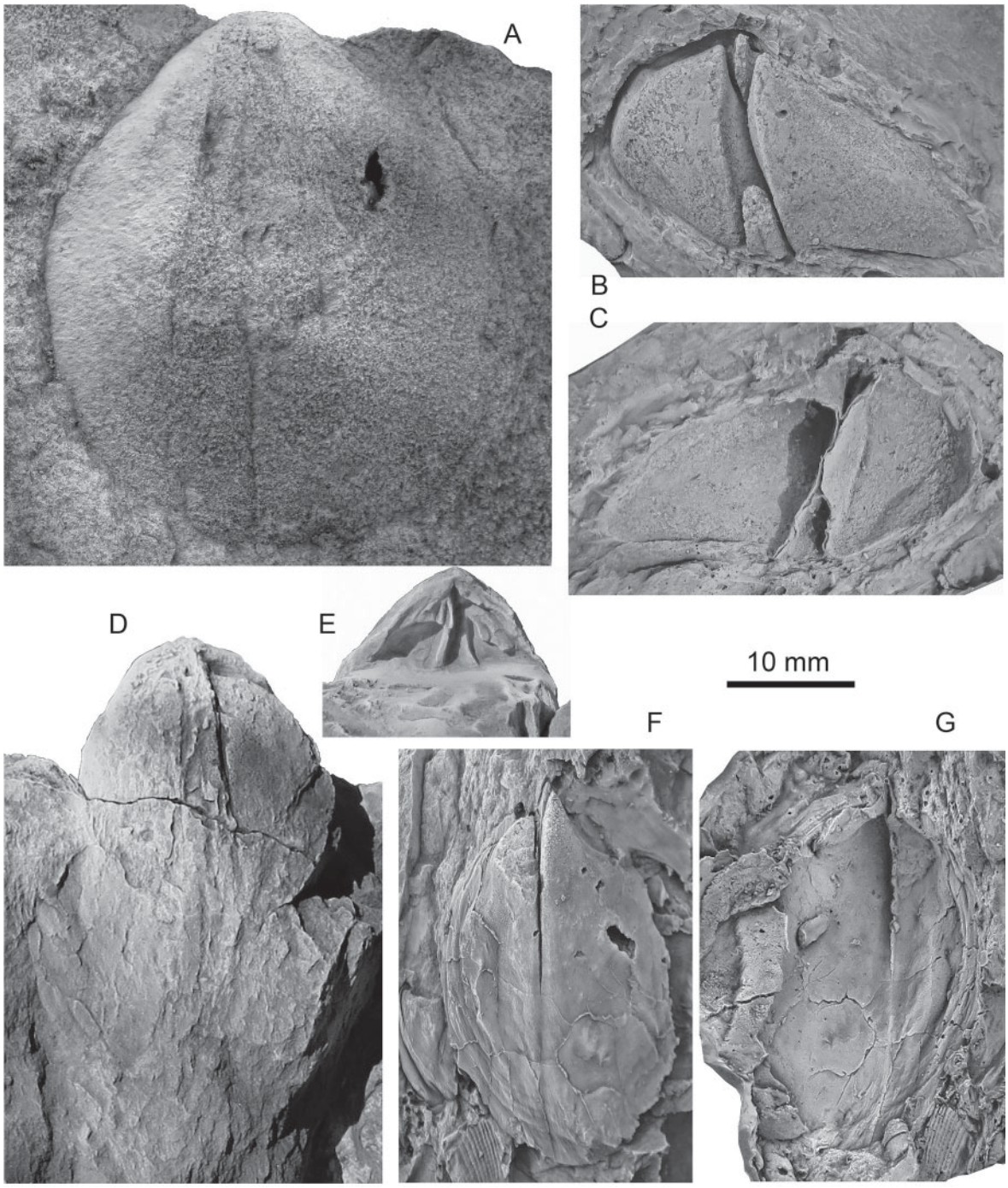

Figure 4. ***Apopentamerus clarkei*** **Strusz, 2011; Canberra Formation, Wenlock; A, CPC44258, locality CC92, dorsal valve internal mould showing long inner hinge plates and myophragm; B-C, CPC44259, locality CC336, distorted dorsal valve internal mould and latex cast, showing convergence of upper edges of inner hinge plates, and curved outer hinge plates; D-E, CPC44255, locality CC57, worn dorsal valve, dorsal view showing long inner hinge plates and myophragm, ventral view of excavated damaged dorsal umbo, left side showing outer and parts of inner hinge plates, and curved crus; F-G, CPC44260, locality AAÖ85, ventral valve internal mould and latex cast, showing long septum supporting short narrow spondylium.**

Description

Shell surface smooth, outline pyriform to elongate subpyriform, profile ventribiconvex. Ventral beak fairly prominent, dorsal beak low. Ventral median septum long and thin, high umbonally and extending to or beyond mid-length, supporting a small, narrow spondylium. Inner hinge plates subparallel, very long, with a low myophragm between them. The hinge plates are high, around mid-length upwardly convergent with their upper edges almost touching (Fig. 4B-C). Outer hinge plates triangular, evenly curved to meet inner hinge plates. Crura curved, oval in cross section, projecting slightly medially from tops of inner hinge plates.

Remarks

The material is limited and distorted, that from locality CC57 particularly poorly preserved, but conforms in all respects to the type series from Woolshed Creek. A worn dorsal valve from CC57 (CPC44255, Figs 4D-E) has long inner hinge plates, small outer hinge plates, and one preserved slender curved crus, but other aspects of the interior are uncertain because of damage. Very worn ventral valves from CC57 (CPC44256, 44257) have the typical pyriform outline and long median septum of the species.

A small number of badly distorted moulds from the Cappanana Formation east of Cooma (Strusz 2013) were compared with this species, but have been re-evaluated as a result of more recent studies, especially Strusz and Percival (2018). It is now clear that they are the gypiduline *Ascanigypa glabra* (Mitchell, 1921).

Genus *Rhipidium* Schuchert and Cooper, 1931

Type species

Pentamerus knappi Hall and Whitfield, 1872. Louisville Formation, Wenlock, Kentucky, U.S.A.

Rhipidium (*Pararhipidium*) Boucot and Johnson, 1979

Type species

Pentamerus tenuistriatus Lindström in Angelin and Lindström, 1880, p. 24, pl. 20, figs 1-16. Slite Beds, Wenlock, Gotland.

Diagnosis

Moderately biconvex, non-trilobate, pyriform, finely costate pentameride with relatively short ventral beak; anterior commissure rectimarginate to faintly sulcate; ventral median septum extending to about mid-length, supports relatively small, narrow spondylium; inner hinge plates subparallel (new, after Boucot et al. in Kaesler 2002).

Remarks

Rhipidium (Pararhipidium) differs from *R. (Rhipidium)* Schuchert and Cooper, 1931, in its pyriform rather than oval outline, less strongly biconvex profile, and finer costae (Boucot and Johnson 1979:102; Boucot, Rong and Blodgett:983 in Kaesler 2002). Boucot and Johnson assigned only the type species to their subgenus; the lectotype was chosen and figured by Bassett and Cocks (1974:23, pl. 6, figs 1a-c).

Rhipidium (Pararhipidium) oepiki sp. nov.
Figs 5, 6

Type material

Holotype CPC44261, paratypes CPC44262-44272, locality CC124.

Other material

CPC44273, locality CC57; CPC44274, locality AAÖ77.

Distribution

Canberra Formation, all except CC57 being certainly in the Camp Hill Sandstone Member.

Diagnosis

Species of *Rhipidium (Pararhipidiium)* differing from the type species in finer costation, smaller spondylium, and outer hinge plates which do not sweep forward to join the inner hinge plates.

Description

The available material consists of one very worn calcareous ventral valve, plus external and internal moulds of separated and mostly incomplete valves of moderate to fairly large size - maximum observed length is a crushed dorsal valve 41 mm wide, about 52 mm long. Ventral valves are pyriform in outline, width and length about equal, with greatest width at about 2/3 valve length. Convexity is moderate (a ventral valve 34 mm long has a depth of 17 mm, smaller valves are relatively shallower); the valve may be slightly flattened anteromedially. One ventral valve shows significant asymmetry (Figs 5F-G; compare Bassett and Cocks 1974, pl. 6, fig. 2a and pl. 7, fig. 1). Dorsal valves are suboval, and are roughly as thick as ventral valves. The ventral beak is sharp, suberect, and not strongly extended beyond the hinge line. The dorsal beak is low but sharp, also suberect. The shell

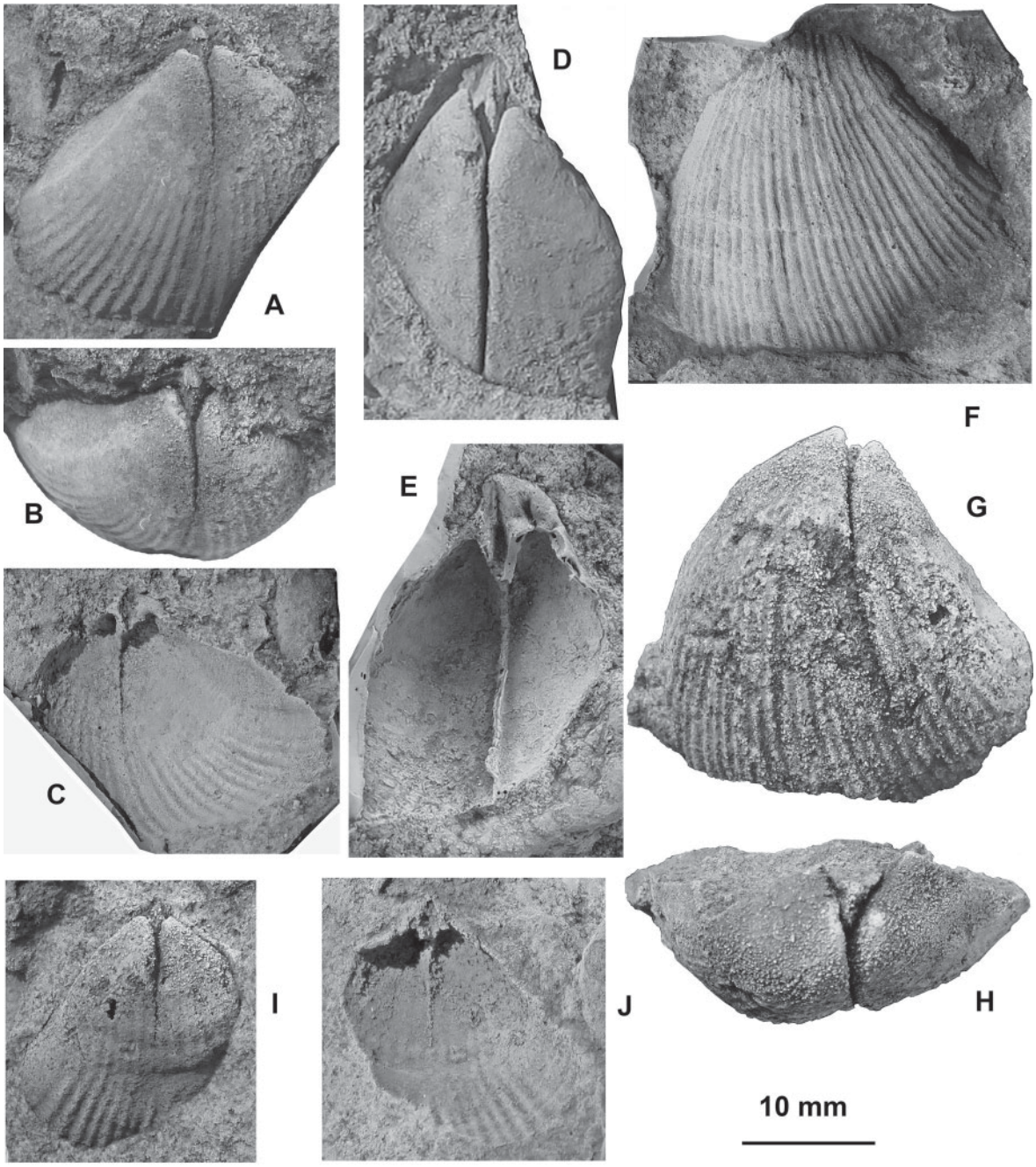

Figure 5. *Rhipidium* (*Pararhipidium*) *oepiki* sp. nov., locality CC124, Canberra Formation, Wenlock; A-C, holotype CPC44261, incomplete ventral valve internal mould in dorsal and posterior views, and latex replica, showing broad pyriform outline, small spondylium; D-E, paratype CPC44262, incomplete ventral valve internal mould and latex replica, the latter showing possible teeth tracks; F-H, paratype CPC44263, latex cast of strongly asymmetric ventral valve exterior, and internal mould in ventral and posterior views; I-J, paratype CPC44267, incomplete ventral valve internal mould and latex cast. All latex casts tore during removal from thin outer edges of septa.

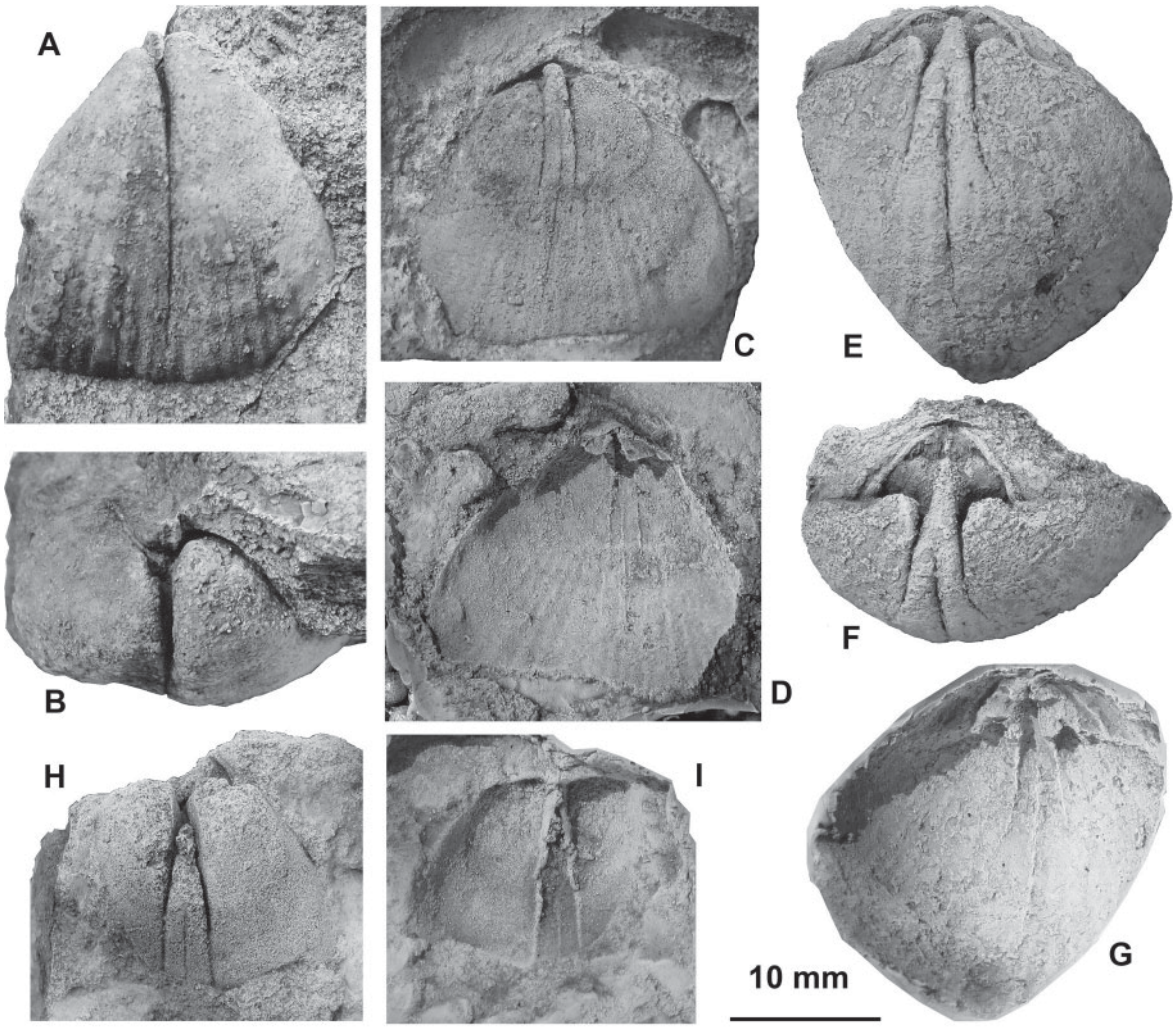

Figure 6. ***Rhipidium*** **(*Pararhipidium*)** ***oepiki*** **sp. nov., locality CC124, Canberra Formation, Wenlock; A-B, paratype CPC44268, locality CC124, ventral valve internal mould in ventral and posterior views; C-D, paratype CPC44270, locality CC124, dorsal valve internal mould and latex cast; E-G, paratype 44272, locality CC124, dorsal valve internal mould in dorsal and posterior views, and latex cast, showing curved outer hinge plates, relatively strong myophragm, and divided triangular ctenophoridium; H-I, CPC44274, locality AAÖ77, incomplete dorsal valve internal mould and latex cast (damaged during removal), with upper edges of inner hinge plates almost touching posteriorly.**

surface, apart from the curved ventral palintrope, is covered by relatively low, rounded, radial to gently outwards-curving ribs, some of which bifurcate; there are about 10-15 in 10 mm at a distance of 10 mm from the beak. The delthyrium is narrow, and there is a suggestion of either tooth tracks or narrow deltidial plates in CPC44262 (Fig. 5E).

Ventral interior with well developed median septum extending to about 1/2 to 2/3 the valve length, posteriorly high and supporting a small, narrow spondylium. Teeth uncertain. Shell floor posteriorly smooth, anteriorly reflects external ribs.

Dorsal interior with thin, upright, parallel to weakly divergent inner hinge plates extending to about valve mid-length. Outer hinge plates short, curve evenly down to join inner plates at well developed crural bases; anterior edges straight, transverse. Dorsal palintrope divided from hinge plates by fine divergent ridges, inside of which are grooves representing the tracks of the dental sockets. At the apex of the hinge plates is a slightly raised medially divided triangular ctenophoridium. A fine, low myophragm extends from about 1/4 to about 3/4 valve length, and is strongest between the ends of the inner hinge plates.

Remarks

Nearly all the available specimens are preserved as moulds in a fairly coarse-grained quartzose sandstone, and consequently are unusual for the Canberra Silurian in being undistorted. However, preservation is generally a bit poor because of the coarse matrix, and there are no complete recognisably adult specimens.

Superfamily GYPIDULOIDEA Schuchert and LeVene, 1929
Family GYPIDULIDAE Schuchert and LeVene, 1929
Subfamily GYPIDULINAE Schuchert and LeVene, 1929
Genus *Ascanigypa* Havlíček in Havlíček and Štorch 1990

Type species

Pentamerus ascanius Barrande, 1879. Motol Formation, middle Wenlock, Prague Basin, Czech Republic.

Diagnosis

Smooth non-plicate gypiduline with ventral fold, dorsal sulcus well developed anteriorly; short ventral median septum; inner hinge plates conjunct apically, discrete anteriorly, gently divergent.

Ascanigypa glabra (Mitchell, 1921)
Fig. 7

Synonymy

Sieberella glabra Mitchell, 1921: 549-550, pl. 31, figs 13-15; Booker 1926:143-145, pl. 7, figs 1-3, pl. 8, fig. 3, text-fig. 6.

Gypidula glabra (Mitchell); Sapelnikov 1985:103

Ascanigypa glabra (Mitchell); Strusz 2005:211-214, figs 4-5; Strusz 2010, figs 4, 5K'-L'; Strusz and Percival 2015, fig. 1K; Strusz and Percival 2018:110-112, figs 19, 20.

cf. *Apopentamerus clarkei* Strusz, 2011; Strusz 2013:9-10, fig. 7

Material

CPC44275-44280, locality CC17; CPC44281-44284, locality CC57; CPC44285, locality CC289; CPC44286-44292, locality AAÖ57.

Distribution

Canberra Formation.

Diagnosis

Rotund species of *Ascanigypa* with wide cardinal margin, perceptible cardinal extremities, well developed subtrapezoid tongue, relatively long ventral median septum (modified from Strusz 2005).

Description

Shell smooth, biconvex, outline oval, with weakly to well developed subtrapezoidal ventral tongue, very shallow dorsal sulcus anteriorly. Ventral and dorsal beaks incurved, rounded. Cardinal extremities rounded but distinct. Largest specimen a relatively weakly distorted dorsal valve internal mould 27 mm wide, 19 mm long.

Ventral interior with high, robust median septum extending to about mid-length, small apical spondylium. Dorsal interior with thin slightly divergent inner hinge plates extending nearly to mid-length, and small curved outer hinge plates. Myophragm low, extends over middle third of valve floor, low between hinge plates, a little higher in front of them. Occasionally, weak traces of the *vascula genitalia* are visible, as in the specimens from the Delegate River Mudstone (Strusz and Percival 2018, figs 19O, U-V)

Remarks

While the Canberra specimens are not very well preserved, consisting of rather strongly distorted internal moulds of both valves, and two or three very incomplete external moulds, they show sufficient details for confident identification, particularly by comparison with the relatively undistorted material from the Delegate River Mudstone at Quidong (Strusz and Percival 2018, fig. 19). The four small specimens from the Cappanana Formation east of Cooma (Strusz 2013), originally compared with *Apopentamerus clarkei*, clearly illustrate the difficulties in identifying small, smooth, strongly distorted pentamerides. By comparison with the less distorted material from Quidong and Canberra, it is now clear that they are all ventral internal moulds of *A. glabra*.

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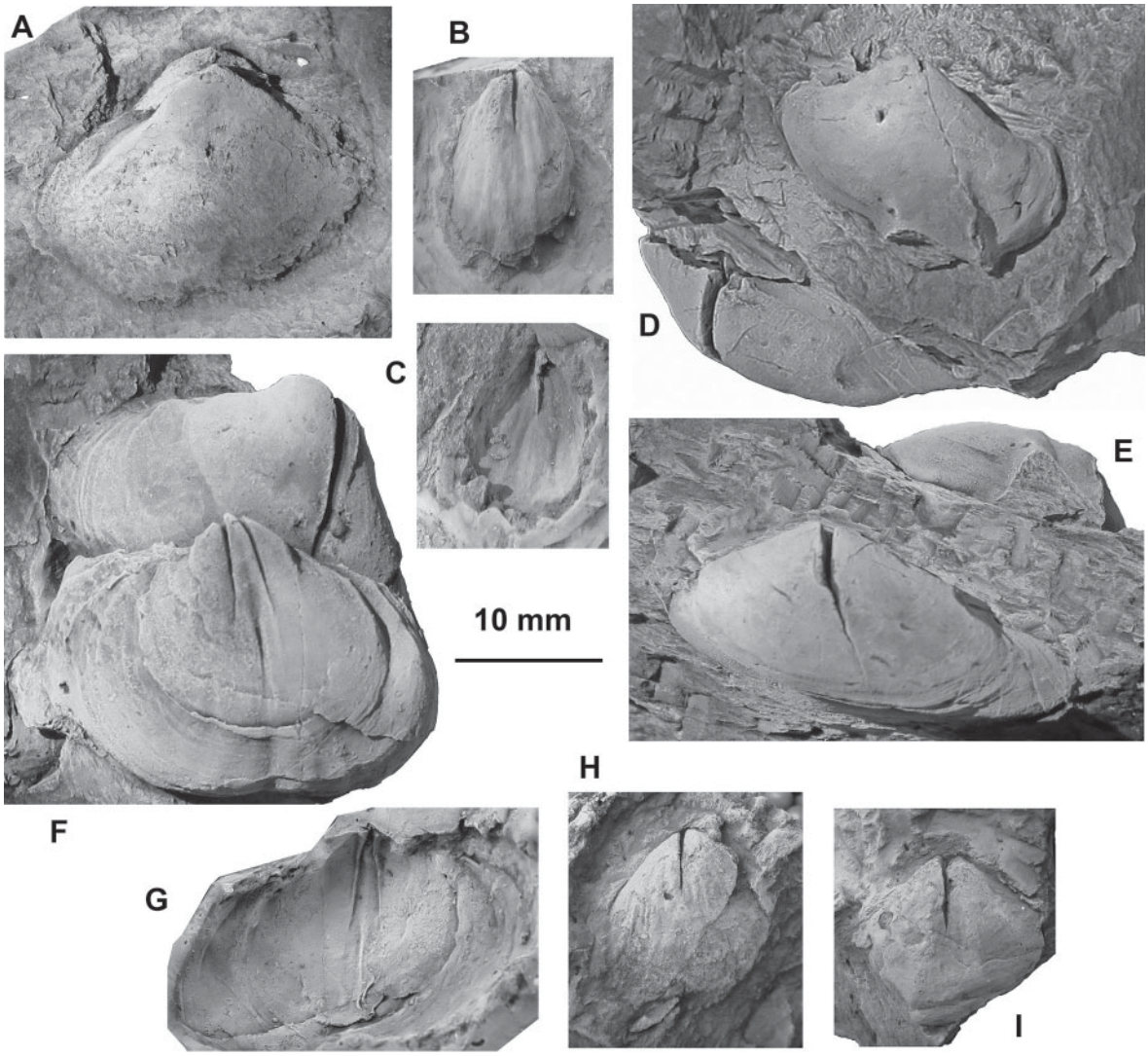

Figure 7. ***Ascanigypa glabra*** **(Mitchell, 1921), Canberra Formation, Wenlock; A, CPC44277, locality CC17, latex cast of shell in dorsal view, showing incurved beaks, wide cardinal margin; B-C, CPC44291, locality AAÖ57, small distorted ventral valve internal mould and latex cast; D, CPC44276 (and adjacent CPC44275), locality CC17, distorted ventral valve internal mould showing anteriorly prominent fold; E, CPC44275, distorted ventral valve internal mould with robust median septum; F-G, CPC44278 (above) and 44279 (below), locality CC17, internal moulds of ventral and dorsal valves, and latex cast of CPC44279 in antero-ventral view; H, CPC44290, locality AAÖ57,ventral valve internal mould; I, CPC44292, locality AAÖ57,ventral valve internal mould.**

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APPENDIX
LOCALITY LIST

The material used in this study came from the Canberra 1:250,000 sheet collections made by Commonwealth Bureau of Mineral Resources (BMR) staff, now held by its successor Geoscience Australia (locality prefix CC), or was collected and retained by Armin Öpik (prefix AAÖ). Öpik's material was transferred to the BMR by Dr R. Nicoll and myself around Christmas 1979, as a distinct collection using his numbers and locality information.

Map coordinates and stratigraphy refer to Henderson and Matveev (1980).

CC17: Crace Hill, collector not recorded. Canberra Formation, mudstone below tuff Smc_2, therefore in the lower half of the formation. FB941.992.

CC57: Foundations of St Edmund's College, Griffith, collected by P.J. Channon in 1952. Canberra Formation, east of the Deakin Fault; mudstone and fine siltstone. FA949.888.

CC59: Excavations for Anzac Park East Portal Building (which housed the BMR until 1997); collected C.G. Gatehouse. Canberra Formation, west of the Oakes Fault; mudstone. FA946.924.

CC92: Quarry north of the Molonglo River northwest of Queanbeyan, recorded as being "on end of ridge above ford, about 400 yards north of the abattoirs", collected by W. J. Perry in 1958. Canberra Formation, probably Camp Hill Member; pale grey to white quartz sandstone. Approximately FA003.875.

CC124: Former summit of Capital Hill, at exposure of unconformity between Black Mountain Sandstone and overlying Camp Hill Sandstone Member, basal Canberra Formation. The locality was destroyed in 1981, during construction of the current Parliament House. Collected A.A. Öpik, J.J. Veevers, and C.G. Gatehouse. Canberra Formation, Camp Hill Sandstone Member; poorly sorted ferruginous quartzose sandstone. FA931.904.

CC233: Trench near former Acton tourist ferry terminal, collector not recorded. Canberra Formation; mudstone. Approximately FA921.930.

CC289: Excavation for Googong pipeline, four metres west of Dairy Flat Road, Pialligo; collected by G.A.M. Henderson, May 1977. Canberra Formation; mudstone. FA965.899.

CC336: Excavation about 100m east of Antill Street, northeast of Watson; collected and donated by R. Lawson, October 2011. Canberra Formation; mudstone. FA972.993.

AAÖ57: "Telopea watercourse, at bridge, at swimming pool" - southwestern end of Telopea Park, Kingston, collected 1949. Canberra Formation; mudstone. Approximately FA941.896.

AAÖ77: "Camp Hill WSW of Parliament (Quarry)" - refers to the old parliament building. Camp Hill Member, basal Canberra Formation; ferruginous sandstone. Approximately FA934.911.

AAÖ85: Crace Hill, as locality CC17, which see.

AAÖ119: "N-foot of Ainslie; at the NE corner of the Alley (Plantation); E of the gate; E of the road; in gully (creek)." Approximately at the eastern end of Maitland Street, Hackett, north of the primary school. Canberra Formation; interbedded mudstone and silty limestone. Approximately FA968.969.